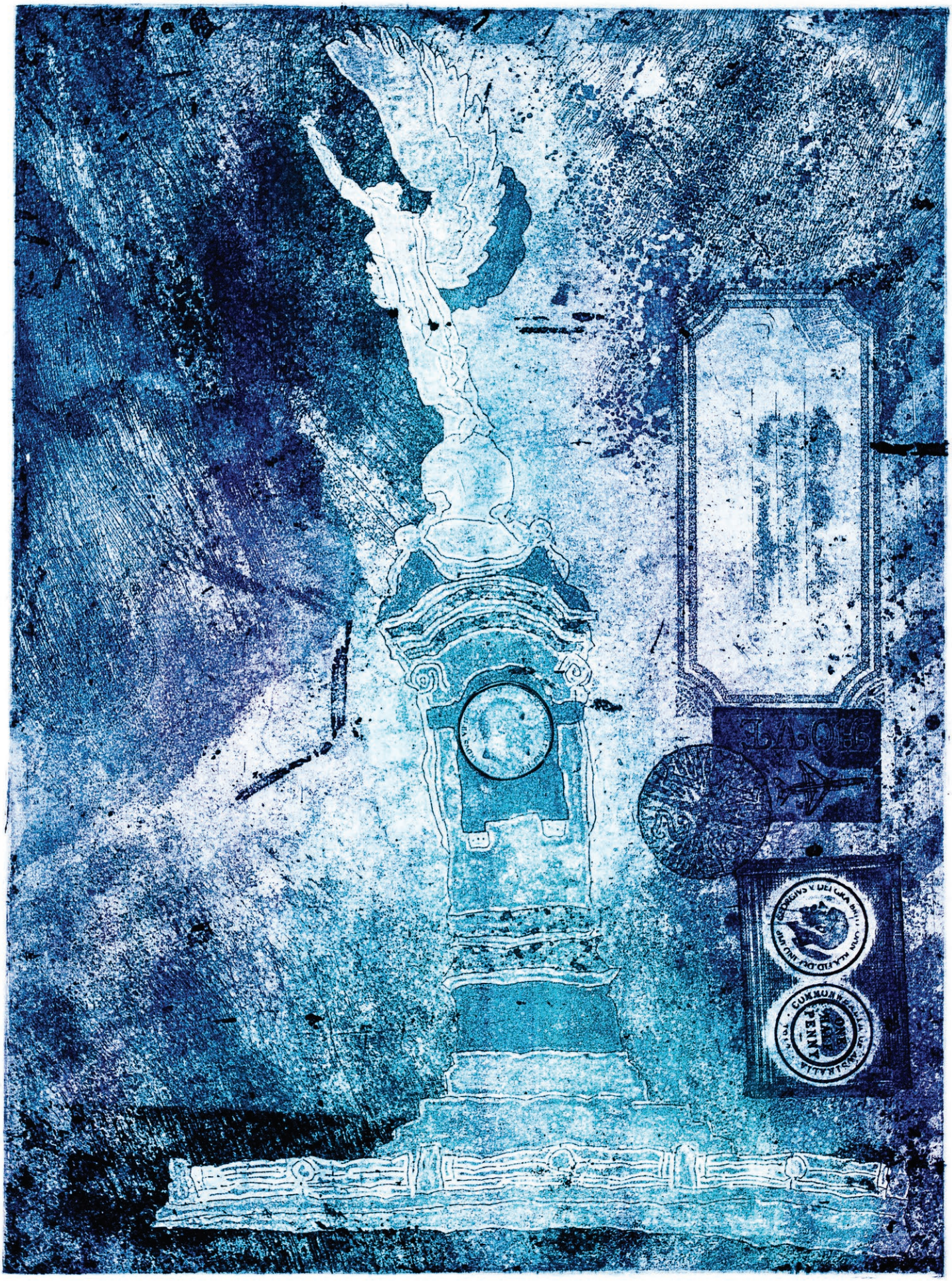

the iafor european conference series 2014

ecss2014 ecsee2014 ebmc2014 ecpel2014

Official Conference Proceedings ISSN: 2188-1146

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The European Conference on
Sustainability, Energy & the Environment 2014

Brighton, United Kingdom

Official Conference Proceedings

ISSN: 2188-1146

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The International Academic Forum (IAFOR)
Sakae 1-16-26-201
Naka Ward, Nagoya, Aichi
Japan 460-0008
ww.iafor.org

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Inclusive Governance by Gender Equality: Innovative Vision to Humanize our Cities

Bushra Zalloom, Birmingham City University, United Kingdom

The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract

This study suggests a broad approach to enhance the social sustainability through socially innovative and inclusive governance when humanizing the urban landscape. This approach requires both "top-down" and "bottom-up" strategies. Socially innovation and inclusive governance can be achieved when both genders are equally included and appreciated in shaping the future landscape of their city, as residents, planners and as decision makers. Consequently, their involvement will decrease the impacts of the proposed development or action on the social dimension.

Inclusive governance modes should base on citizens' empowerment and participation of all relevant stakeholders especially women, because there is increasing evidence that women and men experience cities in different ways. However, if women policies are put in a separate code it gives the impression to planners that woman issues are other. Therefore, this study prefers a broad approach about planning for all, rather than planning for women. Policies can never plan entirely separately for women or for men, and it is a sign of polarization to imagine so. Inclusive practice is sensitive to gender differences in using the city and consequently able to make more creative choices that assumed to fit almost everyone.

Therefore, to achieve the real meaning of socially innovative and inclusive governance, the needs and motivations for men and women should be equally considered, and they have to participate through all design stages, as planners and as users for the urban landscape.

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1. Socially innovative and inclusive governance

It is very important to govern the city in an innovative and inclusive way that increases the sense of belonging among citizens and encourages them to participate in city making. Under global capitalism, the degree of control for the powerful government has been replaced with a fragmented organizations which negatively affect the citizens well in shaping their city, thus, the "challenge for spatial planning has been to adjust to this change from government to governance, where political and economic power lies with not one powerful government but a multiplicity of agencies and interests" (Madanipour et al 2001:2). The new way of governance need to be linked to new ways of thinking in urban space and urban life, moreover, the fragmented responsibilities for administrative space and the changing nature of market relations calls for a comprehensive method in governance the space. Global capitalism has led policy makers in Europe to be concerned about the social consequences of urban transformation, especially social exclusion, as it threatens the sustainability of the European society, thus, they place social aspects very high on national agendas (Madanipour et al 2000). Therefore, this study suggests a broad approach to enhance the socially innovative and inclusive governance when planning and regenerating the urban landscape.

1.1 Social innovation by public participation

Cities play a critical role as motors of the economy, as places of connectivity, creativity and innovation, and as service centers for their surrounding areas. Cities are also places where problems such as unemployment, segregation and poverty are concentrated (EU 2011). The development of the cities will determine the future socioeconomic development, and encourage local business and partnerships between public, private and voluntary organizations. This partnership provides a powerful tool to mobilize and involve local communities and organizations, as well as citizens. They provide a more integrated and inclusive approach to tackling local challenges, with a focus on the quality, inclusiveness and sustainability of growth strategies (PPS 2012, Lin 2010). Public participation is a process that gives individuals an opportunity to influence public decisions (Grabow 2006).

The place-making approach builds on the ability of local organizations to create great community places that bring people together and reflect community values and needs. This is a traditional, organic human skill that often ignored by bureaucracies. A study conducted by the Project for Public Spaces (PPS) finds that governments rarely focus on creating a successful public realm. The structure of departments and the processes they require, sometimes, obstruct the creation of successful public spaces. There is not a comprehensive approach in planning and design, between different departments, as each department focus only on its mission (PPS 2012). This fragmentation negatively affects city planning and wastes time and effort for various stakeholders.

It is not only the structure and process within governmental departments, but also governments rarely focus on public participation when creating public realms. Local government deserve opportunities to learn and develop the skills to integrate public participation within all the elements of comprehensive planning, especially if they hope to make a real difference in giving people a voice in shaping the future of their city (Grabow 2006). A comprehensive approach to developing and managing public

space requires both *top-down* and *bottom-up* strategies. Leadership at the highest level of city is essential if transformation of public spaces is to occur on a large scale, a *bottom-up* grassroots organizing strategy is also fundamental (PPS 2012). The involvement of city residents is crucial to the success of many policies, especially in a context of crisis and possible conflicts between different stakeholders (EU 2011).

Moreover, the *bottom-up* approach empowers and engages people more than the traditional planning processes. It draws on the assets and skills of a community, rather than on relying solely on professional experts (PPS 2012). Only with full public participation in the creation of public spaces can truly humanized places come into being. Building a city is an organic process; local customs must always be considered and honored (Kostof 2009). Thus, planners, designers, and administrators should not decide in a void. Professionals such as traffic engineers, transit operators, urban planners, and architects often have narrow definitions of their job. By contrast, a community has a holistic vision and should lead the professionals in implementing that vision. So, the key is to improve communication between the people and local government (PPS 2012). Dolores Hayden's in her book the "*Power of Place"* argues for more democratic strategies in urban planning. The *Power of Place* signals its own argument that:

> "It is possible to enhance social meaning in public places with modest expenditures for projects that are sensitive to all citizens and their diverse heritage, and developed with public processes that recognize both the cultural and political importance of place" (Hayden 1995:9)

Similarly, Grabow (2006) states that it is highly undemocratic to plan, govern, arrange and impose programs without communication with the people for whom they are designed; it is also impractical. This requires removing bureaucratic obstacles to quickly add value to a place and clearly demonstrate future potential. Working together on short-term changes can help build bridges between city agencies and citizens, benefiting long-term implementation and maintenance as well (PPS 2012). Therefore, residents have the best understanding of the assets and challenges of a particular place. The important starting point in developing a concept for any public space agenda should be to identify the talents and resources within the community, people who can provide historical perspective, insights into how the area functions, and an understanding of what is truly meaningful to them (Greed 1994). Of course, not all citizens need to be involved in the same way, at the same time or for the same purpose. It's important to think carefully about the business of people involvement (Grabow 2006).

The first step in developing a citywide agenda is to make an honest assessment of how existing public spaces are performing or underperforming. The assessment should include every neighborhood and involve the people who live there as well as other key stakeholders. Such a district-by-district approach encourages residents and officials to look at their neighborhoods again and bring unexpected possibilities to light. Unused and underused spaces can be identified and improved in a systematic way, ensuring that the benefits are distributed geographically, strengthening the entire fabric of the city and building equity (EU 2011). Social innovation offers an opportunity to widen the public space for civic engagement, creativity, innovation and cohesion. In cities where place-making has taken hold, local government is often not

directly involved in implementation, but relies on community development organizations, business improvement districts, and neighborhood partnerships to take the lead in regenerating their communities (PPS 2012). This means that when it comes to public spaces, the community is the expert, and that local partnerships are essential to the process of creating dynamic, sustainable public spaces that truly serve people. Communities everywhere can decide what it is that makes their public spaces a destination and increases their sense of belonging.

1.2 Inclusive governance by women involvement

Inclusive governance modes should base on citizens' empowerment and participation of all relevant stakeholders especially women, because there is increasing evidence that women and men experience cities in different ways. Therefore, to achieve the real meaning of inclusive governance, gender policy should be contained within urban planning. Gender includes men and women as well, but the research is more focusing on women issues because various studies across the world show that their status is worse (Johnson 1989, Greed 1994, EU 2011, Grabow 2006). However, if women policies are put in a separate code; such as "*Women Friendly Seoul Project Guidelines 2009*"; it gives the impression to planners that woman issues are other. We all live in the same urban space, and women planning policies should not aim at building a separate women's city, away from men's needs.

The traditional planning that called for "gendered nature of urban space" restricted the women mobility: physically and socially, "physically by imposing patterns of movement and behavior based on fear and restricted access, and socially through the assumptions about women's role in urban society" (Madanipour 1996:85). Safety, transport, and wellbeing are main consideration in different women policies around the world, such as "*Women Friendly Seoul Project*" and "*UNIFEM regional program*", to name some. According to them, city planning for gender must promote safety; safety is an important aspect especially for women; to avoid problems of crime and sexual violence. Safe design includes, for example, good street lighting and parks that are overlooked, but it avoids deserted spaces or areas that are not occupied for parts of the day and places where attackers can easily hide or where women are easily trapped, such as subways and alleyways. Women are also often concerned about the safety of urban spaces for children, such as busy roads, lack of safe places to play, polluted areas and so on. Likewise, good public transport system is a fundamental aspect of urban and regional planning; as it can widen women's employment opportunities (Seoul 2009, Greed 1994).

In urban planning, everything is linked to everything else. If land-use is changed here or a transport route there the effect will vibrate through the system, and have a spatial and social implications for everyone. Greed (1994:173-192) states that "many of the problems which women encounter in the city of man are the result of a dichotomized public/private view of reality, prevalent within the planning subculture". Thus, in order to plan for women, physical divisions between perceived public and private realms manifested in land-use patterns must be dissolved. The nature of land uses must be re-conceptualized, and the likely interrelationship among them reconsidered, to reflect more realistically the way in which women use urban space. "The spatial divisions must be broken down to the advantage of women, by mixing, milling, and making new interconnections between land uses and activities, thus creating new

spaces and possibilities for women". Therefore, to make a progress in the profession, changes are needed in the domestic sphere of home, family, with a reconceptualization of roles, responsibilities, and assumptions. Women have penetrated the public realm, but there has not been an appropriate change in man's role in the private realm. The public/private dichotomy itself has not been broken down but is still full of power (Greed 1994).

Like other built environment occupations, the planning profession has traditionally been gender blind, and planners still lack understanding about gender issues. Greed (1994) mentioned that planners in the development control sections of planning departments in England thought gender considerations had no bearing on their work as their decisions considered only technical matters. Planners typically consult with communities, and the views expressed can influence outcomes. So, unless planners are gender aware such consultations can unintentionally exclude women in general; or particular groups of them. Therefore, gender-sensitive urban planning is needed. Inclusive gender-sensitive planning means understanding the views of women and men equally through all design stages. According to Greed (1994), "*The Royal Town Planning Institute Gender Mainstreaming Toolkit 2007*" shows how to incorporate gender into planning. It can be used at any stage of the plan-making process, as it based on a series of questions. Such as: Who are the planners? Who forms the policy team? Which groups of people are perceived as recipients of planning? How are statistics gathered and whom do they include? What are the key values, priorities and objectives of the plan? Who is consulted and who participates? How are the planning proposals evaluated? By whom? How is the policy implemented and managed? Is gender fully integrated into all policy areas?

Women planners have experimented with different ways of electing public participation and reaching women in their private territory (Johnson 1989). They also seem to cultivate wider intellectual and academic contacts and networks than men, often coming from humanities and art backgrounds and knowing people from a range of academic disciplines, so they bring with them a mix of alternative views (Greed 1994). Moreover, women planners are more familiar with informal, qualitative, and creative approaches to finding out what people want, but they still unrecognized in government policy-making. Feminist academics during the 1970s and 1980s documented the surprising extent of the absence of women in planning, history, geography and other disciplines. Louise Johnson's pointed this out and discussed some likely consequences in her critique of Mather's typical textbook; she highlighted that the absence of women in a book for land use means that they remain invisible and unacknowledged by decision makers when planning and shaping urban spaces:

> "The greatest gap in Mather's book is the total absence of any reference to the word, "woman". It is not just a semantic point but one of enormous importance to future planners… [If women] are not addressed explicitly in book on land use, then they remain invisible, unacknowledged and beyond the caring of those empowered to allocate resources, shape neighborhoods, transport systems and so on" (Johnson 1989:87).

It is clear that women have been marginalized as planners and as users in the process of planning and organizing urban space, thus cities where built and managed by men (Madanipour 1996). Decision makers tended to place women outside their concerns.

Therefore, mandatory codes are needed, to enable more women to participate in urban planning, and more women planners to achieve position of seniority from which they will be able to exercise a more positive influence on urban policy for the benefit of all women in society (Greed 1994), because, neglecting women in various areas has often led to less than optimal effects of development inputs, and to worst negative impacts (Brown and Switzer 1991). Women's participation is essential during urban planning to improve the design outcome, because "woman's uses of the environment are sufficiently different from those of men to represent a distinctive habitat", thus should be more encouraged to participate in government policy-making (NPWS 2004:21).

Over the past twenty years the nature of everyday urban life has been profoundly changed, and the perceived settings has been affected by the global reconstruction of economic, political, social, and cultural processes. A study prepared by Renate Ruhne (2003) demonstrates "how the construction of urban space influences the production of the insecure woman or the self-assured man" (Low 2006:129 citing Ruhne 2003). Similarly, Martina Low (2006) finds that the gendered spaces is affected through the organization of perceptions and social order; which leads to a choice of place and a placing practice that reproduces structural principles of society. Likewise, Setha Low (2000) describes the gendering of plazas in San Jose, Costa Rica, noting that the *Parque Central* is not only dominated by men, but women who use the space come with children or male accompanies at culturally acceptable times. In general, when studying the perception of people who are variously read and consume urban spaces, there is a need to acknowledge that women, like men, are not a homogenous social group, but are differentiated along characteristics such as ethnicity, class, age, and ability.

As a result, it is becoming increasingly clear that gender differences and inequalities directly and indirectly affect development strategies and hence the achievement of overall development goals. Therefore, to achieve inclusive governance and social innovation both genders should be equally included and appreciated. Moreover, the traditional understanding for women role and status affect the social and spatial organization and divide the society into private/public spheres. This division still unconsciously affects the planners' perspective when planning the city and its urban spaces. Moreover, women as users are ignored from citizen participation, and they are almost excluded as planners in decision making and planning policies. Thus, to achieve the real meaning of socially innovative and inclusive government, the needs and motivations for both genders should be equally considered, and they have to participate through all design stages, as planners and as users for the urban landscape.

2. Transformation of gender's role: The case study of Amman

Feminist studies have received uneven attention in anthropology and architecture as well. Recently, researches in several disciplines realize the importance of the spatial dimensions of cultural beliefs and practices in including the description of urban landscape and daily life. Spatial dimensions were used to theorize about the differences between males and females, and asymmetries in power and authority in society. According to Setha Low and Denise Lawrence (2010:7) "gender is defined as the cultural interpretation of perceived physical, anatomical, or developmental differences between males and females", although gender elaborates in biological

attributes, it is culturally constructed, and shapes how we think about others and ourselves and also influences our behaviors (Crossmnan 2013).

The seed of what is wrong with cities today were planted generations ago. Assumptions about the need for the gendered organization of space to express public/private dichotomies might be so deeply embedded in people's minds. The city is the product of the reproduction over space of social relations but, once built, the physical structure can, in turn, influence its residents (Madanipour 1996). The processes of growth and differentiation in cities mean there is a certain amount of instability and change in urban living (Stevens 2007), this instability arises from the increasing conflict in females roles which occurs when they move between various social fields such as family, work and urban spaces (Adams 2006), as they "may experience conflicts between different concepts of order and ways of behaving" (Krais 2006:131). The division of a public/private domain which represents the gender inequality of power, authority and role; it is symbolically reflects the position of women in society during a specific period of time. This phenomenon was very clear in Amman where the transformation of the built environment affected the women role and her sociocultural behavior.

Amman is a multicultural community since the 1920s, people from different origins, ethnic and social background were living peacefully together in small neighborhoods situated near the water stream, Muslims and Christians; Arab, Kurds, Arminian and Circassian; were facing the same problems and looking for effective solutions (Muneef 1994:92,254) (Fig. 1; Fig. 2). This multicultural content reflected on everything in the city, and on the way people socialize with each other in everyday life. As Muneef (1994:93) described "Amman was seen by tourists as a big festival where different languages, customs, traditions and dressing easily observed, […] and where Islam religion is a unifying factor for the multicultural community". Islam affected all sociocultural features of the daily life in the City, customs and traditions, food and drinks, festivals and activities, dressing and socializing. Islam regulations also controlled the house design to maintain privacy, and organized the public spaces to suit the conservative society.

Fig. 1 Amman in forties described as the city of hats (Source: GAM 2013)

Fig. 2 Various styles of women dressing (Source: edited by the researcher)

The multicultural background did not only influence the dress style, but also the lifestyle and socializing. Socializing for women was occurred within their private sphere, at home, especially during the day before the sunset. Rasheed (2002:268) mentions that while children were playing in the street and men enjoy being in public

cafes, women were socializing by welcoming their neighbors at houses. It was a daily rotation from house to another during the week. Bedouin women were welcoming their guests by preparing the Arabian coffee and fried wheat. Palestinian and Syrian women were offering various kinds of fruits and lemon drink to the guests. During their meeting they were communicating, singing, dancing and enjoying. The separation between men and women in everyday life led them to socialize within two different worlds; women in *private sphere* and men in *public sphere*, and consequently affect their behavior.

Another type of socializing was described by Muneef (1994:93,146) as he wrote that in spring and summer, old women distributed backless chairs, made of straw, on the public walkway near the front door, twice a day, at noon and before sun set, sitting with their neighbors and preparing their pipes to smoke *al heshi*, each pipe about one meter in length, at the same time they checked the dryness of the hanged laundry, and welcome anybody walking in the street, and start a conversation with them (Fig. 3). Only old women allowed doing so and sitting in front of their houses (Muneef 1994:145). But, young ladies were sitting in semi-sheltered balcony and observing people from distance. They were not allowed to go outside without accompanying their mothers or brothers. This sociocultural features and beliefs should be discussed by bridging urban studies with social and gender studies, and moving beyond defining the gendered space as a simple division between public and private, as it is affected by women origin, lifestyle, socialization, education, and role, and automatically reflected on architecture and the organization of public spaces.

Fig. 3 Old women socializing and smoking on the public walkway
(Source: edited by researcher)

During the 1970s and the 1980s, the society of Amman transformed rapidly from a closed conservative to a more open liberal, thus, it is becoming harder for women to know what is accepted from their behaviors in this society. Moreover, women started getting better education, going out to work, achieving more in their careers, thus, they became in more competitive situation. But still, sometimes modernization contradict with the local values, the dilemma that women faced was how to maintain an accepted moral social or religious values while dealing with the flow of the advancement of the society. The changes taking place in Amman offered options of behaviors and

worldviews that had not been available to older generations, and a growing number of women were taking advantage of these transformation despite all the disadvantages that resulted from precisely the same processes. Sometimes it was very difficult to choose the correct behavior in specific situation, which could at times bring about unintended consequences (Potter et al 2009, Rasheed 2002).

Later on, the Gulf Wars of 1990 and 2003 had a lasting ripple effect on Amman where the majority of returnees and refugees came to live. Iraqi professionals and intellectuals helped in creating Amman's new cultural renaissance, emphasizing Amman's character as multi-colored collage marked with a variety of Arabian culture (GAM 2013). This transformation affects the women role and relationship with their families. A growing number of young women enjoyed higher education and started working but they still living with their parents, and the sociocultural behavior of men and women was strictly defined and formed on the basics of custom, tradition and religious (Droeber 2005). The ways that young women in Amman view the world is significantly influenced by the roles they played or were supposed to play within society. During this era, these roles had undergone tremendous changes; and women had constantly adapted their behavioral strategies to suit the current state of affairs.

2.1 Humanizing Amman with Gender behavior

A study about *"The role of landscape architecture in humanizing outdoor spaces in Amman city"* prepared by Bushra Zalloom studying *King Abdullah Street* in Amman, revealed the relation between the physical environment and the sociocultural behavior. The studying spot located within about 1Km diameter, which is a logical distance for walking and socializing. Field observation and questionnaire analysis proved that perception and social activities vary according to gender. It found that the participation of males in the street were 76%, while females were 24%. Moreover, the physical and cultural aspects affected the gender's behavior, females were seeking privacy; by sitting in groups on ground at the round-about, hiding themselves behind planted hedges; while males were sitting on the main street's parapet, drinking shisha –smoking- and watching the pedestrian (Fig. 4). Drinking shisha was also recognized in cafes, which are already gendered spaces that only dominated by males for decades, however today; they are opened for both genders, especially in West Amman. Women and young ladies can go alone or with friends to public cafes, smoke shisha, drink juice or have snacks. This behavior is familiar now in West Amman while still not observed in East Amman where the study was conducted, as families still more conservative. However, both genders that live in east parts, usually, go with their friends to the west parts to enjoy sitting in cafes. Thus, the restriction is anchored with the location itself; it is a spatial restriction rather than behavioral one. Likewise, their attitude when waiting the bus during the day is also differs. While males sit near the shops frontage on the steps or stand individually drinking coffee and waiting the bus, females stand in front of the shops' facade under the sunshades to protect themselves from sun and rain (Fig. 5). That's ensuring that the individual's needs, perceptions and behaviors are differing by gender and affected by the physical environment surrounding them.

Fig. 4 Genders' behavior affected by the physical environment and the sociocultural context (Source: Zalloom 2010)

Fig. 5 Genders' behavior while waiting bus (Source: Zalloom 2010)

Zalloom's research approves that gender is affecting the sociocultural behavior of individuals. Although in the year 2010, females were seeking privacy within the public spaces; sitting in groups, on ground, behind planted hedges to hide themselves from others; as they did before four decades when they hide themselves in the semi-sheltered balconies. The same attitude is presented within different time and different spaces, which confirm that they still affected by the traditional division. On the other hand, males enjoy the public sphere as they usually were. Research findings confirm the importance of identifying the sensual experience and recognizing the human behavior when designing or regenerating public spaces which satisfy human needs, these needs are differ between males and females. One of the major recommendations to decision makers and designers was to humanize the city by creating urban spaces that are pedestrian friendly, suit both gender and different ages, day and night. Furthermore, the research showed that gender should be taken into consideration when designing public spaces; as females need more spaces that satisfy their needs.

3. Conclusion

Studying gendered spaces has moved away from earlier conceptions of fixed symbolic and territorial associations to consider more complex understandings. Historical studies of gender constructions over space and time reveal variability within cultures and the complex inter-linkages of gender with social, commercial, and political influences. While recent studies find that changes in gendered behaviors and

roles; may encourage more interaction between fields, between communities or ways of life, so that individuals become aware of new options. In rapidly changing societies these dimensions of gender construction appears the most challenging to understand. All these provide ample room for further explorations of the social dynamic of the gendered spaces in specific, and the urban spaces in general.

This integration between social and physical dimensions is an important step in humanizing the public spaces. The physical space that we perceive and use is embedded in our behavior, therefore, gender issues should be considered within its cultural context. This study confirms that the community is much more than its physical form; it is composed of people and places where they live; it is a social environment as well as a physical environment. Therefore, public spaces should be recognized as spaces for productive and reproductive activities of society, especially for women. Thus, terms like privacy and gender must never be used as trans-historical concept. They need to be anchored in time, space and class, they mean different thing for different people. *King Abdullah Street* is just an example which reflects Amman's need for more women friendly spaces, and more social spaces, these sociocultural issues should be considered when regenerating various urban spaces in order to enhance the social sustainability. Social sustainability should be the main mission for urban regeneration developments. Therefore, the future policies of Greater Amman Municipality's should encourage the social development, look after the local community, and care more about gender differences in perception, behavior and needs in public realm, to enhance the quality of life for all. Socializing our policies is an essential step to humanizing our cities.

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Board Games as Tool for Teaching Basic Sustainability Concepts to Design Students

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
One aspect of sustainability that often baffles design students is the need to balance concepts such as the triple bottom line (environment, economy and social issue) with the product's life cycle in their design process. In some cases, this is a result of a lack of understanding of interactions between these aspects since the theoretical part of them is often removed from the student's daily life experience. One proposal to solve this barrier and allow for a better understanding and integration is the use of board games. Board games have shown to be a useful tool to teach conflict resolution, strategy development, forward and lateral thinking, either through cooperation or competition. Therefore they can be used to teach basic sustainability concepts (i.e. the tragedy of the commons, population bomb) and their participation in the triple bottom line. Games such as Settlers of Catan, Civilization, Carcassonne and CO2 (an example of a board game with environmental aspect as the core concept), are games where winning conditions can be achieved through balancing several aspects. Therefore this can be extrapolated into the development of educative board games that can be used as a tool to explain design students the need for balance the triple bottom line and other sustainability concepts and allow for a better understanding. The aim of this paper is to reflect upon the initial findings of a research project whose objective is to develop board games for use as learning tool in sustainable design courses at undergrad level.

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Introduction

Data from educational psychologists tell that people retains 80% of what they do as opposed to 10-20% of what it is heard and read (Bhamra & Lofthouse, 2004). Individuals tend to filter information based in a series of factors among them interest, preconceptions and clarity of information during the transference and delivery (Treher, 2011). As well, experience by itself hardly grows into meaningful learning unless the events in such experience allow giving meaning and relevance (Treher, 2011) upon reflection and thus, developing the corresponding skill and mind set.

Sustainable development, by its nature can't be taught efficiently by traditional methods. There is too much information, too many variables to consider which at times can difficult how the student or in a broader context the general public takes that information and transform it into action. Adding the topic in current curricula faces the same barriers trying to raise awareness among the general population. Sustainability requires system thinking, hands on- heads on approach with certain degree on multi disciplinarily. People won't internalize the knowledge unless there is a responsive, dynamic and process learning is enabled, simply because for most of them, it is too abstract or detached from their day to day experience. One of the main barriers to adopt sustainable thinking both in design and in everyday activities is the lack of awareness. Both, users and designers claim to be concerned by the effects of their actions in terms of resource consumption, but they rarely, if ever take any action, because when presented with the issue, they only see abstract information that doesn't relate to them.

As result the pedagogic approach for sustainability necessitates a shift away from traditional techniques towards more diverse, fun and engaging one that allow the student and the general public to make sense of the information and apply it into action rather than just merely memorizing it. By making the knowledge something internalized, the barriers faced become less difficult to overcome.

The aim of this paper is to present the early discussion for a research project being carried out on how to develop and use board game in order to help design students to understand, adopt and ground sustainability concepts into their projects and daily life routines. In this regard, it is expected to make the case of why board games should be used as a tool to teach sustainability.

Methodology

The discussion reported in this paper represent the initial stages of a research project which aim is to develop the framework to design and build board games that can help to teach sustainability concepts to design students and if possible, be used to raise awareness amongst a wider audience. In the majority, it has emerged from an in depth literature review being currently carried out, of books, journal articles and game design and hobby aficionado related websites. This with the aim of understanding the state of the art on three main axes for research to draw useful lessons: sustainable design education, game based learning and board game design basics.

Following this, a basic framework layout will be proposed, along with the generation of ideas for games (presented in this paper). Surveys will be used to delimit some

starting points for the project. Testing and research of existent games will be carried out, in order to draw insight on how mechanics can be designed to incorporate the concepts of sustainability in complex, yet fun and useful ways. This will include interviews and observation. The latter part of the project will be to develop at least one of the proposed game concepts into a working prototype that will be tested with gamers (to polish the mechanics), design students (to understand how the process of knowledge transfer is working) and with general public (to understand how the game can raise awareness). Again this will include surveys/interviews and observation to measure the results.

Design Education and Sustainability

In the case of design education the best practice design education shares some key characteristics with a transformative education approach, not dissimilar to how people learn through play during earlier formative stages:

- Creative, solutions-focused learning;
- Self-directed team work;
- Learning by doing (commonly 'live' projects);
- Iterative refinement and reflection;

Like with sustainability, design requires drawing from a range of disciplines: e.g. mechanics; electronics; manufacturing; marketing; sociology; ergonomics; and history, to inform the outputs that emerge as a result of design-based activity. (Bhamra & Lofthouse, 2004)

Sustainability is becoming a topic with a great importance within education programs, from elementary school to postgraduate education. However there is still much work to do in order to increase awareness and to transfer the body of knowledge on sustainability from the academics into the daily life, making the pertaining concepts more understandable in terms of impact on the daily life. This is more important than ever in the case of designers, since the profession carries an important social weight because design can alter the surrounding world, modifies habits and creates solutions (sometimes even new problems) that can have a great reach and even a greater impact both in terms of environment and society.

Be it due social pressure, the current economic system or how learning programs are designed, most people is being educated to be part of a system that rewards competition and consumption, rather that collaboration and conservation (Sterling, 2001). While there is nothing inherently wrong with competition within set boundaries (sports, games, ludic activities), it becomes a problem when this competition is seen through the eyes of the high consumption market, where the people is often valued only in which things can buy and feeds individualism without regard of the needs of others, forgetting that all people are interconnected and the actions of a few effect the rest of population, often negatively.

Thus, the current paradigm regarding the concept of 'sustainable education' is that of seeing it as a simple 'add-on', a patch or at worst, an afterthought (Sterling, 2001). Humphries-Smith (2008) considers that most design students see sustainability as a technical problem often ignore the social and cultural aspects. Experience by the authors of this paper teaching sustainability related modules in higher education for

designers has shown that they see creating a design that is sustainable as only 'look for other materials, better materials', often disregarding the real needs of the user or the social aspects of sustainability and then focusing solely in the production or financial aspects. It is clear that it is needed a paradigm shift where the sustainability is seen more as a socio-centric aspect, where the user, the person is the most important person in terms of design; in equal terms to the environment, rather than just the technology, financial centric views currently adopted.

In the teaching of sustainable design with a focus on social responsibility, students need to have an inquisitive mind that allows them to identify patterns of behavior from the users to develop better solutions. This requires the development of abilities of lateral thinking within a framework of sustainability. Learning through play can allow designers (and in a second stage, users) to ground the concepts of sustainability in the way the design the daily object we use in our lives as well as understanding how the kind of impact they have in the environment and the society.

Learning through play

The concept of learning through play is used as a very efficient way to be used during human development, helping to the mental and physical growth of the person. As well it helps to reaffirm aspects such as personality and the ability to solve problems. Within the classroom, the use of play allows improving creativity and lateral thinking, improves communication and eases the teaching process.

In this case, learning to play becomes an open, engaging experience where every participant is equal to the other in terms of hierarchy, facilitating the knowledge transfer process. Through games, users can undertake different roles, understanding different points of view that they would not normally experience. This has a considerable impact in how people absorb information as it becomes part of a pattern that can be incorporated in habits, rather than feeling that some actions are being imposed on them by social pressure. A major challenge in any education is to keep the learner's attention, while communicating detailed information about the topic. There are many choices when it comes to resources: seminars, pamphlets, activity workbooks, videos and websites with on-line tools. Many of these do not meet the criteria of heads- and hands-on learning tools or promote engagement (Treher, 2011)

In the case of design, which is by definition a creative endeavor, gaming can provide an excellent path, tailored for their particular 'quirks' to understand how sustainability works, both in its environmental and social aspects.

Board games as education tool

Sustainability requires system thinking, hands on- heads on approach with certain degree on multi disciplinarily. Thus board games are the perfect tool to teach the topic as they can combine complex knowledge with hands on practice to improve understanding. Gaming is a natural way for the learning process, allowing for a bridge between theory and practice in a risk free, flexible setting. This helps to develop creativity, strategy and understanding of a particular topic. As well add social interaction, really needed for undergoing sustainable development.

Board games are an important tool to provide hands-on and heads-on skill and knowledge development for people of all ages on all subjects, since they provide an adequate environment where the user can learn from mistakes and success to build upon strategies and knowledge. It also promotes problem solving, visual analogies and metaphors to link new information, and use of abstract concepts (Treher, 2011).

They can be used as a possible solution due the act of play being ingrained in people's learning process from the beginning. Board games are also supported by the tendency that people have to form patterns to deduce information and to incorporate those patterns into the daily habits, using them as conduits to carry out the knowledge transfer process of a specific topic.

Knowledge transfer is defined, by Major and Cordey-Hayes (2000) as:
"…the conveyance of knowledge from one place, person ownership, etc. to another"

It is the process of transferring a series of know-how procedures, information and expertise from those who originated the knowledge or have improved it, into a recipient that will apply it in the foreseeable future (Major and Cordey-Hayes 2000). In order to fulfill this transfer process, there should be a source (usually the original holder) of the knowledge and recipient or destination (Major and Cordey-Hayes 2000). Research in the field has identified a series of requirements in order to allow the transfer to be successful. Organizations should be able to (Major and Cordey-Hayes 2000):

- Search for new information
- Identify potential benefits
- Communicate and assimilate the information
- Apply the information

While there are several models of knowledge transfer, the model showed in Figure 1, developed by Major and Cordey-Hayes (2000) depicts the condensed process.

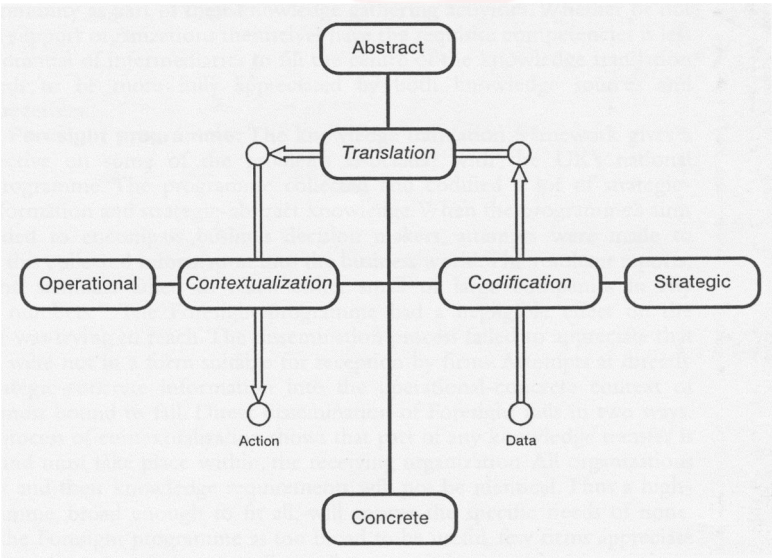

Figure 1: Knowledge Transfer Model (Major and Cordey-Hayes 2000)

The basic process goes from collecting the data, to its assimilation and application, going through a process of 'translation'. However, Major and Cordey-Hayes (2003) warn that this process can be incomplete, and therefore generate a knowledge gap, if concrete and strategic data are not transformed through abstract elements, before they can be used as concrete and operational wisdom, as showed in Figure 1. This gap can be avoided by the contextualization of the information through intermediaries (Major and Cordey-Hayes 2003).

Board games can be used as a possible solution, since they provide all in one the codification, translation and contextualization of a particular topic and transform data into action, by asking the players to understand a set of rules within the context of the game and then put that learning into action. Also, because the act of play being ingrained in people's learning process from the beginning. Board games are also supported by the tendency that people have to form patters to deduce information and to incorporate those patterns into their daily habits. By using this tendency, certain knowledge can be incorporated into the daily life of a person in a way that produces positive results.

Transition towards sustainable development requires a radical change in the way of thinking. How the actions taken by people in areas such as consumption and production affect the world. Games work under a relationship of cause-effect, which can be used to illustrate this, since they can simulate complex situations and relationships between diverse actors while empowering people in making their own choices within a safe environment, ideal situation for topics such as climate change (Eisenack & Reckien, 2013). This, because often, classroom lecturing is limited in how to deal with unexpected situations and surprise, basing its methods more into memorizing and repletion, rather than critical, systematic thinking (Valkering, et, al, 2012). More complex games (in terms of ways to achieve the victory condition) force players to think in a systematic way, balancing different conditions, actions and consequences; as well as understanding the critical routes that allow them to reach the victory in a successful way, developing their own strategies. Game theory is not just something applied to games or mathematics; it has touched sustainability even in the earliest discussions and proposal (e.g. the Tragedy of the Commons). Games are a good way to teach people (and in this case design students) in a creative, appealing way about trying to reach optimum conditions to solve a need in a sustainable way while understanding that there are other people in the board playing as well. Authors such as Gilbert Ahamer (2006) argues in favor of games as a method to learn how to manage large-scale problems, as they promote an explorative, reflexive discussion that goes beyond mere theory and data without any connection to real life experiences.

In this regard, board games are an excellent conduit to learn about environmental impact as well a social responsibility of the actions of the individuals in a different, more immersive manner.

The basics of a board game

Board games can be defined as "an interactive mathematical system, made concrete, used to tell a story" (Daviau, 2011). In other words, a game is a set of rules and mechanics (depending on luck, strategy or both), designed into a set of components

(boards, paper, dices, graphics) and that have a theme or themes that provide a wider framework within the minds of the users.

Game developers usually follow this sentence to describe and thus ground the basic concept of the game (Forbeck, 2011):

"[Game name] is a [category of] game in which [the players or their avatars] [do or compete for something] by [using tools the game provides them]" (Forbeck, 2011. p.p. 21)

This structure can be applied as well to this project when defining the theoretical frameworks under which work to develop games with sustainability topics. Translating such topics into a game has to be done using metaphors and mechanics. In game industry lingo, both are the main components of a board game. Mechanics are the steps and rules that the players need to follow in order to complete the aim of the game while interacting with other participants.

Metaphors are the themes about what the game is supposed to be, what it gives the game meaning for its existence. Matt Forbeck (2011) considers that a game without mechanics is more a toy or a story than a game. One without a metaphor is nothing more than a math problem or a puzzle. Not all the games have a deep and complicated set of rules (Monopoly is as simple as they come by) or full of rich metaphors (Jenga is not exactly dripping stories by the thousands).

But any game has at least a veneer of each one. Understanding this will enable to develop the founding stones to design one or several board games. It has to be noted that in board game design literature it is pointed that it doesn't matter which one comes first, the mechanics or the metaphors, as long as they exist in the planning of the project. In this case, the project has the overall metaphor, which is sustainability.

The next needed step is to choose which particular topics are more suitable to be transformed into such metaphors and desirable to be taught through a board game, in order to create a framework to develop the game or games and thus, elaborate upon the actual mechanics. Although a game could in theory choose to use all of them, this would increase its complexity and make it too clunky. In this regard the old say of 'Keep it simple' would apply, using the before mentioned basics for knowledge transfer. Thus we could choose three main areas, going from the general to the specific:

1. General concepts of sustainability; in this case the three spheres seen in a general context and their influences in general population (some would argue even in policy making).

2. Specific, design related tasks, using lateral thinking, design thinking, system theory or fuzzy end to develop sustainable solutions within a pre-set condition.

3. The relationship between systems (ecosystems, social organizations) by linking actions in a sequence of cause and effect that can develop different strategies for each player.

Topics such as the triple bottom line, consumption vs. resource management and waste, urban planning and incorporating sustainable requirements into a design development are good options. As well, and to determine the kind of mechanics needed for the game or games, it is necessary to understand the type of games that exist.

There are three main types of board games, based on the kind of interaction required from the players (Zagal et al, 2006) and the final aim of the game in question:

Competitive games: Those that require developing a strategy opposing the actions of the other players in order to win. They range from the simpler such as Monopoly and Risk to more complex games such as Magic the Gathering.

Cooperative games: Those that while allow only for a winner, they require that players have at some stage of the game objectives that are compatible or allow for trade and alliances, even if is only for a round. Usually these games have a developed 'economy' system that allow for negotiation and resource management. A good example of this kind is Settlers of Catan.

Collaborative games: Often seen in horror themed games, these require that all players agree in coordinating common strategies to win, since the rival is a 'virtual' foe (or in some cases a single player opposing the rest in a different role). Either all of them win or lose (albeit some games allow for acceptable 'losses'). Examples are: Shadow of Cthulhu, Mansions of Madness and Fury of Dracula.

Putting the pieces together

To develop a board game with sustainability as theme, it is needed to build an adequate transfer knowledge framework in order to convey properly the message and to identify those concepts that are susceptible to be developed into a game as simple as possible. There are good precursors for this kind of project within educational design tools such as Flowmaker, developed by WeMake design and Layered games, developed for a master thesis at Cranfield University (Bhamra & Lofthouse, 2007). There is even an example of a commercial game that uses environmental issues as main theme. That game is named: CO2 and is about stopping global warming. In that game, the players are trying to build renewable energies to stop global warming from annihilating the planet. The core mechanic in this game is a three-step process in which each player in their turn you either start an energy plant research project, convert a research project into a pilot energy plant, or convert a pilot plant into a full-on power plant and requires from cooperation between players to achieve the final objective of the game (Bird, 2013).

While more research is needed to actually ground which particular concepts to use and how to design mechanics around them, it is possible to propose initial ideas for four game ideas can be developed from this. At this point it should be noted that these are mere suggestions and thus, more research has to be carried out to develop the framework needed to design and test such ideas:

One where the player needs to manage the resources of his tribe to achieve sustainability within the context of the three spheres. In a rough draft of the

mechanics, in this game, each player has to provide a 'tribe' through different means available in a 'world map' a sustainable living before the counter runs out and in some way has to cooperate with other players or risk burning his resources faster and ahead of time, ensuring the defeat. For this, games with multiple victory conditions that afford a point tally shall be examined.

In the second game, the player plays the role of a mad designer tasked to create the most crazy/fun/useful gadget to solve a pre-set condition or need draw from a bag of tiles. The players, using a set of cards can mix and match several options for their product, including source of raw materials, energy consumption and user behavior and scores points not only for creativity but for creating the most sustainable invention.

A third kind of game would draw inspiration from Collectible Card Games such as Magic the Gathering, Pokemon and Yugi-oh in order to present fantastic battles between the forces of nature and creatures of pollution. Due the thematic, this game would be more suited for younger kids.

A fourth game would need for the player to 'build' a city using tiles, asking them to interconnect services to run fluently while considering population growth and needs.

It has to be noted again, that these are just some venues worth to explore in the following months of the research project. As well it has to be noted that for the knowledge transfer to occur properly it has to blend in the right mix the metaphors with the mechanics to make a game with commercial potential as to reach easily a wider audience. In words of Rob Daviau (2011):

"Rules shouldn't explain the game; they should only confirm what the rest of the game tells you."

Any proposed game should achieve the right mix between learning and fun. If it works to explain design students concepts about sustainability in a fun way that eases the process of knowledge transfer, it should work as well for a general public and vice versa. The funnier the game, it would be bigger the degree of knowledge absorption, overcoming the natural barriers to learning. A game solely focused in the academic part could become either very boring or very clunky, maybe both. A game focused only in fun will miss the target of knowledge transfer in a meaningful, proper way, glossing over the metaphor and defeating the purpose of the project. Therefore it should be the aim to develop a commercial game (in terms of reaching a wider audience beyond the classroom so as the sustainability awareness increases), with a solid academic background that enables the right mechanics and metaphors.

A good game is one that manages to craft an experience that makes sense to the players in such ways that they become immersed on it. By doing this, it would be possible to immerse people into understanding what sustainability means in their daily lives in a way that overcome most learning barriers and can reach a wider audience.

Conclusions

Board games are a viable way to teach different aspects of sustainability and integrating it into design thinking. However, as the knowledge grows in complexity, different kinds of games are needed to explain certain interactions of such knowledge. As well, an entertaining game should have clear and concise rules and mechanics to ensure meaningful learning and replay value (as well as to allow the game to be used in a commercial way rather than just in the classroom and thus, widespread the awareness on sustainability issues).and as such, it would be hard to compress all the information in a single game. Therefore it is proposed to create a tiered system of games according to the topic in question. One disadvantage to bear in mind is that in the classroom, this would be manageable through several copies of the game or small groups.

As well, and in terms for this project, there is need for more research into game developing, particularly game mechanics; as well as analyzing some of the games mentioned in previous sections to understand how they are incorporating several aims or victory conditions focused in a single objective and how this allow users to develop their own strategies. The development of these strategies is what can help design studies to incorporate sustainable design thinking into their projects from the beginning instead of trying to add it after their proposals are developed as some kind of add-on fix.

Finally, developing a commercial game it is not in conflict with creating an educational tool. On the contrary, developing a commercial game that deals with sustainability and design can help to raise awareness in both topics amongst the general public, which can be a valuable asset. This important now both by the current need to raise awareness in terms of sustainability and since the topic are one way or another, in the mind of most people.

In conclusion, a successful game and more important, an entertaining one, should always provide replay opportunities and as such, allow for the player to learn in a flexible way different strategies. However, better understanding on how to correlate these issues within a framework for the mechanics of the game or games is needed.

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The Role of Wetland Ecosystems as Critical Infrastructure for Climate Change Adaptation

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Natural areas, and wetlands in particular, have long been recognized for the ecosystem services they provide. However, wetlands have been destroyed for farmland, developments or other human constructs to the degree that an estimated 50 percent have been lost worldwide, and many place have lost much more. As the impacts of climate change are beginning to appear – sea level rise, increased flooding, higher temperatures – the remaining wetlands may become critical in naturally mitigating their effects, providing values similar to that of built infrastructure. This creates motivation to better understand these values, both quantitatively and qualitatively – a process that is often time-consuming and resource intensive. This paper provides an overview of the functions and values of wetlands for climate change adaptation. Further, the paper presents cases in which wetlands have been successfully, or unsuccessfully, employed as infrastructure for climate change adaptation. Finally, this paper discusses limitations of such assessment frameworks, including challenges with quantifying the true value of ecosystem service.

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Introduction

Approximately $3.2 trillion USD will be spent globally on transportation, electricity and sanitation infrastructure in 2013, with an estimated $57 trillion USD investment needed by 2030 to accommodate growing populations.[1] Natural areas are increasingly being recognized for their ability to provide functions similar to traditional built infrastructure, while also supplying a range of ecological, economical and social benefits. Wetlands in particular have garnered increased attention for their role in mitigating impacts related to climate change.[2–4] Indeed, wetlands have the capacity to absorb the impacts of floods and storm surges, which can protect shorelines and properties, however the conditions under which wetlands are the best solution to meet these rising challenges are not always clear-cut.[5,6] In fact, managers of wetlands identified as internationally important under the Ramsar Convention on Wetlands often underestimated the functions (i.e., ecosystem services) these areas provide both ecologically and socially.[7]

Understanding both the capacity and value of ecosystem services provided by wetlands is vital for strategic decision-making in terms of restoration, conservation and preservation.[8–12] Further, understanding services could provide information for choosing restoration or conservation over building additional built infrastructure, helping communities to save resources associated with built infrastructure while also benefiting the local environment. This paper describes a set of ecosystem services provided by wetland areas. Each service is illustrated by a case study in which a community or region relies on a wetland for a particular service and the potential interplay between this function and the impacts of climate change. The services identified in this report are not an exhaustive list, but are instead provided as a baseline from which additional examinations could be made.

Wetland Ecosystem Services

Wetlands are commonly found around the world, taking myriad forms, from riparian areas to coral reefs to peatlands and beyond. In fact, wetlands are a vastly diverse ecosystem united mainly by three main factors: hydric soil, hydrophilic plants, and hydrology.[13] They can be hotspots for biodiversity, nurseries for young animals, and in urban areas, one of the last refuges of quasi-wilderness. This report focuses on the functions of wetlands that have the potential to benefit communities facing the impacts of climate change. Table 1 demonstrates a range of climate change impacts, the wetlands functions that could help mitigate, followed by the ecosystem service it represents in the Common International Classification of Ecosystem Services (CICES).[14]

Table 1. Examples of climate change impacts, wetland functions that could assist with their adaptation and mitigation, and the corresponding ecosystem services.

Climate Change Impact	Wetland Function(s)	Ecosystem Service
Change in rainfall timing and amount	Groundwater storage and replenishment	Provisioning service: freshwater
Increased intensity in coastal storms	Shoreline stabilization Storm surge abatement	Regulating service: water regulation
Decreased access to clean water	Pollution uptake and burial	Regulating service: water purification
Increased surface water temperature	Riparian vegetation shades water to reduce water temperature	Regulating service: climate regulation
Increase in algae blooms	Nutrient uptake by plants	Regulating service: water purification
	Water temperature reduction	Regulating service: climate regulation
Excess greenhouse gas	Carbon sequestration by plants Carbon sequestration by soil	Regulating service: climate regulation

The report will focus on a subset of wetland ecosystem services that may be especially useful or relevant in terms of climate change mitigation: the reduction in greenhouse gases, nutrients, and water temperature as well as flood abatement. Each section below will offer a description of the wetland service as well as a relevant case study, or case studies. The case studies chosen do not necessarily represent a success story of wetland infrastructure, but are instead meant to illustrate both the potential and the challenges of this approach.

Greenhouse Gas Reduction

Greenhouse gas emissions continue to rise to unprecedented levels; in fact, between 2000 and 2010, the rate of increase in emissions rose more quickly than the three previous decades.[15] Some wetlands can act as a sink for greenhouse gas emissions, making them an asset for greenhouse gas reduction efforts, while other wetlands can contribute to emissions, sometimes at a very large scale. Wetlands with organic soil, such as peatlands, can emit carbon and methane, in their natural state, but even more intensely when drained or otherwise disturbed.[16]

The most prominent example of emissions from wetlands may be the tropical peatlands of Indonesia. Indonesia's 22 million hectares of peatlands store a vast amount of carbon in their soil and plant matter, with peat in some places up to 11 meters deep.[17] Widespread conversion to agriculture, often through fire, burns not only trees but also the organic matter in the soil. Once the soil is drained and replanted for farms, the soil continues to emit carbon for decades. In Indonesia, this process has been so intensive over the last decades that Indonesia's peatlands, in 2005

alone, emitted over 850 million tons of carbon dioxide – making the country one of the top three global greenhouse emitters.[17]

While the story of Indonesia's peatlands may be alarming, similar destruction of wetlands has happened elsewhere. For example, nearly 95 percent of the area or Switzerland's original peatlands are gone, largely to agricultural conversion.[18] As countries strive to meet emissions reduction goals of the Kyoto Protocol or other national policies, there is an opportunity to restore peatlands in order to reduce or reverse emissions. Restoring wetlands by removing artificial drains and supporting the regrowth of native vegetation can rapidly slow emissions. For example, in temperate areas, rewetting the soil can lead to a net sink of carbon -0.55 to -0.34 tonnes of CO_2 per hectare, compared with emissions of over 7 tonnes of CO_2 per hectare for drained peatlands.[19] If trees are included in the revegetation plan for a restored wetland, the net carbon sequestration is even higher.

As such, there is potential for wetlands restoration to be a mechanism for climate change mitigation. This is especially relevant in areas where temperatures are predicted to increase with climate change. For example, if temperatures in Europe continue to rise, there is a potential for peatlands to dry out,[16] which could increase CO_2 and NO_2 emissions, working against reduction targets.[20] Having a clear view on the wetland landscape has the potential to help the government to plan appropriately to mitigate excess emissions over the long term. In some cases, it could be as simple as removing drainage infrastructure, thus could be a relatively low cost project. However, when considering land use conversion, such as between a restored wetland and agricultural areas, maintaining a balance between socioeconomic and environmental factors, such as supporting agriculture-based livelihoods, is an important consideration. In such a case, poorly performing or unused land may be preferable to productive farms, or a conversion to a wetland-friendly farm, such as one that grows water-loving plants like blueberries, could accomplish similar values.

Nutrient Reduction

Increases in temperature coupled with changes in precipitation and high levels of nitrogen influx have the potential to affect the quantity and quality of water. One potentially serious side effect of climate change, the Intergovernmental Panel on Climate Change (IPCC) states, is algae blooms. While algae are present in almost all waters, they thrive in areas with high nutrient levels. Algae can bloom in suffocating numbers when under high temperature conditions combined with stagnant waters, exacerbated by disturbances like drought, storms and floods.[21] Nutrients come from animal and human waste, as well as agricultural areas fertilized organically or chemically. Some algae can bloom in even small concentrations of nutrients, growing even more aggressively in higher concentrations – creating a situation of eutrophication. In eutrophic waters, algae grow in excessive numbers, and sometimes rapidly, choking out native vegetation, clogging waterways and making navigation difficult or impossible. As the algae dies, decomposers multiply to eat the dead algae, consuming the water's oxygen -- sometimes to such a high degree that fish and other aquatic species die off, known as a fish kill.

Algae blooms are a problem worldwide, but In Southeast Asia, where water quality is compromised by poor sanitation, the potential affect could be accentuated, leading to

larger algae blooms. For example, Cambodia, with only a few operational wastewater treatment plants, relies prominently on water resources (such as wetlands, streams, rivers and lakes) as a form of wastewater treatment,[22] leading to a discharge of approximately 234 tons of feces, 2,335 m^3 of urine, and 8,154 m^3 of gray water each day.[23] Its largest city, Phnom Penh, depends on wetlands in the south and southeastern parts of the city for wastewater treatment. Untreated urban wastewater and sewage lines are directed to these open wetlands, where they passively filter through before entering the Bassac River.[24]

The natural capacity of wetlands to remove pollutants like nitrogen and phosphorus creates a fairly effective, low cost treatment method for the city. However with little or no monitoring of the resulting water quality, it is unknown how consistent the quality of treatment by wetlands is and how it will react to additional pressures of population growth, industrial wastewater, as well as climate change or additional wetland loss. In fact, across Southeast Asia, wetlands are depended on to "work" for the people, providing vital ecosystem services that may or may not be recognized by the wetlands' neighbors, but will likely grow in importance in the coming years.

In another example from greater South Asia, Colombo, Sri Lanka formalized the protection of the wetland surrounding their city, but their wetland areas continue to suffer. After two decades of rapid urbanization, with associated poor sanitation, lack of planning, poverty, and increased flooding, Colombo's many wetlands began to deteriorate. The city recognized the value of its wetland assets and created a master plan and wetland management plan focusing in the 1990s on 12 priority wetland areas.[25] As the city continues to grow, pressures mount on these protected areas and the quality of protection has become questionable as wetlands continue to shrink due to land use change in the surrounding areas.[26]

Furthermore, at least two-thirds of residents surrounding these wetlands are living without improved sanitation, discharging wastewater directly into the protected areas.[25] Industries also contribute untreated or partially treated wastewater, adding chemicals, sediment, and other by-products. Based on this continued degradation, the International Union for the Conservation of Nature conducted a study to calculate the economic value on one of the 12 priority wetlands, the Mathurajawela Marsh, finding that this marsh alone provides over $8 million per year in benefits such as fisheries, firewood, flood attenuation and wastewater treatment. In fact, the value of the household and industrial wastewater treatment alone was over $2.2 million per year. Placing an economic value on these services adds a meaningful (though limited) perspective for policymakers, providing a compelling argument for strengthened protection of these natural areas.

Water Temperature Reduction

In some areas, high temperatures can be considered a pollutant. Thermal pollution, often from the discharge of power plants or industrial operations, can harm or kill temperature sensitive aquatic organisms.[27] As of 2005, nearly 41 percent of freshwater withdrawn in the U.S. was used for cooling power plants (up to 3800m^3 of water per day).[28] In the case of the U.S. State of Oregon, temperature is considered a regulated pollutant in several of its largest river systems due to its impact on

endangered salmon species.[29] Young salmon are especially vulnerable to even small changes in temperature.

The State of Oregon recognized the ability of wetlands adjacent to waterbodies, like rivers, streams and lakes, to reduce the temperature of water. The mechanism is simple: trees and shrubs create shade that allows the water to cool. Over a large area, the cooling from this shade can significantly decrease the temperature of water. Of course, the inverse is also true – riparian areas lacking shade can have higher water temperatures. In southern Oregon, the City of Medford needs to cool discharge water from wastewater treatment to meet state pollution standards. One option was a chiller / refrigerator costing nearly one million dollars. Instead, in an innovative program, a 65km tree-planting project along the city's main waterbody, the Rogue River, was determined to meet the temperature reduction requirement for a lower cost than the chiller.[30] Beyond the temperature reduction, the restored wetland areas have additional ecological and socio-economic benefits for the community, as well as a lower carbon footprint, then the chiller option.

While the project has been in action for several years now, it is not without controversy.[31] Issues around the time for trees to establish sufficient canopy to create the required amount of shade / temperature reduction, as well as how temperature reduction, and its inherent uncertainty, can be adequately accounted for continue to be unresolved. So, while the mechanism of trees and shading may be clear, implementing such a project instead of or to replace infrastructure like chillers on a wider scale may still be a way off.

Flood Abatement

Perhaps the most celebrated function of wetland areas is their ability to minimize flooding. Wetland soils, especially those with high peat content, can have a sponge-like quality, absorbing rain or floodwater before it enters rivers or bays.[32] Wetland vegetation can also slow floodwaters as they move downstream, potentially reducing damage. Further, intact stream or oceanside wetlands shield the banks from erosion, minimizing soil loss and protecting property. However, the prime location of these wetlands has contributed to their loss. Development along coastlines and riverfronts often destroys or damages wetlands. Also, the peat contained within these peatlands makes them rich agricultural areas, thus many streamside wetlands are repurposed for rice or other farms.

In Thailand, the farmed wetlands surrounding city of Ayutthaya, Thailand, are being used to take flooding pressure off Bangkok, which lies roughly 80 kilometers south. Sometimes called the "Venice of the East," Ayutthaya sits at the junction of the Chao Phraya, Lopburi and Pa Sak Rivers, which merge into the Chao Phraya on its way into the heart of Bangkok. Draining nearly 35% of Thailand, the Chao Phraya experiences heavy seasonal flooding, most notably in 2011 when flooding shut down many parts of Bangkok for months, causing $47 billion in damages.[33] Nearly all of the river's riparian wetlands have been converted to agricultural or residential areas, leaving very few of the original wetlands intact.[34] Losing wetlands increases the risk of flooding, destroying areas that soak up and slow floodwaters as well as pollution from wastewater, etc. Furthermore, losing some wetlands make the remaining wetlands even more vulnerable to erosion from flooding, further accelerating the rate of loss.

Working wetlands like rice paddies, however, retain some of these functions. The Thai National Water Resources and Flood Policy Committee is implementing many different flood control techniques, including the the Kaem Ling Project, which temporarily repurposes Ayutthaya rice paddies as outlets for excess floodwaters bound for Bangkok.[35] Known as "monkey cheeks," these flood storage areas trap and hold water until the river's depth subsides and it can be safely released. While the project may be effective, the choice of which fields are flooded and which remain dry is a political issue which has resulted in protests from the farming community.[36]

Discussion

Wetlands have a strong potential to help communities adapt to climate change, as illustrated in the case studies for nutrient reduction, local greenhouse gas reduction and flood control. However, growing populations and a need for places to shelter, grow food or take holidays are often more immediate and lucrative needs. As a result, over half of the world's wetlands have been lost, reducing their ability to provde the ecosystem services community's may have come to depend on, whether recognized or not.

As communities continue to grow, considering existing remaining wetlands as infrastructure in development and master planning can help to deliver more cost effective and multifunctional solutions for climate change resilience. To do this, however, the value of the wetlands must be recognized and then balanced with the needs of the community. One avenue for this is through monetizing ecosystem services, such as flood protection or carbon prices. While this can put a price of a wetland area, that may very well be competitive with prices for development, it oftentimes underestimates the true value of these areas. Ecosystem services like biodiversity or recreational values are difficult to quantify with a dollar price, though we may inherently understand their importance. As such, dollar values are something to be wary of, though may be an important factor to consider nontheless, with a grain of salt.

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Energy Reduction in Wastewater Treatment Plants

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
For wastewater treatment plants (WWTPs) that incorporate anaerobic digestion, which one significant way of capturing this energy is through combined heat and power (CHP). This study, first, compiles wastewater CHP data from available online databases and other available online sources in order to obtain a database that is complete and concise for analysis. Then, it verifies the accuracy of data presented by EPA CHPP and compare methodology for obtaining CHP potential in WWTPs against actual values. And, finally, it develops a reference for WWTPs to use for selecting energy targets for CHP systems.

Keywords: Wastewater treatment, combined heat and power, energy reduction.

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Introduction

According to the Water and Environment Research Federation (WERF, August 2011) wastewater and biosolids have 10 times as much stored energy as that which is needed for treatment. For wastewater treatment plants (WWTPs) that incorporate anaerobic digestion, which is the biological breakdown of organic matter in the absence of oxygen, one significant way of capturing this energy is through combined heat and power (CHP). CHP, also known as cogeneration, is a form of distribution generation (DG) which involves the process of simultaneously generating heat and electricity from a unit fuel source such as biogas, natural gas or fuel oil. In WWTPs, biogas, which primarily contains a mixture of approximately 40% carbon dioxide and 60% methane, is produced as a byproduct of anaerobic digestion. Biogas can be combusted to provide heat, electricity or both when used directly in engines for combined heat and power. This fuel can also be cleaned to be used in the same way as natural gas or further compressed and processed into compressed natural gas (CNG) for use as vehicle fuel. WWTPs that utilize anaerobic digestion can therefore be considered as potential generators of renewable energy. Since the anaerobic digestion process takes place continuously during the wastewater treatment process, biogas is also produced continuously, allowing for constant electricity and heat production.

According to Brown and Caldwell (2010), use of biogas alone from anaerobic digestion in WWTPs can offset up to 40% brown energy consumption through the production of CHP, which, according to WERF (2012), is the most common application of biogas in WWTPs. The energy potential can further be increased by the addition of nonhazardous high-strength wastes (HSW), such as fats, oil, and grease (FOG). However, despite the opportunity WWTPs have of producing renewable energy through CHP systems, according to the Environmental Protection Agency Combined Heat and Power Partnership (EPA CHPP, 2011), more that 20% of the WWTPs with anaerobic digestion in the United States do not utilize CHP. One factor that has slowed the growth of CHP in the wastewater industry is lack of a strong baseline data of biogas generation in WWTPs and a lack of guidance for setting energy targets based on biogas production. In 2012, WERF and the New York State Energy Research and Development Authority (NYSERDA) published a report based on a survey study they undertook in 2011 with more than 200 respondents, to determine the barriers WWTPs face in implementing CHP Systems and indentify ways to overcome these barriers. In line with the recommendations from the survey study, which includes efforts to fill the information gaps that exist, this study attempts to compile, summarize and simplify data that quantifies CHP energy potentials and installations at WWTPs in the USA, in order to facilitate selecting achievable CHP energy goals and targets.

This study recognizes that there are other studies that have had similar goals and therefore builds on those related studies. In 2007, EPA CHPP published a guide entitled “Opportunities for and Benefits of Combined Heat and Power at Wastewater Treatment Facilities”, which was later update in 2011. In addition to providing information for assessing energy potential for CHP at WWTFs that have anaerobic digesters, the guide also provides basic WWTP CHP data and such as the number of WWTP utilizing digester gas for CHP in the USA, the total CHP electrical capacity by state and potential CHP capacities. However, according to the North East

Biosolids and Residuals Association (NEBRA, 2012), "industry experts" have found that the data included in the report is both incomplete and with error. In July 2011, the Water Environment Federation (WEF) sought ways to improve the data available to WWTPs through initiating and funding The National WWTP Biogas Data Project, "Preparation of Baseline of the Current and Potential Use of Biogas from Anaerobic Digestion at Wastewater Plants". The project was awarded to a team comprising of InSinkErator, NEBRA and Black & Veatch. Data captured in this phase includes: facility name, location and contact information wastewater flows; type of digestion and CHP technology used, application of biogas generated, indication if outside waste is fed to digester; whether electricity is generated and if is fed to the grid. The database is currently available online through the biogasdata.org website. Though the database currently does not have information such as the biogas production at each plant, CHP capacities and estimated energy production that WWTPs planning for CHP systems may deem useful, it is anticipated that such information will be provided in the second phase of the project. In order to obtain CHP capacities that are currently not included in biogasdata.org, the study used an online database maintained by ICF international for the data compilation - www.eea-inc.com/chpdata/index.html. In addition to listing CHP capacities at various industries in the USA including WWTPs, the ICF international database also indicates the CHP prime mover (type) and the fuel type as not all the industries included in the database use biogas.

The objectives of this study can be summarized as follows:

1. To compile wastewater CHP data from available online databases and other available online sources in order to obtain a database that is complete and concise for analysis.
2. Verify the accuracy of data presented by EPA CHPP and compare methodology for obtaining CHP potential in WWTPs against actual values.
3. Develop a simplified reference for WWTPs to use for selecting energy targets for CHP systems.

Methodology

The US EPA Combined Heat and Power Partnership (CHPP, 2011) estimates that approximately 26 kilowatts (kW) of electricity and 2.4 million British Thermal Units (MMBtu) of thermal energy can be produced for every 1 million gallons per day (mgd) of wastewater treated. The electric production and thermal energy (heat) recovery was estimated by the CHPP based on modeling the fuel produced and needed by a typically sized digester (20 ft. deep and 40 to 60 feet in diameter), operating under mesophilic temperatures (temperatures between 95°F and 100°F), and with a loading rate of 9.1 mgd.

Though there are various types of CHP prime movers, the CHPP report only considered those most commonly used at WWTPs, namely: microturbines, reciprocating engines (rich burn and lean burn) and fuel cells as indicated in Table 1. Gas turbines, steam turbines, and combined cycle systems are mostly used for wastewater flows greater than 100 mgd (Spellman, 2013). The Electric Production and Heat Recovery per mgd were obtained using the average values of the mentioned most commonly used prime movers in WWTPs. The Electric Production (Btu/day)

may be calculated by multiplying Electric Efficiency with the Energy Potential of biogas (Btu/day).

The Energy Potential of biogas may be obtained using the formula below:

$EP = (HHV)VBiogas$ *(Equation 1)*

Where
EP = Energy Potential (Btu/day)
HHV = Higher Heating Value
VBiogas = Volume of Biogas

Heat Recovery (Btu/day) can be obtained by dividing the Electric Production (Btu/day) by the Power to Heat Ratio of the respective prime mover. The electric efficiency data and power to heat ratios shown in Table 1 were obtained from manufacturers' data.

Additional heat for nondigester heating uses such as space heating and hot water available from CHP systems can be calculated as the difference between Heat Recovery and Digester Heat Load (Btu/day).

The Digester Heat Load can be obtained by summing the Heat Requirement for digesting sludge and that lost through wall, floor and roof heat transfer.
Heat Requirement values can be approximated using the formula below:

$Q_1 = W_f C_p (T_2 - T_1)$ *(Equation 2)*

Where
Q_1 *= Digester heat requirement (British Thermal Units/day or Btu/d)*
W_f *= Volatile Organic feed load removed (Pounds per day or lb/d)*
C_p *= Specific Heat of Sludge (Btu/lb/ºF)*
T_2 *= Reactor Temperature (ºF)*
T_1 *= Temperature of sludge entering digester (ºF)*

Heat loss may be approximated using the formula below:

$Q_2 = UA(T_2 - T_1)$ *(Equation 3)*

Where
Q_2 *= Heat Loss (Btu/d)*
U = Heat-transfer coefficient (Btu/hr.ft2.ºF)
A = Surface area of digester over through which heat loss occurs (ft2)
T_2 *= Reactor Temperature (ºF)*
T_1 *= Surrounding Temperature (ºF)*

Based on the relationship between wastewater flow and potential electricity from CHP systems, it is apparent that the higher the plant flow, the greater the electricity potential. According to CHHP (2011), the greatest 'economic potential', defined as one having a payback period less than or equal to 7 years, are realized for larger plants with flows equal to or higher than 30 mgd.

Further, a study conducted by the Electric Power Research Institute (EPRI, 2012), shows that the electricity intensity (kilowatt hour per million gallon – kWh/mg) for larger WWTPs remains fairly constant as can be seen in Figure 1, indicating that further benefits, in terms of percentage savings from CHP systems, can be realized by larger plants. Nevertheless, smaller plants can boost their biogas production, by adding nonhazardous high-strength wastes (HSW), such as fats, oil, and grease (FOG), or where feasible, incorporating thermophilic digestion systems in the treatment process.

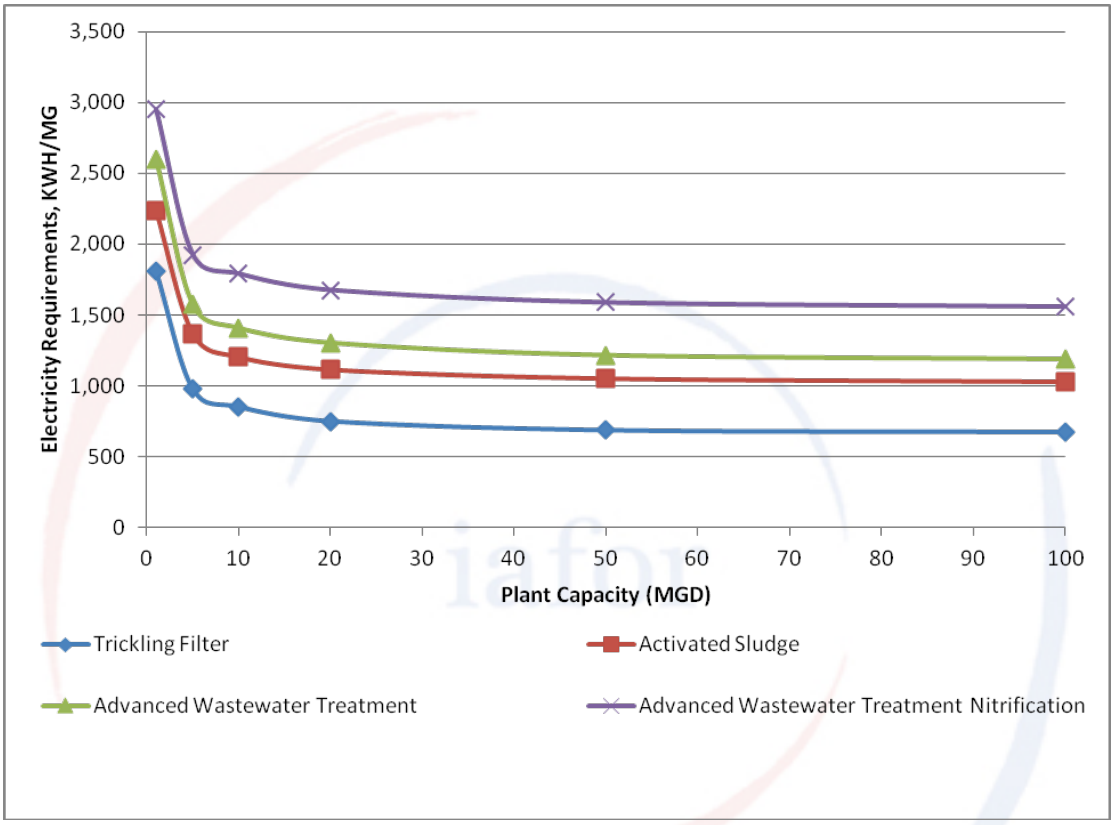

Figure 1: Electricity Demand for Wastewater Treatment by Size of Plant and Treatment Type – Plants.Source: EPIC (2012)

Energy Reduction Goals and Target Setting for CHP from Individual WWTP Case Studies

WWTPs may have several energy related goals and performance indicators which may include, but are not limited to, reduction in brown energy consumption and increase in renewable energy sources, reduction in energy cost, reduction of peak load demand, and reduction in greenhouse gas emission in treatment processes as well as in utility vehicle use.

Recognized as a leader in energy efficiency in the wastewater Sector, the Sheboygan WWTP implemented a 300 Kilowatt (kW) capacity Combined Heat and Power (CHP) system and is an example of a facility that implemented CHP to reduce energy consumption, with the ultimate goal of becoming a net-zero or energy neutral facility. The plant, which has a treatment capacity of about 18 million gallons per day (mgd), is currently able to achieve between 70% and 90% energy sufficiency from its CHP

system, resulting in an annual savings of approximately $78,000 from the electricity generated and approximately $60,000 based on heat generated (ACEE, 2011).

The Gloversville Johnstown Joint WWTP in New York is an example of a facility that highly benefited from energy cost savings due to installation of CHP systems. The plant was expanded in 1992 to 13 MGD in order to treat both domestic wastewater (30%) and industrial wastewater (70%) from fishing and leather and tanning industries in the cities of Gloversville and Johnstown. Through the early 2000s, after the leather and tanning industries within the service areas closed down, the Gloversville Johnstown Joint WWTP experienced a reduction in revenue and excess capacity at the facility. The implementation of a CHP system made it possible for the facility to reduce operating costs and control their financial situation. The current location of the WWTP and its proximity to dairy processing facilities further enabled the facility to incorporate dairy waste into its processing stream thus generating more biogas and energy, as well as utilizing the unused treatment capacity. The WWTP is able to produce between 90% and 95% of the electricity required to operate the facility though a 700 kW capacity CHP system (Cogeneration and On-site Power Production, 2011).

The Des Moines Wastewater Reclamation Authority is an example of a facility that implemented CHP in order to reduce electrical peak demand load (peak shaving).
In addition to minimizing the amount of natural gas used for process heat by over 100% and electricity usage by more than 40%, the Delhi Charter Township WWTP, Michigan was also upgraded to include CHP systems in order to reduce fuel associated with transporting biosolids, based on the reduced digest rate volume.
There are numerous case studies in literature that focus on selecting achievable energy goals for water and wastewater treatment facilities.

According to US EPA (2008), even though various case studies exist as pointed out above, there are no standard energy objectives and targets that can be directly selected to suit individual plants that plan to implement energy improvement programs. This study compiled and analyzed actual CHP data that can be used in lieu of individual case studies for selecting achievable CHP energy goals and targets. The actual data analyzed was compared to calculated electrical potentials obtained by methodology developed by the U.S. Environmental Protection Agency Combined Heat and Power Partnership (October 2011).

A list of wastewater treatments plants in the USA that utilize biogas was developed from an online database, http://www.biogasdata.org . The database was created through a collaborative effort by InSinkErator, NEBRA, and Black & Veatch with funding from Water Environment Federation (WEF), and contains wastewater treatment plants within the U.S.A that operate anaerobic digestion systems as of 2013. The information that was obtained from this database included the type of anaerobic digestion prime mover, average plant flow and plant capacity. WWTPs that do not produce electricity from the biogas (no CHP systems) were eliminated. A second online database, developed by ICF International (former Energy and Environmental Analysis, Inc.), and accessible from http://www.eea-inc.com/chpdata/ was used to obtain the CHP capacity of the wastewater treatment plants considered.

The WWTPs were then categorized according to flows ranging from 1 to 5 mgd, 5 to 10mgd, 10 to 20 mgd, 20 to 50 mgd and 50 to 100 mgd and the actual CHP electrical capacities evaluated to identify outliers in each range. The outliers were eliminated using standardized z-scores, calculated using the category averages and standard deviations. This methodology assumes that the data is somewhat normally distributed. For each range, a value was considered an outlier if its standard z-score was greater than ±2.5.

The 95% confidence range of electrical capacities were then calculated using the remaining data to obtain corresponding electrical capacities for each range. Electrical capacities based on actual data as well as those approximated using a factor of 26 KW per mgd of average plant flow, were plotted on the same graph for a visual comparison (Figure 2). Where average flow data was not available, the plant flow capacities were used to estimate electrical capacities for comparison with actual values. Error bars were used to represent the 95% confidence interval selected for the analysis. The error bars in Figure 2 represent the difference between the average values in each range and the upper or lower limits.

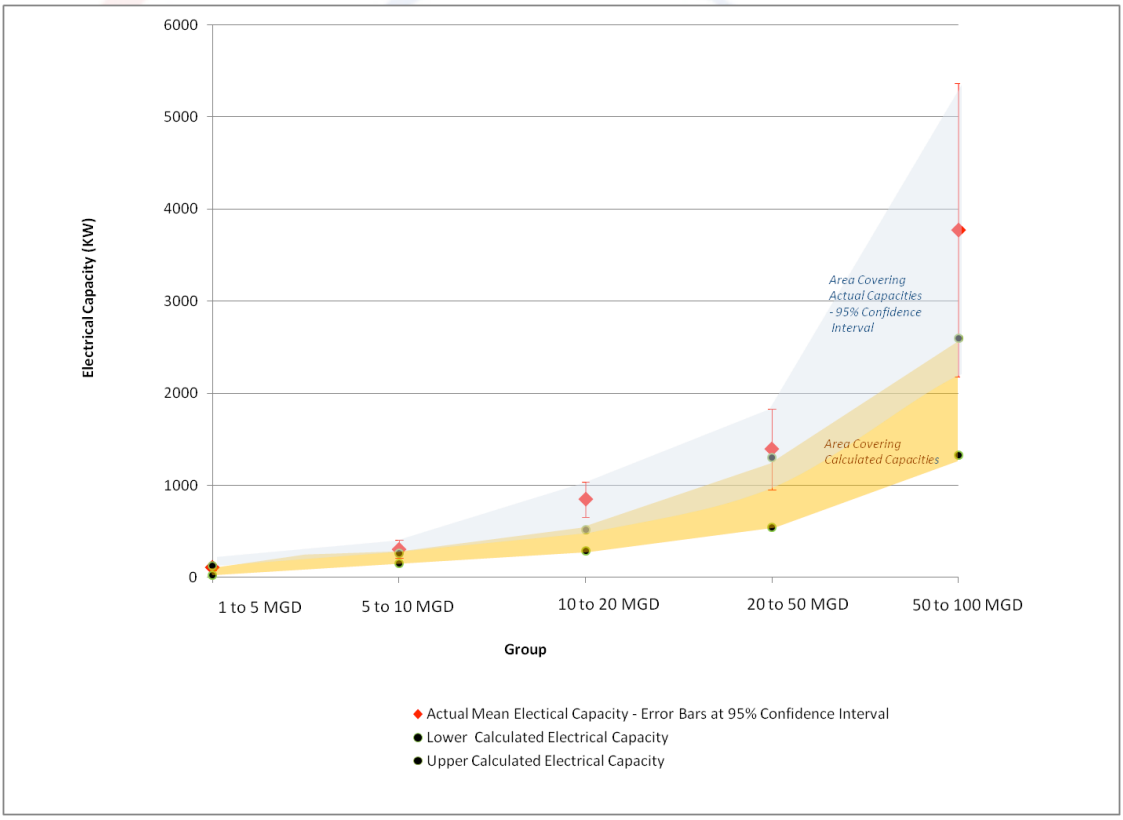

Figure 2: Wastewater Flow against Actual and Calculated Electrical Capacities

Conclusions

As can be seen in Figure 2, for flows ranging between 1 to 10 mgd, calculated electrical potentials are comparable to the actual capacities based on a 95% confidence interval. The methodology developed by CHPP (2012) for approximating electrical potential is therefore applicable for such flows. However, as the flows increases, actual calculated capacities deviate more from the calculated values.

Though the CHPP methodology is still a good tool for conservative targets of electrical potential based on plant flow, the analysis on actual data shows that electrical capacities that have been achieved from CHP systems nearly double the calculated values. The deviation seen for higher flows may be due to the fact that the model used to approximate electrical capacity was carried out by CHHP (2011) using a flow of 9.1 MGD and flows in this order result in electrical capacity closer to the calculated estimate more than the higher flows match up. It is therefore recommended that further studies be carried out to establish the relationship between flow and CHP electrical potentials for larger flows. In setting energy targets for new CHP system installations, it is recommended that decision makers use the CHPP methodology for conservative goal setting, but also consider the achievable potentials based on actual systems as presented in this study.

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Determinants of Residential Building Occupants' Behavior in Sustainable Living: A Questionnaire Survey in Hong Kong

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Green building movement has been playing a major role in sustainable urbanism as well as current architectural development. In addition to its energy achievement, it could be influencing our living style according to some Environment and Behaviour (EB) studies. EB research showed that there are transactions between individuals and their physical setting that could change each other's performance. In its application on environmental problem, widespread human lifestyle change was suggested as the core factor of sustainability. To understand occupants' behaviour for improving the performance of green buildings, this paper studied four demographic variables (income, educational level, household size and area of apartment) and one variable about environmental belief for two pro-environmental behaviours (PEB) (control of shower time and waste sorting) in sustainable living. A questionnaire survey was carried out to analyse these PEB of over 400 staff from a property management company in Hong Kong. The result showed that though the display of PEB depends on environmental belief, income, area of flat and type of dwelling, the correlations are weak. This suggested that demographic factors and single environmental awareness have small impact in explaining PEB. As it is a preliminary study aimed at solving the problem of slow green building development in Hong Kong by enhancing behavioural change, further studies were planned for investigating other possible predictors of household PEB. For this research project, the author expected to identify variables which could activate PEB to engage in green building movement and learn the actual impact of these PEB on the performance of green buildings.

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Introduction

Green building movement has a key role in sustainable development (SD). Aligning with these global consenses, Hong Kong (HK), a well-developed and prosperous city in Southeast Asia, has committed to foster a quality and sustainable built environment since 1999 (Office of the Chief Executive, 2011). The HK green building certification (BEAM), which was launched in 1996, is the first of its kind in the Asian region. Besides, there are various policies and campaigns to promote green building development. But unfortunately, the performance of them is not satisfactory in term of quantity according to the joint study by Greenpeace East Asia and the University of Hong Kong (Lau, Gou, Mah, Tsang, & Cheung, 2011). The number of green building in HK falls behind that of Taiwan and Singapore. In addition to the quantity of green buildings, the success of green building development also depends on its quality. The quality of a green building is not determined only by its systems and materials, but more importantly, by human behaviour which influences its operation and maintenance. Research showed that widespread human lifestyle change is the core factor of sustainability (Howard, 2000; McKenzie−Mohr, 2000), so human behavioural research seems to be crucial for improving the unsatisfactory green building development in HK.

Promoting human behavioral change is an extremely challenging task. Stern (2000b) pointed out that there is a long causal chain of personal and contextual factors for pro-environmental behaviours (PEB). Thus, it is worth to study the correlation among the factors to figure out the most effective strategy to encourage households PEB for supporting the role of green building in SD. This paper is going to present the first study of a project that helps architects consider users' behaviour in green building design. First, the contribution of PEB towards the performance of green buildings will be explained. It is followed by the sustainable living campaigns in HK and factors for driving PEB. Then, the methodology and findings of the questionnaire survey will be presented for discussing possible factors of household PEB. This study is limited to demographic factors and water saving and recycling behaviour.

Pro-environmental behaviour & Green Building

The assessment for new green buildings in HK is mostly under BEAM (Building Environmental Assessment Method). It is a voluntary scheme consists of a set of comprehensive standard procedures for benchmarking and improving the performance of buildings. By adopting international consensus about defining green buildings, BEAM embraces the following aspects for the holistic assessment.

- Site: land use, site impacts & transport
- Material: reuse, recycling & waste management
- Energy: energy efficiency, conservation & management
- Water: water quality, conservation & recycling; and
- IEQ (Indoor Environment Quality): hygiene, health, comfort & amenity.

The fulfillment of credits mainly depends on the works of architect and building services engineer. Selection of material and systems, design of window and building layout, and provision of facilities can determine the grade of the new building. But the actual performance of the assessed building cannot be guaranteed since it is sensitive

to variability of occupant behavior (Wener & Carmalt, 2006), especially for buildings designed to utilize natural ventilation.

Natural ventilation can only be achieved by opening the windows. If the occupants always keep the windows shut, much energy will then be consumed by means of mechanical ventilation, such as fan and air-conditioner, for achieving thermal comfort. In addition, provisions of recycling bins, water flow regulators and windows for access of daylight might not able to reduce waste generation, water consumption and energy use for lighting unless occupants act environmentally responsibly. So it is significant to encourage sustainable living style to help secure the performance of green buildings by complementing with the green building equipment and systems.

Water Saving & Recycling Campaigns in Hong Kong

The PEB studied in this primary research are water saving and recycling behaviour as there is no mandatory measure for domestic waste and water reduction in HK yet. So far, the sustainability-related regulations for buildings are mainly for controlling energy consumption[1]. Environmental campaigns and programs are used for promoting water saving and source separation of domestic waste. For instance, lately, Water Supplies Department launched "Let's Save 10L Water" Campaign offering water saving tips for the household to encourage the public to actively utilize the precious water resources[2]. Non-Government Organizations (NGOs), such as Green Power, launched "5-minutes shower" to encourage the public to minimize the time for shower. Since 2005, the government has been offering funding for building management company and Incorporated Owners' Committee to reimburse the partial cost of setting up waste separation facilities to encourage domestic waste recycling. HK people have access to knowledge and information as well as financial incentives for domestic waste and water reduction by a wide range of means offered by the government and NGOs. However, statistics showed that the daily domestic water consumption in HK is more than that in many first world cities such as London and Singapore, and the daily domestic waste generation rate per capita is much more than that in other developed Asian cities (China Water Risk, 2012; Environment Bureau, 2013). It seems that, in general, HK people are wasteful despite the great effort by the government and NGOs.

Though the gap between environmental knowledge and the act of PEB has been studied by various theoretical frameworks with numerous factors, no definitive explanation has been found yet (Kollmuss & Agyeman, 2002). Since behavioural change is so complicated that it is almost impossible to be completely explained by a single model (Kollmuss & Agyeman, 2002), it is worth to understand the nature and possible effect of each factor before adopting the most desirable model to analyse an environmentally behavioural change for supporting green building development.

[1] For example, Hong Kong Ordinance Chapter 598, Energy Efficiency (labelling of products) Ordinance; Hong Kong Ordinance Chapter 610, Building Energy Efficiency Ordinance; Hong Kong Ordinance Chapter 123M, Building (Energy Efficiency) Regulation

[2] "Let's Save 10L Water": http://www.waterconservation.hk/en/main.html

Pro-environmental Behavior (PEB)

Steg and Vlek (2009) introduced PEB as "behavior that harms the environment as little as possible, or even benefits the environment." Use of nontoxic products, practicing water conservation and waste recycling, eating less meat and driving less are some of the examples (Krause, 1993). As advised by Steg and Vlek (2009), factors influencing PEB can be categorized as (1) motivational; (2) contextual and (3) habitual.

Motivational factors are about intrinsic motives, such as, attitudes, values and belief as well as affect. McCarty and Shrum (1994) showed that values do affect the attitude of recycling of solid waste, but could not display the behaviour directly. According to the studies (e.g. (Hernandez, Tabernero, & Suarez, 2010; Stern, 2000a; Vining & Ebreo, 2002), values can be categorized into "self-centered", "socio-altruistic" and "ecocentric". It was argued that both altruistic and econcentric values have positive effect on PEB whereas egoistic value is mostly negatively related to it. However, Brown and Kasser (2005) revealed that care about personal well-being can be complementary with PEB. Environmental attitude was defined as "a psychological tendency expressed by evaluating the natural environment with some degree of favour or disfavour" (Milfont, Duckitt, & Wagner, 2010). Though it is one of the significant factors in Ajzen's Theory of Reason Action and Theory of Planned Behaviour (Ajzen, 1991), research showed that it usually has small impact on PEB (Kollmuss & Agyeman, 2002). Referring to the review of Vining and Ebreo (2002), affect/emotion is the self-conscious or self-evaluative motions, such as pride, shame, and guilt, that are central to conservation motivations. It can be a possible strong predictor of behaviour when the effects of attitude are weak.

Contextual factors include interpersonal influence, built environments, accessibility and availability of supporting facilities, monetary costs and benefits and legal and institutional factors, etc. (Stern, 2000a).

Aarts, Verplanken, and Knippenberg (1998) described habits as a learned, goal-directed act that automatically responds to specific circumstances. The stronger the habit, the less metal effort and conscious attention are required to induce the behaviour. Klöckner and Matthies (2004) and Knussen and Yule (2008) showed that the effect of habit for recycling behaviour and travel mode is dependent on the strength of habits and interventions available.

In addition to these factors, demographic factors showed influence to environmental attitude and PEB (Stern, Dietz, & Kalof, 1993). Women might be more aware than men of environmental issue due to emotion and the experience and effects of parenthood (Dietz, Stern, & Guagnano, 1998). Education, income, size of the living area and type of dwelling were found to be significant determinants of the use of recycling facilities (Berger, 1997). Research also showed that sociodemographic variables were related to impact-defined behaviours, such as energy and water use and waste production (Gatersleben, Steg, & Vlek, 2002; Poortinga, Steg, & Vlek, 2004). Hence, for a preliminary study, we studied the impact of demographic factors on two commonly promoted PEB in HK as well as that of an environmental belief as the motivational factor.

Methodology

Participants and Procedure
Participants were property management staff employed by a development company in Hong Kong. They, 100% Chinese, were recruited at their workplace for completing a Chines paper questionnaire in the summer of 2013. No benefits were offered to them for the participation. In total, 412 (208 male, 194 female, and 10 unreported) self-administration papers were returned. 376 papers were fully completed for this study.

Measures
This preliminary study is an intent-oriented measure of PEB as it only focused on what may predict the intention. The environmental impact of PEB will not be discussed.

Pro-environmental behavior (PEB). Based on the most common campaign about sustainable living, two household PEB were identified. Participants reported the frequency of waste separation before disposal and minimizing the shower time based on their past experiences on a 5-point scale ("never" to "always").

Demographic factors. In order to compare the effect of the demographic factors which have been studied by other authors, family monthly income, educational level, household size, gender, type of dwelling and area of apartment were studied.
Environmental belief. Participants reported if they agreed with the statement saying that "the capacity and natural resources on earth is limited" on a 5-point scale ("strongly disagree" to "strongly agree").

Result and Discussion

More than half of the respondents (57.1%) reported that they usually or always minimize the shower time if possible and nearly half of the respondent (46.2%) usually or always separate the domestic waste before disposal. By the result of Chi-square test, both minimizing the shower time and separating waste before disposal are independent with educational level, household size and gender. Only environmental belief about the limited capacity and natural resources is related to the two PEB. Income and area of flat are only related to the shower time while type of dwelling, varied from cheap rental public housing, public housing of subsidized sale-programme to private housing, is only related to the waste separation. Pearson's bivariate correlation was then used to examine the relationship among the factors (Table 1). The result showed that though the display of PEB depends on environmental belief, income, area of flat and type of dwelling, the correlations are weak. The strongest relation is the one between minimizing shower time and environmental belief, yet it is only 0.203. Hence, it can be concluded that the variables studied in this questionnaire survey are not likely to be the reliable predictor of minimizing shower time and separating waste before disposal.

The negative correlation between the shower time and monthly household income can explain that Hong Kong people with more money probably prefer longer shower for enjoyment even though they may be aware of the environmental problem. According to the survey by Green Power, Hong Kong people, on average, takes 14 minute for

each shower (Green Power, 2013). It seems that taking long shower has become a social norm in Hong Kong. Though the water charge is heavily subsidized by the government, the use of water is still related to the monetary factor. It is interesting that area of flat is also related to the shower time positively, so studies are required to examine such surprising result in the next phase of study. For waste separation, type of dwelling is positively related to it. This indicates that people living in private housing probably are more willing to participate in waste recycling. It is then worth to study the actual recycling process in different kinds of housing to find out the contextual factors of encouraging recycling behaviour.

Since the correlations are so weak, it is suspected that social desirability is as a suppressor variable that hide the actual correlation between the factors as suggested by Ganster, Hennessey & Luthans (1983). For improving this potential bias, further studies will conider the remedial advices by Podsakoff, MacKenzie, Lee & Podsakoff (2003), such as measureing the dependent and independent variables from different sources and introducing a time lag between the data collection of dependent and independent variables if there is only the same source.

Table 1
Bivariate correlations between PEB and demographic factors (N=376)

	IN	ED	FA	HS	GE	TD	EB	SH	SW
IN									
ED	.408**								
FA	.342**	.339**							
HS	.057	-.026	.242**						
GE	-.034	-.132*	-.047	-.084					
TD	.265**	.273**	.397**	-.127*	.048				
EB	.124*	.104*	.012	.099	-.005	-.012			
SH	-.048	.011	.123*	.005	.091	.083	.203**		
SW	.020	-.009	.175**	-.003	.094	.108*	.089	.203**	

**p<.01; *p<.05
Note: IN = monthly household income; ED = education level; FA = area of flat; HS = household size; GE = Gender; TD = type of dwelling; EB = environmental belief; PEBs are all scored from 1 “never” to 5 “always”), SH = reducing shower time as short as possible & SW = separating waste before disposal

Conclusion

In summary, the green building movement seems to have failed to make a significant contribution to SD in Hong Kong as expected. Though there are various sustainable living campaigns, the effect of them on behavioural change is little due to the complex chain of factors of PEB. Thus, it is worth to learn all factors inhibiting or promoting PEB for forming the best strategy to improve green building performance. In this preliminary study of a research project aiming to encourage households PEB for supporting the role of green building in SD, demographic factors and belief about limited capacity and natural resources on earth were studied with behaviours for water reduction and waste recycling. The result showed the weak correlation among them, but it led to several questions for the next phase of study. In the next step, the authors

would like to focus on intrinsic motives and contextual factors (e.g. provisions in green buildings) and then the actual impact of these PEB on the performance of green buildings will be examined.

Acknowledgment
We would like to thank the great support from Henderson Land Development Company Limited for helping with the data collection of this study.

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The Effect of Temperature and Biodiesel Fraction on the Viscosity of Biodiesel-Diesel Fuel Blends

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The Second European Conference on Sustainability, Energy & the Environment
Official Conference Proceedings 2014

Abstract
This study aims determination of the effects of biodiesel fraction and temperature on the viscosities of blends of corn oil biodiesel with petro-diesel fuel. Corn oil biodiesel was produced by using sodium hydroxide (NaOH) as catalyst and methanol (CH_3OH) as alcohol. To produce the lowest viscosity corn oil biodiesel, many production parameters such as catalyst concentration, reaction temperature, reaction time and alcohol/oil molar ratio were optimized respectively at the first stage which is not consisted in this study. At the second stage concerned mainly with this study, the biodiesel produced by using predetermined optimum parameters was blended with petro-diesel fuel at the volume ratios of 5, 10, 15 and 20% and then each blend was studied to determine viscosity at different temperatures such as 10, 20, 30 and 40°C. One- and two- dimensional curve fit equations were derived by applying the least squares regression to experimental data. One-dimensional exponential equation ($\mu = \mu_0 + ae^{-b\phi}$) was found suitable to predict dynamic or kinematic viscosities of the blends with respect to temperature or biodiesel fraction. In this exponential equation, ϕ represents either biodiesel fraction in blend X or temperature T while μ_0, a and b are regression constants. Two-dimensional polynomial equation such as $\mu = \mu(T, X) = a + bT + cX + dT^2 + eTX + fX^2 + gT^3 + hT^2X + kTX^2$ was fitted to the dynamic or kinematic viscosity data to represent change of dynamic or kinematic viscosities of the blends versus temperature and biodiesel fraction in blend. For all the fitted equations, the calculated regression constants (μ_0, a and b) and regression coefficients (R^2) were given as tables.

Keywords: Alternative fuels, Corn oil biodiesel, Biodiesel-diesel fuel blends, Prediction viscosity models

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Introduction

The depletion of fossil fuel reserves in the world has led to a growing and urgent interest in alternative energy sources, especially renewable ones will be more required soon [1]. For diesel engines, which will be used more widely in the near future due to their high thermal efficiency and superior fuel economy compared to gasoline engines [2], biodiesel is gaining more attention as a renewable alternative fuel. From a chemical point of view, biodiesel can be defined as mono-alkyl methyl or ethyl esters of long-chain-fatty acids derived from vegetable oils or animal fats via a reaction as transesterification. The reaction is achieved with mono-hydric alcohols like methanol and ethanol in the presence of an alkali catalyst [3]. Even though biodiesel cannot entirely replace petro-diesel fuel, it has many advantages such as: (1) Biodiesel is a renewable fuel, non-toxic, significantly reduces life-cycle net carbon dioxide emissions, and essentially free of sulfur and aromatic [1,4]. (2) Biodiesel comprises of about 10 to 11% oxygen by mass in the molecular structure. Therefore, it has higher cetane number, better ignition quality and produces less particulate matter, unburned or half-burned hydrocarbon, and carbon monoxide, in comparison with petro-diesel fuel [5]. (3) Biodiesel improves lubricity and reduces premature wearing of fuel pumps [3]. (4) Biodiesel can be completely miscible with petro-diesel fuel, allowing the blending of these two fuels in any proportion [6]. It can be used as neat or blended form in existing diesel engines without any significant modifications to the engines [3]. (5) The flash point temperature of biodiesel is higher than that of petro-diesel fuel. Although the flash point temperature does not directly affect the combustion, it makes biodiesel safer regarding the storage and transport [7]. Although these properties make it an ideal fuel for diesel engines, it has also some disadvantages such as lower heat of combustion and volatility, higher density, viscosity and cloud point temperature compared to petro-diesel fuel.

As the use of biodiesel becomes more widespread, it becomes important to know whether the basic properties of biodiesel-petro diesel fuel blends meets the related standard specifications for petro-diesel fuels. Additionally, researchers have shown a strong interest in modeling the combustion process in the engine in order to understand the fundamental characteristics of biodiesel combustion [4] and they use the basic properties as input data for engine combustion models or software. Also, because of the difficulty of determination of the basic properties of biodiesel-diesel fuel blends for infinite number of blending ratios by measurement, using blending or mixing equations to calculate these properties is very useful. Some studies include these equations are summarized as following.

In the study performed by Tat and Gerpen, the kinematic viscosities of soybean oil biodiesel and its blends (75, 50 and 20% by mass) with No. 1 and No. 2 diesel fuels were measured from the onset of crystallization to 100℃. Second-order polynomial equation was developed to calculate the kinematic viscosities of blends by using regression analysis. The correlation between fitted curve and the experimental data is very well and the lowest regression coefficient (R^2) was found as 0.9995 for all the fuel blends [8].

Alptekin and Canakci measured densities and kinematic viscosities of biodiesels derived from six different vegetable oils (sunflower, canola, soybean, cottonseed, corn oil and waste palm oil) and its blends with two different petro-diesel fuel (purchased

from Shell Extra Diesel and Petrol Office firms). The blends (B2, B5, B10, B20, B50 and B75) were prepared by volume. Linear equation and a mixing equation originally proposed by Arrhenius were used to predict the densities and viscosities of the blends. For all blends, there was an excellent agreement between the measured and calculated densities and viscosities values [7].

Nita and Geacai reported that the changes of densities and viscosities of a corn oil, petro-diesel fuel and corn oil biodiesel at the temperature range of 20℃ to 60℃ with an increasing step of 5℃, and suggested empirical models to predict these fuel properties. According to results, it can be said that the estimation of the density using a linear correlation is very accurate in case of all fuels, and the estimation of the viscosity of fuels using a third-degree polynomial empirical equation has different accuracy [9].

Benjumea et al. measured some basic properties (viscosity, density, heating value, cloud point, calculated cetane index and T10, T50 and T90 distillation temperature) of several palm oil biodiesel-diesel fuel blends. Arrhenius-type equation and Kay's mixing rules were used in order to predict kinematic viscosity and the other properties, respectively [6].

Joshi and Pegg carried out a study on the determination of flow properties of biodiesel-diesel fuel blends at low temperatures. In their study, the cloud point, pour point and dynamic viscosity of biodiesel derived from ethyl esters of fish oil, No. 2 diesel fuel, and their blends were measured from 298 K down to their respective pour points. Blends (B80, B60, B40 and B20) were prepared by volume. Arrhenius equations were used to predict the viscosities of the all fuels as a function of temperature. The calculated viscosities agreed well with measured values. An empirical equation for estimating the viscosities of these blends as a function of both temperature and biodiesel fraction was developed. It was specified that the dynamic viscosity of biodiesel and its blends increases as temperature decreases and shows Newtonian behavior down to the pour point temperature [3].

As seen from the some literature survey above, there is generally sufficient data available about determination of viscosities of biodiesel-diesel blends at certain temperatures. Hence the main objective of the present work is to measure viscosity of the corn oil biodiesel and its blends with Ultra Force Euro Diesel at different temperatures (10, 20, 30, 40℃), and derive new one- and two-dimensional equations to predict the viscosity by using the least square method. The biodiesel-diesel blends (B5, B10, B15 and B20) were prepared by volume. The names of blends are defined by the first letter of the name of the biodiesel B followed by the volume percent of the biodiesel in the blends as usual. For example, B5 signifies that, it is a blends of 5% volume corn oil biodiesel and 95% volume petro-diesel fuel. Also, B100 and D represent pure biodiesel and petro-diesel fuels, respectively.

Experimental Study

Biodiesel Production

In this study, commercially available refined corn oil was used in biodiesel production. It was not needed to perform a pretreatment to the oil because of being refined. Thus, methanol (CH_3OH) of 99.8% purity as alcohol and sodium hydroxide

(NaOH) of pure grade as catalyst were used in transesterification. The transesterification reaction was carried out in a 1 L flat-bottomed flask, equipped with a magnetic stirrer heater, thermometer and spiral reflux condenser. Haake Falling Ball Viscometer, Isolab pycnometer, top loading balance, Haake Water Bath and a stopwatch were used to measure dynamic viscosity and density. Many reaction parameters such as catalyst concentration, reaction temperature, reaction time and alcohol/oil molar ratio were optimized formerly to produce the lowest viscosity corn oil biodiesel, which were not mentioned in this study. These optimum reaction parameters were obtained as 0.90% catalyst concentration, 60°C reaction temperature, 60 minutes reaction time and 9:1 alcohol/oil molar ratio. Before starting the reaction, the catalyst was dissolved in methanol to make alcoholic solution of catalyst in a narrow-neck flask. In the flat bottomed flask, this alcoholic solution was added to the 200 g corn oil that was formerly warmed to about 80°C in a beaker. These reactants were mixed for 60 minutes at 50°C with stirring speed of 500 rpm by means of the magnetic stirrer heater. Transesterification reaction was carried out with the spiral reflux condenser for avoiding loss of alcohol. Also, reaction temperature was controlled by using thermometer to remain constant reaction temperature during the reaction. At the end of reaction, the resulting products mixture was transferred to a separating funnel. After a day, two phases occurred in the separating funnel. The upper phase consisted of methyl esters, and the lower one contained the glycerol, the excess methanol, the remaining catalyst together with soaps formed during the reaction and some entrained methyl esters and partial glycerides. After separation of the two layers by gravity, the upper layer (biodiesel) was washed with warm distilled water until the water became clear. Washed biodiesel was heated up to about 100°C to remove methyl alcohol and water residuals.

Density Measurement

Density can be defined as mass per unit volume. The densities of the produced biodiesel and its blends were measured in accordance with ISO 4787 standard by using Eq. (1) and making measurements by means of the top loading balance and Isolab pycnometer:

$$\rho_{\text{biodiesel or blends}} = \frac{m_{\text{total}} - m_{\text{pycnometer}}}{m_{\text{water}}} \rho_{\text{water}} \quad (1)$$

where $\rho_{\text{biodiesel or blends}}$ (kg/m^3) is density of biodiesel or its blends at intended temperature (10, 20, 30, 40°C), m_{total} (g) is mass of the pycnometer filled with biodiesel or its blends, $m_{\text{pycnometer}}$ (g) is mass of the empty pycnometer, m_{water} (g) is mass of water (empty pycnometer mass subtracted), ρ_{water} (kg/m^3) is density of distilled water at intended temperature. $m_{\text{pycnometer}}$ and m_{water} were experimentally determined as 42.74 g and 49.09 g, respectively. The measurements were conducted three times for each sample and the results were averaged. For example, by using Eq. (1) the density of B5 at 20 °C ($\rho_{B5,20°C}$) was calculated as:

$$m_{\text{total}} = 83.73 \text{ g}$$

$$m_{\text{pycnometer}} = 42.74 \text{ g}$$

$$m_{\text{water}} = 49.09 \text{ g}$$

$$\rho_{water,20°C} = 998.20\ kg/m^3$$

$$\rho_{B5,20°C} = \frac{83.73 - 42.74}{49.09} 998.20 = 833.49\ kg/m^3$$

Dynamic Viscosity Measurement

Viscosity is a measure of the resistance offered by a fluid to flow [10]. The dynamic viscosities of produced biodiesel or its blends were determined in accordance with DIN 53015 standard by using Eq. (2) and making measurements by means of the Haake Falling Ball Viscometer, Haake Water Bath and stopwatch:

$$\mu_{biodiesel\ or\ blends} = K_{ball}(\rho_{ball} - \rho_{biodiesel\ or\ blends})t \quad (2)$$

where $\mu_{biodiesel\ or\ blends}$ (cP) is dynamic viscosity of biodiesel or its blends at intended temperature (10, 20, 30, 40 °C), K_{ball} ($mPa \cdot s \cdot cm^3/g/s$) is constant coefficient of the viscometer ball, ρ_{ball} (g/cm^3) is density of the viscometer ball, and t (s) is falling time of the ball moving between two horizontal line marked on viscometer tube at limit velocity. K_{ball} and ρ_{ball} are $0.057\ mPa \cdot s \cdot cm^3/g/s$ and 2.2 g/cm^3, respectively. The measurements were done also three times for each sample and the results were averaged. For example, by using Eq. (2) the dynamic viscosity of B5 at 20 °C ($\mu_{B5,20°C}$) was calculated as:

$$K_{ball} = 0.057\ mPa \cdot s \cdot cm^3/g/s$$

$$\rho_{ball} = 2.2\ g/cm^3$$

$$\rho_{B5} = 833.49\ kg/m^3$$

$$t = 37.05\ s$$

$$\mu_{B5,20°C} = 0.057(2.2 - 0.83349)37.05 = 2.886\ cP$$

The kinematic viscosities of the produced biodiesel or its blends were determined by dividing dynamic viscosity to density at the same temperature, by using Eq. (3):

$$\nu_{biodiesel} = \frac{\mu_{biodiesel}}{\rho_{biodiesel}} \quad (3)$$

In Eq. (3), if $\mu_{biodiesel}$ and $\rho_{biodisel}$ are in the unit of (cP) and (kg/L), respectively, then $\nu_{biodiesel}$ is obtained in unit (cSt). For example, the kinematic viscosity of B5 at 20 °C ($\nu_{B5,20°C}$) was calculated as:

$$\nu_{B5,20°C} = \frac{2.886}{0.83349} = 3.463\ cSt$$

The other properties of the fuels such as flash point (EN ISO 3679) and higher heating value (DIN 51900-2) were measured in Karadeniz Technical University Prof. Dr. Saadettin GUNER Fuel Research and Application Center. The properties, EN 14214 and ASTM D 6751 standard values are given in Table 1.

Uncertainty Analysis

The results obtained from experimental studies are generally calculated from measured physical quantities. These quantities have some uncertainties due to uncertainties of measuring tools and measurement systems. Therefore, uncertainty analysis should be applied for proving reliability of the calculated results. In this study, uncertainties of the measured and calculated physical quantities such as dynamic and kinematic viscosities and density values were determined by the method proposed by Kline and McClintock [11]. According to this method, if the result R is a given function of the independent variables $x_1, x_2, x_3, \dots, x_n$, and $w_1, w_2, w_3, \dots, w_n$ are the uncertainties of each independent variables, then the uncertainty of the result w_R is calculated by using the equation:

$$w_R = [(\frac{\partial R}{\partial x_1} \cdot w_1)^2 + (\frac{\partial R}{\partial x_2} \cdot w_2)^2 + (\frac{\partial R}{\partial x_3} \cdot w_3)^2 + \cdots + (\frac{\partial R}{\partial x_n} \cdot w_n)^2]^{1/2} \quad (4)$$

In this study, for example, by using the uncertainties of the top loading balance and stopwatch as 0.01 g, 0.01 s, respectively, the uncertainty of dynamic viscosity at 20 °C ($w_{\mu_{B5,20°C}}$) of B5 was calculated as:

$$\mu_{B5} = K_{ball}(\rho_{ball} - \rho_{B5})t$$

$$\mu_{B5} = \mu_{B5}(\rho_{B5}, t)$$

$$R \equiv \mu_{B5}$$

$$x_1 \equiv \rho_{B5} = 833.49 \text{ kg/m}^3$$

$$x_2 \equiv t = 37.05 \text{ s}$$

$$\frac{\partial \mu_{B5}}{\partial \rho_{B5}} = -K_{ball}t$$

$$\frac{\partial \mu_{B5}}{\partial t} = K_{ball}(\rho_{ball} - \rho_{B5})$$

$$w_{\mu_{B5,20°C}} = \{[-K_{ball} \cdot t \cdot w_{\rho_{B5,20°C}}]^2 + [K_{ball} \cdot (\rho_{ball} - \rho_{B5}) \cdot w_{t,20°C}]^2\}^{1/2} \quad (5)$$

It is necessary to know $w_{\rho_{B5,20°C}}$ for calculating $w_{\mu_{B5,20°C}}$. For this reasons, Eq. (4) should be reused for $w_{\rho_{B5,20°C}}$ as below:

$$\rho_{B5} = \frac{m_{total} - m_{pycnometer}}{m_{water}} \rho_{water}$$

$$\rho_{B5} = \rho_{B5}(m_{total}, m_{pycnometer})$$

$$R \equiv \rho_{B5}$$

$$x_1 \equiv m_{total} = 83.73 \text{ g}$$

$$x_2 \equiv m_{pycnometer} = 42.74 \text{ g}$$

$$\frac{\partial \rho_{B5}}{\partial m_{total}} = \frac{1}{m_{water}} \rho_{water}$$

$$\frac{\partial \rho_{B5}}{\partial m_{pycnometer}} = \frac{-1}{m_{water}} \rho_{water}$$

$$w_{\rho_{B5,20°C}} = [(\frac{1}{m_{water}} \rho_{water,20°C} w_{m_{total}})^2 + (-\frac{1}{m_{water}} \rho_{water,20°C} w_{m_{pycnometer}})^2]^{1/2}$$

$$w_{\rho_{B5,20°C}} = [(\frac{1}{49.09\ g} \cdot 998.20\ kg/m^3 \cdot 0.01g)^2 + (\frac{1}{49.09\ g} \cdot 998.20\ kg/m^3 \cdot 0.01g)^2]^{1/2} = 0.2876\ kg/m^3$$

If the value is used in Eq. (5), $w_{\mu_{B5,20°C}}$ is calculated as:

$$w_{\mu_{B5,20°C}} = \{[-K_{ball} \cdot t \cdot w_{\rho_{B5,20°C}}]^2 + [K_{ball} \cdot (\rho_{ball} - \rho_{B5}) \cdot w_{t,20°C}]^2\}^{1/2}$$

$$w_{\mu_{B5,20°C}} = \{[-0.057\ mPa \cdot s \cdot cm^3/g/s \cdot 37.05\ s \cdot 0.2876 \cdot 10^{-3}\ g/cm^3)^2] + [0.057\ mPa \cdot s \cdot cm^3/g/s \cdot (2.2\ g/cm^3 - 0.83349\ g/cm^3) \cdot 0.01\ s]^2\}^{1/2}$$

$$w_{\mu_{B5,20°C}} = 9.8772 \cdot 10^{-4}\ cP$$

Since the dynamic viscosity of the B5 was determined by using Eq. (1) as 2.886 cP, dimensionless uncertainty of dynamic viscosity becomes as:

$$w_{\mu_{B5,20°C}} = \frac{9.8772 \cdot 10^{-4}}{2.886} \cdot 100 = \%0.0342$$

For all values calculated using the same method, the highest and lowest uncertainties for dynamic and kinematic viscosity values were determined as 0.0201%-0.0408% and 0.0408%-0.0535%, respectively. According to these uncertainties, it can be said that the results have fairly high reliability.

Results and Discussion

Effect of Biodiesel Fraction on Viscosity

The changes of dynamic and kinematic viscosities of blends with respect to biodiesel fraction in the blend for different temperatures are shown in Fig. 1 and Fig. 2, respectively. It is clear from these figures that all the blends follow the same trend, i.e., viscosity of the blends increase exponentially with increasing biodiesel fraction in the blends for studied temperatures. In order to characterize the variation of the blends viscosities with respect to volumetric biodiesel fraction in the blends, it has been found suitable to fit exponential equations in the form:

$$\mu = \mu(X) = \mu_0 + ae^{-bX} \quad (6)$$

$$\nu = \nu(X) = \nu_0 + ae^{-bX} \quad (7)$$

where μ is dynamic viscosity (cP), ν is kinematic viscosity (cSt), μ_0, ν_0, a and b are regression coefficients and X is percent volumetric biodiesel fraction in the blend.

It can be seen in Fig. 1 and Fig. 2 that the changes of viscosities tend to be about linear with increasing in biodiesel fraction as temperature is decreasing. The minimum and maximum dynamic viscosity values are 2.233 cP of pure petro-diesel fuel at 40°C and 7.023 cP of pure biodiesel at 10°C, respectively. Similarly, the minimum and maximum kinematic viscosity values are 2.700 cSt of pure petro-diesel fuel at 40°C and 8.009 cSt of pure biodiesel at 10°C, respectively.

Table 2 shows the calculated by using Eq. (6) and measured dynamic viscosities of fuel blends, errors between them, and regression coefficients. The maximum absolute error ratio between the measured and calculated dynamic viscosity values is 3.738%. The regression coefficients (R^2) are between 0.9948 and 0.9991.

Similar quantities of Table 2 are given for kinematic viscosities in Table 3. In this case, the maximum absolute error ratio were obtained as 3.783% and the regression coefficients (R^2) were computed as between 0.9932 and 0.9989. According to regression analyze, it can be said that exponential regression properly fits the data and represents perfectly the both dynamic and kinematic viscosity-biodiesel fraction relationships.

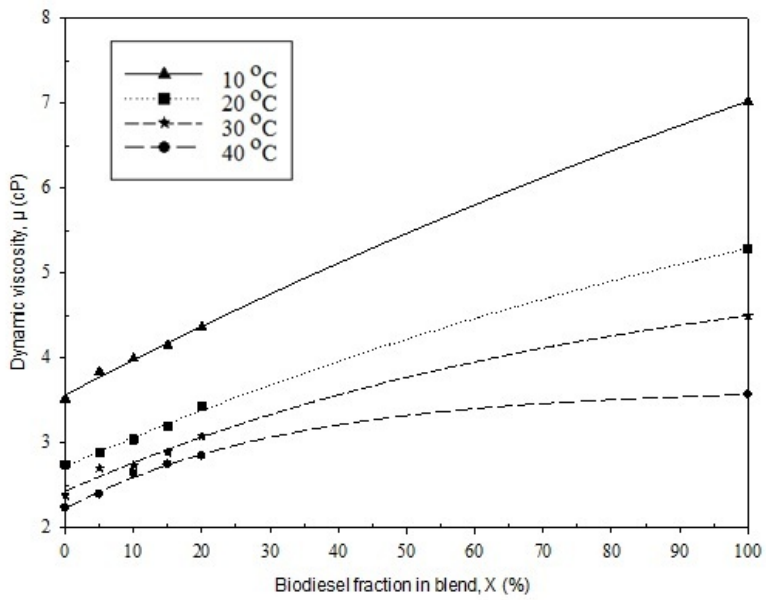

Fig. 1. Variation of dynamic viscosity with biodiesel fraction in blend

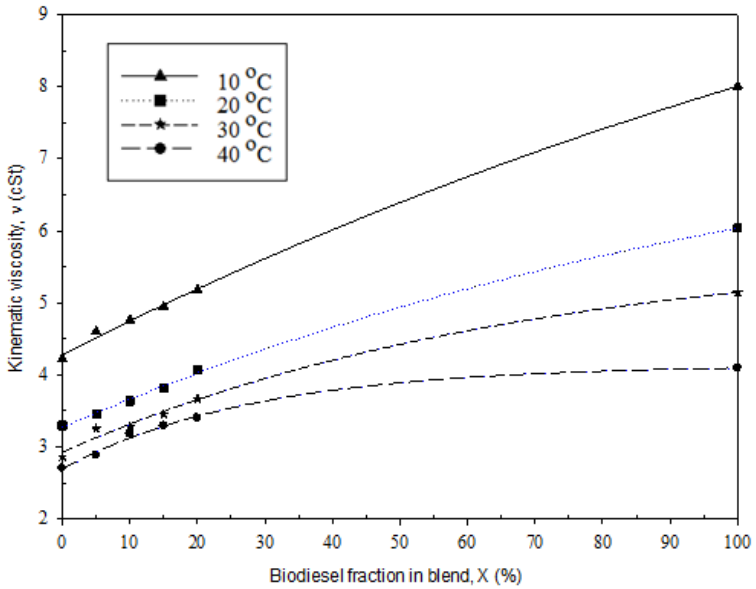

Fig. 2. Variation of kinematic viscosity with biodiesel fraction in blend

Effect of Temperature on Viscosity

Fig. 3 and Fig. 4 show the effects of temperature on dynamic and kinematic viscosities of biodiesel-diesel fuel blends. It is clear from these figures that all the blends viscosities follow the same trend: that of decreasing exponentially with increasing temperature. The experimental data, represented by different symbols for each blends in these figures, were correlated with an exponential equation by applying the least squares method:

$$\mu = \mu(T) = \mu_0 + ae^{-bT} \tag{8}$$

$$\nu = \nu(T) = \nu_0 + ae^{-bT} \tag{9}$$

where μ is dynamic viscosity (cP), ν is kinematic viscosity (cSt), μ_0, ν_0, a and b are regression coefficients, and T is temperature (°C).

The calculated by using Eq. (8) and measured dynamic viscosities of all fuel blends are shown in Table 4. The maximum absolute error ratio between the measured and calculated dynamic viscosities were computed as 4.089%, and regression coefficients (R^2) were obtained between 0.9832 and 1.0000. It can be clearly said that there is a good agreement between the measured and calculated values.

Table 5 also presents the experimentally measured kinematic viscosities, the calculated kinematic viscosities by Eq. (9), regression constants and coefficient (R^2) values and errors. As seen in the table, the maximum absolute error ratio is 4.084% and regression coefficients are obtained between 0.9829 and 0.9999. Thus, it can be said that Eq. (9) represents the experimental data in adequately accurate.

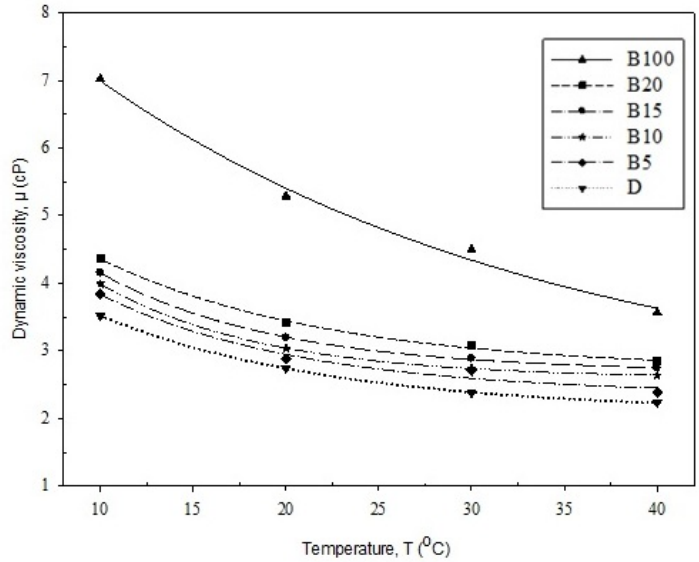

Fig. 3. Variation of dynamic viscosity with temperature

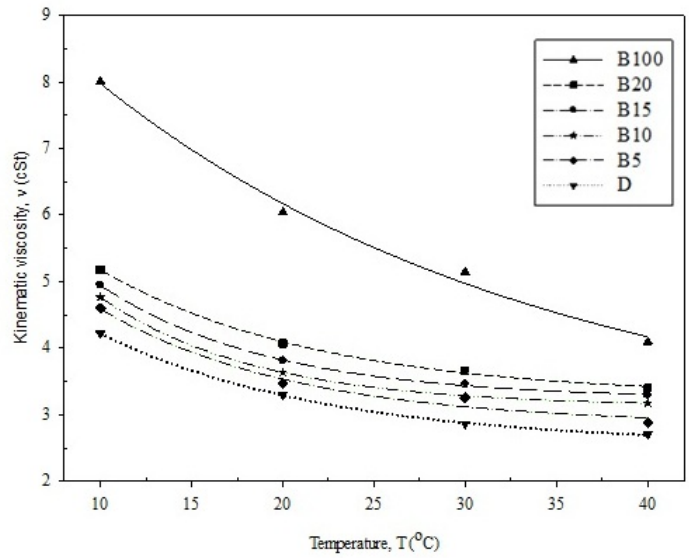

Fig. 4. Variation of kinematic viscosity with temperature

A Model for the Viscosities as a Function of Temperature and Biodiesel Fraction

In this study, also two-dimensional surface curve fit equations were derived for dynamic and kinematic viscosities. In these equations, second order dependence to biodiesel fraction and third order dependence to the temperature of viscosities were found appropriate, as given in Eqs. (10) and (11):

$$\mu = \mu(T, X) = a + bT + cX + dT^2 + eTX + fX^2 + gT^3 + hT^2X + kTX^2 \quad (10)$$

$$\nu = \nu(T, X) = a + bT + cX + dT^2 + eTX + fX^2 + gT^3 + hT^2X + kTX^2 \quad (11)$$

In these equations, μ is dynamic viscosity (cP), ν is kinematic viscosity (cSt), a, b, c, d, e, …, k are regression coefficients, T is temperature (°C) and X is biodiesel fraction in blend.

The values of the regression constants and coefficients (R^2) for dynamic and kinematic viscosities calculated with Eq. (10) and Eq. (11) are given in Table 6 and 7, respectively. As seen in these tables, the maximum absolute error ratios between the measured and calculated dynamic and kinematic viscosities are 3.438%, 3.448%, and the regression coefficients (R^2) are 0.9956, 0.9954, respectively. Therefore, it can be said that the measured and predicted values are in good agreement.

Fig. 5 and 6 show contour plots of dynamic and kinematic viscosities of biodiesel-diesel fuel blends obtained from Eqs. (10) and (11) as a function of temperature and biodiesel fraction, respectively. These plots can be used to make quick estimates of viscosities for a given blending ratio at a specific temperature.

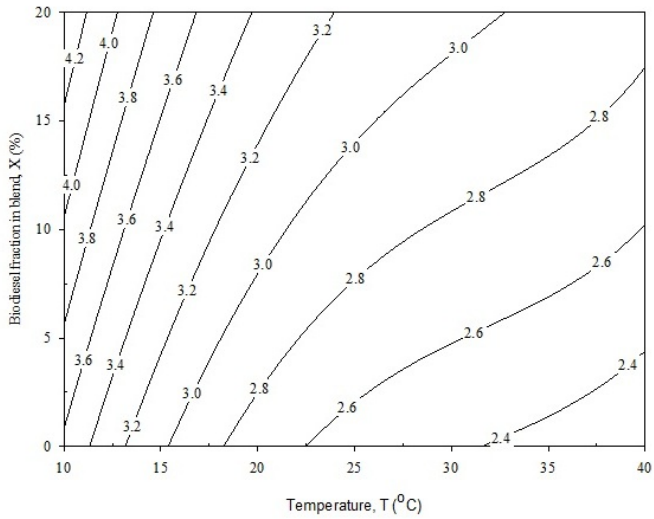

Fig. 5. Variation of dynamic viscosity with biodiesel fraction in blend and temperature

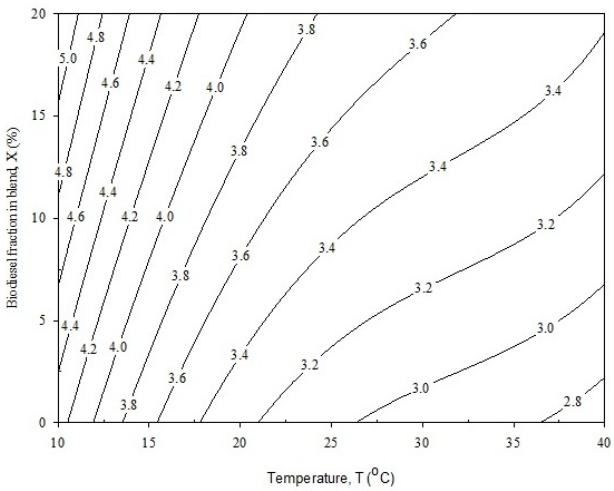

Fig. 6. Variation of kinematic viscosity with biodiesel fraction in blend and temperature

Conclusion

In this study, the effects of biodiesel fraction and temperature on the viscosities of blends of corn oil biodiesel with petro-diesel fuel were investigated experimentally. One- and two-dimensional regression models were proposed to predict viscosities of the blends for various blending ratios and at different temperatures. The following conclusions can be drawn from this study:

- The exponential equations are quite suitable to represent viscosity-biodiesel fraction or viscosity-temperature variations.
- The two-dimensional surface equations show fair degree of accuracy with regression coefficient (R^2) of 0.9956 and 0.9954 for representing change of dynamic and kinematic viscosities with biodiesel fraction and temperature at the same time, respectively.

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Tables

Table 1. Some fuel specifications of commercial petro-diesel fuel, produced biodiesel and its blends, and corresponding standard values for biodiesel

Fuel Properties	Units	Corn Oil Biodiesel	Petro-Diesel Fuel	B5	B10
Kinematic viscosity at 40°C	cSt	4.095	2.700	2.882	3.174
Density at 15°C	kg/m^3	877.13	833.33	834.96	837.61
Flash Point Temperature	°C	169	63	68	69
Higher Heating Value	kJ/kg	39930	45950	45368	44984

Table 1 (Continued)

Fuel Properties	Units	B15	B20	EN 14214	ASTM D 6751
Kinematic viscosity at 40°C	cSt	3.291	3.400	3.50-5.00	1.90-6.00
Density at 15°C	kg/m^3	839.44	842.09	860-900	*
Flash Point Temperature	°C	70	72	101≤	130≤
Higher Heating Value	kJ/kg	44643	44399	*	*

Table 2. For different temperatures, measured and calculated dynamic viscosities of corn oil biodiesel, petro-diesel fuel and biodiesel-diesel fuel blends using Eq. (6), error ratio between measured and calculated dynamic viscosities, and regression constants (μ_0, a, b) and coefficients (R^2)

Temp. T (°C)	Measured dynamic viscosity, μ (cP) Biodiesel fraction in blend, X (%)						μ_0	a	b	R^2
10	3.514	3.838	3.989	4.150	4.360	7.023	14.0393	-10.4765	0.0040	0.9990
20	2.743	2.886	3.040	3.193	3.423	5.287	7.9546	-5.2334	0.0067	0.9991
30	2.376	2.702	2.736	2.889	3.074	4.496	5.3475	-2.9207	0.0123	0.9948
40	2.233	2.388	2.638	2.741	2.841	3.564	3.6325	-1.4050	0.0300	0.9964

Table 2 (Continued)

Calculated dynamic viscosity, μ (cP)	Absolute error ratio (%)
Biodiesel fraction in blend, X (%)	Biodiesel fraction in blend, X (%)

0	5	10	15	20	100	0	5	10	15	20	100
3.562	3.770	3.973	4.172	4.368	7.016	1.388	1.766	0.386	0.551	0.190	0.089
2.721	2.893	3.060	3.221	3.377	5.276	0.794	0.263	0.667	0.895	1.329	0.196
2.426	2.601	2.764	2.918	3.063	4.493	2.138	3.738	1.052	1.035	0.335	0.048
2.227	2.423	2.591	2.736	2.861	3.562	0.246	1.474	1.755	0.160	0.718	0.042

Table 3. For different temperatures, measured and calculated kinematic viscosities of corn oil biodiesel, petro-diesel fuel and biodiesel-diesel fuel blends using Eq. (7), error ratio between measured and calculated kinematic viscosities, and regression constants (ν_0, a, b) and coefficients (R^2)

Temp. T (°C)	Measured kinematic viscosity, ν (cSt)						ν_0	a	b	R^2
	Biodiesel fraction in blend, X (%)									
	0	5	10	15	20	100				
10	4.218	4.598	4.764	4.945	5.179	8.009	13.2377	-8.9602	0.0054	0.9987
20	3.298	3.463	3.636	3.811	4.072	6.038	8.1759	-4.9035	0.0083	0.9989
30	2.863	3.251	3.281	3.456	3.666	5.147	5.8257	-2.9006	0.0145	0.9932
40	2.700	2.882	3.174	3.291	3.400	4.095	4.1356	-1.4441	0.0354	0.9955

Table 3 (Continued)

Calculated kinematic viscosity, ν (cSt)						Absolute error ratio (%)					
Biodiesel fraction in blend, X (%)						Biodiesel fraction in blend, X (%)					
0	5	10	15	20	100	0	5	10	15	20	100
4.277	4.516	4.748	4.974	5.194	8.016	1.410	1.779	0.325	0.600	0.305	0.089
3.272	3.471	3.663	3.846	4.022	6.037	0.776	0.280	0.742	0.928	1.218	0.005
2.925	3.128	3.316	3.492	3.655	5.145	2.169	3.783	1.085	1.044	0.291	0.033
2.691	2.925	3.122	3.286	3.424	4.093	0.314	1.519	1.638	0.139	0.711	0.031

Table 4. For different biodiesel fractions, measured and calculated dynamic viscosities of corn oil biodiesel, petro-diesel fuel and biodiesel-diesel fuel blends using Eq. (8), error ratio between measured and calculated dynamic viscosities, and regression constants (μ_0, a, b) and coefficients (R^2)

Biodiesel fraction in blend, X (%)	Measured dynamic viscosity, μ (cP)				μ_0	a	b	R^2
	Temperature, T (°C)							
	10	20	30	40				
0 (Pure Diesel)	3.514	2.743	2.376	2.233	2.0970	3.1420	0.0795	0.9998
5	3.838	2.886	2.702	2.388	2.3546	3.6769	0.0914	0.9832
10	3.989	3.040	2.736	2.638	2.5921	4.3553	0.1137	1.0000
15	4.150	3.193	2.889	2.741	2.6888	4.1488	0.1045	0.9995
20	4.360	3.423	3.074	2.841	2.7173	3.7008	0.0814	0.9985
100 (Pure Biodiesel)	7.023	5.287	4.496	3.564	2.1895	7.1773	0.0402	0.9933

Table 4 (Continued)

Calculated dynamic viscosity μ (cP)				Absolute error ratio (%)			
Temperature, T (°C)				Temperature, T (°C)			
10	20	30	40	10	20	30	40
3.515	2.737	2.386	2.227	0.054	0.193	0.433	0.237
3.828	2.945	2.591	2.449	0.242	2.065	4.089	2.579
3.989	3.040	2.735	2.638	0.005	0.006	0.003	0.007
4.147	3.202	2.869	2.752	0.050	0.281	0.681	0.412
4.357	3.443	3.039	2.859	0.066	0.607	1.132	0.665
6.991	5.401	4.338	3.627	0.455	2.167	3.507	1.767

Table 5. For different biodiesel fractions, measured and calculated kinematic viscosities of corn oil biodiesel, petro-diesel fuel and biodiesel-diesel fuel blends using Eq. (9), error ratio between measured and calculated kinematic viscosities, and regression constants (ν_0, a, b) and coefficients (R^2)

Biodiesel fraction in blend, X (%)	Measured kinematic viscosity ν (cSt)				ν_0	a	b	R^2
	Temperature, T (°C)							
	10	20	30	40				
0 (Pure Diesel)	4.218	3.298	2.863	2.700	2.5450	3.7630	0.0810	0.9998
5	4.598	3.462	3.251	2.882	2.8520	4.4266	0.0937	0.9829
10	4.764	3.636	3.281	3.174	3.1230	5.2583	0.1164	0.9999
15	4.945	3.811	3.456	3.291	3.2341	4.9808	0.1069	0.9996
20	5.179	4.072	3.666	3.400	3.2649	4.3955	0.0834	0.9986
100 (Pure Biodiesel)	8.009	6.038	5.147	4.095	2.5735	8.1089	0.0406	0.9932

Table 5 (Continued)

Calculated kinematic viscosity ν (cSt)				Absolute error ratio (%)			
Temperature, T (°C)				Temperature, T (°C)			
10	20	30	40	10	20	30	40
4.219	3.289	2.876	2.692	0.023	0.251	0.464	0.281
4.586	3.531	3.118	2.956	0.145	2.007	4.084	2.578
4.764	3.635	3.283	3.173	0.016	0.011	0.064	0.031
4.944	3.821	3.435	3.303	0.014	0.270	0.587	0.373
5.173	4.094	3.625	3.421	0.098	0.540	1.118	0.626
7.976	6.173	4.972	4.171	0.405	2.245	3.394	1.875

Table 6. For different biodiesel fractions and temperatures, measured and calculated dynamic viscosities of biodiesel-diesel fuel blends using Eq. (10), error ratio between measured and calculated dynamic viscosities, and regression constants (a, b, c, d, … , k) and coefficient (R^2)

Temperature T (°C)	Biodiesel fraction in blend X (%)	Measured dynamic viscosity μ (cP)	Calculated dynamic viscosity μ (cP)
10	0 (Pure Diesel)	3.514	3.563
	5	3.838	3.773
	10	3.989	3.976
	15	4.150	4.172
	20	4.360	4.362
20	0	2.743	2.704
	5	2.886	2.893
	10	3.040	3.069
	15	3.193	3.232
	20	3.423	3.382
30	0	2.376	2.423
	5	2.702	2.609
	10	2.736	2.774
	15	2.889	2.920
	20	3.074	3.046
40	0	2.233	2.225
	5	2.388	2.422
	10	2.638	2.593
	15	2.741	2.738
	20	2.841	2.856

Table 6 (Continued)

Absolute error ratio (%)	Coefficients	Regression coefficient
1.420	$a = 5.5000$ $b = -2.6400x10^{-1}$ $c = 4.9310x10^{-2}$ $d = 7.8680x10^{-3}$ $e = -8.2640x10^{-4}$ $f = -8.5710x10^{-6}$ $g = -8.2870x10^{-5}$ $h = 1.6150x10^{-5}$ $k = -1.2940x10^{-5}$	$r^2 = 0.9956$
1.672		
0.308		
0.549		
0.045		
1.414		
0.270		
0.983		
1.243		
1.194		
2.007		
3.438		
1.410		
1.080		
0.907		
0.353		
1.440		
1.690		
0.105		

0.545		

Table 7. For different biodiesel fractions and temperatures, measured and calculated kinematic viscosities of biodiesel-diesel fuel blends using Eq. (11), error ratio between measured and calculated kinematic viscosities, and regression constants (a, b, c, d, … , k) and coefficient (R^2)

Temperature T (°C)	Biodiesel fraction in blend X (%)	Measured kinematic viscosity ν (cSt)	Calculated kinematic viscosity ν (cSt)
10	0 (Pure Diesel)	4.218	4.279
	5	4.598	4.520
	10	4.764	4.751
	15	4.945	4.972
	20	5.179	5.182
20	0	3.298	3.252
	5	3.462	3.472
	10	3.636	3.674
	15	3.811	3.858
	20	4.072	4.023
30	0	2.863	2.922
	5	3.251	3.138
	10	3.281	3.329
	15	3.456	3.495
	20	3.666	3.634
40	0	2.700	2.693
	5	2.882	2.925
	10	3.174	3.123
	15	3.291	3.289
	20	3.400	3.420

Table 7 (Continued)

Absolute error ratio (%)	Coefficients	Regression coefficient
1.446	$a = 6.5950$ $b = -3.1590x10^{-1}$ $c = 5.6600x10^{-2}$ $d = 9.4200x10^{-3}$	$r^2 = 0.9954$
1.685		
0.260		
0.552		
0.069		
1.370		
0.306		
1.056		
1.235		
1.183		
2.067		

3.448	$e = -9.1080x10^{-4}$	
1.490	$f = -5.4290x10^{-5}$	
1.131	$g = -9.9030x10^{-5}$	
0.856	$h = 1.8500x10^{-5}$	
0.255	$k = -1.5370x10^{-5}$	
1.499		
1.578		
0.057		
0.611		

Transitional Spaces: Reconciling Conflicts in Dense Housing Projects

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Density strategies are generally perceived as a powerful leverage for sustainable built environments. Reality unveils however a more nuanced appreciation. While the 'Prosperity' pillar of sustainable development is mostly covered, dense building developments tend to lack addressing 'here and now' social and environmental aspects of sustainability, which could mortgage the recognition of the embedded sustainability value and benefits that such projects offer. Design research on European demonstration and best practice sustainable dense housing projects uncovered 'transitional spaces' as a possible outlook.

This paper verifies the feasibility of 'transitional spaces' as a reconciler for conflicts regarding sustainability in dense housing projects. First, based on theoretical insights, density is identified and commented. Second, the problem statement is underlined by a balance on the concept based on strengths and weaknesses. Third, backed by a literature study, sustainable transitional spaces are proposed as a promising reconciling hypothesis. Fourth, case study research on demonstration and best practice projects, as well as research by design on real-life test cases explore, unveil and develop stated hypothesis.

It is concluded that due to intrinsic features and related consequences, dense building strategies contain besides perceived advantages, also barriers for achieving sustainable built environments. The implementation, the activation and the full deployment of 'transitional spaces' is promising in delivering full sustainable successes in dense housing projects. Suitable sustainable concepts for this (re)solution space likely result in beneficial synergies leading to a broader base for both density strategies and sustainable development.

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1. Introduction

The idea of density as a sustainable concept, as a powerful leverage towards sustainable built environments, is collectively agreed by international panels (technocrats and academics) on conventions and targets such as The Brundtland Report (1987), The earth Summit at Rio de Janeiro (1992) and The Green Paper on the Urban Environment (CEC) (1990). As a consequence, it is noticed that within the building sector, contemporary housing developments implement this strategy of density in a rigorous way. There seems to be an urge, a necessity for density when planning and designing new housing projects, regardless the scale (e.g. building block, neighbourhood, district), the typology (e.g. apartment, single family house) or the morphology (e.g. slab, tower, infill, low rise).

History, and unfortunately recent set up projects, unveils however a more nuanced appreciation. While the 'Prosperity' pillar of sustainable development is mostly covered (due to intrinsic features), dense building developments tend to lack addressing 'here and now' social and environmental aspects of sustainability. This deficit causes conflicts which could mortgage the recognition of the embedded sustainability value and benefits that such projects offer.

Design research on European demonstration and best practice sustainable dense housing projects uncovered 'the transitional space' as a possible perspective for stated deficit. Due to specific and embedded features of transitional spaces in dense housing projects (e.g. organizational, spatial, ownership status) it is plausible to state that these spaces contain potential to be uploaded with measures leading to both social and environmental qualities. Qualities intended to prevent conflicts. This paper verifies the reconciling ability of transitional spaces in dense housing projects.

Designed methodology, and structure of this paper, starts with an identification of density. Non exhaustive insights are provided in section two regarding quantitative and qualitative features. Illustrative and prevailing qualitative features, the push and pull factors, are listed, leading to a balance for density and ultimately the problem statement of this paper. Second, based on typological and morphological points of view, a possible first counteracting approach is mentioned. Third, in the core of the research, a reconciling hypothesis is formulated based on a literature review on the aspects of sustainability and especially on sustainability in transitional spaces. The feasibility of stated hypothesis is verified in section four. While the trend of densification is also noticeable in European demonstration and best practice projects regarding sustainable housing, case study research is conducted on the transitional spaces of these up front projects. In addition, research by design verifies the hypothesis in mainstream dense housing projects. Section six discusses the outcomes and reflects on proposed reconciling hypothesis. Towards the conclusion, issues and perspectives finalize the paper.

This paper adds to the knowledge of density strategies, housing projects and more in specific of dense sustainable housing projects. It identifies the transitional space as a solution place for reconciling conflicts and so for sustainability.

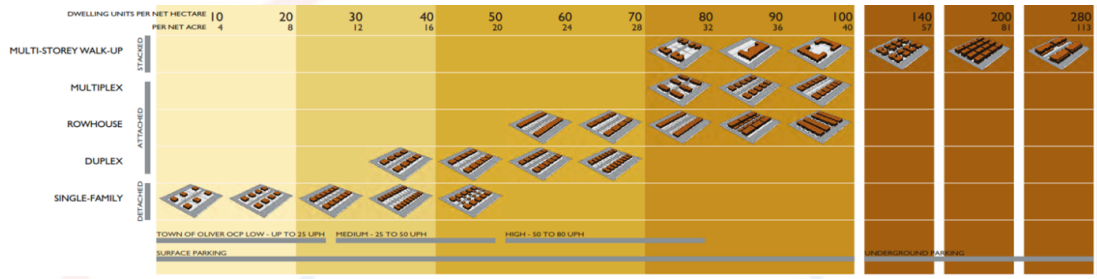
This paper is derived from the second part of an ongoing doctorate dissertation on sustainable dense housing projects (Janssens, ongoing). As the research methodology

focusses on case study research and research by design on a selection of housing projects within the context of Europe, the outcome of this study is tentative and preliminary and needs further discussion and verification.

2. Features of Density

2.1 Quantitative

When planners and designers talk about density, they often use and/or refer to the quantitative approach. Common in this discussion within housing developments is the basic parameter: units per hectare (UPH). Another prevailing parameter, not specific for the housing sector, is the floor space index (FSI). The higher the amount of units or the higher the index, the denser a development is.



In figure 1 some reference values are mentioned, illustrated with possible typological and morphological compositions.

Figure 1: Housing density scale. Source: Neighbourhoods Lab – Design Centre for Sustainability at UBC (University of British Columbia, Canada).

Density is, besides a matter of figures, also and maybe more important a matter of perception. The same density value could be appreciated differently depending on the sociocultural background, the living habits. This perception and appreciation of density is often the result of historical developments.

2.2 Qualitative

Quantitative features are used during planning and design processes, as a tool, a reference, a guidance. At the end, the project needs to have qualities. This subsection identifies strengths and weaknesses regarding qualities of dense housing projects.

The concept of density has some important positive quality features:

- Efficiency of transport, due to spatial concentration of actors and proximity of core destinations
- Less need for motorized transport, reducing transport energy and emissions
- Reduced commuting distances
- Less and efficient infrastructure and energy use (micro, meso and macro level)
- Prevention of the transformation of Greenfield land and reduction of the loss of valuable habitats
- Affordability, both on investments costs as on operating costs
- Support base for facilities & amenities which increases the attractiveness for living in the city
- Increasing the interaction between people (with talent) resulting in innovation.

Regarding the last point, Florida (2008) states: "When people – especially talented and creative ones – come together, ideas flow more freely, and as a result individual and aggregate talents increase exponentially: the end result amounts to much more than the sum of the parts. This clustering makes each of us more productive, which in turn makes the place we inhabit even more so – and our collective creativity and economic wealth grow accordingly. This in a nutshell is the clustering force. One consequence of the clustering force is a sorting of regions into an economic hierarchy." Glaeser (2011) defines this phenomenon as 'Tacit Knowledge'.

On the other hand, density may lead to conflicts, conflicts due to some important weaknesses:

- No or disappointing privacy (physical, visual, sound, …)
- Infringed views
- Limited solar access
- Limited natural light inside and outside buildings
- Low fordability, low visibility
- No or limited recognizability, high uniformity
- Despite high population: social isolation, exclusion, limited social contacts
- Low air quality
- Trapping of anthropogenic heat from buildings within the urban fabric
- Creation of long wave radiation from sealed surfaces that contribute to increase the urban heat island effect
- No or low biodiversity – fauna and flora
- Rigidness / no spatial expandability.

2.3 A Balance of Density: Quality Deficit

The French architect Le Corbusier and Jane Jacobs both defended density as a positive attribute for urban life. Le Corbusier based his arguments on functional grounds, while Jacobs presented a more social approach with her vision of people interacting in streets, propitiated by a mixture of activities, old buildings and small blocks.

When balancing listed features of density, we can conclude that there is possibly a quality deficit on the micro level: poor living conditions, low residential qualities leading to conflicts, both inside the project and between the project and its surroundings. Of course, the degree and range of this deficit depends on the density value and on sociocultural and historical aspects (interpretation of features as 'problems' as such).

Strengths are mostly top down oriented, while the weaknesses are bottom up oriented. No or limited support base for the concept of density is found with the actual users, the residents. Density is felt as a burden, not as a successful concept, not in the least for a sustainable built environment. Breheny (1995) warns that the gains may be trivial relative to the pains.

3. Reasoning a Counteracting Approach

In order to create density, dwellings must be linked and stacked. The way dwellings are clustered depends on the configuration, with could be described geometrically. The housing typology and the chosen morphology determine the geometric configuration. Based on Leupen & Mooij (2011) this could be a clustered low-rise, a row, a mat, an urban villa, an infill, a slab, a block or a tower.

It is seen that housing projects with different configurations can still have the same density figure (UPH or FSI) (see figure 2). In contrast, despite the same quantitative feature, the qualities could be totally different, as are the conflicts.

Figure 2: Different configurations with the same density figure: FSI = 1(m²/m²).
Source: Rodríguez-Álvarez (2014).

By defending the concept of density, Le Corbusier focused on a combination of tower-blocks and vast open spaces. History unveiled that this approach, prevailing in many modernist views, results in real qualities on the ground floor, the public level, but often has led to conflicts in the upper floors, both the collective and the private parts. Other configurations with the same density could turn out in totally opposite results. So, the choice for a configuration is important.

4. Building An Innovative Reconciling Hypothesis For Stated Quality Deficit

The counteracting approach clarified in section 3 could never be a holistic solution for all scales and all parts of dense housing projects. Also in existing buildings this choice is not an option due to the existing, rigid configuration. In order to avoid or resolve conflicts, a more specific, downscaled and fine tuning approach is required. Following subsections build an innovative reconciling hypothesis.

4.1 Sustainability As A Quality Aim

The development of the reconciling hypothesis starts with the general aim for quality, for sustainability. According to the definition of Our Common Future (WCED, 1987), a sustainable development necessitates a focus both on 'here and now' issues and 'elsewhere and later' matters. Following Our Common Future, numerous efforts were made to operationalize the concept. The most common attempt is the triangular representation with three pillars "environment", "society" and "economy". In some contexts these pillars come to be referred to as "Planet, People, Profit", following Elkington (1995). In recent years the term "Profit" was changed for "Prosperity", and

"Politics", which aims for participation in decision making, was added to the pillar model.

The two most tangible pillars of sustainable building are ecological (Planet) and social (People) aspects. Buildings have adverse impacts on environment during their entire life spans, starting during construction works and going up to demolition until handling of the waste. In order to reduce these effects, the central principle of ecological sustainability within the building sector is flow management. This implies a diminishing of flows, the closing of loops, the prevention of negative flows and at best the creation of positive flows. This pillar stood at the start of the development of sustainability, and since then there is a broad consensus regarding its components (see table 1).

In recent years, focus split in favour of the people pillar, the anthropocentric approach. Buildings meet demands. These are besides functional and physical also based on social matters. The social aspect of sustainable development cares about the welfare and well-being of users and residents. Focus lies on the core concept of livability, introduced by Van Dorst (2005), which concentrates on emotional and sensorial requirements. Available literature is limited so in order to make social sustainability discussable, a set of components is compiled (see table 1).

ECOLOGICAL COMPONENTS (PLANET)			**SOCIAL COMPONENTS (PEOPLE)**		
ENE	ENERGY	heating, cooling, lighting, …	IDI	IDENTITY & IDENTIFICATION	recognition, cultural embedding, …
WAT	WATER	potable, rain, brown, black, …	SIA	SOCIAL INTERACTIONS	privacy, social contact, social control, …
MAT	MATERIAL	construction, techniques,	SCO	SOCIAL COHESION	amenities, management, involvement, …
AIR	AIR	indoor, outdoor, …	SEC	SECURITY	privacy, safety, …
WAS	WASTE	construction, domestic, demolition	HEC	HEALTH & COMFORT	requirements, needs, quality of life, …
TRA	TRANSPORT	motorized (carbon) vehicles	FLE	FLEXIBILITY	adaptability, expandability, …
SOI	SOIL	displacement, …	AVA	AVAILABILITY & ACCESIBILITY	usability, functional differentiation, …

ECO	ECOLOGY	wildlife, vegetation, …	ATT	ATTRACTIVENESS	dearness, recreation, …

Table 1: Ecological (Planet pillar) and Social (People pillar) components of sustainable development supplemented with illustrative focus points.

4.2 Transitional Spaces As Solution Spaces

When we talk about transitional spaces we implicitly deal with the status of places, and more specific with the transition between spaces with a different kind of user status: the private or the public. Regarding this, it is useful to look at the origin of the word 'private'. It appears to be derived from the Latin word 'privare', which means as much as 'deprived from the public', as Romans believed space belonged to everyone. In ancient Rome there was a strict classification of private and public zones, very well illustrated by a map of Rome by Nolli of 1748 (see figure 3). Everything in black is private, and so 'lost' from the white, the public. Private parts were bedrooms, bathrooms, dining rooms, etc.; public spaces were streets, plazas, atriums, courtyards, etc.

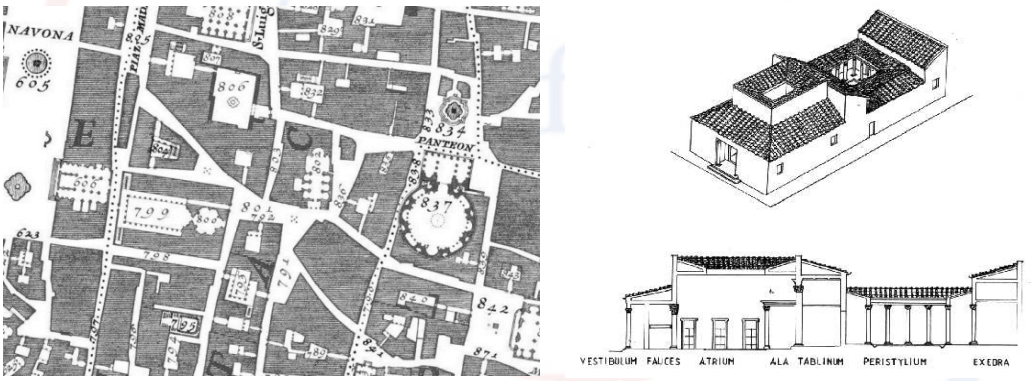


Figure 3: Left: Map of Rome by Giambattista Nolli (1748); Wright: typical roman urban villa, with inter alia the vestibulium and the atrium.

Gradually a changing relationship occurred between the private and the public. The appearance and development of an 'atrium' and a 'vestibulium' in typical roman urban villas were the first formal spaces between the public and the private, introducing a gradual change of the user status of spaces. A vestibulium was a formal transition between the public and the private while the atrium represented the private to the public and the peristilium were private outdoor, informal living rooms. (see figure 3)

Within numerous formulated definitions of transitional spaces, the one from Bolos (2009) is mentioned here: 'Transitional spaces bridge the gap between solely interior and solely exterior. These spaces, in being transitional, take people from outside and through the overlap of nature and building, transfer individuals to a destination defined as inside.' Transitional spaces are common in both historical and contemporary architectural objects. Depending on the function of the building, their relevance and function differ. Like mentioned earlier, when we want to create dense housing projects, we must cluster dwellings horizontally or vertically or a combination of both. In order to guarantee the usability of these projects, spaces for access, circulation, outdoor spaces, etc. are necessary. We could define those spaces as transitional spaces. Within housing projects we identified 6 different kinds of transitional spaces, based on Van Dorst (2005) and Leupen & Mooij (2011): the public oriented margin zone, the private oriented margin zone, the street/plaza/courtyard, the staircase, the gallery and the corridor (see figure 4).

4.3 Hypothesis

Consulted literature emphasizes the reconciling abilities of primary functional oriented transitional spaces. Bolos (2009) states: 'Transitional space helps to ease architecture's interaction with the natural environment, creating a relationship rather than a conflict.' And more: 'Transitional spaces are potential agents of unmatched experiential, intellectual, and sensory stimulators. They have also functioned as, and can once again become, the successful mediation of humans upon the earth.'

By broadening and interpreting the mentioned natural environment in the context of dense housing projects as the built and sociocultural environment, transitional spaces are seen as reconcilers regarding possible conflicts with the surrounding natural environment, but also conflicts with the sociocultural environment, inside or outside the housing project on both the project level and the neighborhood level.

Due to the fact that transitional spaces are inextricably linked to the concept of dense housing projects, and these spaces are within the sphere of influence of the project team (public parts exceeds most individual projects; private is lost space, cfr. Romans), it is plausible to state that these spaces have high potential to act as solution spaces. They are manageable and not or only limited users dependent.

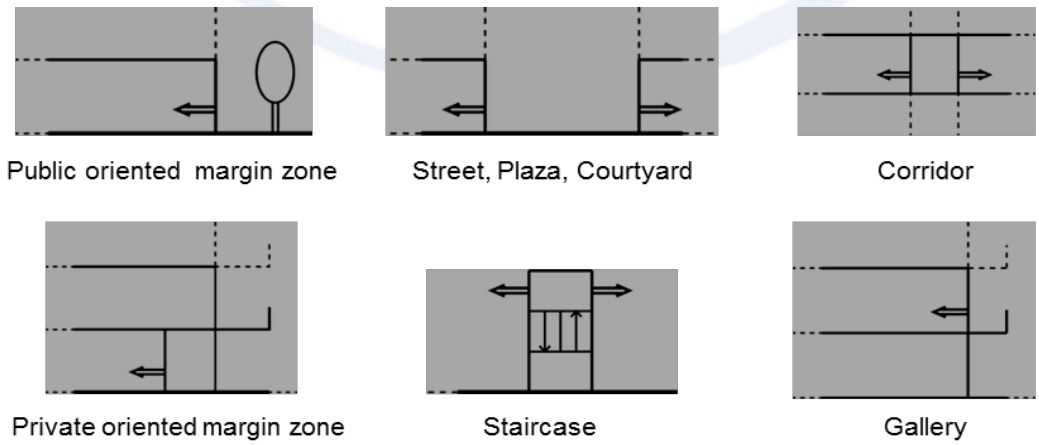


Figure 4: Identified kinds of transitional spaces in housing projects.

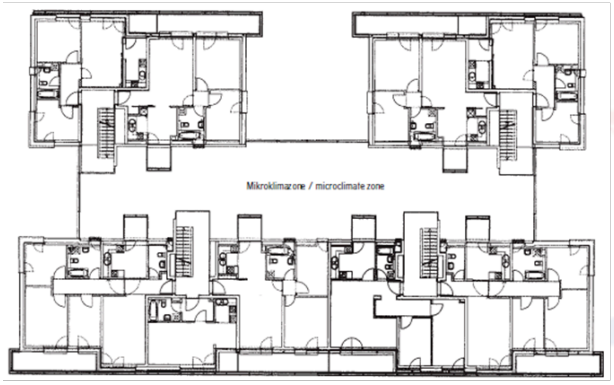
Based on these findings, following hypothesis is formulated:
The integration and full utilization of both intrinsic and potential features of transitional spaces according to the aspects of sustainability in dense housing projects has the ability to reconcile prevailing conflicts and moreover create full sustainable projects.

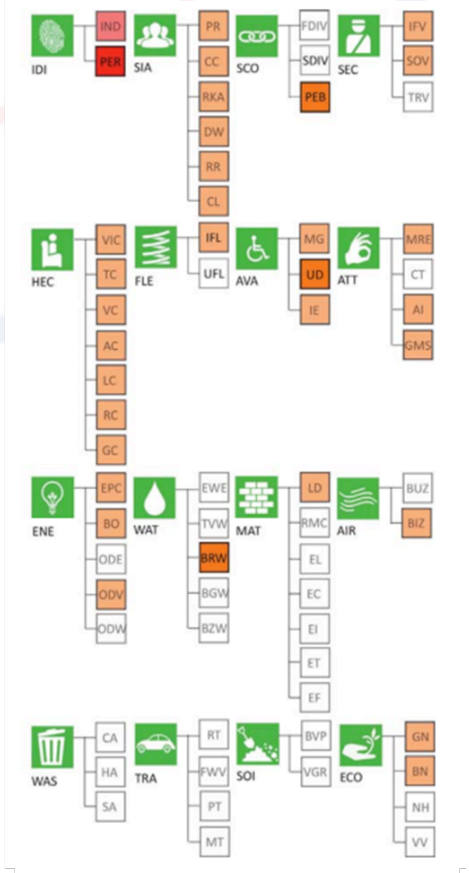
The implementation of sustainable transitional spaces could create a support base both for density (also bottom up) and sustainability leading to mainstream sustainable built environments in the long run. Only when conflicts are tackled the idea of density as a sustainable concept, as is collectively agreed by international panels, is acceptable and is able to act as a powerful leverage towards sustainable built environments.

5. Verification

5.1 Case Study Research on Real-Life Examples

In order to verify stated hypothesis, case study research was conducted on 45 European demonstration and best practice sustainable housing projects. Transitional spaces were analyzed and more specific design decisions and implemented sustainability measures were determined together with their impact on the private and the public parts of the building, as well as on the projects surroundings. By means of a reference scheme regarding components of people and planet pillars, we determined the sustainability profile of the transitional spaces of these dense housing projects. In addition of listing implemented measures, decisions and their outcomes, transitional spaces were also optimized by research by design. This way we wanted to get insights in the maximum possibilities of transitional spaces regarding sustainability, regarding qualities.





By means of illustration of the case study research, figure 5 provides a synthesis of the verification and optimization process for the project 'Kronsberg' in Hannover Germany. The microclimatic street (the transitional space) links the residential blocks, providing accesses, circulation, recreation, green, water, energy, etc. As can be seen by the marked subcomponents, the sustainability profile is very extensive.

5.2 Research by Design on Real-Life Test Cases

In the second step of the verification process existing mainstream dense housing projects were optimized in view of sustainability by focusing on transitional spaces. The aim consisted of figuring out whether and to what extend these spaces could be upgraded into real sustainable transitional places, and so reconcile conflicts, even when the building is already in use. For practical reasons, test cases were selected within the context of Flanders (north part of Belgium). Due to the fact that for decades focus in Flanders was on individual and low density planning programs, qualitative dense housing projects are scare. As a result there was a huge choice in contemporary projects able to act as a possible test case. All lacked qualities, all had conflicts.

Figure 6 illustrates the test case of a social housing complex 'Potenblokken' in Antwerp, characterized by galleries. As can be seen these galleries were very narrow, very functional, but with no residential qualities. In a designerly way, qualities were added, qualities by which residents could hang out and meet each other on the gallery. In other words create an attractive place for recreation.

Figure 6: Illustrative optimization for the project 'Potenblokken' in Antwerp Belgium. Above: photos of the existing building and gallery; mid: sections of the research by design; below: picture of the optimized gallery.

Figure 7 provides an example of a project in Leuven. An existing car free street between two housing blocks was optimized by incorporating a microclimatic space, margin zones, greenery, water, etc.

Figure 7: Illustrative optimization for a project in Leuven Belgium. Left: existing 'street': wright: optimized 'street'.

6. Discussion of the Outcomes

The verification research made clear that a broad sustainability profile (regarding Planet and People pillars) of dense housing projects is feasible and so preventing-reconciling-eliminating conflicts, by concentrating on transitional spaces. The majority of components of the two tangible pillars of sustainable building could be dealt with in transitional spaces, by embedded sustainability features and/or acquired by sustainability measures and decisions. In addition with the intrinsic sustainable benefits of the concept of density, transitional spaces complete the sustainability profile of projects as a whole.

When we look back at the prevailing conflicts in dense housing projects, it is plausible and feasible that sustainable transitional spaces could reduce or even eliminate these conflicts. This means that sustainable transitional spaces and dense housing projects are a promising combination.

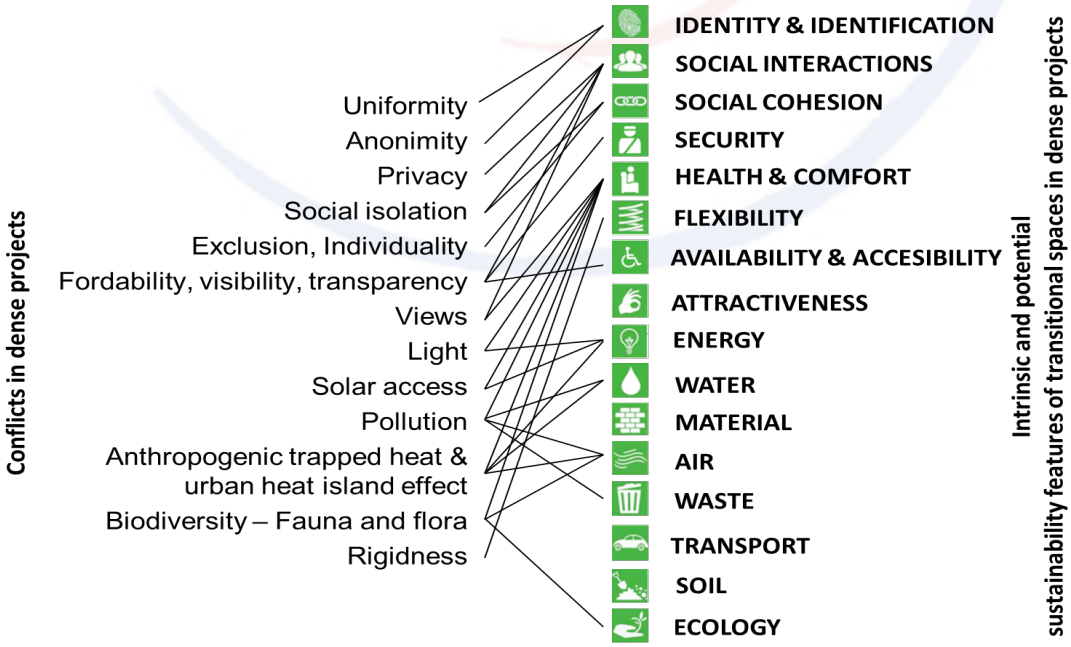


Figure 8: Tackling of conflicts in dense housing projects by sustainable transitional spaces.

And maybe the potential is even higher. Rodríguez-Álvarez (2014) states: 'One of the consequences of urban concentration is that more people are demanding an additional supply, thus increasing the externalities of cities'. In other words, one of the consequences of density are source – sink problems following the Ecodevice Model (Van Wirdum, 1982) (Van Leeuwen, 1973, 1981) (Tjallingii, 1996).

We see that some sustainable developed transitional spaces respond by implementing measures which closes loops. Examples are:

- internal cultivation: food > e.g. kitchen gardens, small scale allotments,
- reuse/buffering/infiltration: water > e.g. wells, ponds, canals,
- generation: energy > e.g. solar panels, bioclimatic design,
- internal handling of flows: water/waste > e.g. greenery, recycling station,
- needs: space > e.g. open plan, flexible walls,

They decrease the dependence of external resources and prevent passing on problems to higher scales. They think global and act local with local, internal benefits both on planet and social aspects.

7. Remarks: Issues and Perspectives

The subject, the research and its outcomes raises some remarks. What follows are non-exhaustive issues and perspectives brought up by the author.

Research unveiled that not all kinds of transitional spaces are as promising, and that relying only on transitional spaces in order to create full sustainable projects is not feasible. A good selection of promising transitional spaces during the concept phase of a project is needed. The street, the plaza and the gallery seems to be the ones with the most potential. Besides a good selection, designers should aim for synergies. On the one hand between the different transitional spaces, and on the other hand with sustainability measures on other levels or in other building parts. Creating a durable core combined with a sustainable shell is such an example. The core could in this regard be the private spaces, while the shell is/are the transitional space(s). The durable, private core could be uploaded with low tech, basic and long term sustainability measures, while the sustainable, public shell has potential to implement high tech, flexible (accessible for maintenance, changeable, addable), short term measures. Figure 9 shows a project that meets this concept: 'Futura' in Zoetermeer The Netherlands.

Figure 9: The project 'Futura' in Zoetermeer The Netherlands combines a durable core with a sustainable shell, a sustainable transitional space.

We saw that the upgrading capacity of certain transitional spaces in existing projects is sometimes limited. This means that initial achieved qualities of these spaces, or realized conflicts of these spaces or of these projects as a whole, are irrevocable. In order to eliminate these irrevocability's, recommendations regarding dimensions, proportions, positioning, etc. should be taking into account during early design stages of new projects / transitional spaces. This way, the sustainability profile of a project can evolve during the buildings life span. Transitional spaces could in this regard be seen as 'flexibility options' (Janssens & Verbruggen, 2012). Another perspective could be the add ability of transitional spaces as a whole. This concept has already been implemented in outdated, unsustainable dense housing projects. Figure 10 illustrates this perspective by the project 'Ellebo Garden Room' Copenhagen Denmark.

Figure 10: The project 'Ellebo Garden Room' in Copenhagen Denmark implements addable transitional spaces in order to increase the projects sustainability profile.

When discussing the feasibility of sustainable transitional spaces, all pillars of sustainability should be taken into account. Aiming at the tangible Planet and People aspects implies considering both the Prosperity and Politic pillars of the operational framework of sustainability. Regarding the Prosperity pillar, a financial study is of course needed due to the proposed development of the transitional space in to a 'place'. Also the believed extra space could pose some issues. However, it is assumed that in fact no additional space is required, at least not on the project level. What in fact has to change is the ratio between the private and the public parts. The ratio between the total size of the individual dwellings and the private outdoor spaces, and the area of transitional spaces. Providing smaller private and bigger public space will be an important incentive, for both the financial feasibility and the proper use of the transitional spaces. This 'proper use' (actual use, no confiscation, etc.) together with e.g. the management and the maintenance are important points of attention of the Political pillar.

8. Synthesis – Outlook – Conclusion

8.1 Synthesis

The starting point of this research was the awareness of conflicts occurring in dense housing projects. Despite intrinsic sustainability features of density, pin-pointed weaknesses resulted in the identification of low residential qualities leading to conflicts and no bottom up support base for dense housing developments. As a counteracting approach it was mentioned that the strategy of densification should be implemented in a qualitative way. Reasoned decisions regarding typology and morphology are important, although the limits (only new build, no comprehensive scope). The focus of this research was on pointing out the possibilities of sustainable developed transitional spaces in view of preventing, reducing or even eliminating conflicts in dense housing projects. Developed and verified hypothesis made clear that the full utilization could be promising.

8.2 Outlook

This research has its limits. A more elaborate research is needed on a wide range of cases. Such a research should provide answers to questions like: What is a good private-public ratio index? What are recommendations to keep in mind for transitional spaces in order to safeguard later upgrading? What are possible incentives for creating a support base for implementing sustainable transitional spaces? Could sustainable transitional spaces be more feasible, more acceptable than the cohousing concept? Could the idea reconcile the, in some regions prevailing, ideal image of living in detached, low density developments with the necessity of group housing, of densification, of living in the city? Etc.

8.3 Conclusion

Besides aiming at a thoughtful density figure, taking into account the sociocultural context, and a reasoned decision regarding the projects configuration (morphology, typology, …), architect-designers and other project partners should focus more on transitional spaces. These spaces have the potential to act as a powerful leverage for not only social sustainability (often intrinsic embedded in the concept), but also ecological sustainability (acquired by deliberate actions) resulting in both internal and external benefits. Intrinsic and embedded qualities could be added with potential and acquired measures and decisions, in both existing (with terms and conditions) and new build projects.

The main key to success is the recognition and attention of architect-designers for the development of ‘places’ instead of ‘spaces’. Transitional spaces should be seen as an opportunity, not as a necessity. ‘Place making’ is crucial. This corresponds with the finding of Bech-Danielsen (1998). He means that the 20th century and modernism led to the loss of ‘places’ which were replaced by abstract ‘spaces’. A ‘place’ is formed by the inhabitants and their participation, in design as well as in daily life and coming transformations of the artefacts. This ‘place making’, together with a proper private – public ratio index is crucial in developing sustainable transitional spaces as solution or reconciling places for possible conflicts, and for strengthening the

collectively agreed idea of density as a sustainable concept in view of sustainable built environments.

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Evaluating Material Flow Cost Accounting Method for Energy Efficiency in the Forest Sector

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Resource efficiency is one of the crucial aspects in the production process of public and private sector and it affects society on the road to sustainability. Forest sector, as a sector which works for producing environmentally friendly products through sustainable forest management, is responsible for taking into account the negative environmental impacts produced in its production process, too. Their minimization is demanded so as no externalities are created to society. Several methods have been introduced for the recognition of inefficiencies in the production process which result in the creation of waste and emissions. One of these, Material Flow Cost Accounting, is evaluated in the present research for deciding if it is suitable for finding out the sources which produce the inefficiencies and externalities in the production process of forest sector. The focus is on the production of a service in the forest sector, the one of law enforcement in mountainous areas for securing the minimization of forest crime (for example illegal logging and illegal hunting). Based on the results of the research, it is discussed if it is possible to reduce the material and energy use during this activity and succeed in supplying the society with "clean" produced forest services.

Keywords: energy, environment, forestry, sustainability accounting

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Introduction

One of the crucial aspects in the production process of public and private sector is resource efficiency (Stahel, 1994). Resources can be, among others, materials and energy that are used for the production of products and services for fulfilling human needs (Jasch, 2009). The unreasonable use of these resources is responsible for many of the environmental problems worldwide and may have affected global climate. Therefore, a need was recognized worldwide to manage these resources in a sustainable way to prevent further environmental degradation (Wagner and Enzler 2006, Suh 2010).

Several scientific disciplines have been involved in proposing solutions to manage resources. Indeed, environmental management for sustaining climate is an interdisciplinary issue. One of these disciplines is environmental economics and accounting (Gray and Bebbington 2001, Schaltegger and Burrit 2000). Environmental accounting proposes methodologies for better measuring impacts of material and energy use, either in physical or in monetary units. It is believed that by having a clear picture in which sectors and products these resources are consumed, a better management can be achieved (Schaltegger et al., 2008).

Environmental accounting has evolved during the years and several sub-disciplines have emerged, such as sustainability accounting and reporting and environmental management accounting (EMA) (Jasch, 2003). Material Flow Cost Accounting (MFCA) is part of EMA and lately a lot of research is conducted for using it in the industry sector (Jasch, 2009). In this research, we evaluate if this methodology could be used by Public Forest Service in Greece for energy efficiency. Driven by our background as forest economics and forest management scientists and by our belief that sectors with an environmental mandate (Lodhia et al., 2012) should lead by example in material efficiency (Ball et al., 2009), we feel that such methodologies can have a high impact in the sector's production process.

However, as other methodologies such as Life Cycle Assessment (LCA), Life Cycle Costing (LCC), and Material Flow Accounting (MFA) have already been used for examining the impacts of wood production in the forest sector (Buonocore et al., 2014), we focus on a service that is produced by the Public Forest Service production process, the Environmental Law Enforcement. Therefore the two objectives of the research are: i) to explore if MFCA, a method arising from industry sector can assist forest managers in reducing energy use in the process of Environmental Law Enforcement, and ii) if MFCA is suitable for finding out the sources which produce the inefficiencies and externalities in the production process of this service in the Public Forest Service in Greece.

Background

Material Flow Cost Accounting

Material Flow Cost Accounting is one of the approaches for performing an Environmental Cost Accounting analysis and it is included in the more general Environmental Management Accounting framework (Burritt et al., 2002). It origins from the manufacturing sector and it has been used mainly in Germany and Japan

(Nakajima, 2006). It can also be used in the service sector (Jasch, 2009) and it has been proved that it can be a useful tool to partially augment the accountability of the nonprofit sector (Papaspyropoulos et al., 2012). It is based on the input-output analysis aspect of sustainability accounting and the principle "what goes in must come out" (Lamberton 2005, Suh 2010).

An organization should track all the material inputs and all the outputs of its production process in physical units. Material inputs are the a) raw and auxiliary materials, b) the merchandise and packaging, c) the operating materials, d) energy and e) water that enter an organization. Outputs are a) the finished goods, b) services, c) by-products, d) emissions or e) waste. Non-product output is any output which does not leave the organization as a manufactured physical product (Jasch, 2009).

Two groups of environmental costs are recognized under the MFCA framework: i) those related to the environmental protection expenditure and ii) those related to the material flow costs, that is the purchase cost of materials that become non-product output. These two groups are distinguished into six cost categories (Jasch, 2009):

i. Materials costs of product outputs, including the purchase costs of materials that become physical products
ii. Materials costs of non-product outputs, including the purchase costs of materials that become waste and emissions
iii. Waste and emission control costs, including the costs for treating the non-product output, costs for restoration of environmental damages, and regulatory compliance costs
iv. Prevention and other environmental management costs, including the costs for proactive environmental behavior
v. Research and development costs, including costs for research in environmental issues, and
vi. Less tangible costs, including internal and external costs related to future regulations externalities, or stakeholder relations (Jasch, 2009).

All these costs are derived from the annual expenditure accounts, refer to the same fiscal year, and under a usual cost accounting method (like activity based costing) can be assigned to cost categories, cost centers and cost carriers. These costs are afterwards distributed to the environmental domains which they affect, such as: i) air and climate, ii) wastewater, iii) waste, iv) biodiversity, and v) soil and ground (Jasch, 2009).

Public Forest Service

Public Forest Service's main mission is the provision of forest commodities and services to society (USDA, 2007). This objective may differ among countries, among states in the same country and throughout the years (Koontz, 2007). For example, Federal Forest Service in United States has gradually changed its view about appropriate forest management from the principle of multiple-use forestry with a focus on timber production, to the provision of ecological services and recreational amenities which are now preferred compared to other commodities (Koontz, 2007). However, this is a general trend when income is increased in society and people look for other services in forests than primary produced products (Stamou, 2006). In

Greece, forestry produces low quality roundwood and mainly fuelwood, forest management is focused on timber production, but it also takes into account the principles of multiple-use forestry and sustainable production. Thus, it also produces not timber forest products, and services such as carbon sequestration, land protection, protection from erosion and floods and Environmental Law Enforcement. The latter is very significant for the protection of natural environment. Forest rangers work daily for preventing or suppressing illegal logging and illegal hunting activities, illegal clearing of forest land, waste disposal in natural environment, and generally for conserving the ecosystems. Their work, however, is energy intensive, that is it consumes big quantities of fuel for patrol. So there is an opportunity here for testing the environmental impacts produced by Environmental Law Enforcement Service and for managing this energy consumption.

Previous research

Little previous research has been conducted about the resource use in the production process of forest products and services. This research has focused mainly on timber production. This research has shown that there are significant impacts from this process and only for the logging operations of timber from plantations energy consumption may vary from 115 to 155 MJ/m3 solid under bark (Gonzalez-Garcia et al., 2009). Buonocore et al. (2014) have shown, on the other hand, that the timber and wood chip production process in a local forestry system in Italy emits less greenhouse gases than the local current capacity for carbon mitigation. Papaspyropoulos et al. (2012) have worked on the impacts of the operation of a forestry organization and found out that there are also significant positive externalities arising from the operation of such organizations which can offset the negative ones produced by their operation. What is missing in the research is to implement methodologies such as MFCA exclusively for the production process of services. A successful implementation can imply the recognition of negative environmental impacts which can be prevented and the management of energy resources in such a way that it can save money to the organization and have a positive impact on the environment.

Materials and methods

For fulfilling the objective of this research the following methods were used: we researched on the production process of the Environmental Law Enforcement in the Public Forest Service in Greece. We tested which are the inputs and outputs of the service; then we checked the annual report of the organization to see if these inputs and outputs are estimated and disclose (Ministry of the Environment, 2012). PFSG issues an annual “Activity Report” since 2003 informing stakeholders generally about its actions for forests in whole Greece and the financial resources spent or invested for these actions. The 2010 report was checked in terms of the sustainability information included. Then, Material Flow Cost Accounting theory was analyzed with the objective of finding out if and to what extent this theory could be applied to the production process of Public Forest Service in Greece and its annual report.

At a second stage an interview with open questions took place with the expert forester who is responsible for the data collection and construction of the Forest Service Activity Report. He is the only one working in this field for the last two decades with the duty to produce this report. Generally, a research interviewing experts is common

in social and economic sciences (Burritt et al., 2011), and is used when specialized information has to be obtained (Johnson and Turner, 2003). However, for such researches a minimum of 6 to 12 experts are the optimum number (Guest et al., 2006). But in this research no other expert was available. Thus, we presented the principles of MFCA to the expert forester and asked his opinion if this methodology can be implemented by the organization for managing energy consumption in the Environmental Law Enforcement activity. The questions for the interview were set by all authors, the interview was performed by the first author, and the evaluation of the answers and the conclusions were extracted by discussions among all authors.

Results and Discussion

Figure 1 presents the inputs and outputs of the production process of Environmental Law Enforcement.

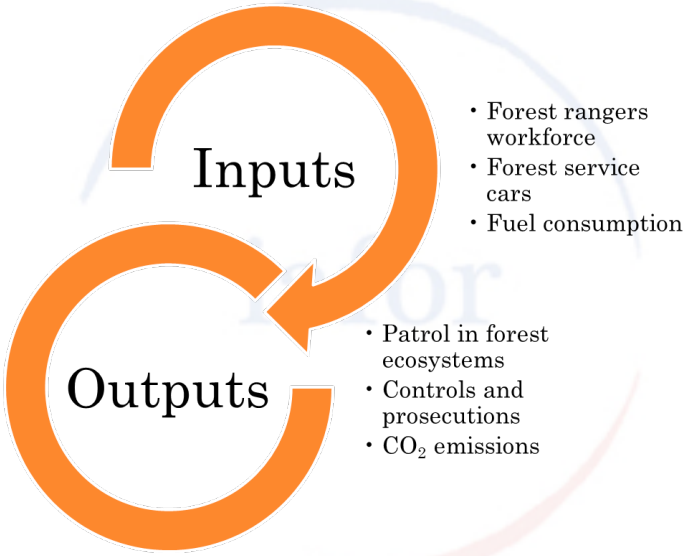

Figure 1: Production process in Environmental Law Enforcement.

The main inputs are distinguished in three categories: i) the forest rangers workforce, ii) the forest service vehicles and iii) fuel consumption. The first input is the human capital input. These people work for environmental protection, thus they are an input which can have positive impacts for the environment. However, the other two inputs are those that are responsible for the consumption of fuel and have a negative impact on the environment. The main outputs are distinguished again in three categories: i) patrol in forest ecosystems, ii) controls and prosecutions, and iii) carbon emissions. The first two outputs are those with a positive impact on the environment. These are the result of the work of the forest rangers for the prevention of illegal practices on the environment. The third one, carbon emissions, are responsible for the negative impacts on air environment and are responsible for possible future liabilities of the organization to EU environmental law. Fuel consumption, thus, affects the financial position of the organization and carbon emissions its behavior on the environment and possible future demand for offsetting the impact.

According to the MFCA theory, this output is called a non-product output. It is an output that is not part of the final product and becomes waste (emissions) disposed on the environment. Every energy input in such processes becomes waste, and especially in services production, all materials and energy are non-product outputs. So, here, energy used does not become a manufactured physical product. This is an inefficiency for the process of Environmental Law Enforcement.

Therefore, according to MFCA theory, Forest Service should collect the data of fuel consumption of all the production processes in the organization and assign the relevant quantities to this service. This will be a part of the 'materials costs of non-product output' for the Public Forest Service in Greece. Other parts for this cost category would be the wood of loggings that remains in the forest, or the wood products that fail to get sold to wood merchants. The Forest Service should find solutions for reducing the quantities of non-product outputs and decreasing the cost of production process. However, Environmental Law Enforcement efficiency should not be sacrificed. Forest Service managers could control this cost annually and make decisions for its management. They probably could find inefficiencies in energy use in some regions, for example large fuel quantities consumed and inefficient work on law enforcement. MFCA seems quite appropriate for analyzing the whole process of this service production and using it for cost reduction.

We presented the methodology and our findings to the forester who is responsible for the collection of forest statistics from all over Greece. We discussed several issues about environmental management in general and about MFCA in particular. The forester was unaware of the method. He was unaware of methodologies arising from the environmental accounting discipline. However, as presented by our above analysis, the forester agreed that energy flows are important for the operation of the organization and that the operation cost could be decreased. He stated that although he could understand the negative impacts that are produced by the production process of Environmental Law Enforcement, he had never thought that such an activity could be managed and produce cost savings and less emissions on the environment. He never had listened to the term "non-product output" and that an increase in this can have significant effects on the natural environment.

However, he believed that new staff would be needed in the Forest Service in order to apply such a methodology in the services production of the Environmental Law Enforcement. The new staff would be educated in methods like MFCA and would be ready to alter the way of operation in the organization in order to success in implementing it. For example, Forest Service does not collect the data on quantities of fuel used in the organization and, generally, there is no statistics department within the organization, something that puts burdens in applying the method. The new staff, both in terms of age, and in terms of employment, would have to change first these barriers and then set up a whole new accounting system.

Discussion and Conclusion

We explored in this research if Material Flow Cost Accounting is suitable for estimating the energy efficiency in the production process of an environmental service (law enforcement). Two ways were used for this evaluation: we corresponded the theory of the methodology to the operation of the production process of the Law

Enforcement service, and then we presented the results to the responsible forester of Public Forest Service and interviewed him about his belief of a potential use of the method in the organization. Through the first way, we found that there are non product outputs (air emissions) resulting from fuel consumption of the vehicle fleet that MFCA can identify and estimate. These energy quantities can be managed for cost reduction within the organization. We concluded that MFCA is a potentially useful method for energy efficiency in the forest sector. Through the second way, we concluded that in the current status of Public Forest Service in Greece, difficultly MFCA would be used. The expert forester doubted that with the structure of the Forest Service MFCA would be applicable. This is due to the fact that there is no relevant personnel to use it, and no one is in prior educated to similar disciplines. On the other hand, there is no statistics department in the organization and this burdens the collection of the appropriate and useful data needed in order to apply MFCA and have a clear picture for the inefficiencies of the production process and the environmental impacts that are produced.

The above conclusions show that probably guidelines which simplify the method should be created and given to the Forest Service. Future research should focus on this issue, together with focusing on a case study with real data from a local forest office for testing a real application of MFCA in Environmental Law Enforcement. This probably would make easier the adoption of the methodology in Forest Service and offer the advantages that the present research showed that can be obtained.

Acknowledgments

The first author would like to thank the IKY Fellowships of Excellence for Postgraduate Studies In Greece – Siemens Program for funding him for this research.

This paper is in memory of the third author, Professor Athanassios S. Christodoulou, who passed away during the research.

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'EAPM-CW:' An Ecosystem Approach Framework for Planning and Management in Environmentally Sensitive areas – with a Special Reference to Coastal Wetlands

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Coastal Wetlands are among the most productive ecosystems in the world (Ruffolo, 2002; Larson, 2009; Ramsar convention 1990). Also, they can be considered the kidney of the earth, for their role of filtering wastes and pollutants, as well as "nature's supermarket" for their ability to provide sources of food and materials (Mitsch and Gosselink, 2000). Moreover, they can be considered the first defence line against some effects of climate change such as sea level rise. On the other hand; Coastal Wetlands are facing serious increased challenges from both sea and land sides; the global warming and the accelerated sea level rise and erosion rates are among the most natural causes of coastal wetlands area loss, currently and in the future (Nicholls et al, 1999). The huge losses and deteriorations of this unique ecosystem on one hand and the rich and wide variety of development potentials on the other hand are requiring a special framework for planning and management to make the balance between objectives of preservation and development in order to reach sustainable development.

The EA "Ecosystem Approach" is the most internationally recommended to meet sustainable development especially in such sensitive ecosystems, as it has been recommended by several international organizations such as: CBD, IUCN, UNDP, UNEP, GEF, and Ramsar international convention for wetlands. However EA is still in its initial generic stage, there is a need for developing it into a methodological framework to be applied in such sensitive areas (UNFCCC, 2009; MedWetCoast, 2005). This paper introduce the EAPM-CW "*Ecosystem Approach Methodological Framework For Planning And Management In Coastal Wetlands*", which has been developed as a main part of a PhD research and tested on the Egyptian case using different techniques of scientific research, including interviews and focus groups (Author,2012). However the EAPM-CW integrated the Ecosystem Services Assessment as the main decision support tool, the GIS and Remote Sensing techniques were integrated to support more accurate results. the theoretical evaluation and practical case study test have shown high capabilities of EAPM-CW for wider applications sensitive ecosystems.

Keywords: Ecosystem Approach; Coastal wetlands; Environmentally Sensitive areas; Environmental planning

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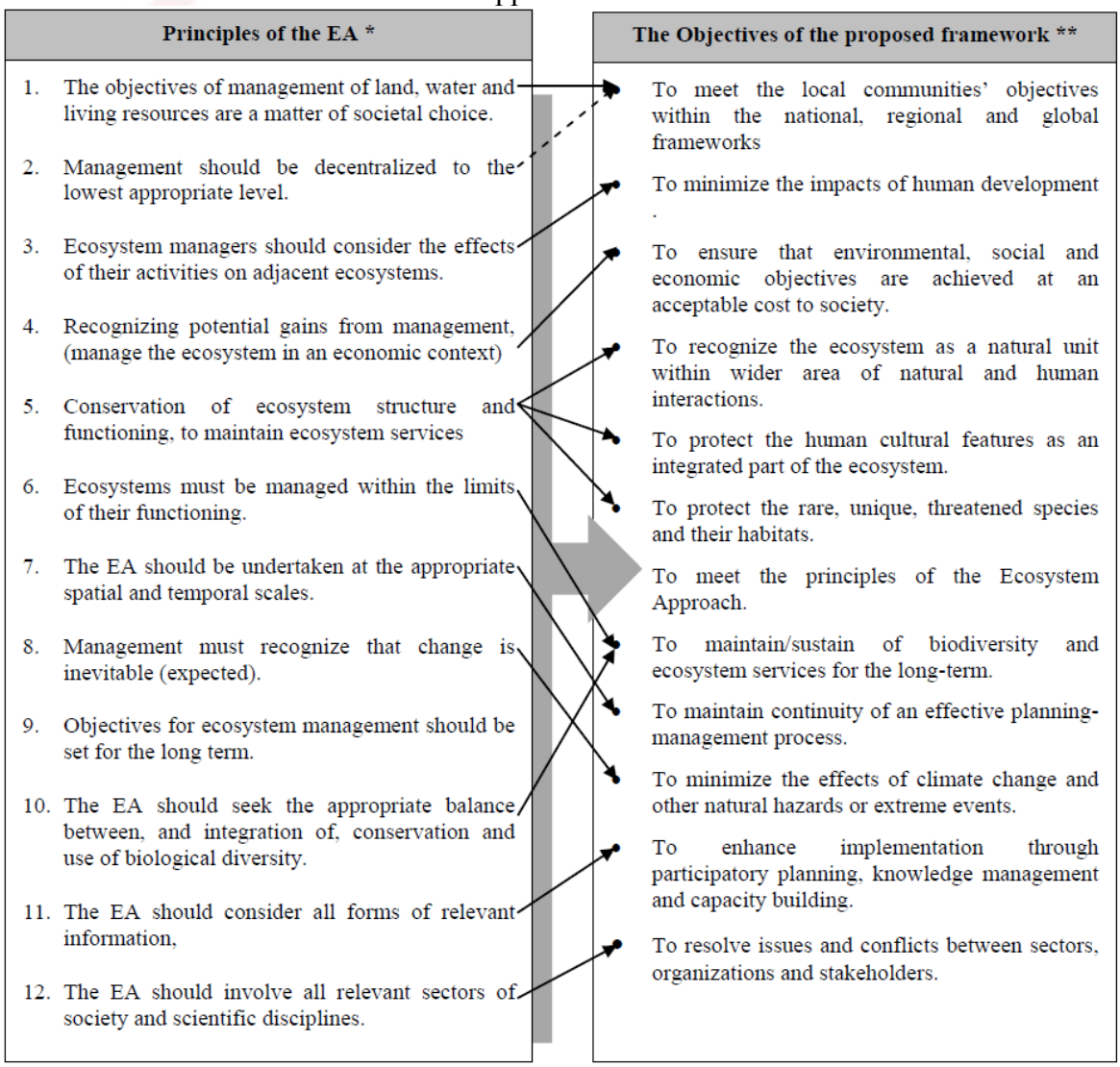
1. Introducing the EAPM-CW Methodological Framework

1.1. **The Objectives:** The objectives of the EAPM–CW have been guided by the main four related international frameworks, which concerned with environmentally sensitive areas including wetlands: the MEA[1] (CARPENTER, et al 2006; MEA, 2005) conceptual framework; the CBD[2]'s objectives (CBD, 2011a) and guidelines especially related to EA applications (SHEPHERD, 2008), RAMSAR recommendations (RAMSAR, 2010) and guidelines; and the ICZM[3] (WHITE et al. 2008; OLSEN, TOBEY & KERR 1997) as the wider and most related ecosystem. However the principles of the Ecosystem Approach are forming the base of the EAPM framework, the objectives have been down upon the spatial features of coastal wetland ecosystems, including: especial characteristics, main importance, and main challenges they are facing- see figure (1).

Figure (1) The objectives of the EAPM framework and principles of the Ecosystem Approach



[1]The Millennium Ecosystem Assessment.
[2] The United Nation Convention on Biological Diversity
[3] Integrated Coastal Zone Management

→ Direct connection ➡ Indirect connection

Source: ** Identified by this research (Author) * Identified by the CBD (CBA, 2011b)

The Main Characteristics

The main characteristics of the EAPL-CW were formed upon understanding; the main characteristics of coastal wetlands as an example of sensitive ecosystems, their importance and values, and the different challenges facing them -see Table (1).

Table (1) characteristics of the EAPM-CW framework

Characteristic	Explanation
Holistic	To facilitate good understanding of the multidimensional interactions and factors affecting the sensitive open ecosystems: internally, externally, and globally
Dynamic	To reflect the continuous changes of the natural ecosystem. (i.e. coastal wetlands)
Respecting the natural boundaries	The natural boundaries and unity of the ecosystem and flow of its natural functions should be maintained to achieve sustainability
Multi-temporal (Long & Short-term)	To achieve suitability in the long term and to respond to short term challenges and needs, the framework should include different time scales of plans and ensure that the short-term management plans are well fitting within the long-term plans.
Multi-spatial scales	Applying the MEA's conceptual framework especially coastal wetlands play vital roles on different scales; So the proposed framework should consider the development objectives and effects on these scales:(local, regional, and global).
Multi-dimensional (Ecological, Social, Economic):	However the environmental dimension should be at the core of interest to preserve highly sensitive ecosystems, the human wellbeing as an integral part of this ecosystem should be considered as the aim of sustainable development. From here, the framework should have a multi-dimensional perspective which requires integration of multi-disciplines.
Balanced (top-down & bottom-up)	Consider both human and natural aspects of the ecosystem, the local communities should be an effective partner in the planning and development process, especially to overcome most of downsides and problems of the current development.
Consider the **Ecosystem Services**	Evaluation of ecosystem services is required to support the planning and management process and enable well informed communication between science and decision making
Flexible	To respond to complexity and uncertainty associated with this very dynamic ecosystem, the proposed framework should be flexible enough. Also, flexibility is required for wider applicability of this framework within different local contexts of coastal wetlands including; social, cultural, institutional, and data characteristics

Source: Author.

1.2. The Main functions

The main functions of the framework were identified to respond to the identified objectives and characteristics, also to meet the professional requirements of the planning and management process. Table (2) shows the identified functions of the EAPM. Although the critical discussion of the concept and principles of the EA has shown that the EA is fully responding to the characteristics and objectives of the EAPM, it lacks of clear functions and methodological steps transferring it into a

practical process. Also, the literature review highlighted some limitations and areas of criticism of the EA (see Ghoneim 2012; Kidd et al. 2011; Hartje et al. 2003; SBSTTA, 2007). From here, the most commonly used approaches of environmental planning were comparatively analysed, according to these functions, in order to determine the suitable approaches to be integrated with the EA and enhance its characteristics.

Table (2) Functions of the EAPM and & what extents can the commonly used approaches of environmental planning integrated to meet them and fill the targeted gaps of the ecosystem approach?

	Other Environmental planning approaches / The required for the proposed Framework	Incremental	Advocacy	Comprehensive	Contingency	Participatory	Community Based	Adaptive	Watershed
Required functions of the proposed framework	Recognize the natural unites	-	-	-	-	×	×	-	◆
	Recognize the wider areas of interactions and flow of impacts and natural processes	-	-	◇	-	×	×	-	◆
	Identify Stakeholder and fundamental issues	×	×	×	-	◆	◆	-	◆
	Identify opportunities, objectives	-	-	◆	-	◆	◇	◇	◆
	Predict effects of climate change and natural hazards	-	-	-	◆	-	-	◆	◆
	Predict/estimate the future changes and effects	-	-	-	◆	-	-	◆	◆
	Assess/evaluate the eco-services	-	-	-	-	-	-	-	-
	evaluate the current environmental conditions	◇	◇	◆	◇	◇	◇	◇	◇
	Set priorities of protection and development	-	-	-	-	-	-	-	◇
	Assess impacts of different development alternatives	-	-	×	◆	-	-	◇	-
	Evaluate alternatives of the development plan	-	-	◆	-	-	-	-	◆
	Identify and set the management required, plan, and	◇	◇	◇	◇	◇	◇	◇	◇
	Set implementation programs	◇	◇	◇	◇	◇	◇	◇	◇
	Define monitoring requirements and programs	-	-	-	-	◇	-	◆	◆
	Build dynamic information base	-	-	-	-	-	-	◇	◆
Gaps of the EA	Compatible with EA principles	×	×	◇	◇	◆	×/◇	◆	◆
	Overcome recorded limitations of the EA	-	-	×	◇	-	◇	◆	◆
	Has clear process and steps	×	×	◇	-	◇	-	◇	◆

◆ Supportive ◇ Synergy/There is no conflicts × Conflicted - No evidence
Source: Author.

Table (2) shows the conclusion of the comparative analysis. A strong recommendation for the Watershed Approach to be integrated with the EA, while reflecting the adaptive approach's concept, in order to address the required functions. However some of the other approaches are seen to be helpful to develop particular aspects or functions of the framework, such as the participatory and contingency approaches.

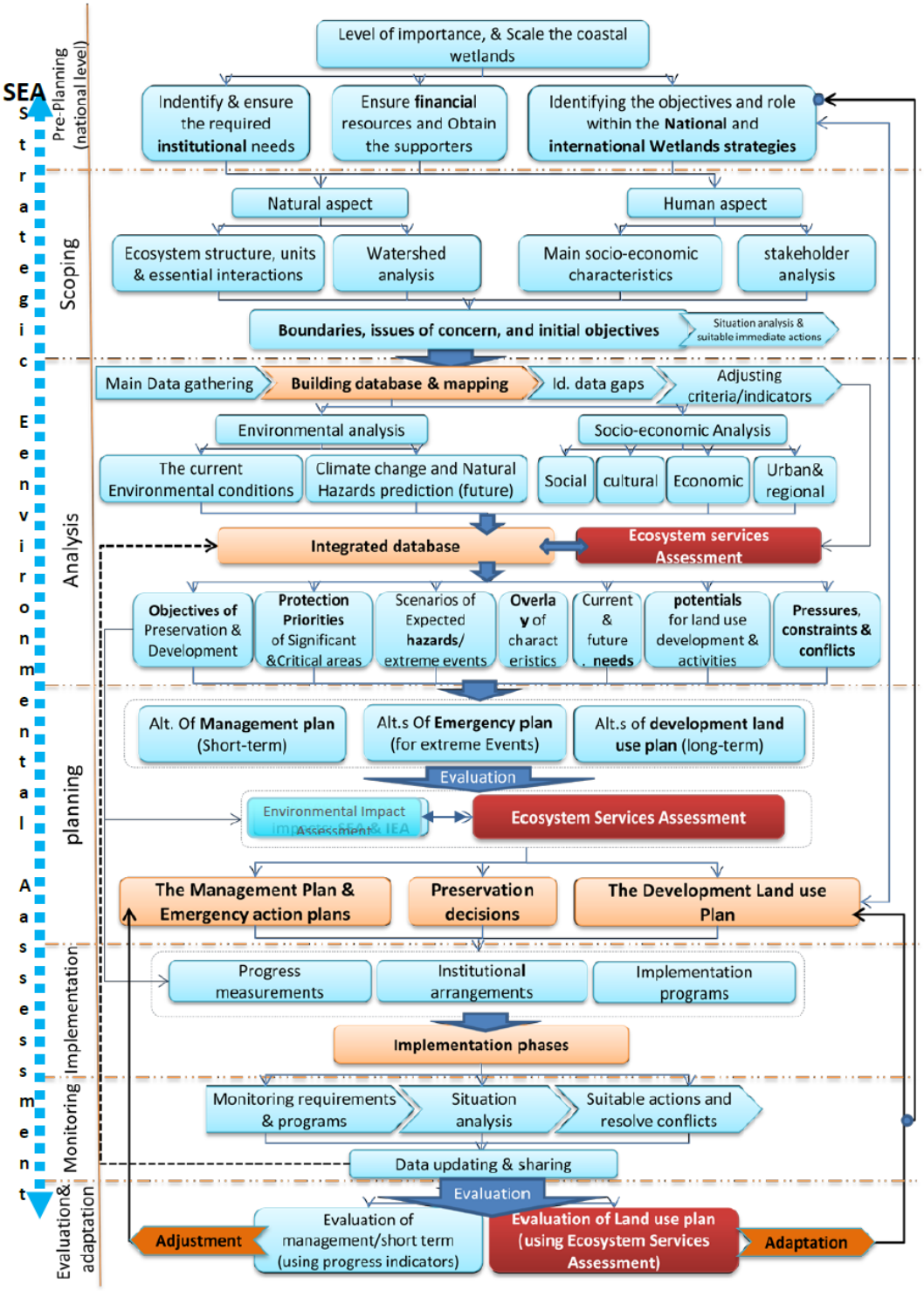
2. The EAPM-CW as a methodological framework (Ghoneim, 2012)

The EAPM-CW framework can be divided into seven stages, which reflect a continuous nonlinear process, as it contains a few feedback loops for checking, updating, learning and adapting different proposals and actions of planning and management. Figure (2) illustrates these stages and their suggested steps, as follows:

2.1. **The Pre-planning stage:** This stage aims to determine the scale of the planning and management regime, and its essential requirements. It starts with looking at the coastal wetland area from global and national perspectives to obtain

strategic reflections of these levels on the planning and management of this area. This stage includes the following steps:
Identifying the class, level and scale of the natural ecosystem (i.e. coastal wetland), Also, the sub-class (e.g. coral reefs, mangroves) should be determined to assess its biodiversity, rarity, and wider role.

Figure (2) The EAPM-CW as a methodological framework for planning and management (full process)



Source: Author

Source: Ghoneim (2012, p. 109)

The level of importance and significance should be determined whether it is a globally (e.g. RAMSAR site), nationally (e.g. a national park, preservation area), or a locally significant area. The scale of the coastal wetland or its relative size can help in determining its level of importance especially within the local context. All these factors together can help determine the preservation and direct the next steps of planning;
b. Identifying the external development objectives and role within international, national, and regional strategies to integrating the objectives and efforts of different planning levels.
c. Financial resources: funding is essential for any planning and management regime and an idea of the resources that may be available is important in informing the scope of activity. So, local, national and international sources of financial support should be sought depending on the role and importance of the case.
d. Identifying and preparing the institutional requirements: This will depend on the results of the previous steps. However, more institutions and sources of financial support may be invited through the next stages according to the issues and objectives that will be precisely determined as the planning and management process develops.

2.2. **The Scoping stage:** This stage aims to draw the direct and indirect boundaries of the planning and management regime. It is a multilevel stage which attempts to create a balance between the natural and the human aspects not only in the definition of spatial boundaries but also in the identification of the main issues of concern, goals, and the primary objectives. So, the following steps are set out:

- Understanding the ecosystem (structure, units, main functions and interactions): although this may be done generally as an introduction to the ecosystem, it should be guided by ecological specialists to meet one of the main objectives of the framework related to respecting natural units and flow of interactions.

- A watershed analysis: aims to draw the direct and indirect spatial boundaries of regime. This is a fairly complex analysis, it is recommended to be done early in the process, to understand the hydrological character of the coastal wetland as a fundamental base for dealing with the ecosystem. The complexity and detail of this step will depend on the scale and importance of the area as determined in the previous stage.

- Understanding the human aspect: to balance with the natural scoping, the human dimension should be understood, through a conceptual characterization of the 'socio-economic structure' and its main interactions with the natural ecosystem. It may be helpful at this stage to identify the different social groups, especially those who directly depend on the natural ecosystem to satisfy their essential needs, or get their income, such as fishermen, farmers and landlords. Directly or indirectly, in some cases, understanding the role and effect of other power groups such as businessmen can help to gain support or overcome conflicts within the planning and management process.

- Stakeholder analysis: This step aims to promote: meeting the social choice of the EA principles, sustaining the development process, achieving the human well-being objectives and the balance between the global and local benefits of planning and

management. The stakeholders should definitely include representatives of the different socio-economic groups within the local community but should not be limited to them, because coastal wetlands as open ecosystems always have much wider interactions and provide ecosystem services to an extensive range of stakeholders. Identification of the main and secondary stakeholders in this step is not final and more can be invited according to the results of the other stages.

By the end of this stage the main issues, preliminary goals, and the direct and indirect boundaries of the project should be determined. Besides this, the main structure, relations and interactions of both aspects of the ecosystem should be understood and conceptualized.

2.3. **The Analysis stage**: It aims to combine the different current and future characteristics of the coastal wetland, and to draw integrated pictures, which will form the basis of decision making in the planning and management stage. The steps of this stage are as follows:

2.3.1. **Mapping & Building Database:** drawing together the information gathered in the scoping stage to build a dynamic database is in the core of the framework, as it is essential to control and ensure the efficiency of all the next steps of the process. The understanding of the natural and human aspects developed in the last stage, will help in designing suitable variables of the database within the determined boundaries. However, more adaptation of the database design and adjustment of the analyses criteria (i.e. indicators of the ESA[4]) will result from the following activities

2.3.2. Analysing the environmental aspects, including:

a. Analysing the current environmental conditions covering physical, ecological and hydrological conditions with special concern for biodiversity, and threatened species. Also change detection and trend analysis would be helpful to determine rates and directions of change and to make projections about the future.

b. Analysing the effects of climate change and natural hazards should consider local and global interactions, in order to predict and build different scenarios for these effects (i.e. natural hazards, extreme events such as tsunamis). These scenarios will be the base for developing alternative plans in the next stage.

2.3.3. **Analysing the human aspect**: this includes identifying the current and future needs of the local communities; analysis of socio-cultural and economic characteristics to develop deeper understanding of many factors that are responsible for loss and deterioration of coastal wetlands. A special focus on urban and regional development is important to inform planning and management decisions. Rates and directions of urban growth, change of land use, effects of current land uses and their interactions with the wider environment should be carefully analysed to understand these dynamics and orient them to maximize the long-term benefits of their interactions with the environment and minimize their impacts on it.

2.3.4. **Developing the database** by integrating variables and results of the previous stages and steps: starting from this step, the analysis will move from single-discipline focused analysis to integrate multi-disciplinary analysis in order to synthesise the results of the huge number of specialized studies and their related layers into a few combined layers. These layers should be easy to read and use by planners, managers,

[4] Ecosystem Services Assessment

decision makers, and non-specialist stakeholders. Also, they should be where possible spatially referenced and mapped. Although the database is growing as the process moves from one step to another, it is important at this point to check and ensure its integrity, to be ready for the following steps.

2.3.5. **Ecosystem Services Assessment:** the ESA is put forward as a main step and integrated as a powerful tool supporting decisions of several stages, including: assessment of the current status of the whole ecosystem; classifying it into sub-units or homogenous areas to produce one of the main integrated multidimensional pictures of the coastal wetland under the study; and to facilitate the planning stage. This picture will be used again later as a comparative reference for evaluation in the next stages of the process.

Results of the stage: Depending on all the previous steps and stages, this stage would significantly expand the database and conclude with the following planning and decision support layers:

a. Protection Priorities: The results of the existing conditions analysis related to the natural and human aspects should include identification of the significant and critical areas and features, such as habitats of rare species and traditional historical features and classification of their importance. So, a ranking of their priorities for protection can be assessed.

b. Scenarios of expected hazardous areas and extreme events: The results of natural hazards and effects of climate change analyses would identify the areas expected to face serious changes. The level of certainty about these scenarios will determine to what extent they will be considered subsequent planning and management stages.

c. Current and future community needs: results of analysing the human dimensions should identify current and future needs and well-being aspirations.

d. Development potentials: potentials for different development activities and land uses can be identified according to environmental and urban characteristics of sub areas, such as areas with high potential for tourism, recreation or scientific study.

e. Challenges: pressures, constraints and conflicts: by the end of the analysis stage, present and expected pressures, constraints and conflicts can be identified and mapped.

f. Setting the detailed objectives of environmental planning and management: at this point of the process most of the resulting final objectives for planning and management should be integrated from different specialized scientific perspectives and interested socio-economic groups. A revision and wider discussion of these objectives should be conducted in participation with all stakeholders, community representatives, specialists, planners, managers and decision makers. Agreement and integration with both national and international strategies on a wider scale should be taken into account, and representatives of central institutions and related governmental bodies should be involved, as well. This would minimize future conflicts, and support and maximize the efficiency,

applicability and sustainability of the development plans that meet these agreed objectives.

2.4. **The Planning stage:** The aim of this stage is to develop effective and efficient land-use plans, management plans, and emergency plans, in order to achieve the agreed objectives, using the results of all previous steps. A summary of the main steps of this stage is as follows:

2.4.1. **Building alternatives plans**: Three types of alternatives should be developed here for different types of plan which reflect different time spans:

Alternatives of Land-Use Development plans (long term): alternatives here should explore different long-term objectives, addressing transformations which may occur over a long time period and relatively large-scale and high-cost desired spatial changes, mostly related to land use and land cover. Decisions related to preservation can be taken first as a separate task or be a part of the development of alternatives according to the institutional structure and local context.

Alternatives of Management Plans (short term): by definition, alternative management plans are more likely to focus on current and short-term actions, while these actions should be integrated with the long-term plans and objectives. So, it is recommended for management alternatives to be developed with, or justified within the context of development plans. However, management actions should not be stopped or postponed until all the required information has been obtained or all the previous analysis finished, because the whole process is time consuming. So, it could be recommended to set and take primary management actions directly after the scoping stage.

Alternatives of Emergency Plans (immediate actions): Coastal wetlands are located in the most dynamic coastal zone areas, and are more likely to face natural hazards, climate change effects and extreme events than many other areas. So, alternative emergency plans should be ready with suitable immediate actions to minimize these impacts. Alternative Emergency Plans should reflect scenarios of expected natural hazards and the available resources.

2.4.2. **Evaluation of alternatives:** To select the most acceptable and sustainable alternative plans. However the Ecosystem Service assessment has a main role several stages in this framework, so it can be used integrated with the EIA or separately especially in the more sensitive environments such as coral reefs. Moreover it is recommended for as monitoring and evaluation tool in the next stage by comparing the change of the ESA values with their initial values at the beginning of the process (i.e. based on the existing environmental conditions) in a regular base time.
By the end of this stage, four main products should be developed and checked with the higher levels of strategies: the land-use development plan, the management plan, alternative emergency action plans, and (in some cases this may include) decisions on protected areas.

2.5. **The Implementation stage:** To ensure efficiency of implementation, a time frame and measurements of progress should be set within each of the plans. Then the institutional arrangements, and other required resources should be prepared because

implementation phases and programmes are very case specific, so they are not discussed in details here.

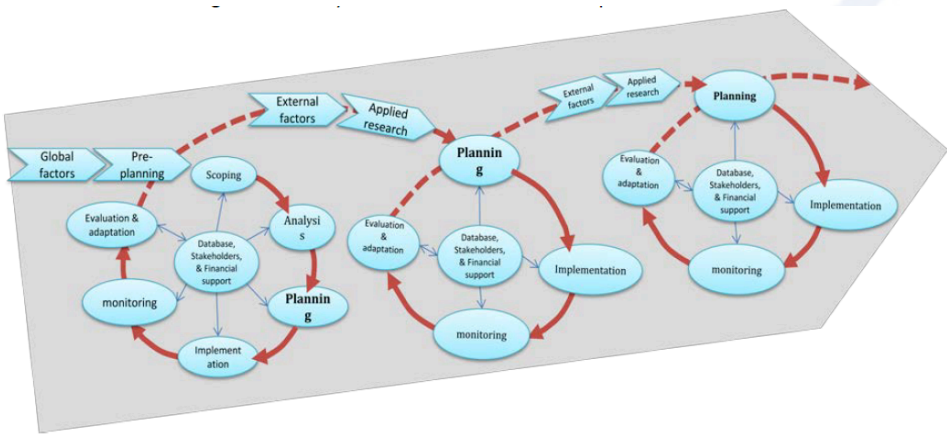
2.6. **The Monitoring (not limited to this stage)**: Details of monitoring programmes and activities are also case specific, but generally regular monitoring programmes should be established and the required human and technical resources should be ensured from the beginning. Situation analysis, taking suitable actions, and resolving conflicts is a continuous set of steps which should run throughout the whole framework and not just be limited to the end of the plan-making cycle to meet the dynamic and sensitive nature of coastal wetlands. Responding to this dynamic nature, the database should be regularly updated with a simple kind of trend analysis, and a conclusion of the situation should be shared with partners and stakeholders. It should be mentioned here that a suitable action at this stage could be applying one of the emergency plans, whenever its related scenario happens.

2.7. **The Evaluation and Adaptation stage:** Evaluation and adaptation again is a multi-temporal process, which differs in details, techniques used and outputs, from one time frame to another. Three levels of evaluation and adaptation can be distinguished as follows:

2.7.1. **- Short-term (adaptation of the management plan):** this aims to evaluate the management actions and monitoring programs to respond to the ongoing and short-term changes. The reference for evaluation and adaptation here is the pre-determined progress measurements.

2.7.2. **- Medium- or Long-term (adaptation of the land-use development plan):** this aims to adapt the suggested land-use development plan to solve the kinds of conflict or disturbance that require changes in land uses. This may happen in the medium time frame and go back directly to the suggested land-use plan after a limited ESA of the changes needed and checks with the agreed objectives have been undertaken. However, long-term evaluation and adaptation may partly go back to the first stage then go through the rest of the stages (see figure 3).

Figure (3) the dynamic adaptive nature of the EAPM



Source: Author

3. Evaluation

3.1. Does the EAPM-CW respond to the previously identified objectives?

3.1.1. *S***ustain biodiversity and ecosystem services for the long term***:* An understanding of the ecosystem units, structure and interaction has been drawn in the scoping stage. The analysis stage gives special consideration to this objective through detailed analysis of the environmental conditions, followed by intensive assessment of the current ecosystem services which help to classify the ecosystem into sub areas, with a detailed diagnosis of their functionality and different values, importance, biodiversity, etc. The same stage should analyse and identify the areas which are expected to face natural hazards or serious changes, and identify the objectives of preservation and development. This early prediction and careful determination of objectives would guide most decisions in the planning stage such as priorities for preservation and alternatives for development plans, while these alternatives will be evaluated depending on their ability to maximize the ecosystem services for the long term and minimize the impacts as well (using SEA, EIA and ESA).

3.1.2. **Protect the rare, threatened species and their habitats***:* The same steps that were integrated to reach the first objective also support this objective, as the rare, unique, threatened species and their habitats present the most important and sensitive features of areas of biodiversity and the productive ecosystem.

3.1.3. **Protect the human cultural features as an integrated part:** The EAPM has put the human dimension in parallel with the natural dimension. Cultural characteristics and features are effectively involved in most stages, and especially feature in the analysis stage as part of the Ecosystem Services Assessment, and in different steps of planning and preservation decisions.

3.1.4. **Meet the local communities' objectives within the global national, and regional frameworks:** All stages of the framework have included direct and strong support for this objective in different ways, such as involving community representatives and stakeholders in the identification of objectives and selection and adaptation of the suggested plans, and setting identification of the local communities' needs as a special step.

3.1.5. - **Minimize impacts of human development:** there are several steps directly feeding this objective, such as using EIA and SEA assessments in the evaluation of the planning and management alternatives.

3.1.6. - **Minimize effects of global warming and natural hazards:** the EAPM gives particular importance to analysing and predicting these impacts, and taking suitable decisions and actions to minimize them. This can be seen clearly in the analysis, planning, implementation and monitoring stages. It has responded to the current and predicted impacts in the different plans produced (i.e. development, management, and emergency), according to their level of expectation.

3.1.7. **Respect the natural units:** It is fundamental in the EAPM. So, the scope and boundaries of analysis and development were determined basically upon understanding the ecosystem structure (i.e. watershed in case of wetlands).

3.1.8. **Ensure that environmental, social, and economic objectives are achieved at an acceptable cost:** Inviting partners from the wider levels aims not only to create a balance between preservation and development objectives but also to share the responsibility and costs of sustainability objectives across these scales, and ensure

different means of support, including financial resources. Also, involving community representatives and stakeholders, aims to ensure the support, satisfaction and acceptance of local society.

3.1.9. **Enhance implementation through participatory planning, knowledge management:** Participatory planning is emphasized in critical steps of EAPM, such as identifying the objectives and evaluating the plans. The scoping stage sets the basis for building and exchanging knowledge and awareness with stakeholders and community representatives, while the actual building of the information base/database is mainly at the beginning of the analysis stage and is significantly increased by the results of different analyses to feed the planning and implementation stages.

3.1.10. **Resolve conflicts between sectors, organizations and stakeholders:** The EAPM uses participation, institutional integration and data sharing to increase the responsibility of the different parties and to develop a common understanding of the situation and objectives. On the other hand, the framework builds strong scientific evidence of different analyses and assessments to support decision making.

3.1.11. **Maintain continuity of effective planning–management process:** The framework tends to ensure feasibility by obtaining resources and capacity building in the pre-planning stage; efficiency in the analysis and planning stages; equity and responsibility by participation in decision making in different stages; and continuity of monitoring, evaluation, adaptation, updating and learning in the last three stages.

3.2. How has the EAPM applied principles of Ecosystem Approach&filled gaps?

Table (3) summarizes how steps of the EAPM are directly and indirectly integrated to meet and apply the 12 principles of the Ecosystem Approach, as follows:

(P.1): The EAPM emphasizes the importance of social choice and involvement of stakeholders, from the early stages of the process, and in the most important steps of decision making, such as identification of primary objective and issues, current and future needs identification.

(P.2) The special nature of coastal wetlands which has high importance, interactions and interests on different levels requires integration and participation of some or all of these levels according to their importance and effects, which may differ from one case to another. However, in all cases, the local level is essential and should be well linked with the national wetland strategy at least. It is recommended that the local level plays a main participatory role in several steps throughout the other stages.

(P.3): The EAPM widens the scope of planning and management process to include areas of interaction with adjacent ecosystems, which is clearly shown in the scoping stage, especially in the watershed analysis and the identification of boundaries.

(P.4) the EAPM considers potential economic gains of planning and management to achieve sustainability in several ways, such as putting the human aspect (i.e. mainly socio-economic dimensions) in parallel with the environmental aspect throughout the process, involving the stakeholders in the main decisions, moreover identification of development potentials and compatibilities based on scientific analysis and social participation.

(P.5) *t*o maintain and sustain the ecosystem services, the framework has developed ESA as a main technique for analysis of current conditions, evaluation of planning and management alternatives, and evaluation of results of planning and management.

(P.6) The EAPM is based on understanding of the ecosystem characteristics and functionality from its early stages. However, enhancement of this understanding is further developed through the developed continuous adaptive process of analysis, planning, implementation, monitoring, evaluation and adaptation. Moreover, the evaluation of the plan depends mainly on the ESA which reflects the health and functionality of the ecosystem.

(P.7) the EAPM suggests that the appropriate spatial scale of planning and management be determined in the scoping stage. However, there is more than one time frame for planning and management adaptation, which should differ from one case to another according to the importance of the case and the related issues.

(P.8) the multi-temporal is represented by different feedback loops in the framework (Figure 2) and discussed in the previous section as short-term adaptation, medium-term, and long-term adaptation.

(P.9) Recognition of the dynamic nature of sensitive ecosystems and predictions of the changes and natural hazards or extreme events are clearly emphasized in most stages of the EAPM. While the analysis stage has the main role of analysing and predicting serious changes, the monitoring, evaluation and adaptation stages are more concentrated on how to respond to these changes and conduct the needed adjustments in both the management actions and planning parameters and decisions.

(P.10) The EAPM has emphasized the balance throughout planning and management process, by considering the environmental aspects in parallel with the human aspects. Also, special importance is given in the identification of the primary objectives and issues, identification of the preservation and development objectives, current and future needs, and formation, evaluation and adaptation of the development plan.

(P.11) Building, developing and updating an integrated dynamic database is a continuous task in the developed, as it is clearly appears in figure (2).
(P.12) the pre-planning and scoping stages of the EAPM are focused on building a suitable partnership based and widen the dimensions of this base by inviting and encouraging cooperation: (i) between sectors, (ii) at various levels of government (e.g. national, provincial, local), and (iii) among governments, civil society and private sector stakeholders.

Table (3) The EAPM responses to principles of the Ecosystem Approach

Stages and steps of the developed framework	Principles of the EA	1	2	3	4	5	6	7	8	9	10	11	12
Pre-planning	Id scale, type, level of importance of the case	Indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Strong direct response	Strong indirect res.	Strong indirect res.	Indirect res.	Generally no conflicts	Strong indirect res.	Strong direct response
	Id. the required institutional needs	Generally no conflicts	Strong direct response	Strong indirect res.	Strong indirect res.	Strong indirect res.	Generally no conflicts	Strong direct response	Strong indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.
	Obtain support& financial resources	Indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Generally no conflicts	Strong direct response	Strong indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Strong direct response
	Guides of National & International strategies	Generally no conflicts	Strong direct response	Strong indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Indirect res.	Generally no conflicts
Scoping	Ecosystem Structure, Units & Interactions	Generally no conflicts	Indirect res.	Strong direct response	Indirect res.	Strong direct response	Strong direct response	Strong direct response	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Indirect res.
	Watershed analysis	Generally no conflicts	Strong indirect res.	Strong direct response	Indirect res.	Strong direct response	Strong direct response	Strong indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Indirect res.
	Main Socio-economic characteristics	Strong indirect res.	Indirect res.	Indirect res.	Strong direct response	Strong indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong indirect res.
	Stakeholder analysis	Strong direct response	Strong indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response
	Id. Boundaries & Pre: issues - goals	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Strong direct response	Indirect res.	Strong direct response	Indirect res.	Strong direct response
	Start needed emergency actions	Generally no conflicts	Indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Strong direct response	Strong indirect res.	Indirect res.	Strong direct response	Indirect res.	Strong indirect res.	Generally no conflicts
Analysis	Mapping & Building database	Generally no conflicts	Strong indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Strong indirect res.	Indirect res.	Indirect res.	Strong direct response	Indirect res.
	The current Environmental conditions	Generally no conflicts	Strong indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Strong direct response	Strong direct response	Indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.
	Climate change & N. Hazards prediction	Generally no conflicts	Strong indirect res.	Strong direct response	Indirect res.	Strong direct response	Strong direct response	Strong direct response	Indirect res.	Strong direct response	Strong indirect res.	Indirect res.	Indirect res.
	Analysis of Social dim.	Strong direct response	Strong indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Strong direct response
	Analysis of Cultural dim.	Strong indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Strong indirect res.
	Analysis of Economic dim.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Strong indirect res.
	Analysis of Urban& regional dim.	Indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Strong direct response	Indirect res.	Strong indirect res.
	Eco- services Assessment	Indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Strong direct response	Strong direct response	Indirect res.	Indirect res.	Strong indirect res.	Strong direct response	Generally no conflicts
	Id. objectives of Preservation & Development	Strong indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Strong direct response	Strong direct response	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response
	Id. Significant &Critical areas	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Strong direct response	Strong direct response	Strong indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Indirect res.
	Id. Expected hazards areas/ extreme events	Generally no conflicts	Generally no conflicts	Strong indirect res.	Generally no conflicts	Strong direct response	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Indirect res.	Indirect res.	Indirect res.
	Id. Current & future needs	Strong direct response	Strong indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Generally no conflicts	Strong indirect res.	Strong indirect res.	Strong direct response	Strong direct response	Indirect res.	Strong direct response
	Id. Potentials & compatibilities	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Indirect res.	Strong indirect res.
	Id. Pressures, constraints & conflicts	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Indirect res.	Strong indirect res.
	Overlay and extending the integrated Db.	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Indirect res.
Planning	Id. Priorities of preservation	Indirect res.	Indirect res.	Indirect res.	Indirect res.	Strong direct response	Strong direct response	Strong indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Indirect res.
	Alt. of Management plan	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong direct response
	Alt.s of emergency action plans	Indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Strong direct response	Indirect res.	Indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.	Indirect res.
	Alternatives of development land use plan	Strong indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.	Strong direct response	Indirect res.	Strong direct response
	Alter. evaluation : SEA & IEA& Eco-services	Indirect res.	Generally no conflicts	Strong indirect res.	Indirect res.	Strong direct response	Strong direct response	Strong indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Indirect res.	Generally no conflicts
	Management Plan & emergency actions	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.	Strong direct response
	Preservation decisions	Indirect res.	Indirect res.	Indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Strong indirect res.	Indirect res.	Indirect res.	Indirect res.	Strong indirect res.
	Development Land use Plan	Strong indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong direct response
Implementation	Progress measurements	Indirect res.	Strong indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.
	Implementation programs	Strong indirect res.	Strong direct response	Indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.
	Institutional arrangements	Indirect res.	Strong direct response	Indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Generally no conflicts	Indirect res.	Strong indirect res.	Indirect res.
Monitoring	Monitoring requirements & programs	Generally no conflicts	Strong indirect res.	Indirect res.	Strong indirect res.	Strong direct response	Strong direct response	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.	Indirect res.
	Situation analysis	Indirect res.	Strong indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Indirect res.	Indirect res.	Strong direct response	Indirect res.
	Suitable actions and resolve conflicts	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.	Indirect res.	Strong direct response	Indirect res.	Strong indirect res.
	Data updating & sharing	Indirect res.	Strong indirect res.	Generally no conflicts	Strong indirect res.	Strong indirect res.	Generally no conflicts	Strong indirect res.	Generally no conflicts	Strong indirect res.	Generally no conflicts	Strong direct response	Strong direct response
Evaluation adaptation	Evaluation of management Short term	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Indirect res.	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.
	Evaluation of Long term plan	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Strong direct response	Indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.
	Adaptation of management plan	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.	Strong direct response
	Adaptation of development plan	Indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong indirect res.	Strong direct response	Strong indirect res.	Strong indirect res.	Strong direct response
	Feed back to national & international level	Generally no conflicts	Generally no conflicts	Strong indirect res.	Indirect res.	Generally no conflicts	Generally no conflicts	Strong direct response	Generally no conflicts	Generally no conflicts	Generally no conflicts	Strong direct response	Generally no conflicts

Strong direct response Strong indirect res. Indirect res. Generally no conflicts

Source: Author

Filling the critical gaps of the EA: three main areas of criticism/gaps, moreover developing the stages and the detailed steps of the framework, could be targeted throughout the developed EAPM, as follows:

a. **Uncertainty:** To minimize the uncertainty characterizing the changes in natural ecosystems the EAPM depends on: an intensive dynamic database, integrating environmental analysis techniques (e.g. SEA, EIA, and ESA), building alternative scenarios of natural hazards and extreme events, developing different alternatives for development management, and following a continuous process of evaluation, adaptation and learning from experience.

b. **Institutional issues:** Issues such as institutional mismatch with natural units, lack of integration among sectors, and inter-institutional conflicts: are reflected in the suggested framework from the pre-planning stage, as it suggests identifying and establishing suitable institutional arrangements that meet the nature, type, scale and importance of the coastal wetland under consideration.

c. **Creation of incentives/motivations:** Because the costs of ecosystem preservation accrue locally, while the benefits are predominantly national or international; the EAPM maximizes involvement of local communities. Stakeholder participation in the main stages, including identification of objectives, needs, development potentials, and alternative plans, is supposed to create more local benefits. Also, it is recommended that national and international interested bodies and organizations be encouraged to share the costs of preservation, especially in coastal wetlands with high global importance.

Conclusion

The EAPM attempts to transfer the concepts & principles of the Ecosystem Approach into a clear methodological framework for planning and management in coastal wetlands, as an example of sensitive ecosystems, in order to achieve sustainability. However it is felt that the framework is potentially applicable for other contexts, especially those wider overlapping ecosystems, such as other wetland types or coastal areas more generally. Also, it is potentially applicable in any other ecosystem, by following the various processes and stages set at. However for wider use the special characteristics, challenges and importance of the ecosystem under application should be reflected in the detail of each step of the process.

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Eco-Efficiency Assessment in Apple Production and Storage in the Northeast of Portugal

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Cost reduction, product quality, and customer demands have been pressing the agro-industrial sector to adopt more sustainable practices. Assessing the environmental performance of the food sector worldwide is crucial to reduce the environmental impact of agricultural and industrial practices. This study focus on the assessment of the eco-efficiency of the apple production and storage in the northeastern region of Portugal, one of the largest production regions, using a set of environmental indicators such as energy intensity (EI), water withdrawn intensity (WWI) and GHG emission intensity (GEI). System boundaries include the farming and the storage subsystems. Upstream and down-stream processes such as fertilization production, apple distribution and waste treatment were not taken into account. Inventory information was gathered from two apple farms and one apple storage company. Data was gathered for a reference year. Results show that each ton of apple exiting the system requires on average 32.7 kgoe of primary energy, 74.9 m3 of water and generates an emission of 75.1 kgCO2e. Apple orchard irrigation was identified as the most energy-demanding activity with up to 63% of the energy input. Industrial cold was identified as the most energy-demanding activity (50%) in the apple storage stage. Water is required in both subsystems but the amount used in the storage is residual (<1%) when compared with its use by agricultural subsystem. Taking into account the GHG emissions from the use of energy, apple cultivation had a lower contribution for GEI (40%) than the apple storage (60%). Unlike other food systems, a more eco-efficient apple production can be accomplished through improvements in both stages, since energy costs and environmental impacts are greatly associated with energy use.

Keywords: Apple production, eco-efficiency, energy use, GHG emissions, water consumption.

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1. Introduction

The global growth of human population (Bartlett, 1994) has forced food production to become more intensive and industrialized, thus depleting natural resources and generating pollution (Kramer et al., 1999; Tukker et al., 2006). Energy and water are two of the main resources consumed in industries worldwide, and their importance is recognized in the global economy and the welfare of the human population (Ayres et al., 2013; Jorgenson et al., 2014; Stern, 2010), so its use should be conscious and efficient. The supply of energy to end users also generates environmental impacts such as those resulting from emissions of gaseous contaminants and greenhouse gases (GHG). The large use of water in agriculture, about 70 to 80% of drinking water according to (Jägerskog and Jønch Clausen, 2012), has also a direct influence on the energy consumption and on the carbon and nitrogen cycles. In fact, we all realize that food production, from farming to consumption, triggers many impacts that are harmful to the environment and to human health. To ensure long-term sustainability, all players of the food sector should therefore improve the environmental performance of their products and processes.

The impact assessment in the agri-food sector has essentially been addressed by Life Cycle Assessment (LCA) tools. Its application in the sector has been increasing exponentially in the last decade (Heller et al., 2013). The environmental impact assessment studies can be categorized according to several food products, such as wine (Rugani et al., 2013), fruit (Ingwersen, 2012; Mila i Canals et al., 2007; Mouron et al., 2006), or seafood (Ziegler et al., 2013). Roy et al. (2009) demonstrate the advancements achieved with LCA methodology as well as a very thorough review of its application to the agri-food sector. The combination of LCA with other methods allows the establishment of a database that can inform policy makers, producers, and consumers when choosing eco-efficient products (Roy et al., 2009). Results from these different methodologies allowed for the concept of sustainable development (Basil, 2001; Hasna, 2012; Robert et al., 2005) based on the eco-efficiency (Fet, 2003) to be implemented in the agro-industrial sector with a good worldwide acceptance (Bonny, 1993; Guzmán et al., 2011; Pervanchon et al., 2002; Swanton et al., 1996). There are several key factors, such as cost reduction and quality, that customers demand from products, forcing the sector to adopt measures to meet the aforementioned concepts. Companies from all economic sectors, including small and medium enterprises (SMEs) are under pressure from regulators, clients and investors, and also their employees. The use of these tools is an opportunity for companies, mostly SMEs, to be able of self-assess and identify their inefficiencies and implement changes leading to higher eco-efficiency.

The present article deals with eco-efficiency in two stages of the apple chain (farming and storage) for the northeastern region of Portugal, by using a set of environmental indicators such as energy intensity (EI), GHG emission intensity (GEI) and water withdrawn intensity (WWI). This study was developed as a part of two larger research projects (Ecodeep and Inovenergy) addressing eco and energy efficiency in the Portuguese food sector.

2. Global and Portuguese apple production

Apples bring multiple benefits to human health, especially by preventing chronic diseases such as cardiovascular disease and cancer (Ness and Powles, 1997; Steinmetz and Potter, 1996; Van Duyn and Pivonka, 2000) and so it should be part of meals on a daily basis. For example, Eberhardt et al. (2000) and Boyer and Liu (2004) report that apple has several phytochemicals, many of which have antioxidant activity, which can help to reduce cell cancer proliferation.

Apple is among the most consumed fruits worldwide. According to the United Nations Food and Agriculture Organization (FAO), as of 2012, apple occupied the second place among the global *Fruit Primary* production (FAO, 2014). This classification comprehends a total of 37 different fruits, where apple represents about 12%. Also, China was the largest producer, with almost half of the global apple production (≈ 48%). The European Union was in second with 14% of the global apple production achieved by aggregating the productions of the 28 member countries. Of the EU28 countries, those with the largest representation are Poland with 26%, followed by Italy with 18% and France with 13%. Portugal was the thirteenth largest apple producer in the EU28, with approximately 2% (Fig. 1.A).

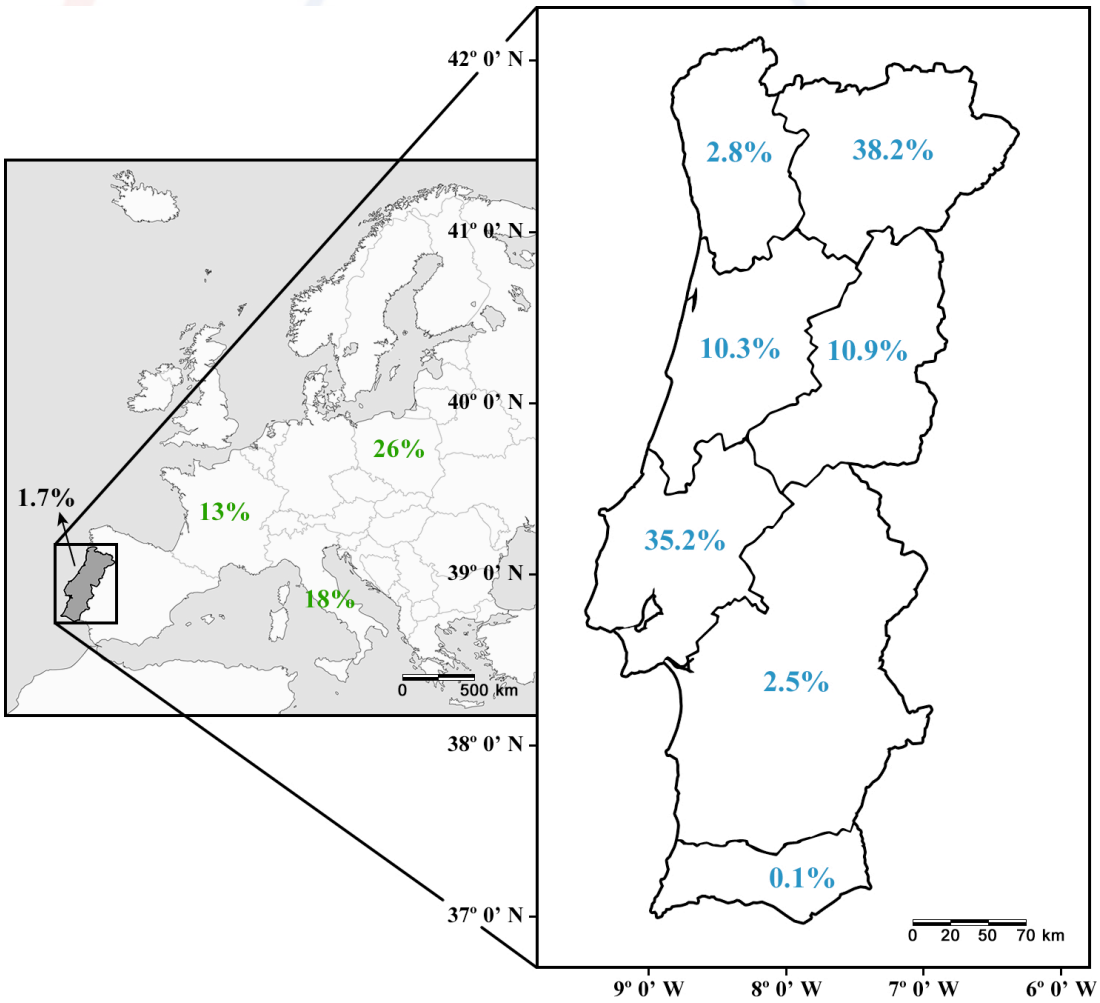

Fig. 1. Major apple producers in the EU28 (A) and percentage of apple production in Portugal by region (B), as of 2012.

As shown in Fig. 1.B, which displays the regional distribution of apple productions in Portugal (INE, 2011), the Northeastern region accounts for more than a third of the Portuguese apple production (38%) and has an average yield higher than the national mean of 17 t/ha. Portuguese apple yields are well below the yields found in other countries, such as Italy or France, where production can reach up to 40 t/ha (FAO, 2014).

3. Methodology

3.1. System boundaries and data collection

Our analysis was applied to a system encompassing the farm (cultivation) and the storage stages only (see Fig. 2). Upstream processes such as fertilizer production and downstream activities such as apple distribution and apple consumption among others were not taken into account.

The study was conducted with the collaboration of two apple farms and an apple storage company, hereinafter referred to as F1, F2 and S1, respectively, located in one of the two sub-regions of apple production in the northeast of Portugal. Both farms are managed according to the specific regulations for integrated production.

Data collected for the apple farming, regarding energy and water consumption, took into account seven farming processes: soil management, irrigation, fertilization, pest control, pruning, apple collection and transport. The two apple farmers were directly approached with surveys regarding the size of the land used for production, the number of apple trees and their age, and the types of apple collected. This survey also gathered information on the farming processes, with special attention to water and energy consumption, and on the use of chemical and organic products.

For the storage characterization, after an initial survey on general industry characteristics (e.g. dimension, annual turnover, etc.), type, costs and amount of energy inputs, raw material and annual production, an energy audit was conducted in order to identify and quantify the major energy consuming processes/equipment, as allowing for the identification of the most relevant energy inefficiencies. This information was then analyzed and used to calculate some environmental/eco-efficiency indicators widely used for benchmarking purposes (see section 3.3).

3.2. System description

The production of apple and its post-harvest storage can be schematized with a simple set of processes. Fig. 2 shows the schematic for apple production and storage, identifying the main inputs and outputs of the two apple chain subsystems focused in this study (farming and storage).

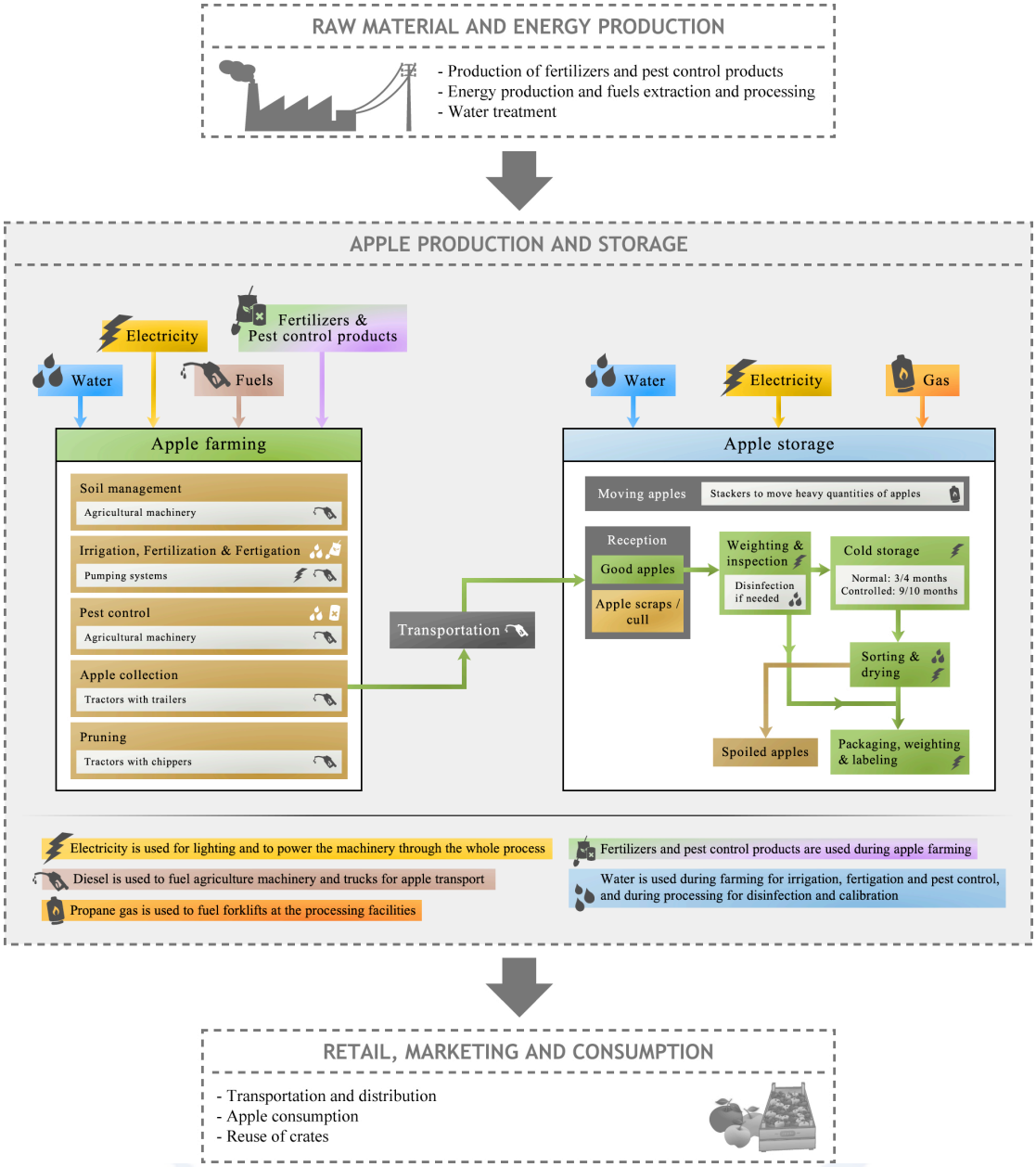

Fig. 2. General schematic for the apple farming and storage stages.

The apple farming is characterized by many processes, occurring yearly, including soil management, irrigation, fertilization, pest control, apple collection and pruning. Soil management in agriculture demands a lot of effort, starting with the soil being plowed (about 3 times a year), in order to clear the soil from weeds and other grass. This treatment is usually done using machinery, consuming fuel and releasing GHG emissions. This process contributes to lessen the use of herbicides. Apple orchards are highly susceptible to both insect and fungi attack, which may on occasions affect productivity. So, the orchards need to be constantly monitored and treated when necessary, using chemicals to prevent or destroy pests. The fertilization is applied directly on the soil and on trees, but it is also takes place along with irrigation (fertigation).

Apple orchards are important water consumers. Water is provided by a set of equipment (e.g. pumps, reservoirs), which in turn consumes energy, either electricity provided by the national grid or generated from the combustion of a specific fuel such as the diesel. After these processes, harvest takes place around September and is usually done by hand with the support of tractors with trailers (or similar transport) to place the apples. The pruning is also done by hand, and so it only consumes energy related to green residues shredding, through the use of diesel powered machinery. After collection, apples are transported to a storage facility to undergo another set of processes in order to ensure its long-term conservation. The transport process is usually done by the farmers using diesel fuelled light-duty trucks or tractors (with trailer), therefore its GHG emissions are accounted for during the farming stage.

Storing apples for a few months can be expensive because a lot of energy is required for several processes. Electricity is required for lighting the facilities and powering its machinery, mostly with the production of compressed air.

When apples are received, first they are separated and the cull (apples with some defect like bruising, sunburns or cut worm) goes to other processing industries (e.g. fruit nectars and flavors). The good apples are weighted and inspected, with disinfection can be applied, and then they are either stored or they are expedited for distribution. The cold storage is done with temperatures below 2 ºC, and in normal atmosphere composition (during 3 to 4 months) or in controlled atmosphere, with an increased nitrogen concentration (during 9 to 10 months). After storage before the product is expedited, it goes once again through manual or automatic sorting, in order to remove spoiled apples which may have decayed during storage. Inside the facilities, apples are most of the time moved by water, so they need to go through electric drying to remove some of that water. Finally, apples are manually packaged, weighted and labeled, thus making them ready for distribution. The facilities also have propane fueled forklifts to move heavy quantities of apples.

3.3. Eco-efficiency indicators

To assess the environmental performance of the farming and storage stages, eco-efficiency indicators such as energy intensity (EI), GHG emission intensity (GEI) and water withdrawn intensity (WWI) were used (Maxime et al., 2006).

The energy intensity, *EI* (Eq. 1), represents the amount of energy, *Q* (primary energy), from source *s*, expended per production volume, *P* (physical unit). Energy units used are based on mass (tons or kilograms) of oil equivalent (toe or kgoe).

$$EI = \Sigma Q_s / P \quad (1)$$

Primary energy in toe or kgoe was obtained by using inventory data and conversion factors displayed in Table 1.

To determine the potential Greenhouse Impact from the different stages of apple production and storage, the GHG emission intensity (GEI) indicator was used (Eq. 2). Its determination requires the greenhouse gas mass (tons of Kg of, *M*, from source *j*, measured in units of carbon dioxide equivalent (tCO_2e or $kgCO_2e$) then divided by the production volume.

$$GEI = \Sigma M_j / P \quad (2)$$

Only GHG emissions related to energy use (fuel combustion) in each stage were taken into account. Carbon dioxide equivalent emissions were therefore determined for each energy source (see Table 1 for conversion factors) and then normalized by the production volume in order to obtain comparable values for both apple farmers.

Table 1. Conversion to primary energy and CO_2 equivalent emission factors for electric power, diesel and propane.

Energy source	Primary energy	Emission factor	References
Electric Power [a]	215×10^{-6} toe/kWh	2186.0 kg CO_2e/toe	(EMEP/EEA, 2013; PEA, 2013)
Diesel [b]	1.01×10^{-3} toe/kg	3098.2 kg CO_2e/toe	
Propane	1.099×10^{-3} toe/kg	2637.7 kg CO_2e/toe	

[a] Considering an efficiency of 40% on converting primary to final energy;
[a] Liters of diesel were converted to kilograms using its density of 0.835 kg/L.

The third indicator used was the water withdrawn intensity, *WWI* (Eq. 3), which allows for the evaluation of the impact on the water resources consumption, taking into account the volume of water, *V*, withdrawn from each source *o*.

$$WWI = \Sigma V_o / P \quad (3)$$

All indicators relate to the production volume because it is the only variable that allows comparisons between the different farmers and the storage facility.

4. Results

4.1. Inventory data for the apple farming subsystem

Main inputs and yields for apple farming stage per year and per hectare are displayed in Table 2. Apple trees are arranged in lines, 4 meters apart from each other, for both producers. In each line, the distance between trees is 1.7 meters for F1 with an average age of 10 years. For F2, 70% of the trees were 6 years old and the remaining 30% were 17 years old on average, with a distance of 1.4 meters between each other. The apple varieties produced are very similar between farmers, all within the same species, *Malus domestica*. The Golden apple is the variety with higher production in both cases (F1:70%, F2: 50%), followed by Royal Gala and Red apples. In general, both farmers have similar land area for apple orchards, but F1 has higher yields (50 t/ha) than F2 (30 t/ha). These higher yields in F1 were associated to the higher material and energy inputs. F1 consumed nearly the double of the water and energy used by F2.
The energy use during the farming stage was accounted for a total consumption of 322 GJ (7.7 toe) for F1 and 163 GJ (3.9 toe) for F2.

Table 2. Main inputs and yields for the apple farming stage per year and per hectare.

Apple farming	Farms	
	F1	F2
Water		
Water (m^3)	3702	2230
Energy inputs		
Electricity (kWh)	2600	692
Diesel (L)	164	176
Yield/Production		
Apples (t)	50	30
Area harvested (ha)	11	13

Electricity and diesel are the two sources of energy used by both farmers. Electric power was the most consumed energy source with about 80% in F1, while in F2 it only accounted for about 50% of its energy consumption. In both orchards irrigation is the most energy demanding process.

5.2. Environmental performance of apple farms

In order to evaluate the environmental impact of each apple farms, the eco-efficiency indicators (EI, WWI and GEI) above-described were calculated using the inventory data. Fig. 3 shows the results from such indicators for each farmer. The relative contribution of each apple farming process is also presented.

Concerning the EI indicator, F1 has higher energy inputs per unit of apple produced than farmer 2, about 40% more. Farm 1 has a EI of 13.9 kgoe/t (0.58 MJ/kg) and F2 is characterized by a EI of 9,9 kgoe/t (0.41 MJ/kg). Mila i Canals et al. (2007) reported for European countries values ranging between 0.4 and 3.8 MJ/kg, for the farming subsystem comprising field operations but also energy inputs associated to upstream processes such as fertilizers and agro-chemicals production.

EI values also show that the irrigation process is the most energy demanding in the apple farming subsystem, with energy consumptions (per ton of apple) of 11.1 kgoe (79%) for F1 and 5.0 kgoe (51%) for F2. F2 consumes less water than F1 and therefore requires less energy. Apple collection in F2 represents 15.3% of the total energy expended per ton of apple produced, while in F1 its contribution is about 8%.
As observed for the EI indicator, F1 releases more GHG per ton of apple than F2. The GEI for F1 was 33 $kgCO_2e/t$ while for F2 it was 26.2 $kgCO_2e/t$ due to the higher use of energy resources by the former. Therefore, F1 can reduce GEI by lowering its energy dependence or by replacing current energy sources by carbon free or carbon neutral energy sources. As expected, irrigation process is the major contributor to GHG emissions in both farms. Slight differences detected between the EI and GEI indicators are caused by the differences in the mix of energy sources used in the irrigation process, either electric power or diesel, which have different emission factors.

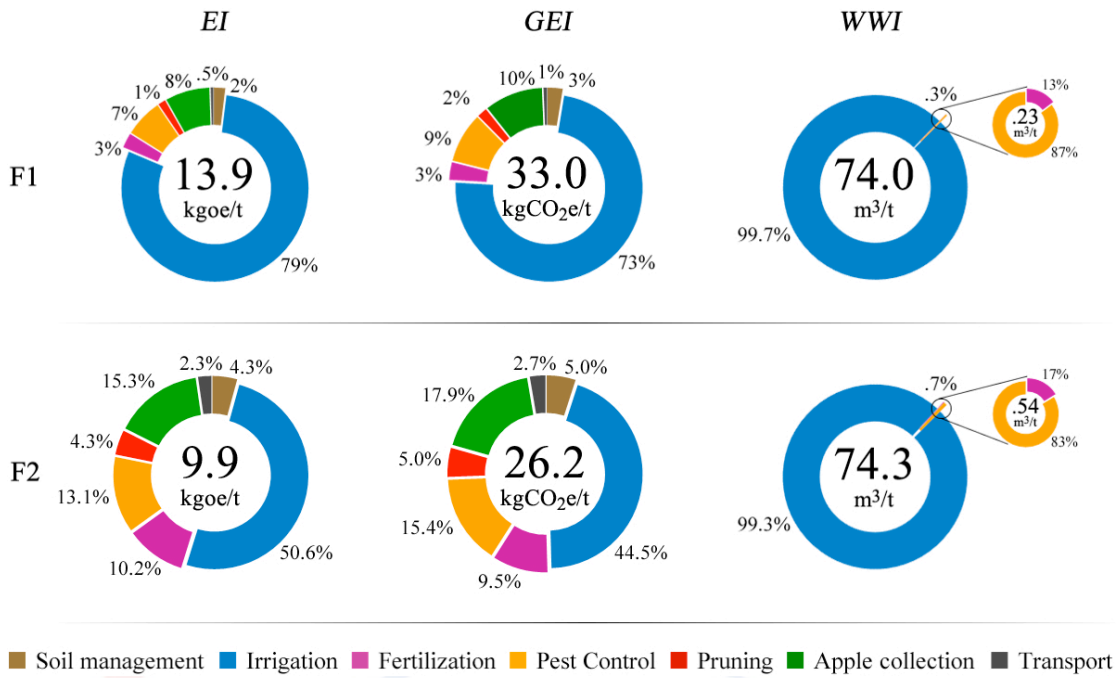

Fig. 3. Energy, GHG emission and water withdrawn intensities for both farms. Relative contributions of farming processes are also displayed.

Regarding water use, both farmers have a similar WWI (≈ 74 m^3/t), although F1 is consuming approximately 1.4 times more water than F2. Therefore, this indicates that a higher consumption of any resource should not be interpreted as a system's inefficiency, as it may lead to higher yields. Similar findings were also observed in studies applied in Swiss orchards (Mouron et al., 2006).

4.3. Inventory data for the apple storage subsystem

The storage facility processes on average six thousand tons of apple per year. The purpose of this stage is to provide the market with apples throughout the year, beyond the harvest season. The unit is equipped with 4 cold chambers with the capacity for 330 tons of apple each, and another 8 cold chambers with a controlled atmosphere, and the equivalent storage capacity.

Electricity is the main source of energy used in the storage unit (see Table 3). About 50% of electricity is used providing cold for storage for up to ten months. Moving apples through the different stages of the processing line requires about 30% of electricity, including the generation of compressed air. The remaining 20% is used for lighting and heating equipment. Propane gas is responsible for only 0.3% of the energy use, as it is only used to power forklifts.

Table 3. Main energy and material inputs for the storage stage per process and per year.

Apple storage	Storage facility		
	S1		
Material inputs			
Apples (t)	6000		
Water (m^3)	4524		
Energy inputs			
Electric power	[kWh]	[toe]	[%]
Apple Processing	176496	37.9	28
Compressed air	13190	2.8	2
Industrial cold	311537	67.0	50
Lighting	74116	15.9	12
Heating devices	52760	11.3	8
Propane	[kg]	[toe]	[%]
Apple Processing	363	0.4	100

4.4. Environmental performance by the apple storage subsystem

Fig. 4 shows the results for the eco-efficiency indicators applied in this study for the storage process. This subsystem of the apple production chain was responsible for the consumption of 20.8 kgoe/t and a GHG emission of about 45.6 $kgCO_2e/t$.

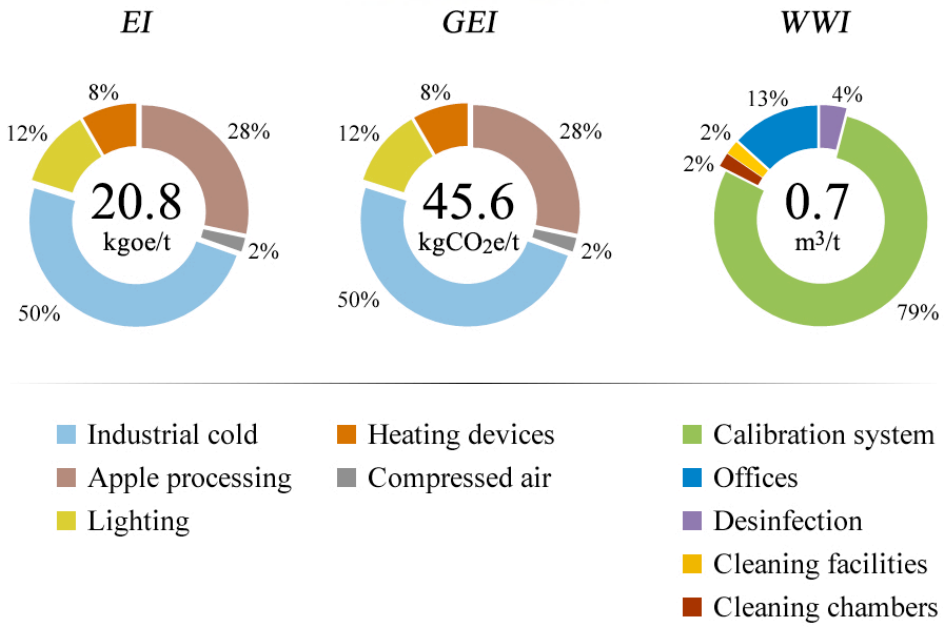

Fig. 4. Eco-efficiency indicators for the storage stage. Relative contributions of the storage processes are also displayed.

The water use in the storage facilities is about 4500 m^3 per year. The apples transport to the calibration system uses about 79% of the total water consumption. Around 13% is used in several office activities and physiological needs (e.g. toilets). The disinfection process can consume up to 4% of the water, and the cleaning of chambers

and facility uses about 2%, each. The WWI of the facility was about 700 liters per ton of apple, a much lower value when compared to the apple cultivation.

4.5. Environmental performance for the apple production and storage system

The purpose of this section is to evaluate the environmental performance for the apple in the northeast of Portugal, integrating all stages from farming to storage. To perform such analysis various assumptions have been taken into account. The sub-region has about 455 ha of apple orchards, with an apple yield of around 12000 ton/year. All apples are transported from the different farms to a storage unit having the same characteristics and performance than S1. Furthermore, according to Portuguese statistical data (INE, 2011) the farthest apple orchard is located about 12 km away from the storage facility (see Fig. 5). However, information gathered during the survey performed at the storage unit reveals that on average the cultivars from which storage unit receives apples are located within a 4 km radius. So, two scenarios were established, in which the fuel consumed during the transportation of apple to the storage facility and back was averaged by those two distances, maintaining the same energy consumption for the other processes. Apple transport to the storage facilities was assured through 2 t capacity light-duty trucks (75%) and 4 t tractors with trailers (25%). Both vehicles are equipped with diesel engines with a fuel consumption of 10L/100km and 4L/h, respectively.

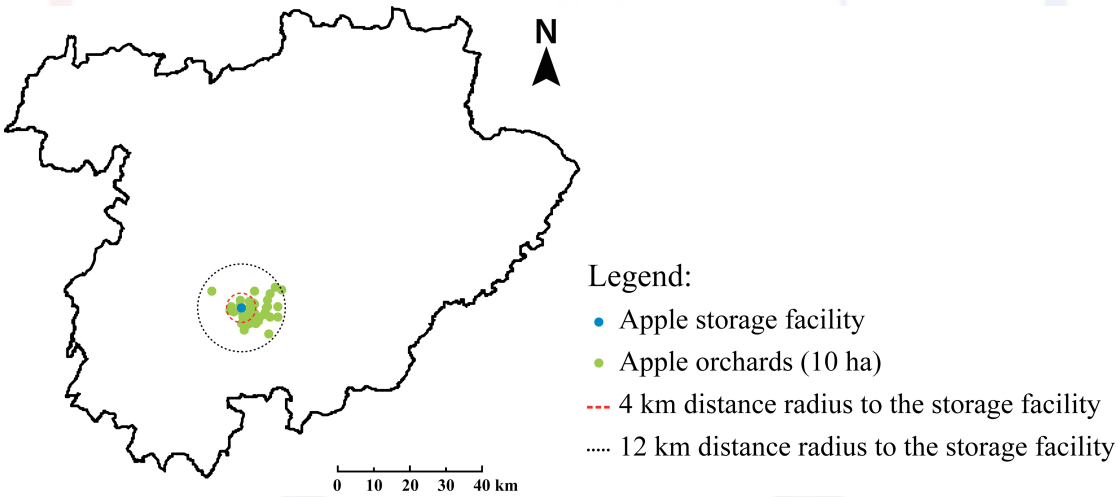

Fig. 5. Main apple cultivars around the storage facility, located at the northeast region of Portugal.

Based on these assumptions, all indicators were calculated for combinations between the apple farms and a storage unit (F+S), regarding the two simple scenarios, whose only difference is the distance associated with the apple transportation from farms to storage (4 km and 12 km).

Fig. 6 shows results for each scenario expressed in terms of EI, GEI and WWI. It also shows the relative contribution of apple farming, apple storage and transport between farms and storage unit for the magnitude of each indicator

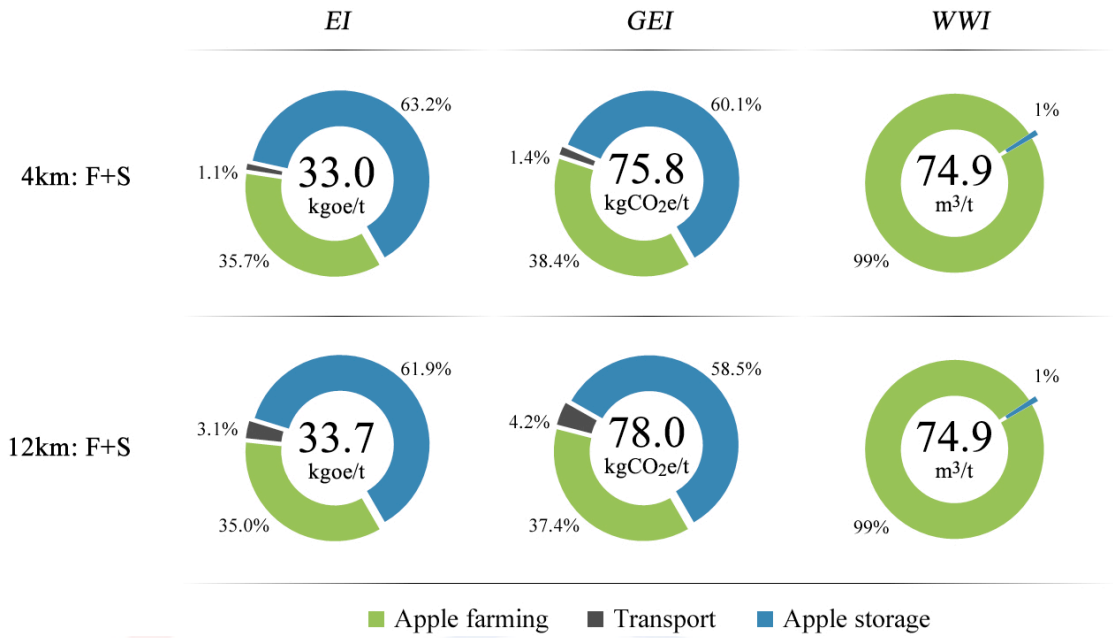

Fig. 6. EI, GEI and WWI for the two scenarios, with the relative contribution of farming, storage and apple transport between the two stages.

On average, a ton of apple at the storage delivered to the market requires about 33.4 kgoe of primary energy and around 75 m^3 of water. Apple storage has a larger demand for energy than apple farming and has a very residual need for water when compared with apple farming. The cumulative GHG emissions for farming, storage and transport from farming to storage was about 77 $kgCO_2eq/t$. Storage has a contribution of about 60% for energy consumption and GHG emissions while the farm stage accounts for about 40%. Transport between orchards and storage unit has a very low contribution to GHG emissions (<5%).

5. Conclusions

This study assesses the environmental performance of two stages of the productive apple chain - cultivation and storage – for a specific geographical context, the northeastern region of Portugal. The assessment was based on three environmental indicators: energy intensity (EI), GHG emission intensity (GEI) and water withdrawn intensity (WWI). The calculation of these indicators was based on inventory data gathered from two medium-size apple growing farms (F1 and F2) and an apple storage company (S1), involving a very complex and time demanding methodology.
Concerning the apple farming stage, despite some differences between the two farms, very similar patterns with regard to energy use, water use and GHG emissions were found. Irrigation was identified as the major contributor to energy and water consumption and to GHG emissions. Irrigation accounts for more than half of the total energy consumption, with 79% for F1 and 51% for F2. Similar contributions were found for GHG emissions resulting from the use of the different sources of energy. However, it doesn't necessarily mean that apple farmers should lower water consumption to become their cultivation more eco-efficient, since apple yields are directly related to water use although its excessive use can lower efficiency levels. Increasing eco-efficiency means more value per impact and, in that way, farmers with

high water consumption but also with high yields can simply improve their eco-efficiency by using more sustainable energy sources.

With regard to storage stage, a large part of the energy is used for apple refrigeration, either in normal or controlled atmosphere, process that guaranties apple availability throughout the year. Industrial cold is therefore the process that should require special attention whenever storage companies intend to improve energy and environmental performance. The continuous maintenance of cold systems is fundamental, because the constant need for its use wears off the equipment, reducing its energy efficiency. Unlike other food systems, where farming represents the most energy demanding stage, the long-term storage of apples is responsible for significant energy consumption, having also a large contribution for the apple carbon footprint. So, improvements should be accomplished in both stages in order to increase the Eco-efficiency in the apple sector.

Although the analysis presented in this article needs to be complemented by further developments based on LCA and other tools, it provided a major insight on the eco-efficiency aspects of the two most relevant stages of the Portuguese apple production chain, helping its players to improve their environmental performance.

Acknowledgements

This research was co-funded by the project ECODEEP (Eco-efficiency and Eco-management in the Agro Industrial sector, FCOMP-05-0128-FEDER-018643) and project INOVENERGY (Energy Efficiency in the Food Industry sector, FCOMP-05-0128-FEDER-018642).

The authors gratefully acknowledge the involved apple farmers and the storage company for providing relevant data for this study.

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Biochemical Effect of Antioxidant Nutraceuticals and Functional Foods on Hematology and Serum Lipid of Healthy Wister Rats

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Scientific Research supports biological activity of antioxidant Nutraceuticals and Functional foods. The study compared effect of these two antioxidants in healthy albino rats of the Wistar strain. Eighteen (18) albino rats of opposite sexes weighing between 150-300g were randomly assigned to three groups of six animals each. The control group- Group C were fed with rat chow (vital feed) and clean drinking water, Group A were fed with nutraceutical supplement consisting of caplets of vitamin C - 60mg/day and B-carotene mixed with vitamin E - vitamin A as β-carotene-12,500IU, vitamin E- 200IU and clean drinking water was also given. Group B were fed with functional foods (Oranges, carrot and soybean) and clean drinking water. Hematological parameters were positively influenced by the vitamin supplementation ($p>0.0\ 5$) and greatest effect was achieved in group B. The result also showed a significant ($P>0.05$) decrease in TC, TG and LDL-C in the antioxidants treated groups compared to the control and a non-significant ($P<0.05$) increase in HDL-C.

Keywords: Antioxidants, Nutraceuticals, Functional Foods, Hematology, Lipid Profile

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Introduction

Nutrition science during recent decades has been focused on the detection and understanding of deficiencies. With increasing knowledge of the existence and action of vitamins, specific recommendations were given with the aim of avoiding classical deficiency diseases (Knight, 2000). However, the increasing knowledge about micronutrient including minerals and further compounds like carotenoids, flavonoids, anthocyanin on a molecular level together with result from epidemiological studies open a new and exciting field of nutrition science. Free radicals are known to have effect in the pathogenesis of tissue injury in many diseases which is detrimental to the cell (Devasagayam *et al,* 2003). They produce cellular injury by lipid peroxidation, enzyme inhibition, damage DNA and degradation of structural proteins (Devasagayam *et al,* 2003). The body has multiple defence mechanism against free radicals, these include vitamin A, vitamin E, superoxide dismutase (SOD), catalase, glutathione peroxidase (GPx), under normal circumstances there is a critical balance between pro-oxidant and antioxidants (Vertuani *et al,* 2004) . The compound that have been studied most extremely are the antioxidants, many potential benefits have been attributed to antioxidant in the form of dietary intake or supplementation. Antioxidant in general may be useful in the prevention of cancer and cerebrovascular diseases, supplementation with vitamin C may be beneficial in the management of asthma and high dietary intake of vitamin E may prevent Parkinson diseases (Ogden *et al,* 2000, Wood-Kaczmar, 2006, Di Matteo and Esposito, 2003). An important field of research today is the control of 'redox' status with the properties of food and food components. However, natural antioxidants present in the diet increase the resistance toward oxidative damages and they may have a substantial impact on human health (Boskou, 2006). The concepts of antioxidants, free radicals, and singlet O_2 species are terms that have been topics of research for decades (Azizan, 2006). Antioxidant compounds play an important role in our body due to their favourable effects on human health. Consumption of foods containing phytochemical with potential antioxidant properties can reduce the risk of human disease (Temple, 2000).Oxidation Chain breaking antioxidants are highly reactive with free radicals and form stable compounds that do not contribute to the oxidation chain reaction (El Diwani *et al*, 2009). In the past five years, the world has witnessed the explosive growth of a multi-billion dollar industry known as nutraceuticals. The term "nutraceutical" combines the word "nutrient" (a nourishing food or food component) with "pharmaceutical" (a medical drug). The word "nutraceutical" has been used to describe a broad list of products sold under the premise of being dietary supplements (i.e. a food) and most times in predispose form with the intention of treatment or prevention of diseases, but for the expressed intent of treatment or prevention of disease (Dzanis,1998).Canada defines functional foods as "ordinary food that has components or ingredients added to give it a specific medical or physiological benefit, other than a purely nutritional effect" In Japan, all functional foods must meet three established requirements: foods should be (1) present in their naturally-occurring form, rather than a capsule, tablet, or powder; (2) consumed in the diet as often as daily; and (3) should regulate a biological process in hopes of preventing or controlling disease (Hardy,2000). These foods contain biologically active substances such as antioxidants that may lower the risks of certain diseases associated with aging (Shibamato *et al*, 2008). Examples of functional foods include fruits and vegetables, whole grains, soy milk, enhanced foods and beverages and some dietary supplements.

Objectives of the study: The study compared effect of the antioxidants on hematology and serum lipid and lipoproteins of healthy wister rats**.**

Methodology

Animal study/treatment: Eighteen healthy adult albino rats of opposite sexes of weight 150-300g, were randomly grouped into three experimental groups of six rats in each group. Group A (control) nutraceutical (Forever living capsules: Vitamin C(60mg/day); β -carotene/ Vitamin E (2,000 mcg of Vitamin A and 10mg) respectively. Group B (Treatment) Functional foods (oranges, carrot, and soyabean). Group C (Placebo) no antioxidant group.

Study design: Animals in the three groups fed on rat chow and water *ad libitum*. Dietary intervention commenced after two weeks of acclimatization. Antioxidant supplementation was for ten weeks.

Preparation of blood samples: Blood samples were collected from jugular veins of sacrificed animals in sterile bottles and 0.1% EDTA bottles, serum was collected from sterile bottles after centrifugation at 3000 rpm for 5 minutes and used for plasma lipid and lipoproteins. While 0.1% EDTA bottle samples were used for hematological analysis.

Sample assays: Lipid profiles were analyzed using reflotron system (cholesterol and high density lipoprotein were analyzed by, Third report of National cholesterol education programme, 2001; Triglyceride was analyzed by GPO-PAD method of Tiez; Low density lipoprotein was Calculated with Chawla, 1999). Hematology (Hemoglobin, White blood cells, Red blood cells, and Platelet counts) were analyzed using fully automated Abaccus Junior hematology analyzer based on Coulter method for counting cells that pass through an aperture.

Statistical calculation

Data collected were expressed as mean $\pm$standard deviation (SD) and the Students T-test were used for analysis. Values of $P<0.05$ were regarded as significant.
Results and Discussion

The result of effect of nutraceuticals and functional food antioxidants on some hematological parameters and serum lipid of healthy Wister rats has been presented in tables 1-2. Statistical analyses of the results showed that the dietary supplements significantly increased ($p<0.05$) the levels of WBC, RBC, PCV and HC Compared with the control. Also there is a significant decrease ($P<0.05$) in the levels of LDL, TC and LDL. However, there is a non significant increase ($p>0.05$) in the level of HDL when compared to the control.

Among most aficans and other part of the world. The use of food supplement is steadily gaining acceptance as a mean of preventing diet related diseases. In this present study, the effects of dietary supplements (nutraceuticals and functional food antioxidants) is observed on lipid profile and some hematological parameters of healthy the treatment brought about a significant increase($p<0.05$) in the levels of WBC,PCV,RBC and HC. A significant increased in catalytic activities of erythrocytes

were found in the treatment groups (A&B) when compared with the control group(C) ($p<0.05$) (Chakra borty *et al.,* 2001). The increase is probably due to an increase in the proportion of red blood cells, and the compensatory mechanism after increased oxidant stress (Filiz *et al.,* 2005). Erythrocytes are protected from oxidative stress by intracellular enzymes such as superoxide dismutase (preventive antioxidant) and several other constituents such as vitamin E, A and C. The highest white blood cell count was recorded in group B (7.44±0.17) and lowest in group C (4.46±0.34).

This therefore suggests that after feeding with the supplement, the leukocytes levels of the test group increases which helps to defend the body against infectious diseases and foreign material (Alberts, 2005). An important part of this defence mechanism is the production of active oxygen and its reactive derivatives (e.g., hydrogen peroxide, hydroxyl group, and singlet oxygen) by NADPH oxidase, an activated specific enzyme system (Babior, 1978; Robinson and Badway, 1995; Kobayashi et al., 1998). Also there is a significant increase ($p<0.05$) in haemoglobin levels of the test groups compared to the control. the increase in the haemoglobin concentration increases it function in the blood by carrying oxygen from the respiratory organs (lungs or gills) to the rest of the body where it releases the oxygen to burn nutrients to provide energy to power the functions of the organism and collect the resultant carbon dioxide to bring it back to the respiratory organs to be dispensed from the organism.

The Packed cell volume level, increased significantly ($p<0.05$) in group B (feed with nutraceuticals) when compared to group A (feed with functional food) and the control group (group C). This implies that, there is an increase in the levels of antioxidants in the test groups when compared to the control after treatment

The result also showed a significant decrease ($p<0.0.5$) in the levels of Total cholesterol (TC), low-density lipoprotein (LDL) and a non significant increase ($p>0.05$) in high density lipoprotein (HDL).This may be due to ability of the vitamins to inhibit the oxidation of HDL even in humans (Hillstrom, 2003). A plausible explanation for the observed effect on serum lipids may be due to the activation of the enzyme 7 α-hydroxylase by vitamin C which enhances the conversion of plasma cholesterol into bile acid hence resulting in a decrease in serum levels of cholesterol. In fact (Mayes, 1996) observed that deficiency of vitamin C and E inhibits 7α-hydroxylase leading to the blockage in bile acid synthesis and accumulation of cholesterol in serum with subsequent atherosclerosis in scorbutic Guinea pigs. The present result agrees with previous reports as documented by (Rezaian *et al*, 2002) who reported that the antioxidant vitamins C and E alone or in combination decreased the serum cholesterol and low-density lipoprotein cholesterol (LDL-C) levels and raised the serum levels of high-density lipoprotein cholesterol (HDL-C).

Also (Chatterjea and Shinde 2002) observed a reduction in serum cholesterol levels in experimental animals administered with vitamin C. It also directly meditates through a rate limiting hydroxylation of side chains, the conversion of cholesterol into steroid hormones as documented by (White *et al*, 1978). The reduction in LDL-cholesterol points to the fact that adequate vitamin C intake can reduce the incidence of atherosclerosis. Anderson *et al,* 1999; Bsoul and Terezhalmy, (2004) noted that animal fed on vitamin C and E had reduced risk of coronary Heart disease. The observed decrease in total cholesterol, and most significantly the ability to lower the levels of the atherogenic predisposing factor (serum – LDL cholesterol) yet

desirably increasing the level of HDL implies that dietary vitamin C on account of its effect on lipid profile may have a protective effect against atherosclerosis.

Conclusion

In conclusion, the treatment of adult albino rats with the vitamin A, vitamin C, and vitamin E together improves the antioxidant status of these rats and protects their organs from the damage resulting from iron overload as compare to the untreated group. Also, treatment with antioxidant vitamins is known to improve the liver functions and reduced the percentage haemolysis of erythrocytes therefore improving the total haemoglobin concentration, white blood cell, packed cell volume and platelet. Also, since the dietary supplements brought about a decrease in the levels of low density lipoprotein and total cholesterol and an increase in high density lipoprotein levels, therefore the dietary supplements may therefore protect against arteriosclerosis and attendant coronary heart disease (CHD) and does not also predispose to hypertension.

Table 1: *Effects of dietary supplement on lipid profile of Albino Wistar Rats (mmol/L).*

Groups	Cholesterol	TG	HDL	LDL
Group C	2.92±0.08	2.10±0.07	0.95±0.25	0.94±0.16
Group A	2.00 ±0.20	0.75±0.39	1.52±0.08	0.36 ±0.05
Group B	2.11±0.13	0.80±0.38	1.50 ±0.29	0.40 0.27

Values are represented as mean±SD of three separate determinations from six rats. Values are not significantly different (p>0.05) from the control (group C)

Table 2: *Effect of dietary supplements on Haematological parameters of Albino Wistar Rats* (*mmol/L).*

Groups	WBC	RBC	PCV	HC
Group C	7.44± 0.34	2.28 ± 0.27	36.00 ± 2.92	13.12 ± 0.87
Group A	4.72 ± 0.19	4.48± 0.11	47.20 ± 1.30	18.8 ± 0.16
Group B	5.46 ± 0.17	5.28 ± 0.19	49.60 ± 1.14	18.50± 0.21

Values are represented as mean±SD of three separate determinations from six rats. Values are not significantly different (p>0.05) from the control (group C)

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The Justification for Further Research into Energy Saving Behaviour in the UK: A Literature Review

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
This paper presents the findings of a literature review into energy saving behaviour. The first section examines research conducted within a domestic environment. The previous research was investigated for both limitations and correlations. The second section of this research also analyses past studies into energy saving behaviour but within a variety of different commercial companies, investigating the success rates with these initiatives and the formula for effective motivational tools. A particular emphasis was placed on the comparison of UK based research with investigations conducted over the rest of the world. It was found that at present the greatest percentage of studies focus on energy saving behaviour in households but that the scope and remit of these papers had great variations. This literature review also highlighted, that although the UK has only a small percentage of previous research conducted in a domestic environment the primary shortage of research exists in the commercial sector. This paper concludes that not only should more research be conducted in both domestic and commercial environments due to the limitations of the existing studies, but that there is a pressing need for this to be conducted in UK premises.

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Introduction

Energy conservation can be achieved through both, the adoption of technical measures and the changing of behaviour (Aini, Chan & Syuhaily 2013). Consequently, energy conservation and related environmental issues are of increasing interest for psychological research (Corradi et al 2013)& (Viklund 2004). Breukers et al (2011) commented that for energy saving strategies to be successful new research would need to take a transdisciplinary integration approach. This approach has resulted in a fast-growing field of research that focuses on both, the adaptation and resilience of buildings and the adaptation of their occupants to a changing climate (De-Wilde & Coley 2012).

It has also been proposed that if energy reduction measures are to be successful, then it is important to examine its effectiveness in three different sectors; 1) changes in direct and indirect energy use, 2) changes in energy-related behaviours & 3) changes in behavioural antecedents (Abrahamse et al 2007). Environmental concerns are tied to a person's notion of self and the degree to which they are interdependent with living things. These concerns may serve as the key motive for green behaviour because a person's attitude towards environmental concerns is usually rooted in his/ her own value system (Moon et al 2013), hence the growing importance of behavioural studies in the field of energy conservation.

Within this paper, previous research into energy saving behaviour has been examined in two broad categories; 1) Households and 2) Commercial premises, with the greater focus on the latter and the implications for UK businesses. The total number of papers investigated within this literature review are 113, all conducted since 2002.

Energy saving behaviour in households.

The residential sector accounts for one-fifth of global energy consumption, from daily needs, and has therefore gained importance in recent years (Brounen, Kok & Quigley 2013).

There have been numerous papers that investigate the link between household energy conservation and consumer behaviour. These studies have encompassed a broad range of countries.

Allcott (2011) evaluated an energy saving exercise by OPOWER a nationwide energy company in the USA. OPOWER ran a series of programmes in 600,000 households across the US that involved sending their residential customers a two part letter. The first part of the letter compared the customers personal energy usage to that of their neighbours- the customers were given one of three ratings. The ratings used a simple but effective smiley face system- "Great" received 2 smiley faces/ " Good" received one smiley face/ " Below average" received two frownie faces. The frownie faces in particular proved so emotive with consumers that high levels of customer complaints ended this practice ("Below Average" had the frownie faces removed). The second part of the letter included simple but personalised action tips for the resident that were based on the customers energy use and housing profile. Allcott (2011) evaluated the findings from the OPOWER research concluding that these simple letters and residential energy saving tips had the potential to save 20% energy usage. One of the most positive aspects of this study is it's accessibility to all residents regardless of

socio economic profile, environmental awareness, home owner status and educational level. This, therefore, makes this method worth considering in future studies and is highly applicable in future research in the UK.

Many studies have been conducted into household energy saving behaviours in China; among those was Wang , Li & Li (2011). Wang, Li & Li (2011) proposed a conceptual model of environmental responsibility affecting household energy, in a sample area of Xuzhou, China. Results showed 3 principal findings; 1) The stronger the environmental responsibility is the stronger the energy- saving behaviour intention is, 2) the stronger the energy-saving intention is, the stronger the behaviour of residence energy saving investment is & 3) the environmental responsibility has an indirect positive effect on the behaviour on the behaviour of residence energy saving investment via the energy-saving behaviour intention. This study disagreed with Yue, Long & Chen (2013), as they found no statistical relationship between any demographic variable other than ownership of house, family structure and education level. The main limitation of this study by Wang, Li & Li (2011) is the small sample size- 212 households in one area. Ma, Andrews-Speed & Zhang (2013) state that the Chinese government will need to develop new strategies and measures to inform and educate its citizens on energy saving at home.

Mizobuchi & Takeuchi (2013) conducted a study to evaluate the influences of both financial and non-financial factors on encouraging electricity-conservation behaviour, within randomly selected Japanese households over an 8 week period. Within this investigation were three groups 1) reward only, 2) reward with comparative feedback (their households performance in comparison to others & c) a control group. Both a pre and post experimental questionnaire was also conducted with all participating households. Mizobuchi & Takeuchi (2013) concluded that, like many similar studies before, a financial incentive is effective in encouraging electricity conservation but that the findings of the comparative research were inconclusive. Although this study proved statistically positive for showing the effectiveness of financial reward against energy conservation, the timeframe of 8 weeks is too short. There are also other contentious issues within this paper including the proposal of an New Ecological Paradigm (NEP). The NEP worked on participant's agreements/ disagreements (either strongly or partly) with 15 different statements. The questions used within the NEP tended to have a moral or ethical basis, rather than a scientific quality. Examples of these included: "Humans ingenuity will insure that we do not make the earth unliveable", "Plants and animals have as much right as humans to exist" & "The earth is like a spaceship with very limited room and resources".

One of the challenges that arise when comparing research completed in countries that have a markedly different culture is assessing their relevance to studies in a westernised society. For example, research by Na Na, Sung & Jeong (2012) conducted into apartment's residents' energy saving awareness and behaviour in Korea using questionnaires. However, the questionnaire options showed inequality between male and female participants. This inequality would be unacceptable in a westernised society so puts the validity of the findings into question when considering it's suitability for testing in the UK.

Numerous energy conservation research papers have been published from studies in Europe, with the majority of research hailing from Sweden and The Netherlands. Back in 2006 Linden, Kanyama & Eriksson, conducted a questionnaire study within 600 Swedish households to provide an insight to current energy saving behaviour patterns. It was found that many of the households questioned had energy inefficient behaviours that existed, either due to a lack of education/ awareness or even through "habit". Linden, Kanyama & Eriksson (2006) concluded that further work was necessary and suggested that a combination of information, economic measures, administrative measures, more user friendly technology and equipment with a better aesthetic quality. The two main limitations of this study was that all the 600 households questioned live in the same city and secondly that the combination of measures to improve residents energy saving behaviours suggested by Linden, Kanyama & Eriksson (2006) have not been tested and only existed as an untested theory.

Han et al (2013) conducted a study to investigate how local government in the Netherlands could use interventions effectively to stimulate local residents to save energy. It was found that feedback, rewards and financial incentives are the most positively effective, whilst information, demonstration, free products and commitment were not. Limitations within this analysis included a low response rate, small geographical area sampled and detailed technical characteristics of the dwellings themselves were absent, so it would have been unclear how this would have affected the behaviour of the residents. Wood & Newborough (2003) agree with Han et al (2013) that regular feedback was vital to increasing energy conservation behaviour.

Sardianou (2007), conducting research in Greece, partially agreed with both Martinsson, Lundqvist & Sundstrom (2011) and Mills & Schleich (2012). The Greek research examined seven energy saving variables and compared the responses against the demographics of the respondents. Several results were found. Firstly the results indicated that as income increased households tended to be more willing to conserve energy as with their higher levels of affluence they could afford to invest in more energy saving technologies. Secondly sex, educational level and marital status do not affect householders choice with regards to the combination of energy saving activities undertaken. Thirdly, home ownership status has a positive correlation with energy conservation behaviours/ activities. Next, Sardianou (2007), found that age was a statistically significant variable, as the age of the respondent increases, the number of reported energy saving conserving actions decreases. Lastly, environmental awareness was found to be a strong predictor of energy saving behaviour, which agrees with many previous studies. The main limitations with this research was that the questionnaires used were only limited to seven variables which only consisted of one simple question each. Martínez-Espińeira, Garćia_Valińas & Nauges (2014) agreed with the findings of Sardianou (2007) stating that both affluence and environmental awareness could have both a direct and an indirect effect of households energy saving behaviour. The research conducted by Martínez-Espińeira, Garćia_Valińas & Nauges (2014), in Spain, stated that campaigns to raise environmental awareness should take into account differences in terms of socio-demographic household characteristics and would therefore be made more targeted for each individual household, depending on their differing circumstances. However, Martínez-Espińeira, Garćia_Valińas & Nauges (2014) did note that in most circumstances this would be prohibitively expensive and therefore not cost effective. The main limitation of this research was

that only six energy conservation variables were used to test the households environmental awareness and these variables were very simple in nature, an example being do you fill, (to the top), the washing machine before using it.

Energy conservation within a domestic environment in the UK, has also been a growing concern for research in recent years, with the frequency of published papers increasing every year.

Scott, Jones and Webb (2014) designed a research framework to improve understanding of how people living in deprived communities, (in Yorkshire and The Humber), think about energy use and, in particular, what they think about different household energy efficiency interventions that were being proposed as part of a project known as "The BIG Energy Upgrade". Different communities received different household energy efficiency interventions depending on eligibility and funding from external sources. These interventions included cavity wall insulation/ Loft insulation/ External solid wall insulation/ Fuel switching/ Heating controls/ Solar water heaters/ PV panels/ Boiler replacements/ Window glazing improvements/ Voltage optimisation/ Smart meters and Energy advice provided by Yorkshire energy services. It is worth noting that all the various communities received energy advice from Yorkshire Energy Services. Scott, Jones and Webb (2014) the Theory of Planned Behaviour (TPB) as a framework to analyse how residents felt about a particular development. FIG 1 shows the items used to measure perceived benefits, familiarity, and beliefs specified by the TPB.

Their responses were then measured against various factors such as; home ownership/ membership of a community organisation/ Exhibition of green behaviours/ Belief in our ability to tackle global climate change/ Belief that global climate change is currently affecting or will affect you/ Income/ Educational attainment/ Belief in global climate change/ membership of an environmental organisation and familiarity with energy conservation interventions.

Scott, Jones and Webb (2014) made the following conclusions;

- Home ownership had a positive correlation with the intention to invest in the energy saving interventions.
- Belief in global climate change itself had no significant effect on intentions but both, belief in humans being able to tackle global climate change and belief that global climate is currently affecting/ going to affect had a positive effect on respondents attitude to the energy conservation interventions.
- Familiarity with energy efficient interventions had a positive effect on respondents willingness to adopt said interventions.
- Income, educational attainment and membership of local community group did not have a significant effect on willingness to adopt any of the interventions.

Construct	Items
Perceived Benefits	-To what extent do you feel the proposed improvements will benefit your household? - To what extent do you feel the proposed improvements will benefit your community? - To what extent do you feel the proposed improvements will benefit your council?
Attitudes	- "X" would help me to reduce my energy bills - I would feel good about having "X"
Subjective norms	- People who are important to me would want me to have "X"
Perceived behavioural control	- It would be easy for me to have "X" installed in my home
Familiarity	- How familiar are you with "X" as a way to conserve energy?
Intentions	- I would be willing to have "X" installed in my home - I would be willing to contribute financially to have "X" installed in my home

Fig 1. Table deomstrating Items used to measure perceived benefits, familiarity, and beliefs specified by the Theory of Planned Behaviour (TPB) taken from Scott, Jones and Webb (2014), pp340, Table 4.

One of the main limitations of this research is the differences in the interventions between the various communities. For example, deprived communities in Leeds only received external solid wall insulation and energy advice whereas deprived communities in North East Lincolnshire received External solid wall insulation, Fuel switching, Heating controls, window glazing update, Voltage optimisation, smart meters and energy advice. The second limitation was that of the targeted 1121 households only 279 questionnaires were returned, so there was only a percentage response rate of 25%. It also worth noting that of the return questionnaires the responses varies greatly between the different communities (see Fig 2) and this would have had effects on the results that were not taken in to account.

Local Authority	Targeted Households	Questionnaire responses received	Percentage response rate (%)	Percentage of total sample (%)
Barnsley	271	63	23	23
Doncaster	288	147	51	53
Kirklees	201	39	19	14
Leeds	60	10	17	4
North East Lincolnshire	50	5	10	2
North Lincolnshire	251	15	0.2	5
Total	1121	279	25	100

Fig 2. Table to show Questionnaire distribution and response in each local authority area adapted from Scott, Jones and Webb (2014), pp 339, Table 3.

Not only, is there several conflicting opinions on the barriers and drivers in motivation of householders to engage in energy saving activities but there is also s distinct lack of research being carried out in the UK, Table 3.

Energy saving behaviour in commercial premises.

Employees constitute an important target group for energy saving, but only a few research efforts have been paid to study what drives employee energy saving behaviour in organisations (Zhang, Wang & Zhou 2013). Janda (2014) suggests that a significant challenge exists when improving the energy performance of commercial buildings as it is necessary to understand and tackle the complexity that stems from the inter-relationships between 3 different factors. Janda (2014) proceeds to list these factors as;

a) Physical and technical factors (The range and variety of commercial building stock, the existing technologies they were designed to contain, the state of current operational systems.
b) Social and organisational factors (The number of stake holders- investors, developers, agents, owners, tenants, facilities managers, users of the space [employees and customers] and mixtures of these groups.
c) Legal factors (lease hold etc).

It is imperative that working environments should not only provide comfort to occupants but, they should also be in line with energy saving practices and promote energy conservation and energy efficiency (Nisiforou, Poullis & Charalambides 2012). Teng et al (2012) stated that for energy conservation strategies to work in organisations then effective communication and participation with both internal and external stakeholders was vital. These communications should include raising-awareness, training, educating and even offering incentives to increase motivation. Cagno (2013) identified barriers to energy conservation in industry. Two of the barriers were stated as “Lack of information” and “Financing”.

Since the Japanese tsunami in 2011 and subsequent energy shortages, there has been an increasing number of research papers into energy conservation behaviours in Japan (Hori et al 2013), (Mizobuchi & Takeuchi 2013) and (Hamamoto 2013). Energy conservation has been made number one priority with Japanese companies, even changing traditional cultural practices to facilitate greater energy efficiency (Davies 2013).

Jiang & Tovey (2009) introduce a sustainability approach, tested in a commercial environment in Japan. This approach concentrates primarily on three complementary aspects: a) the introduction of an effective energy management system, b) the incorporation of relevant advanced energy saving technologies and measures and c) the promotion of awareness among occupants to make changes in their behaviour towards a more environmental-friendly behaviour. Unfortunately the behaviour management was not investigated in detail within this study as the paper only made reference to three aspects of change; closing windows and doors, turning off lights and appliances and lastly wearing different “summer” clothes to work in place of a conventional suit.

Zhang, Wang & Zhou (2013) proposed a theoretical model of employee energy saving in China, using a research model where personal norm and electricity saving as

predictors of employee energy saving behaviour (personal norm referring to an employee's moral obligation to save electricity in one's company). Through the literature review 7 hypotheses were constructed and statistical analysis showed that people's personal norm positively influences electricity saving behaviour. There were limitations to this research; only office workers were enlisted to take part in this study and the study only conducted in one region in China and may not have the same implications for studies carried out in more westernised societies.

Prukvilailert & Wangskarn (2011) reported analysis of an energy-conservation-participation-scheme governmental initiative in Thailand. The scheme was ran as the Thai government had suggested that "most small-and-medium sized organisations are not able to perform energy conservation activities by their own because lacks of technical skills and workers", however, the evidence for this statement was not included within this study. The government participation scheme was set to run throughout 2009-2010, although the evidence used within the surveys was actually collected over a single month within this time-frame (February 2010-March 2010). Workers within these factories (117)/ commercial premises (18) were asked to attempt to make 830 energy saving measures. After the energy saving measures were implemented the workers were then asked to provide their opinion of the measures and their importance. This study was limited in several ways; as already mentioned the lack of evidence for the original statement on which the investigation is based, it was limited to 135 companies, the majority of the companies used were factory based and the short time-frame for gathering research, but it was also limited in other approaches. The surveys used to assess the workers attitudes to the implemented measures were restricted to only 5 categories of priority, (very-high, high, medium, low and very-low) and the surveys themselves were also limited (opinions on the activities themselves, improvements to these activities and satisfaction from these activities). It is worth noticing that the study highlights that future support within Thailand should include training, raise-awareness (within companies) and the introduction of new technologies.

Although a number of strategies have been advocated to foster carbon reduction in the built environment but few studies have acknowledged that strategy adoption is a matter of organisational culture. Wong & Zapantis(2013) developed a theoretical model to examine the relationship between carbon reduction drivers , strategies adoption and organisational culture. It was concluded that significant relationship between the carbon tax and adoption of carbon reduction strategies can be further enhanced by organisational culture in terms of goal clarity, rewards and innovation, however, it was also noted that much more research is needed, particularly relating to policy implementation (Wong & Zapantis 2013).

Peschiera & Taylor (2012) analysed feedback on employees' energy usage, through a peer feedback network. It was commented that within an office environment when participants received energy consumption feedback there was a positive effect as it promoted the implementation of more energy saving practices as more peers share energy information. This research was conducted in New York but was limited as the sample size was 22 rooms within an office environment. Another limitation was the fact that when a room had more than one occupant the energy usage total would just be divided between number of occupants, rather than establishing a true figure for each employee. This had implications, due to the fact that if an energy conservation

consequence employee occupied the same room as an energy wasteful employee, they would cancel the effects of each other's energy consumption levels.

Carrico & Riemer (2011) also conducted a study into the energy-saving behaviour within employees in 24 office buildings within a southern state university. (It should be noted that this study is included within the commercial premises section and not the educational establishment section as the students that attended the university were not surveyed within the research). The research employed two different but "easy to implement" intervention techniques to assess energy-saving potential, in the form of electricity use. Carrico & Riemer (2011) justified that research stating that behaviour within an organisational setting poses a particular challenge to those wishing to promote energy conservation because employees typically have no direct financial incentive to reduce energy use and rarely have access to information regarding their level of consumption. The first method used group-level feedback on energy used over the last month and reinforced this with a positive encouragement statement "Keep up the good work" if the building had achieved a reduction in electricity use. The second method used "peer-education", from 15 who had received training prior to the study. A control measure was used within the study, employees within buildings that received neither of the intervention techniques were targeted by an information campaign. This consisted of a series of four postcards delivered to the occupants' mailboxes. The results of the research indicated that feedback and peer education resulted in a 7% and 4% reduction in energy use, respectively. It was also found that buildings that received the control measure actually experienced a 4% increase in energy use. Carrico & Riemer (2011) concluded that further work would be needed to explore these results. Limitations of this study include the use of volunteers who only received a short training session were used to conduct the peer education sessions. These volunteers received no payment or incentives for their efforts, nor were they screened prior to their training to see whether they were likely to be successful in motivating other staff members or to assess their prior knowledge. This short-coming was demonstrated by only 2 out of the 15 peer educators complying fully with the demands of the program instructions. A different, but major, limitation in this research was that monthly electricity bills, for each building, were used to assess energy savings made but that how these energy saving measures were achieved were not tested or measured or even included in the study.

Paille & Mejia-Morelos (2014) assessed employee energy conservation behaviour within companies in Canada using several psychological frameworks, regarding Pro-environmental behaviour (PEB) in the work place. One of the conclusions made from this study was that there is a positive correlation between employee commitment to an organisation, job satisfaction and PEB. The main limitation of this study was that even though real participants and their attitudes/ behaviours were surveyed no energy data, (gathered, utility bills or even historical library data) was used to calculate actual energy saved through behavioural measures.

There have been numerous studies conducted within Europe to assess energy conservation and the cost effectiveness of energy conservation measures within various companies; an example being Burke & Blesl (2014), who investigated energy saving measures in the steel industry, but few of these studies relate this research to the behaviour of the staff themselves. Research from Sweden identified that expressing environmental friendly attitudes, within the work place, significantly

increase the adoption of energy saving and renewable technologies and also result in a greater engagement in energy-efficient behaviours (Borgstede, Andersson & Johnsson 2013). Tabi (2013) disagreed with these findings, stating that in Hungary there was no significant difference the energy consumption between environmentally aware employees and non-environmentally aware employees. The study by Tabi (2013) was limited to questions based on monthly energy expenses and the research by Borgstede, Andersson & Johnsson (2013) was based on the analysis of surveys from two opinion polls only.

Nisiforou, Poullis & Charalambides(2012) presented a study that investigated the energy usage habits of a large commercial company in Cyprus. A detailed questionnaire was circulated to all staff to assess behaviour, attitude and opinion on energy usage and energy saving measures. Nisiforou, Poullis & Charalambides(2012) also analysed decisions made by the upper management and its role in energy management. Five simple actions were recommended to improve both energy efficiency and the image of the company to its employees. These recommendations were deliberately kept simple so they could be adapted and applied to a variety of commercial buildings. Nisiforou, Poullis & Charalambides(2012) also highlight the lack of promotion of energy saving measures by upper management.

There has been very little research documented within UK commercial premises. Currently UK non-domestic building stock contributes 18% of the UK total carbon emissions (Carbon Trust 2009). Murtagh et al (2013) investigated the effect of individual feedback on energy use at the workdesk, to test the relationship between individual determinants, energy use and energy reduction. They conducted a field trial with 83 office workers in the same work place. It was found that energy saving behaviour through feedback diminished overtime and that an absence of motivation to undertake energy reduction actions were in evidence. Despite national plans in the UK to save energy in small and medium businesses there is little knowledge of occupant energy use in office buildings and individuals commitment to energy conservation (Murtagh et al 2013). Delmas, Fischlein & Asensio (2013) also agreed with this finding. Limitations of this study to be noted include the small sample size and and short time frame of 16 weeks.

Discussion

Various research articles concerned with reducing energy consumption and achieving energy efficiency in different environments have been discussed in this paper. Fig 3 shows the breakdown of percentages of the different studies in the three environments. It is clear from these results that the commercial are deficient when assessing energy saving strategies, with 80% of past research focusing on the domestic environment. The evidence clearly shows that the UK needs to fund research in all three sectors but especially the commercial sector.

Breakdown in continent/ country	Percentage breakdown of journal studies published in the last 10 years into Energy-conservation behaviour, type of building and country of field trial.(%)	
	Domestic	Commercial
World-wide	80	20
Europe	42	8
UK	14	3
Rest of the world	38	12

Fig 3.Table to demonstrate the distribution of field trials into energy conservation behaviour and the percentage of studies between different building type,* based on 113 research papers into Energy conservation behaviour.

Fig 4 presents the percentage breakdown of number of questions used in research that had questionnaires in their methodology. The greatest percentage of questionnaires contained over 20 questions. This number would allow the researchers to elicit the required information from participants. Questionnaires that were restricted to a smaller number of questions were only capable of eliciting simple information such as Jiang & Tovey (2009), whose research asked three simple questions; closing windows and doors, turning off lights and appliances and lastly wearing different "summer" clothes to work in place of a conventional suit.

Number of questions used in questionnaire	1-5	5-10	11-20	20+
Percentage of past research papers (%)	29	15	13	43

Fig 4 Table Demonstrating a breakdown of number of questions asked on the questionnaires (if applicable).

The previous research, examined in this literature review, used a raft of different questionnaire styles and a variety of different questions. Although varied the questions could be categorised in three broad classes: Physical, concepts and Perceptions (Fig 5). Future studies would have to ensure that latter questionnaires had an equal spread across the categories to ensure that no important information was absent.

Examples of questions used within questionnaires in past research papers	
Physical Instructions/ Interventions	• Energy efficient light bulbs • Turn lights off • Use car less • Open windows • Choose Environmentally Friendly Products • Turn computers off • Recycle- various • Use a full washing machine
Understanding of concepts	What is meant by: • Renewable energy • Global climate change • Global warming • Saving energy • Integration of renewables
Perceptions	• Do you care about energy wastage? • How will saving energy effect you? • Is energy saving worth it? • Can saving energy save you money? • Do you family / friends you energy efficient products • Do you know what is meant by energy efficient appliances?

Fig 5 Table showing examples of questions used within past questionnaires divided into three broad categories.

The vast majority of research was limited by the short time frame in which the research was conducted (Fig 6). 60% of the research was conducted under 2 month timeframe. 90% was conducted in under a year. This has ramifications for the scientific basis for the research. To ensure that trends within energy data are reliable then energy audits should be completed for each of the case studies buildings used, which will take a whole year of data collection. The ideal scenario is that energy audits are completed over three years to give a realistic figure of energy consumption for that particular case study.

Time scale for duration of research	2 weeks and under	2 months and under	2 months + to 1 year	1 year +
Percentage of past research papers (%)	5	60	25	10

Fig 6 Table to show the percentage duration of study times between the varying studies.

The greater the number of participants used for data collection the more reliable the results, which was clearly the rationale behind the greatest percentage of past research in this field (Fig 7).

No. of participants used in the research project	0-20	21-50	51-100	100-200	200+
Percentage of past research papers (%)	5	27	9	14	45

Fig 7. Table listing the percentage of research studies with varying numbers of participants.

The greatest percentage of studies were conducted using secondary evidence or based on theoretical modelling techniques rather than actual primary data (Fig 8). This would therefore provide the justification for further study within this field.

Method of data collection/ theoretical modelling only that research was based upon.	Primary evidence	Secondary evidence	Theoretical modelling only- no evidence collected from participants/ case studies.
Percentage of past research papers (%)	21	45	34

Fig 8 Table to show percentage of data collection methods

A variety of motivational tools were used within the past research papers (monetary savings have been omitted from the Table, Fig 9). As you can see from Fig 9 the split across the categories was fairly even but future research should include specific success rates each of the categories.

Type of motivation used to engage participants in energy saving schemes/ projects.	Feedback (Various)	Posters/ leaflets	Social networking	All three
Percentage of past research papers (%)	36	22	20	22

Fig 9 Table to demonstrate different types of motivation used to motivate participants.

Fig 10 demonstrates minor categories used within research papers. These sections should all be included in future work to compare and contrast the differences that exist within them.

Various minor categories include in research papers	Percentage of past research papers (%)
Actual data from energy meters used in the research	29
Research relied upon participants self-reporting evidence	43
Research used feedback "smilie" / "frowny" faces	6
Research limited to a particular field ie electricity only/ water only/ travel efficiency only	23
Research specifically limited to one demographic group ie teenagers	8
Research investigated barriers involved in achieving energy efficiency/ carbon reduction	4
Research not linked to any actual or forecast energy savings	40
Research that employed the use of categorisation by socio-economic groups	83

Fig 10 Table to demonstrate percentages found in various minor categories in past research papers.

Conclusion

This literature review concludes that not only should more research be conducted in both domestic and commercial environments due to the limitations of the existing studies, but that there is a pressing need for this to be conducted in UK premises

Recommendations for further work

- Increased research within the UK, with a particular emphasis on commercial case studies

- Further studies should include 20 questions minimum that encompass three braod categorise
- Research that makes recommendations for a reduction in energy consumption should be conducted over at least a 12month period, employee over 200 participants and gather primary evidence/ data.
- Not only should further work be carried out into motivational tools used for energy reduction but also incorporate an examination of barriers against energy reduction.

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Acknowledgements to : Professor T.T Al-Shemmeri

The Co-Benefits of Energy Efficiency Policy to Manage the Electric Load in Delhi

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Delhi's power demand has been increasing continuously and the dependence on the power from outside has been increasing simultaneously. Satisfying this rapidly rising demand requires huge investments, and these investments usually have significant social, and environmental consequences. The supply-side measures of meeting the growing demand for electricity will require not only increasing generating capacity, but also improving the transmission and distribution systems. The solution to this problem is to use the conventional resources more efficiently, while simultaneously developing new sources of energy. This paper has been written to address a policy designed to reduce the growth rate of electricity demand through adopting more efficient technologies in residential and commercial sectors in the city of Delhi as well as introducing the use of renewable energies and clean technologies in the city's power supply sector. The results show the saving at the end-user level would be 0.75 TWh/yr per annum, which could be achieved through improving lighting efficiency and air conditioning performance and replacing conventional water heater with efficient solar water heater in certain categories of building. On the power supply sector, the introduction of about 5MW of medium- and large-sized PV systems beside the installation of about 100 MW new capacity for hydroelectricity and generating approximately 46 MW electric power from municipal solid waste could enable a sufficient surplus for the power supply sector to meet the city's electricity demand. Finally, the Co-benefit arising from the implementation of the policy in the city of Delhi is estimated about 328 kt/yr

Keywords: Electric load, Co-benefit, supply, demand, Delhi

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Introduction

Managing the electric load is all about matching supply and demand. In some case, cities may be faced with the increasing deficit in power supply, both in meeting its normal electricity requirements as well as its peak load demand. It means that the total installed power capacity is not sufficient to meet the city's electricity demand over the certain time period.

In spite of a total installed power generation capacity of about 7249 MW (as of April 2013), Delhi is still struggling to meet increasing power demand [1] . Delhi is being a city state with diminishing rural areas and agricultural activities, the thrust on the energy front in Delhi is mainly to have uninterrupted power supply and to take care of the increasing power demand. The demand and supply gap in the present phase is estimated about 6.5% due to growing demand. Delhi's demand can go up to 23 TWh/yr or even more and the gap between demand and supply is expected to grow further in the coming years.

The gap between supply and demand can be bridged only with structural reforms in the energy sector. These reforms will however take time to be implemented considering the numerous challenges involved. Consumers can mitigate these rises by taking pro-active measures. Energy efficiency, re-scheduling of operations to benefit from low off-peak tariffs and investment in renewable energy are immediate opportunities for mitigating increase in energy costs.

The aim of this paper is to analyze the power crisis in the city of Delhi as a function of both supply and demand. Given the history of underachievement in meeting the supply-demand gap, we explore some short and medium-term solutions both on supply and demand side. Adding generation capacity alone will not solve the power crisis in this big city. Efforts need to be made on the demand side as well, even though demand-side solutions can not replace supply augmentation in satisfying Delhi's power hunger. So, what short and medium-term options are available on the supply and demand sides? What are the upcoming climate co-benefits of these options? In this paper, we explore these questions looking at the Delhi power system and evaluating possible policy choice.

Delhi Power System

The power requirement in Delhi is met by generating capacity within Delhi, allocations from Central Generating Stations (CGS). The city's power plants, due to problems of low age, generate way below their capacity, at the plant load factor of 45%. The total installed capacity in Delhi is represented in table 1 [2]. The existing network of DTL consists of a 400KV ring around the periphery of Delhi interlinked by the 220KV network spread all over the city [3].

Table 1. Installed capacity to meet electricity demand in Delhi []

	Installed capacity (MW)
Coal fired	4259
Oil fired	297
Natural gas	1886

Nuclear	122
Hydro Power	666
Solar PV	3
Waste-to-electricity	16
Total	7249

The share of coal and other fossil fuels is expected to be about 88.8 per cent in total commercial energy produced by 2013. Other renewables such as wind, geothermal, solar, and hydro electricity represent a 9.2 percent share of the Delhi state electricity mix. Nuclear holds a two percent share.

Delhi has the highest per capita power consumption of electricity among the States and Union Territories of India The per capita consumption of electricity in Delhi has increased from 1259 GWh per annum in 2000-01 to 1448 GWh in 20010-11 [4].

In Delhi, domestic (Residential & Commercial) customers dominate the electricity consumption profile not only in terms of numbers but also in terms of load and consumption. Figure 1 shows the electricity consumption of different sectors.

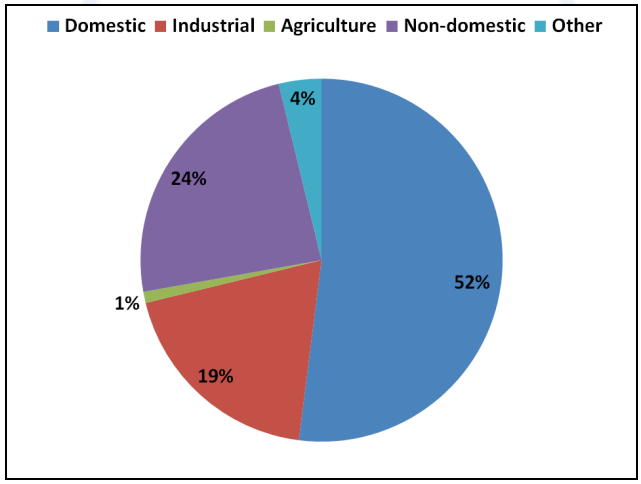


Fig. 1. Delhi sector-wise electricity consumption [3]

Total consumption of electricity in the domestic sector as a percentage of total demand has been increased to 52% in 2010. Total consumption of electricity in Delhi during 2011-12 is 21700 GWh out of which 10396 GWh used for domestic purpose, 6253 GWh used for non-domestic purpose, 2989 GWh used for industrial purpose and rest in others.

There has been a consistent gap between electricity requirement and availability and between peak demand and peak met. The peak seasons in Delhi coincide with that of the other nearby states, thereby creating a peak deficit in the grid. The peak demand is increasing every year, while the load shedding has reduced tremendously. Figure 2 highlights with peak demand in Delhi likely to increase to 5942 MW by 2013, the gap between demand and supply is expected to grow up to 6.5% [5].

Owning to their dominance in the overall consumer profile, domestic consumers also contribute to a high residence of peak load and it would be worthwhile to examine the

introduction of managing demand and improving the efficiency of various end-use appliances to reduce power demand in residential and commercial customers and its impact on the overall load profile of the city.

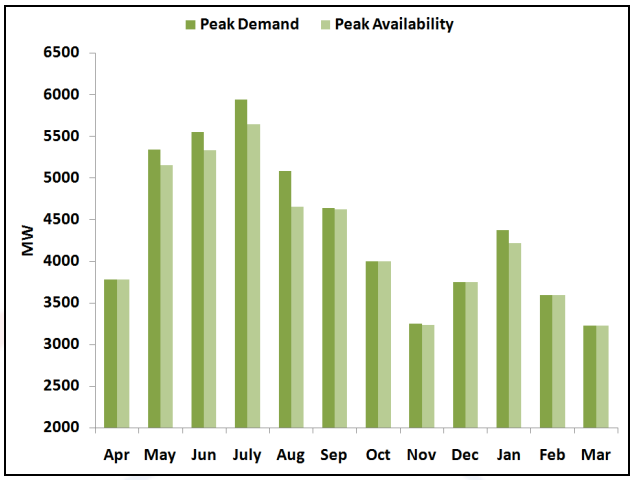


Fig. 2. Month wise power supply/demand position of the city of Delhi during the year 2012-13 (in terms of peak demand) [4]

Methodology

A large number of urban climate-energy evaluation models now exist with different assumptions about the important features of city's profile that need to be incorporated. These models have been developed to incorporate urban features for different applications climate-energy modeling.

SynCity is a model for the integrated assessment and optimization of urban energy systems, developed at Imperial College London and supported by funding from BP. The model has been developed on the basis of a mixed-integer linear programming approach that seeks to satisfy urban demands for housing and activity provision, while minimizing energy demand from buildings and transport [6]. "MEU" is the acronym for 'Innovative tools for planning and management of energy systems in urban areas'. The main goal of this model is to evaluate the impact of the regulatory framework (Laws, subsidies…) on decision processes and on energy supply systems design [7]. An audit tool that evaluates a city's urban mobility policies is developed as QUEST by the European Commission. The aim of the QUEST audit is to support cities in their efforts of developing more sustainable urban mobility systems [8]. ICES Municipal Policy Toolkit takes advantage of cross-sectoral opportunities in the areas of land use, infrastructure, building, water and sanitation, transportation, and waste which is developed by the Canadian Urban Institute [9]. Across these schemes a wide range of urban features is incorporated. The models have varying levels of complexity, and different approaches.

The CAUES (Co-benefits Assessment tool in the Urban Energy System) is a simulation model designed for evaluating the climate co-benefits of an urban energy system in the short term which is developed by UNU-IAS. The tool evaluates climate co-benefits of the urban energy system based on different scenarios of socioeconomic,

technological and demographic developments and relates systematically the climate change based on the specific energy demand in different sectors in cities to the corresponding social, economic and technological factors that affect this demand. The nature and level of the demand for energy are a function of several determining factors, including population growth, number of inhabitants per dwelling, number of electrical appliances used in households, local priorities for the development of certain economic sectors, the evolution of the efficiency of certain types of equipment, penetration of new technologies or energy forms, etc.

The objectives of the methodology which is used through developing the tool can be categorized as follows:

- ✓The structural changes in the energy system of a city in the short term. This is done by means of a detailed analysis of the social, economic and technological characteristics of the given city's energy system. This approach takes especially into account the evolution of the social needs of the population, such as the demand for space heating, lighting, air conditioning, and this as a function of the distribution of population into different dwelling ranges; the city's policies concerning, housing etc., as well as the technological development;
- ✓The evolution of the co-benefits resulting from the structural changes in the energy system.

In this survey, CAUES has been used to simulate the gap between electricity supply-demand of the city of Delhi and to estimate the potential reduction of GHG emission and air pollution by offsetting the existing gap through the following steps:

Estimation of the electricity supply-demand

The tool calculates the total electricity demand for each end-use category, aggregating the Delhi energy system into three main "energy consumer" sectors: Residential, Commercial and Service. According to this procedure, the demand for each end-use category of electricity is driven by one or several socioeconomic and technological parameters, whose values are given as part of the scenario. The calculations for the domestic sector are performed taking into account the living conditions of the population, i.e. the place of residence (city local climate conditions), and type of residence (dwelling mode and size). This permits a better representation of the proper needs of the individuals, of their living style, as well as a more appropriate definition of the potential markets for the alternative forms of final energy and using new technologies. The final electricity demand is then calculated from the penetration into the potential market and the efficiency of each energy form (network loss, heat loss, COP) as specified in the assumptions.

The tool estimates the total electricity required to meet the energy demand for each end-use category in Delhi, segregating whole urban power supply system into different electricity generation technologies through considering two connection modes: On-grid (from the network) and Off-grid (District Generation) by using the set of following equations:

$$\mathrm{ELEC_k(GWa)} = \left[\mathrm{Cap_k(GW)} \times \mathrm{OF_k}\left(\frac{\mathrm{h}}{\mathrm{yr}}\right) \times \mathrm{LF_k(\%)}\right]/8760 \tag{1}$$

$$\mathrm{ELEC_T(GWa)} = \sum_{\mathrm{k}} \mathrm{ELEC_k} \tag{2}$$

Where : $\mathrm{ELEC_k}$, $\mathrm{Cap_k}$, $\mathrm{OF_k}$, $\mathrm{LF_k}$ and $\mathrm{ELEC_T}$ are defined respectively as: annual electricity generation form technology k, installed capacity of technology k, annual operation, the load factor of technology k and total annual electricity generation.

Managing the electricity load

To ensure supply can meet expected demand at a given moment in time *t*, the city's power supply system must plan and procure generation in staggered amounts over the course of time leading up to time *t*. The level of demand for electricity in a city varies hourly, daily and seasonally as well as regionally. In this case, local generations can be able to concurrently match or exceed that portion of demand for electricity at each moment in time. The CAUES provides a simple approach to formulate matching electricity supply with demand in the context of the capacity constrained electricity system by introducing the build-up new capacity variable as follows :

$$F_{T_{\mathrm{elec}}} = \mathrm{ELEC_T} + \Delta\mathrm{ELEC_T} \tag{3}$$

$$\begin{cases} \Delta\mathrm{ELEC_T} > 0 & if \quad F_{T_{\mathrm{elec}}} > \mathrm{ELEC_T} \\ \Delta\mathrm{ELEC_T} = 0 & if \quad F_{T_{\mathrm{elec}}} = \mathrm{ELEC_T} \end{cases} \tag{4}$$

$$\Delta\mathrm{ELEC_T} = \sum_{\mathrm{k}} \mathrm{NewAdd_k} \tag{5}$$

$\mathrm{NewAddCap}$ represents the amount of new-built capacity and *k*, refers to alternative energy types such as: photovoltaic, small hydro, wind turbine, geothermal, waste-to-electricity and biomass. The amount of $\Delta\mathrm{ELEC_T}$ can be estimated through calculating the electricity gap at time *t* by the implementation of new intervention policy to facilitate the city's local generation by different available alternative energy sources.
F_T is a function of the activity level and the energy intensity in each end-user and its amount can be reduced through introducing different policy intervention scenarios as "energy efficiency programs in the domestic sector".

Evaulation of the co-benefits

The tool estimates the potential reduction of GHG emission and air pollutions which is accessible through offsetting the electricity gap at a given moment in time *t* based on the life-cycle analysis method considering the operation, transportation, and processing levels for each contributor technology.

Results and Discussion

Reference Energy Diagram

The diagrammatic representation of the main energy flows in the Delhi energy system which is used by the CAUES tool is given in Figure 3. End-use methodology is used for energy demand forecasting and related emissions.

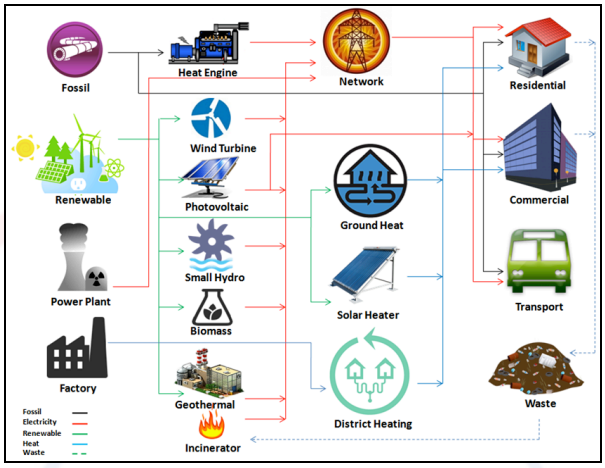


Fig. 3. Delhi Reference Energy Diagram in CAUES

Application of the tool is subject to the identification and estimation of the performance function of the urban energy system which is possible by segregating the whole energy system of the city of Delhi into incremental elements such as end-user, final energy, energy conversion and energy resources.

Scenario Generation

The scenarios are used for a number of ‘‘what if’’ questions, such as—what if more efficient appliances are introduced or what if the percentage share of a particular fuel use is changed in the urban energy system of the city of Delhi. The set of conditions is detailed in the respective scenarios. The scenarios in CAUES are generated to encompass any factor that is anticipated to change over time. For the Baseline scenario, data have been generated using end-use methodology. In the present study, extensive micro-level data have been collected from various sources. The Baseline scenario computes energy consumption and emissions for the base year (2011). The demographic details of this scenario are taken from the Economic Survey of Delhi [10-12]. The number of dwellings is a refined determinant of energy use than population, as a dwelling acts an energy consumption center. The number of dwellings is a function of population and household size.

Two different policy intervention scenarios are developed in the tool under different sets of alternative energy usage scenario and end-user efficiency improvement scenario to show that how the gap between electricity supply and demand can be set in this city.

The efficiency improvement scenario takes into account different energy conservation technologies coupled with policy options for energy emission reduction. This scenario takes into account the replacement of energy-intensive appliances by efficient and less

energy-intensive technologies.

The policy options and assumptions are given in table 2.

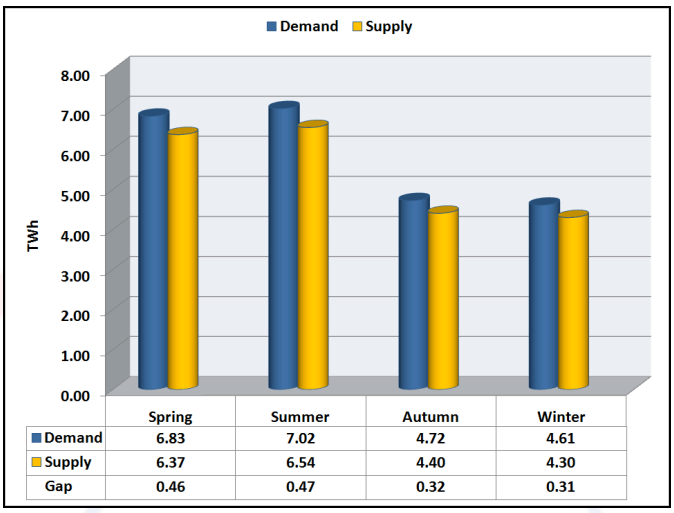
Table 2. Policy options and assumptions for scenario generation

Scenario	*Policy option*	*Assumptions*
Baseline		• Basic demographic data availability: Population,Average household size, Fraction of dwelling by type, Average floor area, Degree of urban electrification, Commercial sector floor area and fraction of commercial sub-scetors in total area • Installed electrical capacities (table 1) • Monthly temperature and solar irradiation[13] • Electric load distribution

Alternative Energy usage	1) Introducing 5MW solar PV	• NDPC Photovoltaic Plant, Delhi [14]
	2) Increasing the installed capacity of hydro up to 100 MW	• 300 MWh Hydropower Lakhwad project [15]
	3) Increasing the installed capacity of waste-electricity to 46 MW	• Generating power from waste, with three plants at Okhla and Timarpur (16 MW), Gazipur (10 MW) and Narela-Bawana Road (36 MW)[16]
End-user efficiency improvement	1) Replacing conventional water heating system with solar collector	• Global Solar Thermal Energy Council. The cabinet's decision no.1309 [17]
	2) Replacing regular lighting system with Compact Fluorescent Lighting in residential sector	• For 3 million Delhi households to save nearly 1200 MW of power[18]
	3) Improving COP of air conditioning to 2.7	• At present, for air conditioners, co-efficient performance (COP) has to be minimum 2.5 to qualify for 1-Star rating, which will be raised to 2.7 by January 2014 [19].

Results

Figure 4 shows the estimated load profile for the domestic sector of the city of Delhi. It seems that the ACs are the major contributor to the peak load in summer and lighting can be considered the second main contributor. In winters, space heating and water heaters have significant contribution to the peak load.



	Spring	Summer	Autumn	Winter
Demand	6.83	7.02	4.72	4.61
Supply	6.37	6.54	4.40	4.30
Gap	0.46	0.47	0.32	0.31

Fig. 4. Estimated electrical load profile for the baseline scenario in the domestic sector

In the above figure, the load curve analysis is based on the estimation of CDD (Cooling-Degree-Day) and HDD (Heating-Degree-Day) in different seasons and simulation of energy consumption in domestic end-users. The electricity supply is estimated on the basis of the maximum power made available from existing capacity (table 1) and the technical restrictions on power supply (Figure 2). The seasonal load profile is a typical bell-shaped curve showing peak variations in summer months. The average gap between electricity demand and availability is estimated about 6.5 percent.

Figure 5 shows that how the annual electricity supply and demand can be matched through implementing the policy interventions which have been indicated in table 2.

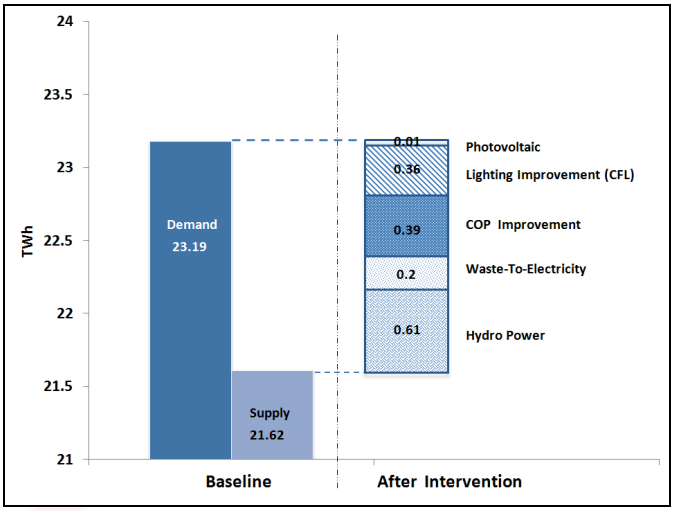


Fig. 5. Matching electricity supply/demand load by the implementation of policy interventions over the year 2012

The end-user efficiency improvement has a lead role to play through the improvement of the lighting and the coefficient of performance of space conditioning in the residential and commercial sectors. Lighting improvement can be possible when the customers shift from using incandescent lamps to CFL's, savings accrue to them by way of reduced consumption due to the lower wattage rating of CFL. Commonly used appliances for space conditioning during summer in the residential sector are air-coolers and AC. There are more air-coolers with low COP (< 2) in lower income groups of the city of Delhi, which can be replaced with high COP air conditioners (> 2.5).

Small Hydropower is playing an important role in Delhi competitive power supply sector. It can provide sustainable energy services, based on the use of routinely available, indigenous resources and provide better solutions to longstanding energy problems being faced by the city's power supply system.

Solid waste management remains one of the most neglected sectors in Delhi. On an average, 80% of the municipal solid waste generated is collected and about 90% of the collected solid waste is disposed in landfills, and the remainder is composted. The total amount of municipal solid waste is estimated about 5500 tonnes per day contributing to about 80% of the total CH4 emission [20]. The implementation of technology like incinerator facilitates the electricity production on the supply side and reduces the emission of GHG and other air pollutions in this city.

Table 2 shows calculated co-benefits potential of the implementation of policy intervention scenarios that had been considered in this survey. The results demonstrate that, emissions mitigation accounted for 328 kt/yr of GHG emission by promoting the city's energy performance in both electricity supply system and end-user level.

Table 2. Potential reduction of GHG and Air pollutions (kt/yr)

	Baseline	*After Intervention*	*Difference*
GHG	22819	22491	-328

CO	48.10	47.31	-0.79
NMHC	2.17	2.16	-0.01
NOx	77.80	77.18	-0.62
SO_2	205.50	202.68	-2.82
PM10	9.53	9.43	-0.1
PM 2.5	2.98	2.93	-0.05

Figure 6 shows the calculated MAC (Marginal Abatement Cost) based on the midterm payback period through considering the following definition:

$$MAC\ (\frac{\$}{tCO2}) = \frac{Total\ capital\ investment\ - Present\ value\ of\ the\ project}{Comulative\ GHG\ saving\ over\ life\ of\ the\ project} \quad (6)$$

The project total capital investment is estimated about 1500 million USD. It is notable that, the cost values derived in this survey are based on the theoretical ideas which provide indicative potential values that may differ from the actual field measurement value due to the number of factors which influence the capital and operational costs of different electricity generation technologies.

It can further be observed from figure(6) that improving energy efficiency at the end-user levels originates a rapid and cost-effective decrease in emissions. The cheapest option to manage the electrical load and reduce emissions in the domestic sector is the lighting improvement.

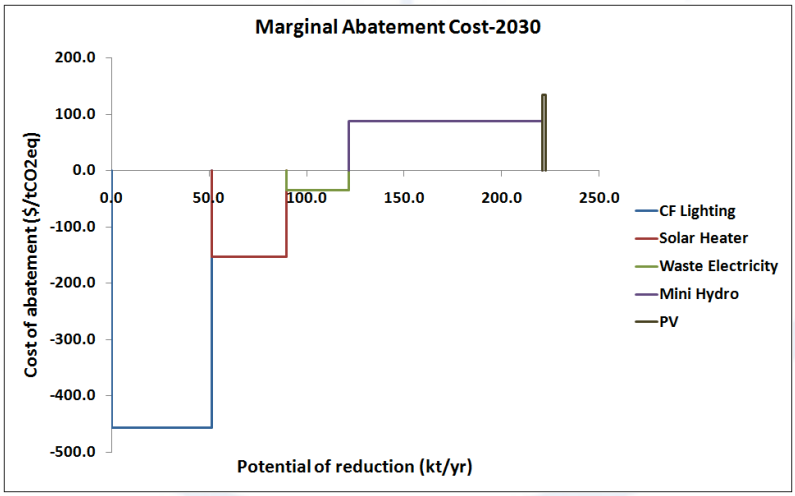


Fig. 6. Midterm Marginal Cost Abatement curve for policy intervention scenarios (based on the average electricity price about 6.5 Rs/kWh and the annual discount rate about 5.5%)

Conclusion

In this paper, a new strategy has been proposed and the associated co-benefits are simulated by the tool "GUEST" for electrical load management in the city of Delhi. It has been observed that a successful implementation of the proposed scheme can help the city of Delhi to free from load shedding. The results showed that the co-benefit policies which promote low-carbon communities have a GHG emissions reduction potential of about 328 kt/yr. The proposed intervention scenarios help in motivating

both of power supply system and the connected customers to participate in system peak demand reduction. The results also reveal that about 48% of the total electricity gap (1.57 TWh/yr) can be managed by improving the lighting system, the COP of the AC's and also introducing the solar energy in the domestic sector. The city's power supply system needs to be reformed through the deployment of renewable energy sources (particularly hydropower) and also introducing the municipal waste to electricity generation system.

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Public Participation in Environmental Conflict Management in Development Projects in Thailand

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Over the past four decades, a rapid economic growth and industrialization have been cased natural resource degradation, environmental pollutions and health impacts in Thailand. These create environmental controversies across the country. Presently, Thailand is facing many environmental conflicts from developing large scale project. Many development projects are delayed or postponed because of the public opposition. To solve the problems, public participation in Environmental Impact Assessment should be strongly established. Although, public participation has become an essential element of environmental decision-making and has grown considerably in Thailand, it frequently fails to solve environmental conflicts. A case study approach was selected for this research. One case of Thailand's power plant project controversies is central to this study. Environmental laws and regulations relating to public participation practice in the Thai EIA system were studied and examined. The study revealed that the requirements for public participation in environmental management function have been marked in the 2007 Thai Constitution. However, the current practice of public participation in the EIA system has not been successfully established. Thai government prefers a top-down approach to handle environmental conflicts which noticeably ineffective. This leads to a critical problem in project implementation and environmental sustainability. As a result, Thai people call for meaningful participation in the decision-making processes concerning highly controversial issues of development activities. They realize that public participation should play an important role in environmental conflict resolution. It could be said that where public participation is overlooked or inappropriately conducted, environmental conflicts may be created.

Keywords**:** Public Participation, EIA, Environmental conflict, Thailand

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Introduction

Moving from an agricultural base to more industrialization, Thailand now faces many environmental problems, particularly air pollution, resulting in health impacts consequences [1, 2]. The industrial development of Thailand has contributed to air pollution problems in which it has influence on environmental conflicts and health problem of Thai people who lived in the development areas. The significant regions involved with the air pollution problems are such as, Map Ta Phut Industrial Estate, Rayong Province, Laem Chabang Industrial Estate, Chonburi Province, and the downtown of various cities [1].

The impacts from the coal-fired power plant were critical and severe, in particular air pollution. Either the construction period or the operation period, the communities surrounding the power plant are directly impacted from the pollutants. The cumulative impacts from the power plants were also critical to local residents. In the past many coal-fired power plant projects had been implemented by the authorities without appropriate community involvement or public participation. In particular, a previous coal-fired power plant, Mae Moa, in the North of Thailand has a bad reputation for its air pollutions. These rules will rely upon proven and widely available emissions control technologies to level that all power plants follow the same systems [2, 3].

Many projects have faced the problem of public protest due to their impacts and the NIMBY syndrome (Not in My Back Yard) resulting in more expenditures and time delay [3, 4]. Many projects were cancelled or delayed by the local people or the protestors. This might because the public participation process has not been taken appropriately in the development of these projects until the conflicts among stakeholders in particular the government/project proponent and the local community occurred [4, 5]. To solve the problem, the participation in the planning and decision-making process of the project should be carried out in a proper manner. Presently, Thai people demand greater participation in the decision-making processes concerning highly controversial issues of development activities, in particular the sitting of coal-fired power plants. They recognize that public participation should play a substantial role in environmental development projects and the Environmental Impact Assessment (EIA) in order to prevent the project's pollutions [3].

1.1 Significance of the Study

Immediately, Thailand needs an effective approach to deal with air pollution problem; particularly, air pollutants from coal-fired power plants. However, Thailand has a very limited expert and specialists; this is then still an ongoing problem that still needs to be solved. Another problem is that the authorities usually stand by at central government centre. Presently, the government recognizes the importance of public participation to play a substantial role in the Environmental Impact Assessment (EIA) of coal-fired power plants in order to prevent their severe impact. Thai citizens also demand greater participation in the decision-making process concerning highly environmental and health impacts of development activities [3, 5], in particular of coal-fired power plants.

To deal with air pollution issue, Thai government is taking a coordinated approach to control air pollutions released from coal-fired power plants. Issuing several laws and regulations to limit these pollutants from power plants provides the industry with the certainty they need to make smart and cost-effective investments in control technology. It also encourages the public to involve in preserving and conserving the environment though many mechanisms, in particular legal framework. Thus, public participation in EIA process is expected to be an effective tool to solve these environment impacts and conflicts from the power plants.

This study aims to identify the problems of enhancing public participation in solving air pollutions in EIA process and to investigate strong and weak points of the EIA system in Thailand. A case study of the Khao Hin Son Coal-fired Power Plant Project was studied and analyzed. Finally, recommendations on how to enhance public participation in controlling pollutions form power plants in the Thai context are presented.

Methodology

A case study approach

In this study, qualitative approach was applied to examine the current state of EIA of power plant projects, both at the legal processes and adequacy of public participation in the EIA system. The case study approach is chosen as a key research strategy to explain and conduct an in-depth study of a public participation process in the EIA system in Thailand. In-depth interview and documental reviews were employed to collect data. Stakeholders who or played important roles in the public participation process were identified and interviewed. The secondary data were collected from relevant source including publications, substantive document on public participation, government publications, conference proceedings, research, books and journals. All relevant data were reviewed to build up knowledge and framework about the case study and public participation process. These processes aimed to provide background on the rationale for public participation and the Thai EIA system.

Results and Discussion

Controversy of the Case Study: The Khao Hin Son Coal-fired Power Plant

The Khao Hin Son coal-fired power plant project is one of a large-scale project in the east of Thailand which having significant environmental problems, in particular air pollutions. The project is planned to be located in Chachoengsao province and is a co-investment between Thai firm Kaset Rungruang Peudphol and US Company CMS Co. Ltd. According to the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), power plant projects that have a production capacity exceeding 10 megawatts per day, must conduct and Environmental Impact Assessment (EIA) study and submit this EIA report before getting an approval from the Authority. Thus, the Khao Hin Son power plant project was required by law to conduct an EIA study. Accordingly, the Khao Hin Son coal-fired power plant is suitable to be examined how public participation process in managing environmental pollution control did not succeed since the project is having conflicts with a high level of controversy among stakeholders.

A coal-fired power plant is cited as one of the largest sources to particulate pollution, ozone, and global warming [6]. In this case, the affected villagers claimed that hazardous air pollutions emitted by coal-fired power plant could influence environmental quality and health on local, regional, and continental scales. One research participant claimed that *"Their air pollutions blow across state lines into states thousands of miles away"*. The protesters said they did not want the power plant in their communities as they feared environmental impacts, particularly air and water pollution. One villager claimed that, *"if the coal-fired power plant is established, it may result in the acid rain that will damage agriculture and cause mercury and heavy metal contamination in the air and food chains"*.

The villagers protesting against the construction of a coal-fired power plant in Chachoengsao called for a revised environmental impact assessment report of the project. They claimed that the existing report was conducted without appropriate public participation. The authority, the Office of Natural Resource and Environmental Policy and Planning (ONEP), approved the EIA study even though the company had not held public hearings or conducted a health impact assessment study as required by law, Section 67 of the 2007 constitution. One project opponent said that *"The project's EIA has been done without appropriate public participation"*. A coordinator of a network monitoring the impact of the power plant also stated that *"This means the EIA study does not cover all well-rounded information"*. However, one officer claimed that the office had considered the EIA report cautiously and the study complied with all legal requirements.

The protestors also believed that the power plant would cause massive environmental and social impacts, in particular air pollution, and agriculture sector. They also warned the government against repeating the mistake of Map Ta Phut, where the authority have been charged with violating Section 67 of the 2007 Constitution requiring the agencies to consult an independent body before approval of projects deemed harmful to people's health and the environment. Importantly, the affected people did not trust the environmental monitoring and mitigation program of the project and still opposed the project. The local communities did not believe that the project's monitoring programmes could control any impacts to the environment from its operation. They believed that the government and the project owner were not honestly attempting to solve their problems and did not pay attention to their concerns. A network to monitor the impacts of the Khao Hin Son coal-fired power plant projects was then set up by the affected clusters. Thus, the Khao Hin Son power plant project was delayed and conflicts among stakeholders still exist. Similarly finding is found in the study of Tippett *et al.* [7]. The study found that mistrust has severed impacts to public participation in the EIA process. A lack of trust among stakeholders could hinder effective public participation and lead to conflict among stakeholders.

Public Participation in EIA in Thailand

The EIA process is an essential component of environmental legislation in many countries including Thailand [8]. Historically, in Thailand, public participation is formally required only in the scoping stage of the EIA process but the current EIA practice requires public participation to be held in three main stages of the EIA

process including screening, scoping, and EIA review. However, public participation as part of the site evaluation and selection processes, which are arguably sub-stages, is not compulsory and this potentially leads to conflict among stakeholders. This might be because project sitting has always been a key issue that created problems for project implementation in Thailand. Indeed, there were several factors that contributed to the conflicts, but the fact that people who lived near the proposed site did not know or have a chance to participate at the beginning stage of the project implementation, in particular the site selection process, is viewed as a key factor that caused the problems. Indeed, there are at least 5 steps in the Thai EIA Process including; screening, scoping, report preparation, EIA review, and monitoring. Public participation must be integrated in all steps [5, 8]

Although the EIA process was established more than 30 years in Thailand, it is still controversial; many developers regard EIA as an undesirable barrier, some seek to avoid the EIA process, and also some government administrators in charge of EIA view the process as a heavy burden. Moreover, political and financial support for EIA study is low in many developing countries, and environmental agencies are practically powerless compared with economic development agencies. Two key reasons for poor quality of EIA reports are lack of qualified environmental experts, and insufficient time and money [9], and Thailand is no exception in this regard.

Many scholars have commented on ineffective public participation process in Thailand on environmental issues and, particularly in the EIA process [4, 8, 9]. The draft EIA does not have to be released to the public, public comments are not asked for, and, critically, the government does not have to officially respond to public concerns. The EIA review is made by the authority in charge of the EIA approval only. Local expert panels and local administrative organization officers are not authorized to take part in the process. Usually after the EIA report is sent to the authority for review, the public could not get access to it [9, 10]. Moreover, the EIA reviewers themselves are not experts in all areas, they work under pressures of time limits.

Clearly, public participation in the EIA process is crucial, particularly in Thailand. Weak public participation and unsatisfied communication produce many limitations, both legally and in practice, and result in limited knowledge and uneven distribution the project information to the local community. Finally, then the local communities distrust the EIA report and violent protests have been happened, like in this case.

Law and Regulations regarding Public Participation in Thailand

Public participation has been constantly adopted and developed in Thailand since the government and the public recognised its significance and capability for solving environmental conflicts in the country [4]. Accordingly, the concept of public participation was officially introduced into Thai society through different laws and regulations, especially at national level. Thailand's core laws and regulations concerning the rights of citizens to participate in environmental management are such as: the Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992); A Prime Minister's Public Hearing Order B.E. 2539 (1996); the Constitution of the Kingdom of Thailand B.E. 2540 (1997); The Official Information Act B.E. 2540 (1997); and the Regulation of the Office of the Prime Minister B.E.

2548 (2005). More recently, in 2007, the Constitution of the Kingdom of Thailand B.E. 2550 (2007) was declared. This Constitution explicitly responds to weaknesses of the old constitution and it is valuable to review this in order to determine its political and environmental context to correctly understand the present Thai system [10].

The Constitution 2007 encourages public participation in environmental management in Section 66 and 67. Particularly, Section 67 stipulated that any activities or projects that might cause seriously affect the quality of the environment and people's health could not be permitted, unless the impacts on the quality of the environment and the public's health have been studies and evaluated [11]. The 2007 Constitution also aims to reduce direct violence and environmental conflicts by enhancing public participation in decision-making process. However, Thai citizens are still being excluded from the participatory process, allowing violence to be reoccurrence in Thai society. This might because the Constitution has not had any impact on Thai social structure, political context, and conflict resolution approaches [3]. These barriers contribute to future conflicts. Thus, without appropriately analysis of these obstacles, it is difficult to understand the reoccurrence of environmental conflicts in Thailand.

With respect to the provisions of the Thai legal and regulations, it can be seen that Thailand's legislation encourages, confers and formalizes the concept of public participation in managing and protecting the natural resource and environment issues [10]. However, as evidenced from the Khao Hin Son Coal-fired Power Plant Project. The Thai legal and regulation are unable to effectively handle the environmental problems and public participation is not appropriately set up. The failure of the Thai legislation might result from the lack of effective enforcement. This issue is also a practical problem of in the legal system in many countries, such as Turkey [12], and Kenya [13]. The studies showed that if laws and regulations relevant to public participation practices were inefficiently enforced, people would not participate appropriately and in the implementation of development projects. Environmental problems and conflicts would be more arisen.

Lessons from the Case Study

From the case study, it could be seen that the implementation of public participation in Thailand is now reaching an impasse. Many stakeholders, in particular the impacted communities, were reluctant to participate in many participatory forums provided by the government or the developer. Many public hearings or other activities were ignored by affected groups. The protestors did not accept them because they believed that these activities, particularly public hearing should have been processed before the decision-making process was completed. The Khao Hin Son coal-fired power plant is obviously demonstrated for the problem of lack of appropriate public participation in the right stage. Moreover, many mega development projects in Thailand cause conflict because the location of the proposed project had already been selected. In this case, land was already selected for proposed project without informing local people. There is no alternative for the public. Only the chosen location of the project is introduced and presented to the public during the hearing forum.

Public participation in the EIA process is important. Without the public being participated there is too much of a tendency to hide things, which can eventually lead to corruption and conflict among stakeholders [14]. Keeping the EIA study (or related documents) secret completely defeats the purpose of the EIA system. This can especially be a problem where the local communities are adversely impacted. Particularly in this case study, violent protests have been set up.

Although public participation process is possible to express a government's willingness to share all perspective with stakeholders, in many cases in Thailand, public participation has been simply employed to ratify a decision that had already been made [5]. Furthermore, despite public participation arrangements, to accept these programs does not mean that the final outcomes of participation processes will be accepted and influenced the authority's final decision [4, 5].

A significant problem is that when opportunities to be involved are distorted and blocked by political structures and processes, affected people may employ direct action to increase their level of participation and power [15]. In Thailand, this direct action is often resulted in direct violence. The foregoing consideration and finding are fully supported by this case study. Similarly, Persson's [16] and Vantanen and Marttunen's [17] studies found that trust was closely related to openness and transparency. If trust is lacking, the public then are difficult to see the decision is transparent and led to protest and antagonism among stakeholders. When the stakeholders did not trust each other, conflict was likely to be more aggressive.

Importantly, in Thailand, the public has a limited role in the monitoring process, including either the constructing or operating stages. Indeed, the project proponents should be provided assurances over the running and maintenance of the power plant in order to increase the public's confidence that the project is of good quality with social, health and environmental soundness. Otherwise, it will be difficult to get support from the public. This is because the participation of local people and NGOs in monitoring the operational impacts of a project can lead to the early identification of environmental and social problems, and can increase public acceptance. Importantly, public participation must be continued throughout the project to prevent failure of the power plant's operation. In this study, one academic suggested that, *"to deal with this issue, the developers should provide effective mechanism such as call centres or hotlines to respond to the public complaints and concerns. Thus, the developer could take prompt action to alleviate the problem"*.

Conclusions

Air pollution is one of the most serious environmental issues in Thailand. High levels of pollution endanger people's health, the quality of the environment, and provoke serious climatic changes on the global level. Therefore, this issue should be resolved immediately. For the Thai government, it is essential to take action to resolve and improve the situation with the air quality within the country urgently.

Enforcement of the EIA requirements is a compulsion. Having an appropriate review and approve a project's EIA report could help reduce the conflicts among stakeholders. However, mitigation of industrial air pollution, particularly from the

coal-fired power plant, is not only the responsibility of the developers, but it also involves the diverse stakeholders including the government, experts, local communities and NGOs to participate in brainstorming of finding the desirable and accepted alternatives for air pollution abatement. Effective monitoring should be based on constant public participation. The government needs to ensure that the public could access to monitoring center information of the project. The authority and the developer need to get a variety of viewpoints from the affected citizens, particularly different ideas how to improve environmental quality, suggestions and comments. If this kind of two-way communication with society is ensured, it will help not only to increase the efficiency of monitoring problems, but also involve the public into active participation in environmental problems, air pollution management in particular.

Public participation is perceived as a wise strategy for a developing country, like Thailand. Public participation can prevent argument and conflict between the authority/project proponents and the affected communities and can reach a higher level of support for the decisions during all phases the project's planning, construction, and implementation. It could be sum that effective public participation can lead to a desirable and acceptable outcome, resolve conflicts, establish cooperation and collaboration among stakeholders, and improve the process and outcome of the environmental decision-making.

In Thailand, public participation is a key element of the government's administration. Public participation is granted in the 2007 Constitution, The Official Information Act, and many clauses in the environmental legislation. However, there are many limitations to these laws, both legally and in practice. Within these laws and regulations, the public right to information is often subject to the judgment of the government officials in charge. In this case, it was found that public participation of Thai citizens did not comply with a real concept of public participation; direct impacted people in the project did not have a chance to be informed and express their opinions from the very beginning and their concerns were not appropriately influence the decision.

It could be said that the public participation process was not yet appropriately established in the Thai context. Thus, there is an urgent need to create a sound approach and conditions of effective public participation which can assist in resolving environmental problems and conflicts. Effective enforcement of laws is essential. No matter how good they look on paper, if each stakeholder continues to go their own way without proper balances and participation, environmental conflicts would still occur and the quality of the environment could not be improved.

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Russia and UK: Studying the Problem of Energy Efficiency in Household Sector

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
Energy efficiency in household sector has recently become an issue of pressing topicality according to the latest studies and reviews in this domain. The issue can be found in numerous publications of the renowned scientists of the past and nowadays it is still receiving a wide support. There are a number of circumstances connected with the emergence of this phenomenon.

Firstly, energy consumption of households in Russia and UK is constantly growing. This is true for many other sectors in both countries as well as worldwide. The Statistical Review of World Energy released by British Petroleum in June 2013 states that global consumption of primary energy grew by 60% over the last 25 years and the growth is continuing. It is expected that by 2035 global consumption will grow by 41%.

Secondly, energy strategies of both countries call switching to the path of innovative and energy-efficient development one of the main objectives of household sector development.

The paper intends to draw attention towards the energy efficiency issue. The paper observes existing energy efficiency problems in household sector in Russia and United Kingdom and governmental programmes that serve to address them. It also considers the peculiarities of energy efficiency programmes of these countries. The paper shows the distinctive and similar features of legislation and policies in energy efficiency area in Russia and United Kingdom. The research reveals each country's good practices in household sector that can be adopted for another country and can contribute to sector development.

Keywords: energy efficiency, household sector, programme management

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Why is it important to address energy efficiency problem?

Energy has always played a significant role in human and economic development and the welfare of the society. We used wood to get fire and wind force to travel by sea. Today we use heat, electricity in production, service sector, on transport and in our homes.

Saving energy resources in all sectors of the economy is one of the most important strategic challenges of the 21st century. Energy consumption nowadays is growing in many sectors worldwide. Over the last 25 years global consumption of primary energy grew by 60% [4], it is expected that by 2035 global consumption will grow by 41% [3].

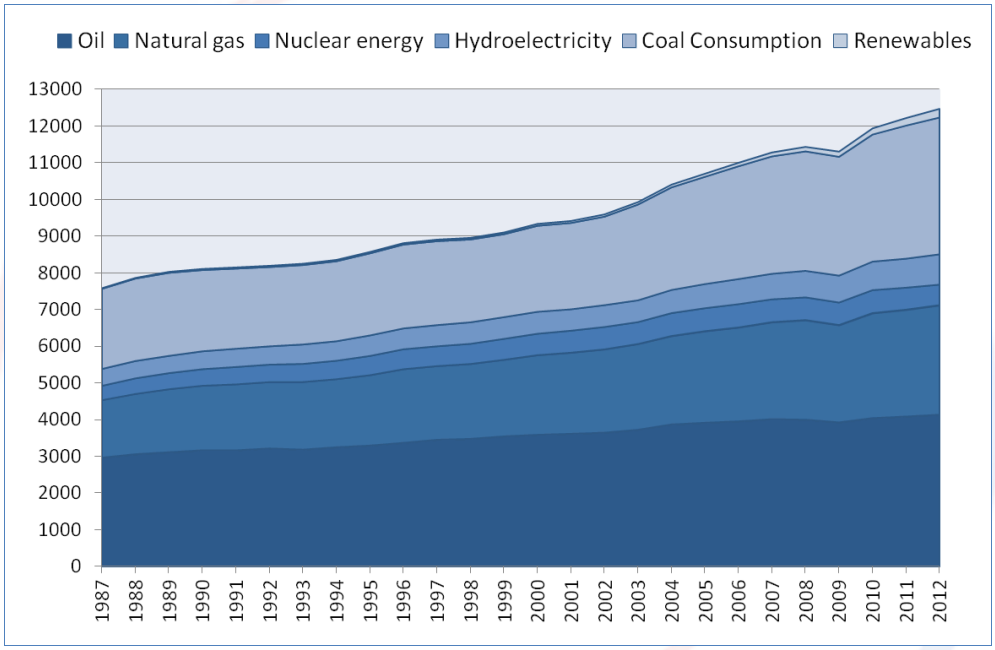

Figure 1. Growth of world primary energy consumption in 1987-2012, million TOE

Energy strategies of both countries declare that one of the main objectives of household sector development is switching to the path of innovative and energy-efficient development. In order to be competitive you have to be energy-efficient. The UK government focuses on establishing an energy-efficient economy, as it is one of the key climate and energy priorities. According to David Cameron, Prime Minister of the UK, European countries «are in a global race and the countries that succeed in that race, the economies in Europe that will prosper, are those that are the greenest and the most energy efficient» [10]. The same attention is paid to the issue of energy-efficiency in Russia. Russian Minister of energy, Alexander Novak, claimed that «today the question of energy efficiency is a question of economic competitiveness, introduction of new technologies, modernization and ecology; generally, it's a question of competing on world markets».

Energy efficiency is a matter of individual behaviour, it reflects the rationale of energy consumers [9]. Energy efficiency is a strategically important issue that allows to:

- Enhance energy security of the country and contribute to economic growth;

- Improve environmental safety of the country;
- Facilitate the implementation of national projects;
- Increase the welfare of society.

Despite the social and economic importance of energy-efficiency in household sector, the countries still suffer from various problems that need to be addressed.

Energy efficiency problems in household sector in Russia and UK

Energy efficiency problems in household sector can be divided into two components: houses and people. Problems connected with houses and buildings refer to the construction process, regulations and standard compliance, the use of energy efficient technologies. Problems connected with people refer to effective energy consumption, awareness and willingness to change. Energy consumption within a household means that energy is used for such activities as lightning, space heating, water heating and appliance use [15].

Each country has its specific problems in the sector, this is why they were studied separately.

The case of Russia

The household sector in Russia has the greatest potential for energy-efficiency, the technical potential of reduction is estimated at 33 million TOE till 2020 according to the Ministry of Energy of the Russian Federation. Energy consumption of households in Russia is by 25-30% higher than energy consumption of the households in Europe.

These are the barriers inherent for Russia.

1. Lack of consumer awareness about the energy efficiency measures.

Lack of information in Russia is one of the key barriers for energy efficiency. Households lack necessary knowledge about energy-saving technologies and measures. Despite the majority of Russian households admit the importance of energy savings, they do not know how to do it and even whom to consult.

2. High depreciation of buildings and facilities.

The level of depreciation of buildings and facilities over the country is nearly 60%, average age of the majority of assets is more than 10 years. Russia has no supervisory authority to control energy consumption and depreciation level. As a result it is very difficult to assess the need in energy efficiency measures during reconstruction and overhaul.

3. Blurring or absence of governmental support and economic motivators.

Governmental support exists only on paper, in fact receiving financial benefits or support is almost impossible. Companies who are responsible for the implementation of energy efficiency programs are usually unable to meet the rigid criteria of project selection and other requirements to get financial support.

4. Low compliance of standards and regulations in construction.

Non-compliance of mandatory requirements in construction and energy efficiency requirements in buildings results in administrative liability. However even the

maximum fine for noncompliance cannot seriously affect construction companies or encourage them to comply with the standards and regulations. Furthermore, some standards and regulations in construction are not binding. These standards recommend to employ certain technologies and construction solutions, but they do not imply that every construction company will follow the recommendations.

5. Poor quality of programme management in the companies of housing and communal services.

There are many issues connected with programme management in these companies. Firstly, the companies have limited budgets and large number of projects to implement. All the projects are effective in terms of net present value, payback period, internal rate of return, but it is obvious that not all projects can be selected for implementation. As a common practice companies choose to implement short-term and low-cost projects aimed at instant payback and minimum investments.

6. High rates and low quality of the housing and communal services.

In 2013 the rates in Russia grew on average by 110,1%. 10 regions out of 83 experienced growth of 112% more. The rates grow from year to year, while the quality of the services remains poor. According to the study of Russian center of public opinion research in 2013, 60% of Russians are dissatisfied with the quality of provided services [22], 71% of Russians declare that the rates cause financial difficulties for their households. Less than 10% of Russians are ready to pay more in order to get high quality services instead. They believe that current rates are well enough to provide better quality. Around 2% of Russians do not pay for the housing and communal services for several months already. There is a risk that the number of defaulters will grow in the case of subsequent growth of rates.

The case of UK

The household sector in the UK has a great potential for improvement in terms of housing stock, the technical potential of reduction is estimated at 38,2 million TOE till 2020 according to UK National Energy Efficiency Action Plan [21]. Nevertheless the household sector in the UK is more efficient than in Russia.

These are the barriers inherent for UK.

1. Conservativeness of construction industry.

Although there are new technologies that allow creating buildings with low or zero space heating demands, people still remain conservative in selecting homes. Despite 84% of buyers admit their readiness to pay extra 2% for an «eco home», such homes are still rare in UK. Significant opportunities for reducing the energy demands of lighting and appliances exist but are not being implemented.

2. Low compliance of standards and regulations in construction.

In 2004 Buildings Research Establishment survey found that one-third of new homes did not achieve the required energy efficiency standard [14]. Disruption is one of the dominating barriers to the process of improving energy efficiency [8].

3. Lack of consumer awareness about the energy efficiency measures.

Existing homes represent the greatest opportunity for efficiency improvements. As well as in Russia, UK consumers are also not well aware of energy efficiency

measures, along with this they lack advice, trustworthy information and reliable brands.

4. Lack of capital, psychological barrier and payback time.
Such barriers as lack of capital (high up-front costs) and «hassle» factor prevent the majority of households from making any improvements. In UK it's more about low public interest than low awareness. Even those people and households, who are relatively well informed, are not likely to install energy efficient measures in their homes [5]. Those who install are motivated by noneconomic reasons. A Local Energy report conducted in 2007 showed that those households who install energy efficient measures and technologies, are not necessarily motivated by a rational cost-benefit analysis, they may be just keen to own the latest environmental innovations [16].

5. Specific house types and high depreciation of buildings and facilities.
UK has the oldest and most inefficient housing stock in Europe. Over the last 40 years there has been a pronounces change in types of the homes. Detached and semi-detached homes are the most common house types nowadays. These houses typically have more energy losses than flats, due to external walls and more windows than equivalent homes of other types. They also tend to be larger than average homes and since the amount of heating energy is associated with the size of floor area, it means that increase in the number of detached houses will result in increase of energy consumption and low energy efficiency. New homes built since 1991 and up to 2011 represent 13% of total housing stock. The largest number of houses exploited were built in 1918-1990, with high depreciation today.

The analysis of the problems in two countries in shown in Table.

Table 1. Comparison of key barriers for energy efficiency in household sector

Problems	Russia	UK
Lack of consumer awareness about the energy efficiency measures	☑	☑
High depreciation of buildings and facilities	☑	☑
Blurring or absence of governmental support and economic motivators	☑	
Low compliance of standards and regulations in construction	☑	☑
Poor quality of program management in the companies of housing and communal services	☑	
High rates and low quality of the housing and communal services	☑	
Conservativeness of construction industry		☑
Lack of capital, psychological barrier and payback time		☑

Problems	Russia	UK
Specific house types		☑

On the path towards energy-efficient economies

Governmental energy efficiency programmes in Russia

Russian government developed an energy efficiency programme till 2030 that covers many sectors of the economy including housing sector. The housing sector in Russia has the greatest potential for energy efficiency, technical potential to reduce energy consumption is estimated at 33 million toe. To compare, the consumption of energy suppliers in housing sector in Russia 25-30% higher than of European suppliers. It is expected to achieve tangible household energy savings up to 2030 and increase energy efficiency by the means of four main programmes:

- Building and energy regulations;
- Buildings, equipment upgrade, innovation and development;
- Energy audit and monitoring;
- Impact on householder behavior.

Table 2. Energy-efficiency programmes in Russia

Government programme	Aims	Actions
Building and energy regulations	1. To enable householders to reduce energy costs and enjoy improved comfort	1. Make rigid mandatory standards of construction and design: For new houses and buildings For existing houses and buildings (certain categories of building work) 2. Focus on compliance of the requirements, introduction of penalties 3. Improve tariff and tax policy in energy sector
Buildings, equipment upgrade, innovation and development	1.To provide safe and energy-efficient homes and equipment, prevent accidents	1. Complete works on modernization, reconstruction and renovation 2. Introduce innovative, highly efficient technologies in homes 3. Develop regional energy supply
Energy audit and	1. To ensure compliance	1. Organize governmental

Government programme	Aims	Actions
monitoring	with energy-efficiency requirements	statistical observation of energy efficiency and energy saving 2. Mandatory energy audits of energy suppliers
Impact on householder behaviour	1. To reduce energy consumption by 20% 2. To influence householder behaviours in how they use energy in their home 3. To encourage the installation of energy saving measures	1.Imlement specific projects: Measure, save and pay New light Energy-efficient district

Building regulations in Russia consist of the following measures:
- Building Regulations 31-02-2001, Single-family houses;
- Building Regulations 31-01-2003, Multicompartment residential buildings;
- Building Regulations 23-02-2003, Thermal performance of the buildings;
- Building Regulations 41-01-2003, Heating, Ventilation and Conditioning.

Existing building regulations are already outdated and do not fit to new technologies and requirements. New revised mandatory building regulations are expected to come not earlier than in 10-15 years. Along with this it is also crucial to tackle the problem of non-compliance. The government plans to introduce penalties for non-compliance and improve tariff and tax policy in energy sector.

The need to ***upgrade, innovations and development*** is dictated mainly by the current state of buildings and homes. Today it is critical to complete construction works on improvement of the majority of buildings and homes. The programme is determined to provide safer dwellings first of all, and increase the level of energy-efficiency.

Energy audit and monitoring is aimed at ensuring the compliance with energy efficiency requirements. Statistical observations, audits and monitoring will be organized within a corresponding governmental department. Energy audits of energy suppliers will become regular and mandatory.

Governmental programme ***to impact householder behaviour*** includes three main projects:
- Measure, save and pay;
- New light;
- Energy-efficient district.

Project «Measure, save and pay» intends to provide energy meters for the households (measure), establish a reward system to encourage economic behaviour (save), and set the system to ensure the full payment of energy (pay). The project is driven by the introduction of Smart Metering technology and development of financing mechanisms to install them. The project is currently piloted in Urals region (cities

Izhevsk, Perm, Kirov and Kamensk-Uralskiy). Afterwards the government plans to replicate regions best practices all over the country.

Project «New light» intends to modernize the country's existing systems indoor and outdoor lighting, achieving their highest possible energy-efficiency. One of the tasks is to replace existing incandescent and mercury arc lamps to energy-efficient light sources with a focus on diode lamps. As expected the project will reduce the households electricity bills on average up to 60% from the level of 2009. The project is currently piloted in 5 cities: Gorno-Altaysk, Perm, Kazan, Tyumen and Kirov.

Project «Energy-efficient district» intends to modernize districts and small cities. The project is focused on modernization, reconstruction and renovation of buildings and homes. It is expected the project will help to reduce household expenditure on housing and communal services on average by 15-25%. The project is currently piloted in 4 cities: Tyumen, Apatity, Vorkuta and Kazan.

Governmental energy efficiency programmes in UK

The UK government expects to achieve nearly all estimated household energy savings up to 2020 and increase energy efficiency by the means of four main programmes [19]:

- Building Regulations;
- Obligations on energy suppliers;
- Appliance labelling;
- Impact on householder behavior.

Table 3. Energy-efficiency programmes in the United Kingdom

Government programme	Aims	Actions
Building regulations	1. To enable householders to reduce energy costs and enjoy improved comfort 2. To achieve half of the energy savings of the UK household sector	1. Make rigid standards of construction and design: For new houses and buildings For existing houses and buildings (certain categories of building work) 2. Focus on compliance of the requirements
Obligations on energy suppliers	1. To reduce energy losses in households	1. Provide energy services and products to households
Appliance labelling	1. To influence or dictate the selection, design and labelling of household appliances	1. Introduce labelling schemes: EU mandatory energy labelling scheme UK's own voluntary Energy Saving Recommended label
Impact on householder	1. To influence	1.Imlement specific

Government programme	Aims	Actions
behaviour	householder behaviours in how they use energy in their home 2. To encourage the installation of energy saving measures 3. To promote understanding and awareness of climate change and inspire households for action	projects: Climate change communications initiative Energy performance certificates Better billing and metering

Building regulations consist of the following four measures:
- Building Regulations England and Wales, 2002;
- Building Regulations England and Wales, 2005-2006;
- Building Regulations Scotland, 2007;
- Building a Greener Future.

Building regulations require the developers to build more energy efficient homes. The latest document, Building a Greener Future, sets out the government's ambitions to achieve zero-carbon housing by 2016. Besides from making building regulations more stringent, the government also focused on compliance. It was revealed that poor understanding of the requirements, poor workmanship, and absence of local authorities to enforce compliance are the main reasons for poor compliance. To address the issue of compliance there is a number of building compliance consulting agencies.

Obligations on energy suppliers include the following regulations:
- Energy Efficiency Commitment Phase 1 (2002-2005);
- Energy Efficiency Commitment Phase 2 (2005-2008);
- Carbon emissions reduction target (2008-2011);
- Future supplier obligation (2011-2020).

The goal of the programme is to promote improvements in domestic energy efficiency. Suppliers are obliged to help the households make energy savings by installing such energy services and products as cavity walls, loft insulation, energy efficient boilers and other. By the end of both phases of Energy Efficiency Commitment (EEC), suppliers successfully overachieved their targets of energy savings and EEC proved to be a very cost effective measure. To bring the obligations in line with the UK climate change targets, Energy Efficiency Commitment was eventually evolved in 2008 to the Carbon emissions reduction target (CERT) [20]. Future supplier obligation involves the implementation of microgeneration or other measures aimed at reducing emissions while maintaining the level of energy service alike in CERT. Both Carbon emissions reduction target and the supplier obligation reflect a shift towards mixing short-term, efficiency-based measures with longer-term strategic development of more sustainable energy technologies [23].

As for the ***appliance labelling*** there are two schemes that are now in operation in the UK:

- EU mandatory labelling (label has ratings between A-G, where an A-rating stands for the most efficient);
- Voluntary UK labelling (label aims to endorse the top 20% (in energy efficient terms) of products in each of 29 product groups).

Both schemes have already increased labelling and have been assumed to be vital in short term. According to a EU-wide review of mandatory energy labelling in 2007, the labelling led to significant market transformation towards A-rated appliances [1].

The government runs various communication initiatives, introduces energy performance certificates and provides better information on household energy consumption to make an ***impact on the households behaviour***.

The communication initiatives are primary aimed at raising awareness (Climate challenge fund to support regional and local communication projects, Climate challenge website with free resources and information tools, Climate change champions initiative to encourage young people act as figureheads for the initiative) and behavioural actions («Act on CO_2» calculator, Act on CO_2» campaign).

Energy performance certificates (EPC) provide information on energy performance rating of the dwelling (from A to G, where A stands for the most energy efficient) and recommendations on ways of improving this rating. Having this certificate is mandatory as per EU Energy Performance of Buildings Directive, but following the recommendations is not. However, it is expected that this initiative will increase the awareness and have positive impacts on households behaviour in the future. A research conducted by the Department of Energy and Climate Change in 2013 showed the link between the EPC rating and home's sales price [2]. Those properties rated A or B were sold 14% more than those with G.

«Better billing and metering» project intends to provide households better information on household energy consumption in an easily understood format. «Better billing» provides historical information on electricity and gas consumption. «Metering» provides smart meters to record information on energy consumption and establish direct communication between households and suppliers. The UK government mandated scheme expects to install 53 million smart meters across England, Scotland and Wales by 2020 [11].

Recommendations

Existing energy-efficiency programmes of both countries have a number of projects that already proved to efficient. Along with this there is a potential for improvement. Good practices within the projects in one country can be considered for adoption in the other country, taking into account the feasibility and peculiarities of the country.

Based on the experience with current programmes, suggestions for improvement for Russia include:

- Developing contemporary, clear, easy-to-interpret legislation;
- Creating a supervisory authority and ensuring better control and compliance of legislation;

- Introducing obligations on energy suppliers to promote improvements in household energy efficiency and provide information;
- Organizing communication initiatives for the households to raise awareness;
- Introducing mandatory labelling scheme for appliances to dictate the selection.

Suggestions for improvement for the UK include:
- Developing clear, easy-to-interpret legislation;
- Creating a supervisory authority and ensuring better control and compliance of legislation;
- Carrying out modernization, reconstruction or renovation for existing homes;
- Establishing pilot period and pilot cities for new projects to allow initial bugs to be ironed out.

It is important to mention that the governments of the UK and Russia are already working closely to share their experiences of implementing energy-efficiency policies. To develop the energy dialogue between two countries the governments set up the UK Russia Consultative Committee on Energy Efficiency and Renewables. The first meeting took place in October 2013, and brought together the UK and Russian governments, representatives of the UK Energy Services Technology Association and Russian businesses [10].

The path towards energy-efficient economy in the country should be carried out within the framework of enhanced cooperation and interaction among the key stakeholders: the government, energy suppliers, scientists and developers and households. Cooperation must be comprehensive and the government should stand for the «engine».

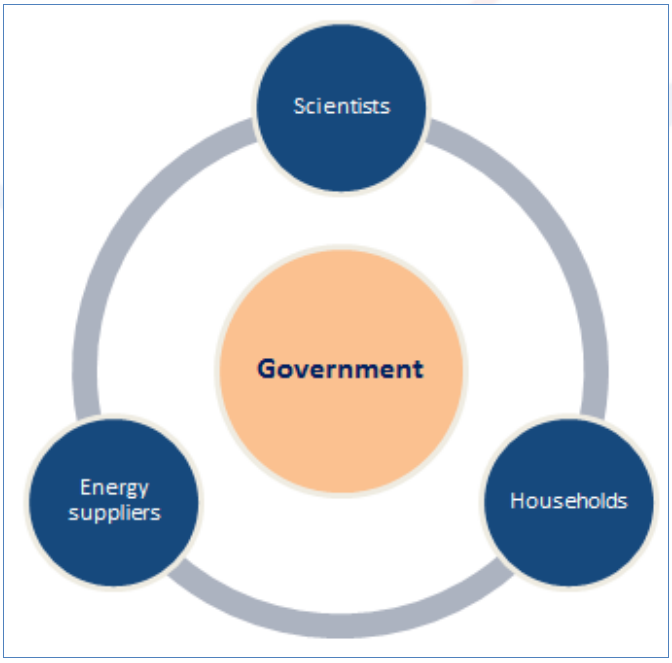

Figure 2. Interaction between key stakeholders

The government is responsible for introducing energy-efficiency policies, regulations and increasing society welfare. The government plays the central role in communication, coordination and execution of the country's energy-efficiency programmes and initiatives.

Scientists and developers are responsible for delivering new technologies and moving forward scientific and technological progress.

Energy suppliers should encourage the households to install new energy-efficient technologies and provide necessary information concerning the ways of reducing energy consumption at home. They are also responsible for carrying out energy-efficiency projects.

The households, primarily interested in reduction of energy bills, should install energy-efficient technologies at home.

Further research

Further research will be dedicated to programme management mechanism of energy efficiency in Russia. The problems lie in the field of programme management:

- Low quality of programme formation and management;
- Limited budgets of the programmes and large number of projects for implementation;
- Lack of governmental financial support.

The object of the study is a Russian company that executes energy-efficient projects. The research will be aimed at developing programme management mechanism that will allow to increase programme management efficiency and compatibility of the company.

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To Build a Harmonious Society: Relationship Management in Corporate Philanthropy in China

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
The Chinese government's ultimate goal is the construction of a harmonious society. As corporate philanthropy helps firms gain brand recognition and loyalty, establishing them as "socially responsible" is an advantage for the Chinese companies to promote themselves in the intense global competition. This study investigates the cultivation strategies of companies in China with their publics during corporate philanthropy processes. Sixteen participants from companies and NGOs were interviewed. Nineteen cultivation strategies (access, positivity, openness, assurance, networking, sharing of task, some dual-concern strategies, cooperation, keeping of promises, stewardship, responsiveness, continued dialogue, listening, face-to-face communication, personal relationships, respect, organisational credibility, educational communication, and visible leadership) were identified in corporate philanthropy in China; One new strategy, being an opinion leader, was proposed. The study lists implications for public relations scholars, public relations practitioners, and companies in China that undertake corporate philanthropy or are planning to undertake corporate philanthropic programs in the future.

Keywords: organisation-public relations, corporate philanthropy, China, relationship management, cultivation strategy

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Introduction

In today's world of integrated and interdependent economy, the relationship between business and society is complex (Lawrence & Weber, 2008). A win-win solution for the company and the society is what corporate philanthropic activities strive for. Corporations give away billions every year for philanthropic causes. The scope, shape, and motivation behind corporate giving have changed dramatically in recent years, therefore a rationale and direction are needed for the institutionalised corporate organisations (Himmelstein, 1997).

A large body of literature on CSR exists; however, very few have focused on corporate philanthropy, especially its situation in China. So far, a few studies on corporate philanthropy were conducted from the point of view of organisational–public relationship (OPR). This study should be useful to: (1) public relations (PR) scholars who are interested in exploring OPRs; (2) PR scholars who are interested in public relations practices in China; (3) multinational companies that intend to build long-term relationships and undertake corporate philanthropy in China; (4) PR practitioners who attempt to develop, maintain, and evaluate relationships with publics of their organisations through corporate philanthropy. This study provides a look at PR in the international area for scholars who intend to study OPRs, especially the cultivation strategies, from a qualitative research perspective.

Corporate Philanthropy

Corporate philanthropy was coined in the 1950s when F. Emerson Andrews wrote his classic *Corporation Giving* in 1952 (Himmelstein, 1997). Varadarajan and Menon (1988) describe the evolution of corporate philanthropy as: voluntarily doing good (e.g., altruism, by Keim, 1978); mandated corporate social responsibility (CSR) (Morris & Biederman, 1985); and doing better by doing good. Theses stages help us understand the importance of corporate philanthropy. Regarding the definitions of corporate philanthropy, Ireland and Johnson (1970) provide a classical and succinct definition of corporate philanthropy: "charitable transfer of firm resources at below market prices." Many studies on corporate philanthropy justify that philanthropic outlays could strategically add value to corporate returns (Hess, Rogovsky, & Dunfee, 2002; Marx, 1999; Mullen, 1997; Shaw & Post, 1993; Smith, 1994; Yankey, 1996). Corporate philanthropy is an emerging strategy that recognizes both risk and opportunities and treats donation as an investment (Dienhart, 1988). This study uses the strategic philanthropy definition of Thorne et al. (2008): "the synergistic use of an organisation's core competencies and resources to address key stakeholders' interests and to achieve both organisational and social benefits" (p. 294). This definition is chosen because it specifically points out the contributions to stakeholders as well as the benefits to the company. In strategic philanthropy, stakeholders include the employees, customers, business partners, the community, and the society as a whole.
However, for the history of corporate philanthropy in China, Wang and Juslin (2009) traced the history of traditional corporate philanthropy in China back to 2500 years ago, Zi Gong (520-475BC) who applied the Confucian virtue of to his business that hold the core principles of CSR. Zi Gong would also use his wealth to help the poor and scholars. Wang and Juslin (2009) has identified 1949-1983 as dislocated corporate philanthropy when traditional Confucianism lost its eminence, and was seriously denounced, especially in the Cultural Revolution. In this period, corporate

philanthropy was replaced by obligatory responsibilities that are authorized by the government. Between 1949 and 1978, China was under planned economy, and Chinese state-owned enterprises (SOEs) delivered lifelong employment and social welfare to state workers (Bai, Lu, & Tao, 2006; Ralston, Terpstra-Tong, Terpstra).
After economic reform in 1978, China adopted a gradual and segmented transition to a market economy (Levine, 2008; Stigilitz, 2009). In 1984-1994, corporate philanthropy was absent or means only the responsibility of pursuing maximum economic profit after the economic reform in China (Wang & Juslin, 2009). 1995-1999 is considered as an introduction period: Chinese enterprises passively accepted some CSR requirements from their foreign purchasers (Zhou, 2006). U.S. and European MNCs began to adopt global CSR standards in their operations in China in the 1990s (Cai & Wheale, 2004; Woodline, 2004). 2000-2003 was the learning period for the Chinese government, NGOs, academics, and international organizations to deal with CSR issues. Lee and Wickerham (2010) conclude the stage from 1994-2004 as official skepticism and hesitant engagement that government attitudes towards CSR ranged from skeptical to hostile. The phase of engagement was from 2004 to present, that CSR has become a matter of consensus for Chinese society.

Few studies made some attempts to explore corporate philanthropy by using the OPRs in China. Wang and Chaudhri's (2009) study is one of the few studies on Chinese companies' CSR and relationship management, but this study is from a quantitative survey method which only answers question like what are the drivers of CSR engagement in China and how is CSR communication viewed. Further, Jahansoozi (2007) explored the organization-public relationship within the context of a petroleum operators group and the local community in Sundre, Alberta, Canada. But these studies are from a Western view, where my research in corporate philanthropy would fill the gap of relationship cultivations strategies in China. The next section will review literatures on the orgazanisation- public relations.

Organisation–Public Relationships (OPR)

Relationship management has emerged as a key paradigm for public relations scholarship and practice (Heath, 2001; Ledingham, 2003; Ledingham & Bruning, 2000). An organisation's relationship with citizen groups can affect its success and survival; however, most citizen groups view corporations as their opponents (Mattingly, 2007). Although there are different perspectives, most scholars agree that OPR is a dynamic process and is not only an output. In addition, an operational definition (e.g. Hung, 2005) is easy for the interviewees to understand. Combining the dialectical and the social exchange perspectives that both recognise the interdependence of the relationships (social exchange and dialectical approach both recognise their interaction with each other), Hung (2005) has defined OPRs as follows: "OPRs arise when organisations and their strategic publics are interdependent, and this interdependence results in consequences to each other that organisations need to manage constantly" (p. 396). This research uses Hung's (2005) definition, because it concisely gives a holistic picture of who the publics in OPRs are, how OPRs begin, and how OPRs take effect in organisations.

Cultivation strategies of OPRs

Relationship cultivation strategies can affect the relationship quality when the companies in China build their relationships during corporate philanthropy. Based on the literature of 'maintenance' strategies (e.g., Dindia & Canary, 1993), Grunig suggested using the word 'cultivate' instead of 'maintenance' (Hung, 2007). Hon and Grunig (1999) and Grunig and Huang (2000) conceptualised seven symmetrical relationship cultivation strategies from publics to organisations as follows: access, positivity, openness or disclosure, assurances of legitimacy, networking, sharing of tasks, some dual concern strategies of the public and organisation. Other scholars identified cooperative, being unconditionally constructive, and stipulating win-win or no deal (Nowman,1995); promise-keeping (Hung, 2002); Cooperative strategies, assurances of legitimacy, and access are used mostly in exchange relationships (Plowman, 2007); Being unconditionally constructive (Hung, 2003); Stipulating win-win or no deal, cooperative, and unconditionally constructive (Plowman, 1995); Stewardship strategies (reciprocity, responsibility, reporting, and relationship nurturing (Kelly, 2001).

Asymmetrical strategies (used mostly in exploitive, manipulative, and symbiotic relationships) include: contending; avoiding; accommodating (Lerbinger, 1997); compromising; and distributive (Hung, 2002, 2003, 2007). Some dual concern strategies are asymmetrical, as they pay much more attention of the organisation's interest than the other, but according to Plowman (2007), two-way symmetrical communication also can include elements of compromise and accommodation. Hung (2004) also contributed family orientation, guan-xi, and relational orientation to the factors that could influence the multinational companies' relationship cultivation strategies in Chinese culture.

Some new strategies were added to these existing ones, and some of them are hard to define symmetrical or asymmetrical, which would considers both situations to some extent. Chen (2005, 2006) has identified personal relationships, personal services, organisational credibility, political accommodation, and social accommodation as effective strategies for cultivating companies–government relationships. Men (2009) has proposed being ethical, thinking from the publics' perspectives, and engagement and involvement to the relationship cultivation strategies list. Parker and Asher (1993), and Bortree (2010) have proposed a new maintenance strategy, guidance, after exploring adolescent–organisation relationships. Guidance is a broader concept than advice, which overlaps the interpersonal literature, and it provides directions for adolescents (Bronstein & Duncan, 1996). This full list of cultivation strategies helps me cite some examples to the interviewees when they do not recalled any more strategies they use in their corporate philanthropy. There are no academic studies on relationship cultivation strategies through corporate philanthropy conducted in China yet. Therefore, the research question of this research is:

What relationship-cultivation strategies did the companies use during the corporate philanthropic program with their publics in China?

Method

This study uses the in-depth interview to conduct the study. The respondents include CEOs, CSR managers, and other managers who are directly involved with the company's philanthropic activities in China. Sixteen interviews were recorded. Each interview lasted about 1–2 hours (McCraken (1988) and Kauffman (1992) suggested that 1.5 hours is as much as the researcher can ask from his or her busy interviewees). The researchers recruited managers as interviewees by sending out emails (or through telephone) to the public relations or public affairs department of each company or, if possible, directly to the CEOs.

Participants' Background Information

No.	COMPANY	POSITION
Multinational Companies		
1	U.S.-based healthcare company	Special Projects Manager (P1)
2	German-based healthcare and high-technology materials company	CSR Manager
3	U.S.-based IT company	Vice-President
4	Korea-based cosmetic company	Marketing Manager
5	Italian-Sino joint venture on watches	Public Relations Manager
State-Owned Company		
6	Telecommunications company	Marketing Manager
Taiwanese Company		
7	Technology manufacturer	Public Spokesman
Hong Kong Companies		
8	Property developer (Beijing office)	CSR Manager
9	Social enterprise	Director
Private Chinese companies		
10	Group with business in infrastructure construction, medicine, electricity, education, etc.	Publicity Manager
11	Software company	Marketing Manager
12	IT company	Founder and President
13	Petroleum company	Marketing Manager
14	Chemical company	Marketing Manager
15	Chemical company	General Manager
16	Auxiliary factory (social enterprise)	Founder and General Manager

Data Analysis

The data were analysed following the three stages illustrated in Miles and Huberman's (1994) qualitative data analysis: data reduction (the data will firstly be reduced by *conceptual reduction* to sort and categorise them into the different conceptual themes), data display, and conclusion drawing and verification. In the stage of data collection, the taped interviews were transcribed verbatim and translated to English. The important concepts were highlighted, the main information for the research questions was summarised, and the data was categorised. Notes were taken for the repeated words and keep files for the interviews by different interviewees. In the second stage of data display, the data was categorised by how they answered the

different research questions. The sizes and structure/ownership of the companies were compared to see whether they were differences or similarities. This is the data–deduction process: Ideas are connected and demonstrated clearly. Data were coded by the companies' size and ownership type. In the third stage of drawing and verification, memos and queries were written in my research file, to find the similarities in the transcripts. In this stage of data transformation and verification, the researchers re-read the transcripts and drew a picture of the data. By finding the most mentioned concepts, highlighting emerging relationships, and using visual forms to compare the data and the cases, a picture began to emerge, and furthered interpreted the data arrives at the conclusions.

Results

This section of results provides the examples that the participants gave and analysed them in themes of relationship cultivation strategies in China. Participants not only presented the examples of the existing strategies, but also the new strategy is identified. The detailed results are shown in Table 1. The frequency refers to the numbers of the participants mentioned of the specific strategy.

Table 1. Cultivation Strategies Mentioned Frequency

	Cultivation Strategies	Frequency
1	Cooperation	**15**
2	Sharing of task	**12**
3	Assurance	**4**
4	Openness	**8**
5	Networking	**5**
6	Positivity	**10**
7	Dual-concern strategies	**9**
8	Access	**12**
9	Keeping of promises	**4**
10	Stewardship	**6**
11	Responsiveness	**1**
12	Continued dialogue	**10**
13	Listening	**4**
14	Face-to-face communication	**13**
15	Personal relationships	**7**
16	Respect	**2**
17	Organisational credibility	**1**
18	Educational communication	**3**
19	Visible leadership	**2**
20	Being the opinion leader	**1**

Being cooperative, sharing of tasks, and assurances of legitimacy

"Sharing of task" (Hon & Grunig, 1999) and "being cooperative" (Plowman, 1995) are the most often-mentioned strategies by the participants. "Assurances of legitimacy" plays an important role when the companies share tasks and cooperate

with the publics. Several big and medium companies stated that they have cooperative relationships with NGOs and government (P2 with Chinese Ministry of Health, P9 & P16). P8 provided a cooperative project her company had with the Ministry of Agriculture. P16 said they needed to first report to the civil administration department before founding a social enterprise. The government then helped them find persons with disabilities to hire. P9 also needed to cooperate with the correction services, and the government helped them hire formerly incarcerated youths. P1 gave me another example of their relationship with the NGOs by using the cultivation strategies "sharing of task," "cooperative," and "assurances of legitimacy" (Hon & Grunig, 1999, 2000). They need to sign a very strict protocol, which requires a very strict legal procedures with NGO and they will contact the NGO to understand their progress, then to do their internal audit and evaluation. P11 said that they provide internship opportunities for college students.

Access, openness or disclosures, and listening

The participants' statements show that "access" and "openness or disclosures" (Hon & Grunig, 1999) are the cultivation strategies used when there is a need to cooperate with NGOs or the government. P1 and P9 mentioned that they keep in touch with the government and NGO either through personal visits, email, or telephone calls. P2 also said they publicize their corporate philanthropy through press conferences. They also let their own employees know that the company not only focuses on earning money but also on ensuring the society's well-being. This encourages the employees to be loyal to the company and even persuade their friends to work for the company. To further elaborate the "openness or disclosure" strategy, he said that each year his company releases a sustainable development report to make them feel more confident of their investment to buy more of their company's shares. P6 and P11 also said that they publish their companies' philanthropic activities online as part of their corporate mission statement values. The employees can then access the contact information of the organizer of the volunteer activities, which show elements of openness/disclosure and access strategies. These are also strategies that advocate workplace giving, identified by Smith and Sypher (2010).

Several participants said that they had meetings with their publics (clients, suppliers, and other companies) and discussed corporate philanthropy with them. For instance, P1 said their subsidiaries have dealers meeting once or several times a year to talk about corporate social responsibility. They hope to motivate the government, to promote cooperation, but this is actually very difficult for them to measure it. She also said that their company conducts seminars with other companies to talk about CSR. From her remarks, we can see that "access" and "openness or disclosure" are used as cultivation strategies, which are the requirements for future "cooperative" relationships. In these seminars, the CSR managers from different countries meet and discuss the ways to improve their work. "Listening" was involved in some "openness or disclosure" strategies. In the meetings with their employees and suppliers, the companies want to hear their employees' opinion on their philanthropic programs. Small companies tend to use the "listening" strategy more frequently.

Networking

"Networking" (Hon & Grunig, 1999) also exists in the corporate philanthropic process. A participant said that although they do not have a cooperative relationship with the government, in a way they have a connection with the government through the experts from the NGOs they cooperate with. "These experts on medical health would share our companies' achievement with the government. Then if the government thinks that some of our corporate philanthropic projects are good, they might promote it." Two other small companies also mentioned this "networking" strategy. P11 remarked that they consult with their suppliers on whether they need to donate (e.g., to earthquake-stricken communities) and how much, which is similar to the practice of giving gifts.

Stafford and Canary (1991) have mentioned that "networking" (i.e., having common friends) as a strategy to get a romantic relationship is enjoyable. Grunig and Huang (2000) have developed this concept to OPRs as organisations built networks with the same groups as their publics. P6 said that they cooperate with the social work department of a university to do research on their potential customers. Some companies also cooperate with NGOs. P6 said that one of their philanthropic activities is to help elderly people learn how to use a cell phone (e.g., one button function), to pay telephone bills, and to buy set services through the "street (community) office."

Dual concern strategies

Some "dual concern strategies" (Hon & Grunig, 1999) were also observed in the relationship between companies and the media. According to the participants, when companies decide to undertake philanthropy, they take into consideration a balance between the interests of the publics with those of the organisation. Companies donate an amount they can afford (a certain percentage of their marketing budget) and at the same time consider the publics they will help. The dual concern strategy considers the publics' needs before corporate philanthropy is undertaken. For example, the manager of a telecommunication company said that one of their activities was to repair the telecommunication facilities damaged by the 2008 Sichuan earthquake. Furthermore, the director of a foundation of a prestigious Chinese university remarked that they use dual concern strategy with their partner company: they receive donation on certain conditions, such as naming a building after the donor company or establishing a research center. He said that they carefully examine their potential donors, and then determine the most appropriate way to deal with them.

Accommodating

Although most dual concern strategies are symmetrical, accommodating is a type of dual concern strategy that is asymmetrical. According to Plowman (1995), accommodating means, the organisation yields, at least in part, on its position and lowers its aspirations. Accommodating strategies can be seen from the examples provided by the participants. P7 commented that his company used to cooperate with the media, but if you cooperate with just one media company, other media companies will not run a report of your philanthropic activities, as they also expect to receive money from the company. This example shows that the company also thinks from the media's perspective. Most of the participants also said that they consider the publics'

interest before making a decision on corporate philanthropy (e.g., employees', potential customers', and the general publics' interests). He also said that they started conducting corporate philanthropy for their employees, as it is burden their employees to donate their hard-earned money to philanthropic causes, as many of our employees belong to lower socioeconomic group.

Political accommodation and social accommodation

Chen (2005) has posited that political and social accommodations refer to the responsiveness or to contribution to a nation's political and social issues. Social and political problems sometimes merge; hence, these two strategies could be unified. In my opinion, political accommodation and social accommodation in some cases are based on dual concern strategy. Regarding the political accommodation, P7 told me that they cannot donate to causes that are related to sensitive political issues. As for social accommodation, corporate philanthropy itself is a practice in which an organization cultivates relationship with the government by helping solve national social issues. Interviewees from several companies said that certain government policies ask companies to donate to specific causes raised by the government. This strategy is similar to the "stewardship" strategy posited by Kelly (1998), which I will discuss in the following paragraphs.

Stewardship and Keeping of promises

Kelly (1998) has identified "responsibility," "reciprocity," and "relationship nurturing" as elements of "stewardship." The interviewed companies' philanthropic activities showed their responsiveness to the society. P15 said that they wanted to maintain a good relationship with the government, and would donate money when the government asks them to, such as in the aftermath of the 2008 Sichuan earthquake. He believes that maintaining a good relationship with the government has benefits; otherwise, they might encounter bureaucratic problems if government leaders do not have a good impression of them. Although this has never happened yet, they would not try to risk it. Interviewees said that their companies mostly keep their promises as long as they do not experience any big financial problem, which shows "Keeping of promises" (Hung, 2002).

Continued dialogue/patience, personal relationships, and face-to-face communication

Continued dialogue/patience (Rhee, 2004) was used by the corporations when they maintain relationships with NGOs. P14 said that they have a long-term relationship with the Red Cross Society of China. When I asked how did they build their relationship with the Red Cross, he answered that they already had a relationship with the organisation and keep regular communication through telephone calls and face-to-face meetings.

The participants also mentioned that they use interpersonal communication strategies in maintaining relationships in their corporate philanthropic programs, which echoes the "personal relationships" strategy identified by Chen (2005). Similar to personal relationships, Rhee (2004) has posited that face-to-face communication is a new cultivation strategy. The strategies identified by Rhee (2004) are more specific than

the previous strategies proposed by Hon and Grunig (1999). The "face-to-face communication" strategy is also used in this strategy. P9 that hires previously incarcerated young offenders provided another example. He said he and another top manager of their social enterprise speak to their employees every Tuesday morning face-to-face.

Responsiveness, respect, and positivity

"Responsiveness" (Rhee, 2004) was also mentioned by one participant. When asked whether their company encounter the problem of the "government persuading them to donate," which other participants have pointed out, she stressed that they do not need to be persuaded as they always react very quickly to philanthropic causes (e.g., earthquake or flood relief). Rhee (2004) has also proposed "respect" as a new cultivation strategy. P8 shared that they practice "respect" strategy when they communicate with their publics, either through telephone calls or when they send greeting cards during special occasions.

During the corporate philanthropic process, "positivity" is also a major strategy in the relationships between the publics and the company. "Positivity" means "doing whatever is necessary to make publics feel more content in the relationships" (Grunig & Huang, 2000). When companies conduct corporate philanthropy with their publics, almost all of them want to make their relationship with their publics a satisfying one. Companies also consider their employees' ideas on corporate philanthropy; they will not undertake programs that their employees would not approve of or afford.

Visible leadership

"Visible leadership" strategy (Rhee, 2004), was also identified. The managers of the companies set examples to their staff by being active philanthropists themselves. P11 said that their company's president donated RMB100, 000 from his own money to philanthropy, and his employees collectively donated RMB200, 000. P12 also said that he let his employees know about the amount that he will donate. In this "top-down approach," the top manager will be the first to donate, followed by the vice-president, then the directors, and finally the junior employers. He added that if the chief director donated RMB500, the vice director will donate RMB400, and so on.

Being the opinion leader and organisational credibility

P9, who also used to be the vice-president of a well-known multinational IT company, put forward a new cultivation strategy: "Being the opinion leader." Customers seek a company's services or buy its products because of its good reputation as a socially responsible company. In addition, customers are willing to pay a little more for a good cause. "Organisational credibility" (Chen, 2005) can also be seen from this strategy. Besides talking about his organisation's credibility and popularity, the top manager told me his strategy is all about being the "opinion leader". They were the first to talk about social enterprise business turnaround, offer money collection, propose ethical consumption, knowledge volunteers, "triple benefits", and shared culture. Each year they have a theme. He said, "When you have a theme each year, you will become an opinion leader." From his remarks, I proposed "Being the opinion leader" as a new cultivation strategy. This is also a strategic type of corporate philanthropy. The

strategies they proposed, such as "knowledge volunteers" are useful for companies when they conduct philanthropy. For example, this social enterprise invited university to do survey and evaluate their customers' opinions, which other companies could learn from.

Educational communication

Educational communication (Rhee, 2004) is also used in strategic philanthropic activities. For example, a healthcare company conducts free training programs for mothers to help them understand the importance of touch therapy. Similarly, P2 said that they travel to villages and speak to farmers about the importance of choosing the right fertilizer, which not only educates the farmers but also promotes their products: They have education training programs for farmers on pesticide and fertilizer (their products). Furthermore, P8 said that they have training programs for farmers to help them get reemployed.

Discussions and Conclusions

The results show that most of the symmetrical strategies have been used in corporate philanthropy in China. The two-way symmetrical communication strategies include access, openness, cooperation, networking, sharing of tasks, and some dual concern strategies and are applied in the relationships between companies and NGOs. Smith and Sypher (2010) find that "always speaking about" is a strategy used by a company to advocate workplace giving. Access, openness, and continuous dialogue/patience are similar to the strategy of "always speaking about," which is to advocate corporate charitable giving in the company's mission statement, employee newsletters, and charitable giving talks. The dual concern strategy is also used frequently. During cooperation between NGOs and companies, assuring legitimacy is used to complete philanthropic programs. Assuring legitimacy is also used in contractual relationships. Some of the companies also cooperate with the government in some philanthropic projects.

Aside from these symmetrical strategies, some asymmetrical dual concern strategies, specifically accommodating and visible leadership are observed. The company also considers its employees' feelings and media's perspective on how to publicize their story when they want to conduct corporate philanthropy. Social accommodation and political accommodation were used in corporate philanthropy. Non-local companies tend to pay more attention to adapt their corporate philanthropic programs to the Chinese social and political environment. A new strategy, "being the opinion leader," is also used by a social enterprise, which could influence more companies to conduct social enterprises business. Participants said that they do not have any sophisticate and complicated strategy for corporate philanthropy and they are also curious about this.

This study has several implications for PR practitioners and managers of companies in China when they undertake corporate philanthropy. First, in China, most companies, especially local ones, do not have strategic programs for corporate philanthropy as MNCs do. Local companies could learn from MNCs and social enterprises to improve their strategic corporate philanthropy. However, to do corporate philanthropy in a strategic and sustainable way is what companies should strive for. Some companies

worry about their companies indiscriminate donating without any clear intention, whereas others stress that if the corporate philanthropic program is not related to their business areas, then would not have the motivation keep doing it. Hence, win-win solutions, or some of the strategies used by social enterprises, are good choices for local companies. Social enterprises simultaneously help the society and do their business. This study extends the relationship management theory by applying it in corporate philanthropy in China. The practitioners or company managers in China should begin to consider corporate philanthropy as public relations, or at least devise a win-win situation between the publics and the company when they undertake corporate philanthropy. The results indicate that certain companies consider corporate philanthropy as an integral part of their overall business strategy, as Himmelstein (1997) posits. In contrast, some companies only conduct corporate philanthropy reactively; for instance, when the government persuades or encourages them to do so, or when disasters strike. No matter what kind of philanthropy, the publics considered these activities good.

From this study's result, most companies that conduct philanthropy developed mutually respectful relationships between funders and grantees (Exception: In this study, only one company said that, sometimes when they donated to the Red Cross Society of China, the grantee do not know that it was their company who donated). In addition, based on grantees' and foundations' own experiences, building collaborations with other funders can increase publicity that benefits the public. The manager of a chemical company said that they learned of other companies through charity events, which eventually became their business partners. As they both conduct corporate philanthropy, they trust each other's credibility, and they plan to cooperate later on in business. Although the participating companies do not have scientifically valid tools to evaluate their philanthropic programs, two of the benchmarks of effective philanthropy can used to do so.

This study only used one method, so its validity still needs to be tested later on using another method. The inability of some participants to express themselves clearly might have caused accuracy problems as well. This results support the previous findings that practitioners lack knowledge and skills in research and evaluations (Kelly, 2001; Walker, 1997). More studies are needed to explore the external publics relationships (and in the context of corporate philanthropy). Practitioners also need future research on volunteer organizing and to study the Confucian corporate philanthropy that many western academic scholars are interested to know. Lastly, researchers from other countries can use the integrated relationship and corporate philanthropy theories to see if it is applicable in their local settings, to test these cultivation strategies.

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ISO 14001 as an Instrument to Reduce Carbon Emissions A Case Study from an Electronics Manufacturer

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
The concern over climate change and its impact on society is steadily increasing with specific warnings from the IPCC about global warming and the need to reduce greenhouse gas emissions globally. To achieve the targets of Kyoto Protocol, governments and organisations have aspired to adopt more sustainable business models and promote low Carbon economies. The Low Carbon KEEP Programme provides funding to support East of England businesses to innovate and grow through University partnerships by improving internal capabilities and implementing a low carbon approach to business through academic guidance.

This article reports on a case study of a project undertaken in a leading Contract Electronics Manufacturer in association with the School of Engineering and Technology of the University of Hertfordshire through the Low Carbon KEEP Programme. The project's objectives were to introduce an ISO 14001 compliant Environmental Management System, integral to the company's accredited Quality Management System, and to reduce the company's resource consumption, carbon footprint and the overall overhead costs.

A framework for setting up an effective environmental management system with specific environmental targets was developed. This was utilised for planning and managing the implementation of new environmental projects. As a direct result of the project, the company acquired a Building Management System, and took specific measures to improve energy performance. Moreover, an awareness campaign to improve the environmental attitude and behaviour of the employees was undertaken to enhance stakeholder participation. The certification of the Environmental Management System was completed in summer 2014.

Keywords: Environmental Management, ISO 14001, CO_2 Emissions, Energy Efficiency, Electronics Manufacturing

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1. Introduction

1.1. Low Carbon Keep Programme

Advances in scientific knowledge highlight clearly the dangers of global warming, and the climate change is at least in part responsible for certain natural disasters and their substantial economic impact (Boiral, 2006).

It is imperative that all companies, especially those industries which are responsible for significant Greenhouse Gas (GHG) emission, should verify their organisation's GHG emissions sources, and determine the most efficient options for reducing these emissions (Boiral, 2006).

Organisations who adopt a proactive strategy, find it easier to implement standards or regulations to govern their environmental performance and reduce the environmental impact of their activities. They also avoid the barriers to markets that not having these measures in place represent (Boiral, 2006).

The main objective of the Low Carbon KEEP Programme is to actively encourage the development of a low carbon economy in the East of England. The programme provides funding for projects where maximum benefit from knowledge transfer will arise through flexible university-employer partnerships for all types of Small and Medium Enterprise (SME) that meet the conditions of the Programme (Anglia Ruskin University, 2014).

By implementing Low Carbon improvements, businesses will either reduce their carbon emissions, those of their customers or their supply chain. Low carbon improvements can take the form of energy savings, design improvements, new products or processes, waste reduction or general resource efficiency. Most actions which reduce the consumption of resources will reduce carbon emissions and also lead to financial savings (Anglia Ruskin University, 2014).

1.2. Project Partners

This Low Carbon KEEP project was undertaken in a leading Contract Electronics Manufacturer in association with the School of Engineering and Technology of the University of Hertfordshire. The company, Nemco Ltd, produces mainly Printed Circuit Boards and General Assembly Products and provides a complete product manufacturing, logistics and repair service to customers. They service a variety of Commercial, Automotive, Aerospace and Defence Markets, with their knowledge of Digital, Analogue, RF and Mechanical Disciplines. Technically advanced and complex products are manufactured, tested, configured then packaged and shipped worldwide from their facility in Stevenage. The university partner supported the project by providing technical supervision.

The aim of this project was to introduce an ISO 14001 compliant Environmental Management System, integral to the company's accredited Quality Management System, and to develop resource monitoring and control systems, focusing primarily

on energy. This would reduce the company's resource consumption, carbon footprint and overall overhead costs, providing increased competitiveness. The certification of the Environmental Management System was completed by the BSI in summer 2014.

1.3. ISO 14001

ISO 14001 sets out the criteria for an Environmental Management System (EMS), by mapping out a framework that a company or an organisation can adopt in order to set up an effective system for managing their environmental impact (ISO, 2004).

The standard can be applied to a variety of levels in the business, from organisational level, right down to the product and service level; highlighting what an organisation needs to do to meet their goals, rather than focusing on exact measures and goals of the environmental performance (ISO, 2004).

ISO 14001, as with other ISO 14000 standards, is voluntary, primarily aiming to assist companies to continually improve their environmental performance, while complying with any applicable legislation. Organisations are responsible for setting their own targets and performance measures, with the standard assisting them to meet their objectives and goals and subsequently monitor their performance (ISO, 2004).

The number of UK organisations with a certified ISO 14001 environmental management system is relatively small; reported to have been 4985 in 2009 (Sammalisto & Brorson, 2008).

It does not state any requirements for environmental performance, nor methods of improving resource efficiency, reducing waste or the operations' costs (ISO 2004).

However, organisations with a certified EMS already in place have the processes that may form the basis for GHG accounting and management. Environmental management standard ISO 14001 supports the measurement and reporting of GHG emissions [4]. It applies the "Plan-Do-Check-Act" model based on the Denin Cycle [see Figure …], which provides a framework for monitoring, collecting data, setting targets and reducing Greenhouse-Gas (GHG) emissions (Suff, 2011).

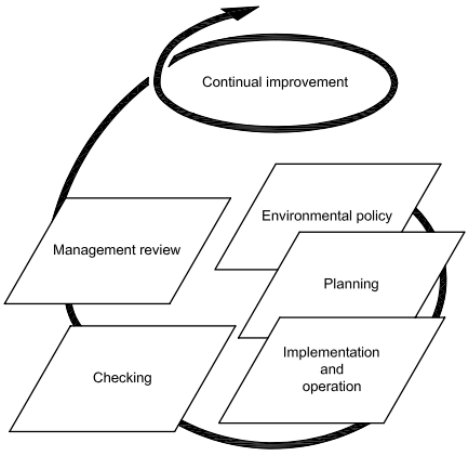

Figure1: The Denin Cycle

ISO sets out how Denin should be applied to management systems ensuring the continual improvement of the system.

Plan Section of 14001 focuses specifically on objectives, targets and implementation plans. GHG emissions can be included in the environmental aspects and impacts register that is required by the standard. These are drawn up following the assessment of how the organisation interacts with the environment, identifying those aspects that are significant. Reduction targets and objectives can be set for aspects of operations and activities that contribute to atmospheric emissions (Suff, 2011).

Do Section deals with the implementation of the environmental management programmes to meet objectives and targets; raising awareness among employees of the environmental policy, and specifically the GHG reduction goals; train relevant personnel to raise their competence. Operational controls, such as standard operating procedures, will ensure current emissions are under control (Suff, 2011).

Check Section focuses on regularly monitoring and measuring GHG emissions, tracking progress towards targets and helping to manage energy and emissions reduction. Records will demonstrate that procedures are being performed effectively. Periodic reviews of targets and objectives will determine whether they are sufficient or need altering in some way (Suff, 2011).

Act Section determines changes to management programmes, processes and procedures that are required to deliver improved results and meet changing targets and objectives (Suff, 2011).

2. Project Plan

The project targeted a number of challenges: i) allocating appropriate internal support resource and setting timescales; ii) identifying specific improvements to be implemented; and iii) instigating and realising behavioural changes.

Initially an environmental review of the company's activities was undertaken focusing on: I) identifying and understanding existing procedures; II) collecting and understanding existing environmental data and performance; III) identifying monitoring needs; IV) examining the existing Quality Management System (QMS); V) and identifying the environmental aspects and impacts.

The environmental review included meetings with the management team and an audit of the site; to develop a precise understanding of the production procedures and products, people in charge of each production procedure, the background of the company and its customers. The review also collected data regarding electricity, gas, and water consumption and the waste produced by the company.

The company had already measures in place to manage certain environmental aspects. However, it was imperative to develop comprehensive documented procedures in order to ensure consistency of approach by all involved.

The quality management system established some work instructions with relevance to the environmental management (equipment maintenance) and had in place procedures to manage documents and records that could be partially adopted by the environmental management system (EMS). Different type of waste was being separated and collected by different companies for treatment. A Waste Management Table was created to collate comprehensive data to improve the provision of waste management, to define the baseline and to develop Key Performance Indicators (KPIs).

Data was gathered for a range of environmental dimensions. However, the project focused primarily on electricity, gas and water consumption and waste. The initial assessment ascertained the ratio of turnover for a unit of electricity (kWh) used, which also highlighted seasonal variations in productivity.

In the preceding year, the company used approximately 638 000 kWh of electricity which meant that approximately 315 tonnes of CO_2 were emitted to the atmosphere as a result of the electricity production, transport and distribution; whilst the gas consumption for the same year amounted to approximately 696 000 kWh representing approximately 129 tonnes of emitted CO2 (DEFRA, 2012, 2013).

The initial environmental review was also used to identify the need for additional monitoring equipment. One of the ovens on-site, responsible for significant electricity consumption, had been continuously monitored for over one year. The analysis of the metered data enabled estimation of the overall consumption of all the ovens. Clamp meters were used to ascertain the consumption of other industrial equipment within the company.

The processes of the quality management system were analysed and a matrix for gap analysis was developed. The matrix compared the existing processes of the quality management system with the processes that needed to be developed for the environmental management system, looking for similar processes that might be adapted by the new EMS. The matrix listed the requirements of the environmental management system, compared them with the existing system and identified the processes and documents that would need to be developed or changed.

A comprehensive register of all the environmental aspects associated with every activity within the company, the equipment and the installations was generated. The environmental impacts of each environmental aspect were also identified in this document. Table 1 indicates a typical entry for one activity.

Table 1: An Illustrative Environmental Aspect Identification

Process	Activity	Aspect	Impact
General assembly	Hand soldering	Electricity consumption	Production impacts (ex: greenhouse effect)
		Non renewable resource consumption	Depletion of non renewablee resurces
		Solid waste	Waste elimination impacts
		Polluting fumes	Air pollution

3. Project Objectives

The primary objective of the project was to achieve ISO 14001 Certification; through the implementation of an environmental management system and the required procedures identified at the project planning phase. The total number of procedures that the EMS required and those that could be adapted from the quality management system after reviewing were identified (see Table 2).

Table 2: Number of Procedures Required by the Environmental Management System

ISO 14001 Requirements	
Procedures	
Needed	21
Existing from QMS	12
Need Reviewing	all

Furthermore, the project aimed to reduce resource use and CO_2 emission; requiring the setting of Environmental Objectives. The Environmental Policy established the commitment to setting environmental objectives and the priorities were identified as i) reducing electricity consumption, ii) reducing gas consumption, iii) improving waste separation and reducing collection frequency, iv) providing environmental training and improving awareness, and v) improving employees' participation. The objectives, as well as appropriate actions/control measures, were established by the top management in the environmental programme with the assistance of the project team; see Figure 2 for a schematic representation of the aspects of each objective as recorded in the aforementioned table.

Objectives	Initial Status	Final Status	Targets	Actions	Person in Charge	Resources	Deadline

Figure 2: Schematic Representation of Objectives' Aspects

Periodically, the status of each action and environmental objective was updated on the environmental programme and/or additional actions and objectives were set, following the "Plan-Do-Check-Act" model. Figure 1 depicts the continuous cycle of setting the policy, identifying objectives and targets, deciding on actions to be taken and the control measures to be implemented, monitoring the results and consequently updating the policy once again.

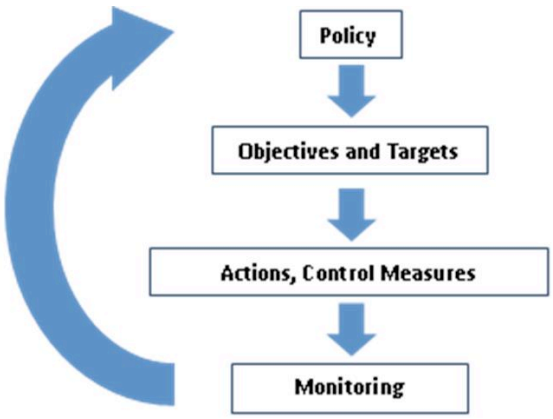

Figure3: Policy Setting and Implementation Cycle

4. Implementation

4.1. Environmental Management System (EMS);

The company's existing environmental policy was reviewed and revised to incorporate the requirements of the ISO14001. The updated approved version was made available to all members of staff.

The matrix of environmental aspects was scrutinised and the significance of each aspect ascertained. The threshold for the level of significance was determined.

Key Performance Indicators (KPI) representative of the company's environmental performance were defined. These were subsequently monitored according to an established plan to assess the company's performance.

An environmental process was developed for managing all the waste in the company in a standardised way.

The environmental requirements that applied to the company (legal and others) were gathered and the company's compliance was assessed. A new process was established to periodically update the environmental requirements and review compliance.

The Environmental Processes that were developed for the EMS used the same template that was used for the Quality Procedures to ensure integration of the two systems would be straightforward. In addition, Environmental Work Instructions and Emergency Procedures were also created. All the procedures were methodically documented for ease of referencing. Table 3 enlists the number of processes, procedures, and work instructions as well as documents that were created by the end of the project.

Table 3: Overview of the Documented Procedures (June 2014)

Environmental Management System
Processes
12
Procedures + Work Instructions
8
Other Documents and Tables
22

4.2. Building Management System (BMS);

The company implemented a state-of-the-art Building Management System (BMS) with an aim to monitor and control certain aspects of their operation which have a significant environmental impact, and to improve their environmental performance. The implemented System measures electricity, water and gas consumption, improves control over electricity and gas consumption and highlights potential new actions for further improvement in the future.

The BMS provides specific electricity consumption figures for the main equipment within each installation at Nemco. It also provides additional data such as operating hours and consumption cycles of the main equipment. This allows for detailed study of the equipment and identifying further improvement projects.

The BMS also measures gas consumption and, by measuring the temperature inside and outside the building, allows for automatic regulation of the temperature indoors. It makes it possible to differentiate between gas used directly for space heating in the industrial area and for heating up water (toilets and office heating) usage.

4.3. Energy and Carbon Emissions Reduction

A number of projects were identified to reduce energy and carbon emission in the company and to improve employees' awareness

4.3.1. Efficient Lighting;

The analysis indicated that changing the existing lights in the warehouse for more efficient variants would accomplish savings, while achieving improved lighting quality with a 3-year payback. An action plan was devised, resources and manpower were committed to the scheme and a deadline was set. The forecast savings in electricity and carbon-dioxide are listed in Table 4.

Table 4: Forecast Savings

	Before	After
Lights	465 W	320/216/160 W
kWh/year	38 000	18 500
tCO2	20	10
£/year	4 000	2 000

4.3.2. Automatic Computer Shutdown;

The company uses approximately 100 computers that had to stay on after work to finish the anti-virus scan and would remain on afterwards. However it was noted that the period could be shortened if the automatic shut down of the computers immediately after the anti-virus was implemented. The power consumption of each machine was measured and IT department implemented the automatic shutdown. This is projected to lead to savings of up to 17000 kWh/year, which accounts for 7.6 tCO2 emissions/year (DEFRA, 2013, 2014).

4.3.3. Energy Efficient Equipment;

Replacement of other inefficient practices provided further energy savings and hence carbon emissions reductions as well as cost savings. One example was discontinuing the use of paper towels (est. £1500/year) and replacing inefficient dryers (2450 W) by energy efficient (1600 W) hand dryers that delivered faster drying action and allowed for cost reductions, with a payback period of less than three years.

4.3.4. Waste Collection Reduction

The frequency of the collection of some recyclables (paper, plastic, cans, and cardboard) was reduced by 50%. This was achieved by rationalising the collection of paper, plastics and cans, and by utilising a larger container for cardboard. This led to a reduction in fuel consumption for the two recycling companies responsible for collecting the waste and lower levels of CO_2 emissions.

4.4. Environmental Training

According to Roninelli and Vastag (2000), one of the strongest impacts of ISO 14001 certification and the adoption of a strengthened Environmental Management System in their case study was behavioural. Managers at the plant in their case study noted that the ISO 14001 certification increased awareness of environmental aspects.

Kitazawa and Sarkis (2000) reported the important role of people (employees, managers) in making the source reduction linkage to the ISO 14001 (EMS) standards stronger and they also refer to other environmental and sustainability management studies that have also shown how critical the “people” dimension is because it goes beyond just product and process dimensions.

In order to increase employee awareness and participation at Nemco, a training programme was devised and delivered to all members of staff divided into small groups. Prior to the training, the general knowledge and attitude of the employees towards a range of environmental issues, as well their role in reducing environmental impacts at the company, was scrutinised though a self-completing questionnaire. One question specifically enquired whether they would like to receive any environmental information and their preferred method of delivery. They were also asked for suggestions that, in their opinion, would improve environmental management in the company.

The results informed the content and method of delivery of the subsequent training provided. The shift in the general environmental knowledge, and their awareness relating to the environmental management in the company, their environmental attitude in general, and their attitude towards environmental management in the company was assessed through a second questionnaire following the training session.

Overall, the training was received favourably by the staff and the initial analysis of the data indicates significant positive results with respect to enhanced knowledge and improved attitude amongst the staff.

The improvement in Nemco's environmental performance could be in part attributed to the raised awareness of the staff.

5. Certification Process

The importance of the certification for the environmental performance of the organisation has been shown by Potoski and Prakash (2005). In their study, they compared ISO 14001 certification with Responsible Care. They state that while Responsible Care – a covenant without a sanctioning mechanism – did not improve participants' environmental performance, their study found that ISO 14001, a covenant with a weak monitoring and sanctioning mechanism, improved participants' environmental performance. The discriminating variable in the design of the two programmes is third-party audits. Their paper concludes that monitoring and sanctioning is necessary for a voluntary programme to improve participants' environmental performance.

The award of the ISO14001 standard is subsequent to an external audit by a 3rd party awarding body. In our case study, we approached the British Standard Institute (BSI), and arranged a pre-certification audit (not a mandatory part of the certification process) to highlight any areas that required further improvements. Subsequently, the certification audit was conducted by BSI, in two stages. The first stage assessed the general implementation of the system and if it was ready for the second stage. The second stage assessed in detail if the requirements of the standard were being met by the environmental system. The certification process was conducted successfully, concluding that the Environmental Management System had been properly implemented and, accordingly, Nemco was awarded the ISO14001 Standard Certification.

6. Conclusion

The Low Carbon Keep partnership proved successful through an effective mechanism for a partnership between an SME and a knowledge institution, and provided part-funding for the project and for investment in the energy reducing equipment. The partnership between Nemco, a forward-thinking company, and the University of Hertfordshire, an established engineering knowledge and training base, led to the successful implementation and certification of an Environmental Management System compliant with ISO 14001.

The process leading to the ISO 14001 certification was utilised as an effective tool, to establish an Environmental Management System that successfully accomplished the implementation of effective schemes to achieve a significant reduction in energy use and CO2 emissions. The recorded results indicated a 7% reduction in electricity consumption over the 12 month period of the project compared to the preceding year. Furthermore, the calculated CO2 emission over the same period of time showed an 18% reduction. This represents a considerable achievement and clearly proves the success of the project and the partnership between the industry and the knowledge institute. The project also led to improved environmental awareness of the employees in the company.

It is fully anticipated that the company's resource use and energy consumption will be further reduced in the coming year once the implemented systems are fully imbedded in the company's procedures and culture.

7. Acknowledgements

The authors acknowledge the support received from the Low Carbon KEEP Programme, East of England Development Agency, European Regional Development Fund and Anglia Ruskin University.

We are also grateful for the support received from the management team and the employees at Nemco Ltd, the School of Engineering and Technology and the Knowledge Transfer Team, University of Hertfordshire.

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Marketing A Net Positive Future – The Demand Side

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
In many climatic regions, both in Europe and the US, it is possible to design and build homes that can be powered solely from a renewable resource. This paper will present the efforts taken in the US and Europe to aid home builders to quantify the performance of a building envelope and the levels of air-tightness that are required to achieve energy consumption goals that are 90% less than typical construction. As building codes evolve and energy efficient construction moves from the fringe to the mainstream, numerous computer simulating software packages have been developed to aid the designer in optimizing building performance. These packages serve the designer well. However, few inform a homeowner of the potential economic benefits of investing in a sustainable lifestyle, centered around a home that provides desired thermal comfort and monitored indoor air quality, all powered by a renewable resource. The first adopters of super insulated, airtight buildings, conditioned with small mechanical units have been eco-conscious architects and engineers. To reach a broader demographic the decision making process needs to be streamlined, the information delivered to potential homeowners needs to be condensed, and most importantly, delivered in a manner that an non-building professional can quantify. In most cases this will require expressing energy efficiency in terms of euros, pounds, and dollars of monthly expenditure, as opposed to kilowatt-hours per square ft, per year.

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The demand for energy efficient homes is a growing market. Building to standards that enable energy consumption to be reduced to the point where it can be satisfied by sustainable power sources is possible. However, further work is required to educate consumers, home builders and property developers, of the advantages of building beyond code compliance. With reference to the Gable Home, a house designed and built to satisfy the stringent Passive House (PH) standard, this paper will reflect on a designers interaction with the Passive House Planning Package. An evaluation of the simulated performance of the Gable Home will be made in light of data collected from the house since being established on a permanent foundation. The Passive House standard will be compared to the International Energy Conservation Code (IECC), and costs and benefits of building beyond code will be discussed. The paper concludes with a recommendation that could hasten the process by which the general public will gain an understanding of the financial benefits of living in an energy efficient building. Once the benefits are more widely known it is the authors belief that the demand for low energy consuming buildings will rise.

Iterative improvements in legally enforceable building codes have led to more energy efficient new construction. Energy rating systems such as the Home Energy Rating System (HERS) in the US, and Energy Performance Certification (EPC), mandated by an EU directive in 2013, have helped consumers compare the projected energy consumption of a home they may wish to purchase. However these codes and ratings have not produce a paradigm shift in the way the majority of buildings are designed, constructed, and operated. In contrast the Passive House standard has made a significant impact in the way buildings are built in a number of municipalities across Europe. For example The Brussels Capital Region, in Belgium, has looked to the PH standard to develop legislation that will enable it to achieve the ambitious energy performance goals, known as the "20-20-20 Targets", established by the European Council (PassREg | the regions). In the US however, the number of Passive House certified homes remain a minute percentage compared to the large volume of houses that get built in the U.S. each year (PHIUS: project). The slow adoption of the Passive House Standard in the US could be influenced by the following factors:

1. It is not possible to gain political support to adopt the most current version of the International Energy Conservation Code in every state in the U.S. (Status of state energy code adoption). Therefore, going beyond the IECC, to comply with a much stricter voluntary code, is politically untenable in many parts of the US. Resistance to adoption is compounded by the fact there are additional costs to achieve Passive House certification.
2. Unlike Germany, the United States has a wide range of climatic variation within its boarders. This means a wide rage of specific construction details and insulation values are required to ensure Passive House compliance can be met throughout the US.
3. Although the definition of the Passive House Standard is succinct, the units of measure: kW/m²/per year or Btu/ft²/per year are not tangible values to an uninformed consumer.

Since its inception in 2000 the IECC has developed a model code to establish minimum design and construction requirements for energy efficiency. Following a process of proposal and review, submitted by those in the building profession, the code has become more stringent with each version that has been released. In parallel

to the strengthening of the IECC the US Department of Energy (DOE) has provided concise and clear information on the differences between codes, and more importantly informing the public and state lawmakers about the financial benefits of adopting the most current version of the IECC. The DOE has modeled energy consumption and construction costs of numerous construction types, in various climatic regions to enable them to inform the public about life-cycle costs over a 30 year time period, and annual cash flow savings. In a seventeen-page document titled National Energy and Cost Savings for Single and Multifamily Homes, the DOE also breaks down the comparison of key elements in a buildings construction, e.g. insulation, window U values, and describes how they vary by climate zone (National energy and cost savings for new single – and multifamily homes). The Passive House movement, and the US Passive House organization in particular, offer some free advice on energy efficient building practices, the most useful being detailed descriptions of PH certified homes via their website (PHIUS: project detail). However to finance their work they need to license energy modeling software, such as the Passive House Planning Package (PHPP), or provide services, such as energy modeling and training seminars. Providing free and clear guidance as to what is required to build energy efficient homes is the first step towards creating an informed consumer market.

Despite the different roles the DOE, the International Codes Council and numerous Passive House accreditors play, their aims and objectives are very similar. All want to encourage the construction of more energy efficient buildings than those currently in existence. In the following section two key components of energy efficient construction will be addressed, insulation and air tightness. Reference will be drawn to the requirements prescribed by the IECC, and Passive House standard. Comment will be given on how compliance to these codes and standards can be achieved in the context of both the US and UK building traditions.

The energy crisis of the 1970's, public information distributed through various media outlets, and product promotional material, have all helped spread a broad understanding that high levels of insulation surrounding a building, will reduce the cost of conditioning rooms that are occupied. A second and much less understood principle of energy efficient construction is the creation of an airtight envelope. Air-tightness requirements have progressively become stricter in the IEEC over the years. In climate zone 4, defined by the IECC, the control on air changes per hour progressed from no requirement in 2006, to a recommended but not tested 7 Air Changes an Hour (ACH) in 2009 to the current IECC, released in 2012, requiring blower door testing to ensure new constructed homes have air leakage of 3 ACH or less. In comparison since its inception in the early 1990's the Passive House standard has always required tight control over air leakage. Figure 1 illustrates the energy and cost savings for a 2,000-ft² building that has been modeled using REM Rate software. When attention is given to the sealing of openings around doors and windows, as well as at junctions between floors, walls and roofs it is possible to achieve air-tightness that complies with the Passive House standard which states, "Uncontrolled leakage through gaps must be smaller than 0.6 of the total house volume per hour during a pressure test at 50 Pascal (both pressurised and depressurised states)" (Passivhaus institut).

The combination of high levels of insulation, with construction that prevents air leakage, or infiltration from the outside, is the key principle of energy efficient building. Markets in the US are more likely to embrace stricter air tightness controls than markets in the UK; the reason for this is twofold. The requirements for tighter control over taped joints in predominately wood framed construction, the norm in the US, is technically easier than achieving air tightness in masonry construction, the predominant form of construction in the UK. The US has also had a long tradition of using forced air to both heat and cool residential buildings. This has not been the case in the UK. One of the founding principles of the Passive House standard is to exchange the desired hot or cool air from the living space with incoming fresh air, which is mechanically drawn into the house to maintain good air quality. The Passive House standard gained traction in Germany in its early years due in part to the fact that economically it was viable to invest in added insulation, allowing costly furnaces and hydronic-heating systems to be replaced with less expensive forced air systems. Subsequent technical advances made heat recovery from air exiting a building possible, further reducing energy consumption.

The UK, being an island nation, has a climate that rarely sees sustained periods in which whole house air conditioning/cooling is required. Buildings with significant thermal mass, such as those built of masonry construction, in conjunction with natural ventilation; the opening of windows, or 'leaky' construction details has typically sufficed the needs of UK residence. Transitioning to airtight construction approaching the levels of those of the Passive House standard will require the introduction of whole house mechanical ventilation, without it interior air quality will rapidly deteriorate. Finding contractors who understand the principles of airtight construction is a challenge anywhere in the world. The challenge is compounded if there are few suppliers who have the ability to install mechanical systems that will maintain good air quality. In the US there is a growing market of products and services to satisfy the growing demand. In Germany, thanks in part to the Passive House movement, there are numerous products, and qualified installers who can install HVAC systems that are appropriately sized for an efficient domestic set up. In the UK the choices are much more limited, leading to a reliance on imported products that may lack the product support required to ensure the technology performs well and is accepted in a niche market.

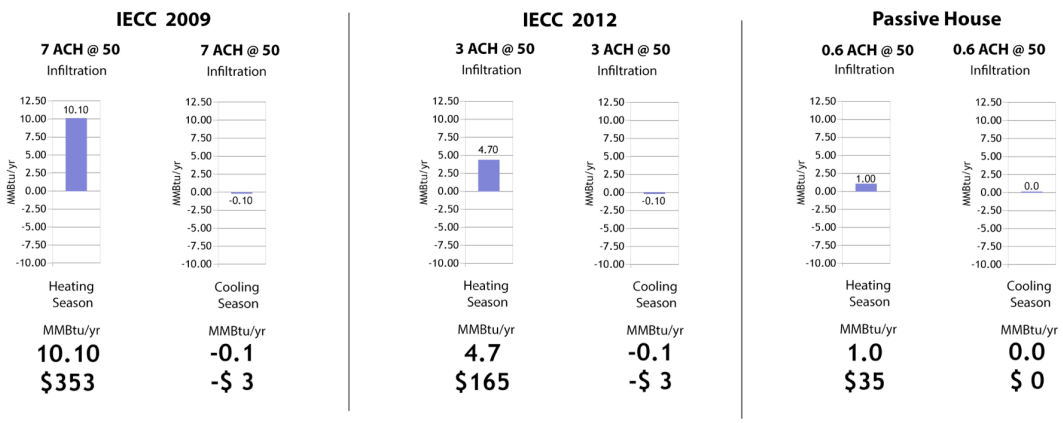


Figure 1. Energy and Cost savings modeled using REM Rate software.

In the following section data collected from the Gable Home will be presented. The data will be compared to the requirements of the Passive House standard, and discrepancies discussed. Built by a collaborative team of architecture and engineering students from the University of Illinois to compete in the 2009 version of the US Department of Energy's Solar Decathlon Competition, the Gable Home was a demonstration of how a Net Positive house could be built, (see figure 2). Informed by the Passive House Planning Package, and surpassing IECC requirements, the house performed extremely well in a competition that challenged collegiate teams from around the world to design and build energy efficient homes that are powered by the sun. During a weeklong competition each house was tested through contests that simulate typical occupancy. Following the competition the house returned to the University of Illinois where it has been monitored to see how it's performance relates to the energy simulation model built to aid the design process.

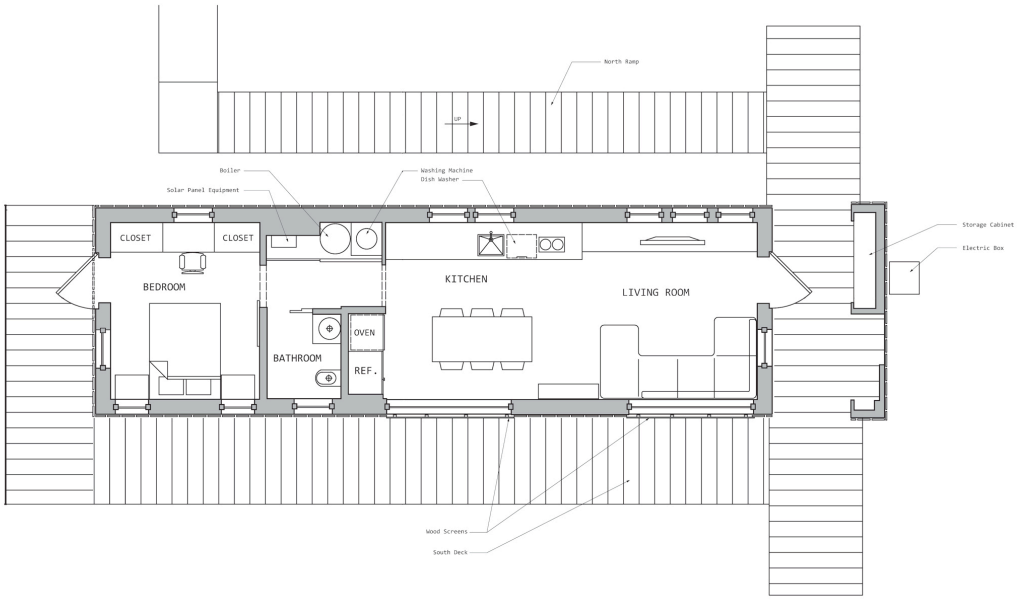


Figure 2. Floor Plan of the Gable Home

Although not required for the competition, the design team understood complying with the strict constraints of the Passive House standard would produce a house that would perform very well in comparison to one that simply satisfied the minimum requirements of the IECC. Air-tightness and insulation levels, prescribed by the 2009 version of the IECC in climate zone 4, are illustrated in figure 3. The IECC requirements are compared to those determined as acceptable by the Passive House Planning Package as it relates to the Gable Home's compliance with the Passive House standard, (see figure 3).

2009 IECC Requirement for Insulation in Climate Zone 4

Air Change Recommendation of 7 ACH (no required testing)

Insulation in Walls	**R 13 (U 0.077)**
Insulation in Attic	**R 38 (U 0.026)**

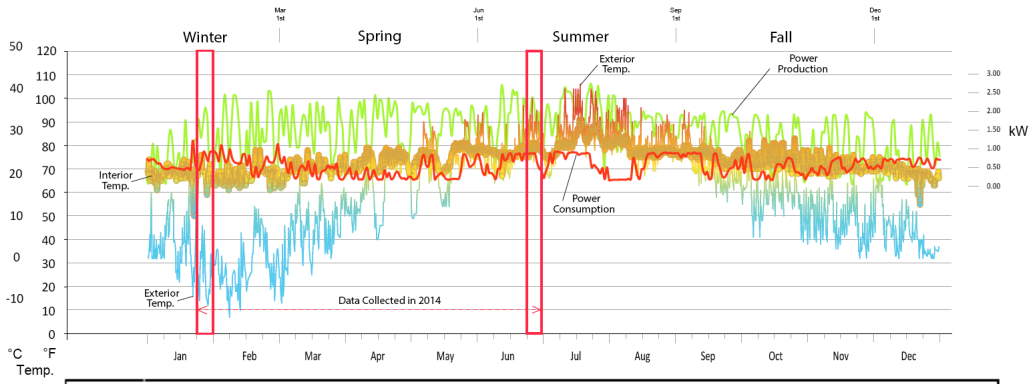
Passive House Planning Package Requirements for the Gable Home

Air Change of less than 0.03 ACH – (blower door tested)

Insulation in Walls	**R 50 (U 0.020)**
Insulation in Attic	**R 60 (U 0.017)**

Figure 3. Comparison of IEEC and Passive House Requirements

A Net Positive House, can be described as one that can produce more energy than it consumes, measured over a one-year period. Designing a Net Positive House requires an understanding of how a house will consume energy, and has the potential to produce it, through the four seasons of the year. In a similar way Passive House compliance is based on an energy model that simulates energy demand over a one-year period, in conjunction with the occupiable area within the house. Figure 4 illustrates numerous characteristics about the Gable Home, while figure 7 outlines the requirements of the Passive House standard.



Total Electricity Used [kWh]													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2014	545	454	371	205	313	47[1]	-	-	-	-	-	-	1936
2013	615	495	434	295	430	496	521	398	458	325	389	486	5341
2012	411	204	176	247	401	462	583	519	369	221	348	465	4406
2011	-	-	-	-	-	-	-	-	0[2]	0	89	220	132

Net Electricity Used [kWh]													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2014	-77	-498	-712	-917	-925	-52[1]	-	-	-	-	-	-	-3182
2013	-251	-521	-837	-1088	-1003	-912	-922	-886	-713	-529	-414	-109	-8183
2012	-400	-481	-1002	-866	-918	-790	-646	-691	-694	-692	-549	-93	-7824
2011	-	-	-	-	-	-	-	-	-0[2]	0	-314	-371	-685

Figure 4. Data from the Gable Home

For a home to be comfortable, interior temperatures need to be maintained between appropriate set points that relate to the season of the year. There are a number of approaches to achieve this. In older, less efficient homes a thermostat within the

living space can be set to trigger heating or cooling when a certain temperature is reached. Maintaining desired temperature in a poorly insulated house can be expensive, especially in summer and winter months. To mitigate for this cost some homeowners opt to switch off any heating or cooling when the house is not occupied. To accommodate this approach furnaces and air conditioning systems have historically been installed with a high capacity to bring a house back to desired temperature quickly, once the homeowner returns to the house. The operation of the Gable Home differs from this conventional approach. Instead of having large equipment with a lot of capacity to respond with large volumes of air in a short period of time, the Gable Home is equipped with a Conditioning Energy Recovery Ventilator (CERV) that provides small volumes of air-conditioned air that may be only a few degrees hotter or cooler than air contained within the living space. This 'low flow' approach to maintaining desired thermal comfort is only possible in a house that is well insulated and of airtight construction. The advantage of this approach is the heating and cooling systems can be down sized, and running costs reduced. Energy efficient heat-pump technology can be used to provide small amounts of conditioned air throughout the day, maintaining desired comfort, with little regard for occupancy levels. The thicker orange band in figure 4 illustrates the attempt to keep the interior temperature of the Gable Home between 68°F (20°C) and 77°F (25°C) throughout the year. The thinner line that fluctuates between blue and red, charts the exterior temperature that falls as low as 10°F (-12°C) in the winter and as high as 100°F (38°C) in the summer. The red line in the middle of the chart records the kW usage of the house to maintain desired interior temperature, other electrical usage, such as socket outlets and lights, are also accounted for in the kW plot. At the bottom of figure 4 a record of total, and net kWh usage per month is presented. Yearly kWh totals are highlighted in the right hand column of these charts.

The following figures describe the performance of the air conditioning systems during the periods of the year when demand is greatest. The airtight construction, and high levels of insulation in the Gable Home are good buffers against daily exterior temperature swings that may occur in the spring and fall. However, during the summer and winter month's greater demands are placed on the systems that maintain desired interior temperature.

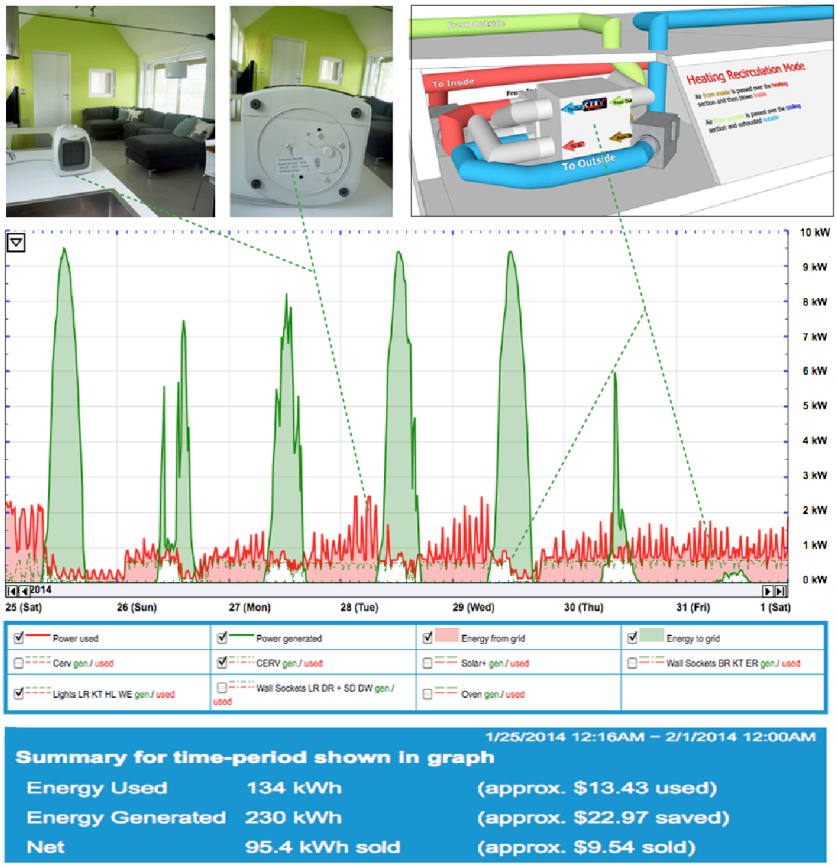


Figure 5. Data from the Gable Home in January 2014

In figure 5, data collected from the Gable Home, over a seven-day period at the end of January 2014 is illustrated. During that period exterior temperatures dropped to 12°F (-11°C) over night. During the early part of the week the sky was mostly clear, allowing significant amounts of electricity to be generated via a 9 kW solar array on the roof of the Gable Home. The plot of the green line on the graph records the generation of power, the red line on the graph tracks consumption. Two systems are used to maintain a desired interior temperature. The CERV is the primary air conditioning unit in the Gable Home. Utilizing heat pump technology it has the capability to heat or cool small volumes of air a few degrees depending if the unit is operating in a heating or cooling season. If the unit detects exterior temperatures that would help condition the space it will draw air in, if exterior temperatures are not desirable the unit will operate by recirculating air, heating or cooling it as required to keep the interior temperature at desired levels. Equipped with CO2 and VOC sensors the unit is also set to trigger fresh air ventilation cycles if air returning to the unit from the conditioned space is contaminated above acceptable levels. With exterior temperatures below 50°F (11°C) during the last week of January 2014 the CERV was in operation nearly 24 hours a day to maintain a desired interior temperature above 68°F (20°C). By tracking the red line on the graph, energy consumption can be seen to reduce in the afternoons of January 25th, 26th, 27th, 28th and 29th. The demand on the active heating systems reduced during these periods as the house was heated by passive means. The sun's rays would have penetrated into the living space through large windows on the south side of the Gable Home during those afternoons, raising the interior temperature by a few degrees. Conversely additional mechanical heating

is required in the home during the coldest part of the night, prior to sunrise. During those periods, to supplement the performance of the CERV, one or two 1,500 W fan heaters were in operation to maintain desired thermal comfort. These times of high heating demand can be seen represented as the peaks on the plotted red line, during the early mornings of January 28th and 29th.

Data collected from the Gable Home over a seven-day period at the beginning of June 2014 is illustrated in figure 6. The week of June 3rd to 9th was hot and sunny with exterior temperatures that peaked above 90°F (32°C). Fluctuations of the green line on the graph reflect the fact that there were some periods of cloud-cover during the week; this is particularly evident on June 4th. However, by comparing the size of the filled areas of green (Energy to Grid) to the filled area of red (Energy from Grid), it is clear to see the house created a net surplus of energy during the week. The quantity of surplus energy, and it's estimated value is presented in the blue box below the graph. Above the graph on the left is a diagram of the CERV unit that during the summer will typically operate in a cooling recirculation mode during the day. In the evening, if exterior temperatures drop sufficiently, air from outside will be drawn into the house. An indication of this change in operation can be seen occurring between June 6th and June 8th. As the sun rises during the morning of the 6th the well-insulated building requires little work from the CERV to maintain a desired interior temperature of below 78°F (25°C). The plot of the red line reflects a small draw on power from the CERV as it samples interior and exterior air approximately every 15 minutes. By midday on the 6th, when solar power production is at its peak the temperature inside the building would have been detected as rising above 78°F (25°C) and the CERV would have switched into its active recirculation cooling mode. The lag in time between the need for the CERV to operate in the morning, is mirrored in the evening, when exterior temperatures remain high after the sun has set. Only late into the night of the 6th is there the opportunity to draw in cooler air from outside the house. If conditions are favorable and a sufficient volume of air can be captured inside the airtight insulated envelope of the home the CERV will not be required to condition the living space until the middle of the following day.

The fluctuations in energy consumption are due to two factors. The larger fluctuation in consumption, which can also be seen as a dotted green line at the base of the graph, is the power draw of the refrigerator in the home. In addition to drawing energy, the refrigerator contributes heat by way of the refrigeration coils mounted on the outside of the appliance, something that provides some small benefit in the winter, however in the summer the refrigerator is adding to the cooling load. The smaller fluctuations in energy consumption relate to the performance of the CERV. To maintain optimal performance while recirculating cool air the CERV will stop operating for approximately 5 minutes in every one-hour cycle. This short period of rest prevents the evaporator within the CERV freezing over.

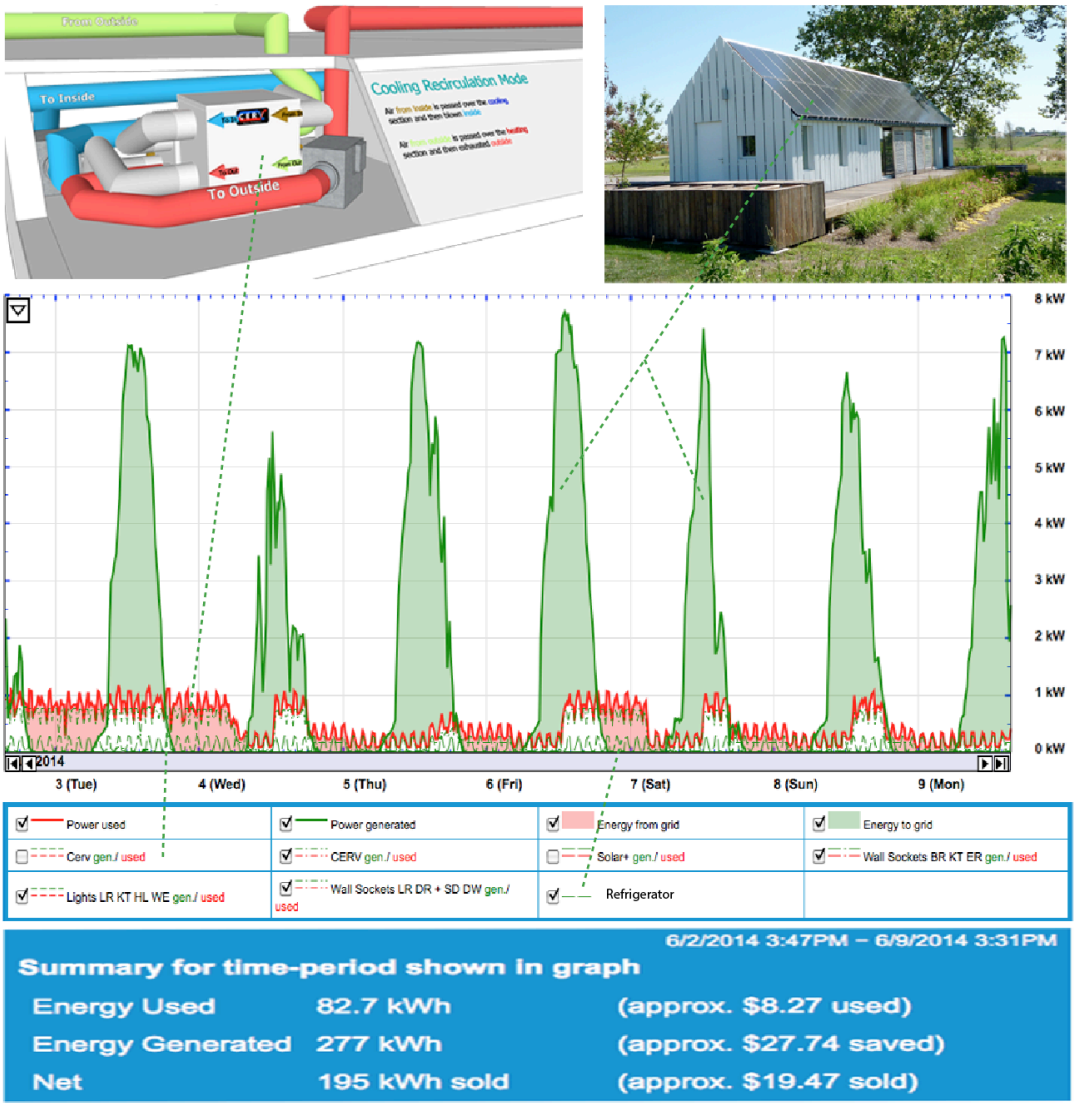


Figure 6. One Week of Data from the Gable Home in June 2014

As mentioned at the beginning of this paper, the definition of the Passive House Standard is succinct, however the units of measure: kW/m² per year or Btu/ft² per year are not tangible values to an uninformed consumer. It is also a challenge to determine if a house is operating in compliance with the standard once it has been built. Blower door tests can be repeated to confirm if air-tightness has been maintained, however of greater benefit to the home owner would be a mechanism by which the electrical meter could be read to see if the house was demanding energy at a rate lower than the 120 kWh/m² per year requirement of the PH standard. The advantage of this, beyond the satisfaction of knowing a house is operating in compliance with the standard, is that if the house is not in compliance there could be some re-commissioning of equipment, or changes in behavior that could bring the house back in line with the modeled performance on which certification is awarded.

	Passive House Standard for Source Energy	
Energy Demand	≤ 120 kWh/m^2. yr	38.1 kBtu/(ft^2 yr)
Heating Demand	≤ 15 kWh/m^2. yr	4.75 kBtu/(ft^2 yr)
Cooling Demand	≤ 15 kWh/m^2. yr	4.75 kBtu/(ft^2 yr)
Air Changes Per Hour	≤ 0.6 @ n50	
or		
Specific Heating Load	≤ 10 W/m2	3.17 Btu/(ft^2 hr)

Figure 7. The Requirements of the Passive House Standard

The Passive House standard stipulates that only 15 kWh/m² per year can be consumed to either heat or cool a house. If other energy draws such as appliances, lights and plug loads are included the total energy consumption has to be less than 120 kWh/m² per year. (see figure 7)

In this concluding section an attempt will be made to quantify if the Gable Home operates within the confines of the Passive House standard. An assumption could be made that the 120 kWh/m² per year limit on total energy use would translate into 5,640 kWh per year, based on the Gable Home's 47 sq/m (506 sq/ft) of useable area, and by simply reading the electric meter in the house, compliance could be determined. Unfortunately for the end user/homeowner that assumption cannot be made. Energy consumed at the house is defined as Site Energy; the Passive House standard is based on Source or Primary Energy consumption. When the Passive Haus Institut established the Passive House standard they defined it in terms of Source Energy to account for all the possible forms of energy and fuel options available to consumers. While commendable for factoring in choice, the scaling factors, or source to site ratios that are built into the energy modeling software that determine PH compliance favor the use of natural gas or even coal, as opposed to electric power. For example the scaling factor for natural gas is only 1.1 where as electricity produced in a nuclear or coal powered plant is scaled by a factor of 2.7. This is understandable when one considers Source Energy accounts for all "losses that are incurred in the storage, transportation and delivery of fuel to a building." (The difference between source and site energy).

Fortunately there is a provision in the software used to determine PH compliance that caters to those who want to invest in producing their own power on site. The provision calculates both site produced and source energy, taking into account the different scaling factors that are applied to the different methods of power supply/production.

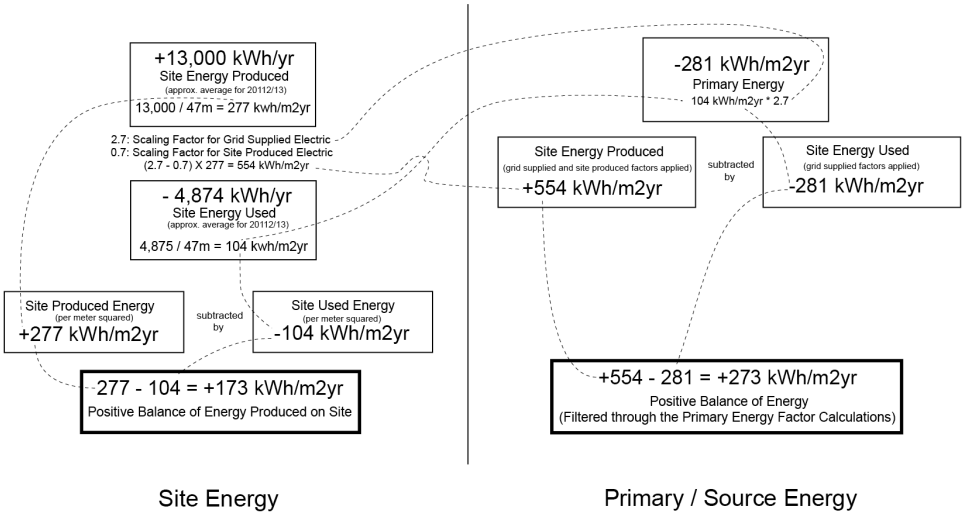


Figure 8. Illustration Showing Relationship Between Site and Primary/Source Energy Using Data from the Gable Home

When two or more sources of energy are used to power and condition a home the calculations become complex; the interplay between different scaling factors needs to be accounted for. The spreadsheet format of the Passive House Planning Package (PHPP), the software used to determine PH compliance prior to construction, has the ability to deal with that complexity. Figure 8 is an illustration of the type of calculations the PHPP could carry out if known data for onsite energy use and production could be determined. The values entered in figure 8 are derived from performance data collected from the Gable Home in 2012 - 2013.

Replacing projected data with recorded data is probably the best way to determine if PH compliance is being met. In the case of the Gable Home, calculations presented in figure 8 confirm that on balance, the Gable Home is performing in line with Passive House requirements. It is true that the Energy Demand, or 281 kWh/m²yr Site Energy Used, as annotated in figure 8, is above the allowable limit of 120 kWh/m² per year. However, a surplus of 554 kWh/m² per year, site produced power, offsets the demand by 273 kWh/m² per year.

While not straightforward, taking meter readings on site and feeding that data into the Passive House Planning Package, or similar spreadsheet calculator, will determine if a house is operating in compliance with the Passive House standard. To encourage homebuilders to build homes that have the potential to be powered by a renewable resource, it is the author's belief that meter readings from PH compliant houses should be published. When onsite power production is coupled with energy efficient construction the result is typically small, or potential Net Positive energy bills. Publicizing this fact may be what is now required to move energy efficient construction from a fringe activity, into the main stream.

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Degradation of Cyanide to Ammonia and Nitrate by Mixed Culture of Agrobacterium Tumefaciens SUTS 1 *and Pseudomonas Monteilii* SUTS 2

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The European conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
A mixed culture of bacteria capable of growth on cyanide was isolated from a wastewater stabilization pond of the cassava starch industry. The two species of bacteria found in this culture were identified as *Agrobacterium tumefaciens* SUTS 1 and *Pseudomonas monteilii* SUTS 2. The maximum growth rate of the mixed culture was 108 cells within 2 days. Cyanide degradation was studied using starting cyanide concentrations of 25, 50, and 150 mg/L. The residual cyanide, ammonia, nitrate, nitrite, pH, and cell counts were analyzed. At 25 and 50 mg/L cyanide, the mixed culture obtained a very high removal efficiency of more than 99.99%. Ammonia and nitrate were produced in the range of 0.14-0.28 mg/L and 1.71-2.69 mg/L, respectively. At 150 mg/L cyanide, the removal efficiency was lower whereas the concentrations of ammonia and nitrate increased to 1.40 mg/L and 5.21 mg/L, respectively. Nitrite was not detected in any experiment. Cell counts of the mixed culture increased when the cyanide concentration was lower but pH values increased when the cyanide concentration was higher.

Keywords: degradation, mixed culture of bacteria, removal efficiency, residual cyanide

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Introduction

The production processes of many industries such as those for petrochemicals, synthetic fuel processing, mining, coal, acrylic fibers and resin, plastic, and cassava starch use many cyanide compounds and generate high concentrations of cyanide (10-150 mg/L) and thiocyanate (50-650 mg/L) compounds (Knowles, 1976; Donberg *et al.,* 1992; Raybuck, 1992; Aronstein *et al.,* 1994; Liu *et al.,* 1996; ATSDR, 2006; Jeong, 2006). Furthermore, cyanide can also react with metals and heavy metals such as copper, zinc, nickel, cadmium, and iron to form metal-cyanide complexes (Young and Theis, 1991; Meeussen *et al.,* 1992). These complexes are usually very stable and toxic (Dzombak *et al.,* 2006). Thus, cyanide toxification depends on physical and chemical reactions and cyanide formation. Hydrogen cyanide is an extremely potent metabolic poison whereas metal-cyanide complexes vary in toxicity according to their concentration (Finnegan *et al.,* 1991). Cyanide can enter the human body by inhalation, ingestion, and adsorption. The fatal doses for human adults are 1-3 mg/kg body weight if ingested, 100-300 ppm if inhaled, and 100 mg/kg body weight if adsorbed (Huiatt, 1984). Moreover, cyanide is toxic to most species in freshwater or marine environments at a level of 0.1 mg/L at normal pH and temperature (Petrozzi and Dunn, 1994).

Treatment methods for cyanide in physicochemical and biological processes have been studied (Dumestre *et al.,* 1997; Dhillon and Shivaraman, 1999; Logsdon *et al.,* 1999; Adjei and Ohta, 2000; Botz and Mudder, 2002; Baxter and Cummings, 2006). Mostly, the use of pure cultures of microorganisms has been reported, for example, Fusarium solani, Burkholderia cepacia strain C-3 and Pseudomonas species. The biodegradation of cyanide and aromatic nitriles by Agrobacterium tumefaciens has been studied recently (Bauer *et al.,* 1998; Potivichayanon and Kitleartpornpairoat, 2010). This bacterium, especially strain SUTS 1, when grown in the presence of cyanide, exhibited very high removal efficiency. It also utilized cyanide and produced ammonia and nitrate (Potivichayanon and Kitleartpornpairoat, 2010) whereas strain d3 converted aromatic nitriles to amides (Bauer *et al.,* 1998). However, the addition of other bacterial strains in the experiment has to be considered because many species of bacteria are present in wastewater and may affect cyanide degradation (Kang and Park, 1997; Barclay *et al.,* 1998). Therefore, the objectives of this study were to investigate cyanide degradation by a mixed bacterial culture containing SUTS 1, to identify other cyanide-degrading bacteria and to study the production of ammonia and nitrate from cyanide degradation.

Materials and Methods

Chemicals and equipment

Sodium hydrogen phosphate ($NaHPO_4$), sodium sulfate (Na_2SO_4), magnesium chloride ($MgCl_2$•$6H_2O$), calcium chloride ($CaCl_2$), sodium chloride (NaCl), zinc sulfate ($ZnSO_4$), and molybdenum trioxide (MoO_3) were purchased from Ajax Finechem. Dipotassium hydrogen phosphate (K_2HPO_4), potassium dihydrogen phosphate (KH_2PO_4), ferrous sulfate ($FeSO_4$•$7H_2O$), and cobalt nitrate ($Co(NO_3)_2$•$6H_2O$) were purchased from Fisher Scientific. Ferric chloride ($FeCl_3$•$6H_2O$) and potassium cyanide (KCN) were purchased from Merck. Bacto agar

was purchased from Difco. All chemicals used in this study were analytical reagent grade.

A rotary shaker (Excella E5; New Brunswick Scientific), an autoclave (TKA steroclave; Teknolabo), a light microscope (Olympus BX51; Olympus), an incubator (Memmert BE 500; Memmert), and an automated DNA sequencer (3100-Avant Genetic Analyzer; ABI) were used in the experiment.

Mixed culture of microorganisms and cultivation

Microorganisms were obtained by repeated grab sampling from a stabilization pond of a cassava starch industry in Nakhon Ratchasima, Thailand. In order to enrich the mixed culture of microorganisms, 10 mL of sample were inoculated into a 500 mL Erlenmeyer flask containing 100 mL of enrichment medium and incubated for 7 days at 30°C on a rotary shaker (180 rpm) (Potivichayanon and Kitleartpornpairoat, 2010). The experiment was done in duplicate. An enrichment medium composed of 4.0 g $NaHPO_4$, 2.13 g Na_2SO_4, 3.10 g K_2HPO_4, 200 mg $MgCl_2$•$6H_2O$, 2.0 mg $FeCl_3$•$6H_2O$, and 1.0 mg $CaCl_2$ in 1 L of de-ionized water at pH 7.2 was used. The medium was autoclaved for 15 min at 15 psi and 121°C before use.

Isolation and identification of cyanide-degrading bacteria

In order to screen cyanide-degrading bacteria from the mixed culture, 10 mL of the mixed culture in an enrichment medium flask was used for each Erlenmeyer flask containing 100 mL of buffer medium (BM) and 25 mg/L potassium cyanide was added and the mixture was incubated at 30°C, 180 rpm for 7 days. After that, cyanide-degrading bacterial isolation was performed using the spreading plate technique on a buffer medium containing potassium cyanide (BMK) agar (BMK with 18 g/L of Bacto agar) which was incubated at 30°C for 7 days. Following this, the morphology and number of colonies were observed under a light microscope. The morphology of the bacterial colony was analyzed using Gram staining (Bergey and John, 1994). In addition, bacterial cells were identified by DNA sequencing using an automated DNA sequencer (3100-Avant Genetic Analyzer, ABI).

Mixed culture growth analysis

The growth of the mixed culture was studied using the colony counting technique. The number of viable colonies was determined daily by the spreading plate technique on BMK agar containing 25 mg/L KCN. From the flask containing the mixed culture in BMK, 0.1 mL was obtained and diluted ten-fold with sterile 0.85% NaCl solution. Then, 0.1 mL of this diluted mixture was thoroughly spread onto BMK agar plates. The plates were incubated at 30°C for 7 days. The viable colonies on plates were then counted and those containing 30-300 colonies were used to calculate the viable cell concentration as colony forming units/milliliter (CFU/mL) (APHA, AWWA, WEF, 1995). In addition to the mixed culture growth analysis, the pure culture growth of the isolated bacteria was studied in the same method of mixed culture growth analysis (Potivichayanon and Kitleartpornpairoat, 2010).

Media condition

Buffer medium (BM) was used as the medium (Potivichayanon and Kitleartpornpairoat, 2010): 1 L of BM contained 2.7 g KH_2PO_4, 3.5 g K_2HPO_4 and 10 mL of trace salts solution (300 mg $FeSO_4 \cdot 7H_2O$, 180 mg $MgCl_2 \cdot 6H_2O$, 130 mg $Co(NO_3)_2 \cdot 6H_2O$, 40 mg $CaCl_2$, 40 mg $ZnSO_4$ and 20 mg MoO_3 in 1 L de-ionized water). The final pH was adjusted to pH 7.2. The medium was autoclaved for 15 min at 15 psi and 121°C before use. Different concentrations of potassium cyanide (KCN) were added to the BM for the cyanide degrading experiment.

Degradation of cyanide

The mixed culture of bacteria was inoculated in the BM containing KCN at 25, 50, or 150 mg/L. The biodegradation of cyanide was set at 10:100 (inoculum volume: BM volume) in 500 mL Erlenmeyer flasks and incubated at 30°C on a rotary shaker (180 rpm) for 7 and 15 days. After incubation, bacterial growth, ammonia, nitrate, nitrite, and residual cyanide were analyzed. In addition, the abiotic experiment was performed using 50 mg/L KCN in a similar BM and incubated for 15 days.

Analytical methods

In all experiments, ammonia (NH_3), nitrate (NO_3^-), nitrite (NO_2^-), and residual cyanide were determined according to standard methods (APHA, AWWA, WEF, 1995). The concentration of ammonia was analyzed by distillation and the titrimetric method (APHA, AWWA, WEF, 1995), nitrate was analyzed by the brucine method (APHA, AWWA, WEF, 1998), nitrite was analyzed by the colorimetric method (APHA, AWWA, WEF, 1995), and residual cyanide was analyzed by the titrimetric method (APHA, AWWA, WEF, 1995).

Cyanide removal efficiency calculation

All experiments were performed in duplicate. The removal efficiency (RE) of the mixed culture was calculated as shown in the following formula:

$$\text{RE (\%)} = \frac{\text{Initial concentration - Residual concentration}}{\text{Initial concentration}} \times 100$$

Initial concentration = Initial concentration of cyanide (mg/L)
Residual concentration = Residual concentration of cyanide (mg/L)

Results and Discussion

Isolation and identification of single strains from a mixed culture

In order to isolate and identify single strains of bacteria from a mixed culture, the external morphology was examined using a compound microscope. The distinguishable colonies showed that there were two different dominant types of microorganisms. The colony of the first type was circular in shape, convex, smooth and non-pigmented to light beige. The second colony type was circular in shape, convex, smooth, white and opaque. Both types represented Gram negative stains with

a rod shape. The colony sizes of the first and second types were 5 to 7.5 mm and 1 to 2 mm, respectively. Identification of the bacterial strains was performed on the basis of morphology using Bergey's manual (Bergey and John, 1994). Following this, DNA sequences were analyzed at the Mahidol University-Osaka University Collaborative Research Center for Bioscience and Biotechnology (MU-OU: CRC). The nucleotide base sequence of the gene which codes for 16S ribosomal RNA was compared with GenBank's databases (Sbjct or Reference gene) of various gene sequences (Benson *et al.,* 2011). The results of the first and second types showed a 100% identity of *Agrobacterium tumefaciens* SUTS 1 (Potivichayanon and Kitleartpornpairoat, 2010) and *Pseudomonas monteilii* SUTS 2 (Figure 1 and Figure 2), respectively. Therefore, the mixed culture contained two species of bacteria capable of growing in the presence of cyanide. Several species of the *Pseudomonas* genus have previously been studied for cyanide degradation (Harris and Knowles, 1983; Dorr and Knowles, 1989; Watanabe *et al.,* 1998; Dhillon and Shivaraman, 1999; Cipollone *et al.,* 2004); however, there have been no reports on *P. monteilii*. Furthermore, the mixed culture of *P. monteilii* SUTS 2 with the high cyanide removal potential of *Agrobacterium tumefaciens* SUTS 1 may increase the overall removal efficiency.

```
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```

Figure 1. The comparison between nucleotide base sequences of bacterial gene of *Agrobacterium tumefaciens* SUTS 1 (Query or Unknown gene) and gene sequences of GenBank's databases (Sbjct or Reference gene).

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Figure 2. The comparison between nucleotide base sequences of bacterial gene of *Pseudomonas monteilii* SUTS 2 (Query or unknown gene) and gene sequences of GenBank's databases (Sbjct or reference gene).

Mixed culture bacterial growth

The growth of the mixed culture of SUTS 1 and SUTS 2 was studied (Figure 3). The highest growth rate was obtained on day 2 of the incubation period. The colony forming units per mL during this time was approximately 5.30 $\times 10^8$ CFU/mL. In the previous study, the growth of SUTS 1 was reported (Potivichayanon and Kitleartpornpairoat, 2010). It showed the highest growth on day 4 of the incubation period that was 4.70 $\times$ 10^8 CFU/mL. In further experiment, SUTS 2 was studied and showed highest on day 3 of the incubation period obtained 2.00 $\times$ 10^8 CFU/mL (Figure 3). Therefore, the mixed culture of SUTS 1 and SUTS 2 was higher cell growth than the pure culture of SUTS 1 and also the pure culture of SUTS 2. For these reason, the mixed culture was chosen to study the cyanide degradation in this research.

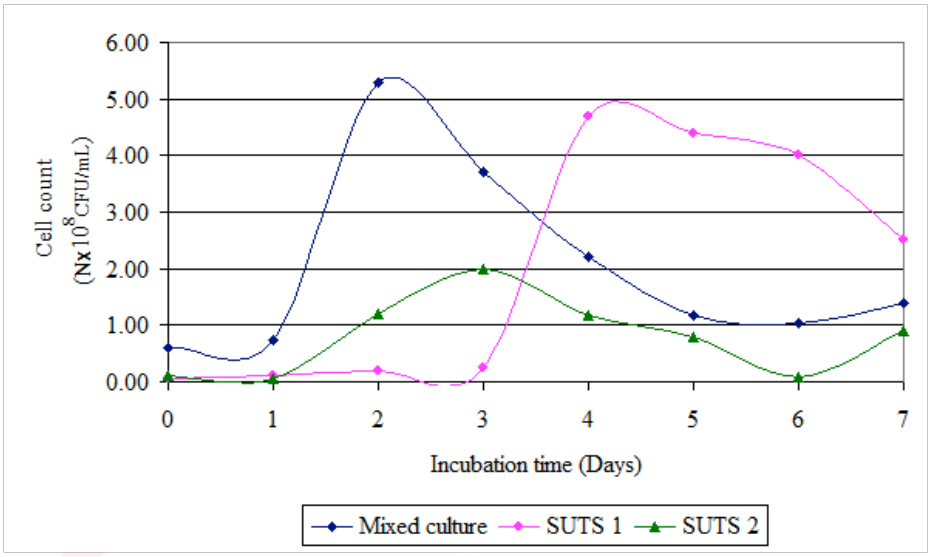

Figure 3. Growth curve of the mixed and pure culture of *Agrobacterium tumefaciens* SUTS 1 and *Pseudomonas monteilii* SUTS 2.

Abiotic experiment

In the abiotic experiment, the cyanide removal efficiency was only 12.5% with 43.75 mg/L of residual cyanide after 15 days of incubation. The ammonia and nitrate concentrations were 0.14 mg/L and 1.48 mg/L, respectively, whereas nitrite was not detected. The pH was 7.21 throughout the experiment.

Degradation of cyanide to ammonia and nitrate

The degradation of cyanide to ammonia and nitrate by the mixed culture of *Agrobacterium tumefaciens* SUTS 1 and *Pseudomonas monteilii* SUTS 2 was studied using starting concentrations of 25, 50, and 150 mg/L cyanide (Tables 1). The relationship between cyanide removal efficiency and the growth of mixed culture in all experiments is shown in Figure 4. At 25 mg/L cyanide, the results showed that the mixed culture of SUTS 1 and SUTS 2 obtained a 75% removal efficiency with 6.25 mg/L residual cyanide left within 7 days of study and the growth rate increased from 4.70×10^8 CFU/mL to 4.10×10^9 CFU/mL. After 15 days, residual cyanide was not detected; therefore, a high removal efficiency of 99.99% had been obtained. From these results, the mixed culture of SUTS 1 and SUTS 2 showed the higher efficiency than the pure culture SUTS 1 that obtained only 87.50% removal efficiency (Potivichayanon and Kitleartpornpairoat, 2010), similar to mixed culture of two *Pseudomonas* species that presented the complete degradation of cyanide and phenol within 40 h in the batch culture (Kang and Park, 1997). However, cells in the mixed culture decreased to 3.80×10^9 CFU/mL. In addition, the ammonia and nitrate concentrations increased to 0.16 mg/L and 1.98 mg/L, respectively, whereas nitrite was not detected. The pH was approximately pH 7.21-7.22.

Table 1. Cyanide degradation at a concentration of 25, 50 and 150 mg/L cyanide.

Time (Days)	Residual cyanide (mg/L)			NH_3 (mg/L)			NO_3^- (mg/L)			pH		
	25 mg/L	50 mg/L	150 mg/L	25 mg/L	50 mg/L	150 mg/L	25 mg/L	50 mg/L	150 mg/L	25 mg/L	50 mg/L	150 mg/L
0	25.00	50.00	150.00	0.00	0.28	0.70	0.00	1.98	3.00	7.22	7.16	7.38
7	6.25	12.50	36.05	0.14	0.00	1.12	1.71	2.69	3.31	7.22	7.24	7.38
15	0.00	0.00	34.00	0.16	0.28	1.40	1.98	2.36	5.21	7.21	7.18	7.43

At 50 mg/L cyanide, the removal efficiency was similar to the previous experiment with 25 mg/L and 75% removal efficiency, and both showed a removal efficiency of more than 99.99% after 15 days of incubation. As similar result from previous experiment, the mixed culture showed the higher efficiency than the pure culture of SUTS 1 that obtained only 87.50% (Potivichayanon and Kitleartpornpairoat, 2010). The growth of the mixed culture increased from 1.00×10^8 CFU/mL to 2.50×10^9 CFU/mL on day 7 but it decreased to 4.10×10^8 CFU/mL on day 15. At 50 mg/L cyanide, no ammonia was detected on day 7 whereas the nitrate had increased from 1.98 mg/L on day 0 to 2.69 mg/L on day 7. After 15 days, the ammonia had increased to 0.28 mg/L whereas nitrate levels showed a slight decrease to 2.36 mg/L. The levels of ammonia increased with the increasing concentration of cyanide as cyanide removal efficiency increased. In addition, nitrate concentration was detected at increasing value where the ammonia concentration decreased or was not detected. This may have been because the cyanide was degraded to ammonia and then converted to nitrate as the final by-product (Dorr and Knowles, 1989; Ingvorsen *et al.,* 1991; Meyers *et al.,* 1991; Petrozzi and Dunn, 1994; Chapatwala *et al.,* 1998; Watanabe *et al.,* 1998; Kao *et al.,* 2003). Other by-products such as methane, carbon dioxide and nitrite can also occur (Chapatwala *et al.,* 1998; Kao *et al.,* 2003; Ebbs, 2004), although no nitrite was detected and methane and carbon dioxide were not investigated in the present study.

Most organisms capable of biodegrading cyanide may be sensitive to the concentration of cyanide, with biodegradation and/or the growth rate decreasing above specific thresholds for each organism (Raybuck, 1992). From this reason, the cyanide concentration was set high and increased to 150 mg/L. The mixed culture of SUTS 1 and SUTS 2 exhibited more than 75% removal efficiency after only 7 days incubation, which increased to 77.33% removal efficiency after day 15 with 34 mg/L of residual cyanide. In addition, the cells of SUTS 1 and SUTS 2 decreased from 3.00×10^8 CFU/mL to 1.40×10^7 CFU/mL on day 7 but they slightly increased to 2.00×10^7 CFU/mL on day 15 of incubation. This may be due to the microorganisms trying to adapt to a higher cyanide concentration in the same way as a commercially marketed strain of *Fusarium* can treat and tolerate cyanide concentrations of up to 100 mg/L (Ebbs, 2004; Sirianuntapiboon and Chuamkaew, 2007). The ammonia concentration increased from 0.70 mg/L to 1.12 mg/L on day 7 and to 1.40 mg/L on

day 15. In addition, nitrate was also in the range of increased values from 3.00 to 5.21 mg/L by the end of the experiment. From the results, when the cyanide concentration was increased, the concentration of ammonia and nitrate increased but the removal efficiency decreased. Furthermore, the formation of degradation products, such as ammonia or nitrate, may also limit the efficacy of microorganisms (Ebbs, 2004), as shown in the present experiment. When higher values of ammonia and nitrate were detected, the removal efficiency of the mixed culture was limited to only 77.33%. This might have been due to the high concentration of ammonia and nitrate, which may have affected the ability of the mixed culture to further degrade cyanide. However, *Agrobacterium tumefaciens* SUTS 1 and *Pseudomonas monteilii* SUTS 2 may be capable of respiration in the presence of nitrate and use nitrate as an alternate electron acceptor for their growth (Bergey and John, 1994). Therefore, the cell numbers of SUTS 1 and SUTS 2 still increased in this study. In addition, nitrite was not detected in any of the experiments, similar to the results of Sirianuntapiboon and Chuamkaew (2007). This may have been due to the increasing rate of nitrification reaction whereby ammonia is rapidly oxidized to nitrate, and it may also have been due to the concentration of oxygen, since oxygen is utilized in the cyanide degradation process by microorganisms (Chapatwala *et al.,* 1998; Tchobanoglous *et al.,* 2004). The pH values may have also limited the removal efficiency and cell growth (Ebbs, 2004). When pH was detected around 7.16-7.24, the removal efficiency and the cells of the mixed culture exhibited very high values. On the other hand, when the pH increased to 7.43, cell growth and removal efficiency exhibited were at lower levels. Previous studies have shown that the pH should be in the range of 6 to 9 (Baxter and Cummings, 2006).

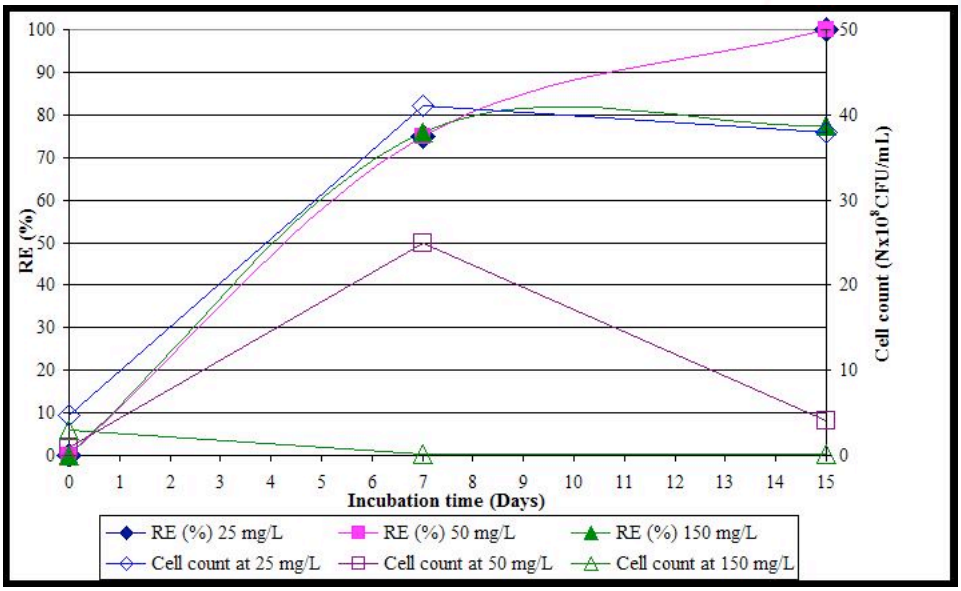

Figure 4. The relationship between cyanide removal efficiency and growth of the mixed culture of SUTS 1 and SUTS 2 at 25, 50 and 150 mg/L cyanide.

Therefore, *Agrobacterium tumefaciens* SUTS 1 and *Pseudomonas monteilii* SUTS 2 were able to degrade cyanide to ammonia and nitrate. Similar to other species, such as mixed culture of *Klebsiella pneumoniae, Moraxella, Serratia,* and *Pseudomonas*

species and pure culture of *Alcaligenes* species, cyanide is used as a source of carbon and nitrogen (Ingvorsen *et al.,* 1991; Kang and Kim, 1993). Moreover, the rate of cyanide degradation also increased due to mixing of bacterial culture (Kang and Park, 1997). Chapatwala et al. (1998) reported that immobilized cells of *Pseudomonas putida* could degrade higher concentrations of cyanide than non-immobilized cells. In contrast, the suspended cells in the mixed culture of *Agrobacterium tumefaciens* SUTS 1 and *Pseudomonas monteilii* SUTS 2 grew in cyanide conditions and also exhibited very high cyanide removal efficiency.

Conclusions

A mixed culture isolated from a wastewater treatment system contaminated with cyanide was identified as *Agrobacterium tumefaciens* SUTS 1 and *Pseudomonas monteilii* SUTS 2. The cyanide degradation by *Agrobacterium tumefaciens* SUTS 1 was recently reported. The pure culture of SUTS 1 exhibited more than 97% cyanide removal efficiency when the cyanide concentration was increased to 150 mg/L. The mixed culture of SUTS 1 and SUTS 2 exhibited the highest removal efficiency of more than 99.99% with no detection of residual cyanide. In addition, the cells of two bacteria grew with the ability to utilize cyanide and produced ammonia and also nitrate. Future work of this study will focus on the capability of the mixed culture of SUTS 1 and SUTS 2 in more technologically advanced wastewater treatment systems.

Acknowledgements

This research was supported and funded by Suranaree University of Technology, Nakhon Ratchasima Thailand.

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Decreasing the Residential Energy Consumption: Habitual Behaviours of Occupants

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The European Conference on Sustainability, Energy and the Environment 2014
Official Conference Proceedings

Abstract
In the residential sector, energy demand may be divided mainly into six different types of final energy use: cooking, air heating, water heating, air cooling, lighting and other electric equipment. The energy consumption associated with the different energy services is influenced by the way consumers use each of them, making consumers playing an important role on residential energy consumption. Up to 20 % energy savings can be achieved by actions targeting behaviour. Accordingly, this work aims to identify, considering the Portuguese reality, the residential equipment with more potential for behaviour change actions in the residential sector as well as the most relevant energy saving behaviour associated with each one. Four criteria were defined to identify the set of equipment to be analysed: the ownership rate of the equipment, its annual energy consumption, its load diagram shape and the availability of general quantitative data. Considering these criteria, it was concluded that, among 25 different residential equipment, the most suitable for actions targeting behaviour are lighting systems, washing machine, refrigerator, television, computer and dishwasher. Each type of behaviour was linked to demand-side management actions by considering the type of loads it represents: investment dependent loads (all the identified equipment except the television and computer), deferrable loads (washing machine and dishwasher), loads responding to changeable parameter settings (refrigerator) and loads prone to energy conservation actions (all the identified equipment). In this work, special attention is given to loads prone to energy conservation actions.

Keywords: energy saving behaviours, residential equipment, behaviour change, energy conservation

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Introduction

In the residential sector, energy demand may be divided mainly into six different types of final energy use: cooking, air heating, water heating, air cooling, lighting and other energy services. In Portugal, a big fraction uses electricity, which fulfils the total demand of air cooling, electric equipment and lighting systems (INE, 2011).

To reduce the energy consumption in this sector, improving the energy efficiency of equipment is crucial. However, the way consumers use the different energy services also plays an important role. General energy efficiency policies in OECD countries have focused essentially on increasing the energy efficiency of buildings, appliances, vehicles and industrial equipment and operations. Less attention has been paid to changing consumer behaviour (Geller et al., 2006) and there is a growing evidence in the literature demonstrating that there is a potential of energy savings up to 20 % due to measures targeting behaviour (European Environment Agency, 2013), such as behaviour change programs and Demand-side Management (DSM) actions.

Despite the Portuguese population already adopt some energy saving behaviours, their adoption rates may have potential to be enhanced. The aim of this work is to identify, considering the Portuguese reality, the residential equipment with higher potential for actions targeting behaviour and the most common energy saving behaviours associated with each one. Moreover, values of the behaviours' adoption rates are also explored, based on studies conducted in Portugal during the last years.

This work is organized as follows: section 2 describes the methodology employed to select the equipment and the behaviours, section 3 presents the results regarding the selection of the equipment with higher potential for actions targeting behaviour, in section 4 the most common energy saving behaviours are presented, as well as some of their impacts on energy consumption and their adoption rates obtained from several Portuguese studies. The main conclusions of the work are presented in section 5.

Methodology

This section is divided in two parts. The first part presents the methodology employed to identify the equipment with higher potential for actions targeting behaviour. In the second part the methodology is presented regarding the identification of the most common energy saving behaviours associated with each equipment.

Selection of Residential Equipment

Twenty five (25) different residential equipment were analysed. To identify the ones with higher potential for actions targeting behaviour, four criteria were used: 1) the ownership rate of the equipment, 2) its annual energy consumption, 3) its availability of quantitative data, namely from past projects and monitoring programs and 4) its load diagram shape, more precisely, the difference between the time of occurrence of the typical daily global load diagram peak, in Portugal usually around 11 am and 8 pm, and of the typical daily load diagram peak of the equipment. The criteria were analysed for Portuguese households. When Portuguese data were not available, European values were used wherever there was not a significant difference between the two realities.

The decision analysis procedure was accomplished using the JSMAA decision analysis tool (Tervonen, 2014). No preference among the criteria was established, having all the same weight.

Identification of Energy Saving Behaviors

Taking into account the selected equipment, a review was carried out of studies which, in one of the phases, surveyed a certain sample of the Portuguese population about energy saving behaviours. It must be noted that, in Portugal, there is no systematic study addressing energy saving behaviours. Moreover, the scopes and methodologies of the surveys reported by the studies reviewed were different. Briefly, Energaia (2011) launched a survey during 2010 among 1014 households spread throughout the country; INE (2011) launched a survey during 2010 among the 3773956 households existing in Portugal at that year; Ferreira et al. (2008) launched a survey during 2007 among 206 households spread throughout the country, although the participation in this project was voluntary; Carvalho (2013) launched a survey during 2013 among 30 households in Amadora, Sintra, Oeiras and Cascais regions; Rebelo et al. (2011) launched a survey during 2010 among 731 students in Lisbon with ages between 12 and 20 years old; Costa (2011) launched a survey during 2011 among 562 individuals, with ages between 30 and 50 years, working or studying at universities, spread throughout the country. ADENE (2011) launched a survey during 2011 among 1005 individuals, with ages between 18 and 65 years old, spread throughout the country; Ferreira (2009) launched a survey during 2009 among 3371 households spread throughout the country, however, mostly located in Lisbon and its outskirts. Pinheiro (2008) launched a survey during 2007 among 89 washing machines and 91 dishwasher's users from a building complex in Lisbon. Morais (2009) launched a survey during 2009 among 32 households in an urbanisation in Vila Real region. János (2011) launched a survey during 2011 among 1582 students of the University of Coimbra.

Based on the studies reviewed, possible energy saving behaviours with room for improvement were identified as well as their adoption rates in samples of Portugal.
Commonly, energy saving behaviours are divided into investment and habitual behaviour. Investment behaviour is related to the adoption of new technology, occurring occasionally and is commonly related to the adoption of new equipment. Habitual behaviour is a routine, being automatically repeated by consumers without a previous evaluation of its consequences. However, in this work, the behaviours are categorized according to the type of electricity load they represent: investment dependent loads, deferrable loads, loads responding to changeable parameter settings and loads prone to energy conservation actions.

The next sections present the results of the decision analysis procedure accomplished to identify the equipment with higher potential for actions targeting behaviour, followed by the identified behaviours associated with those equipment.

Residential Equipment

The 25 residential equipment were evaluated according to the criteria described previously. The load diagram criterion was analysed only for equipment with an ownership rate higher than 10 %. For this reason, a pre-evaluation of the equipment was carried out according to the ownership rate criterion. **Table 1** presents the set of equipment having an ownership rate higher than 10 % and weighing more than 1 % in the household annual electricity consumption.

Table 1: Selected equipment to be analysed under the load diagram criterion

Equipment	Ownership > 10 %	Annual consumption > 1 %	Data availability
Television (plasma, CRT or LCD)	✓	✓	✓
Refrigerator (with or without freezer)	✓	✓	✓
Washing machine	✓	✓	✓
Computer (desktop or laptop)	✓	✓	✓
Dishwasher	✓	✓	✓
Lighting	✓	✓	✓
Microwave oven	✓	×	✓
Separate Freezer	✓	✓	✓
HVAC	✓	✓	×
Water heating	✓	-	×
Electric stove/oven	✓	-	×
Clothes dryer	✓	✓	×
Vacuum cleaner	✓	✓	×

The load diagram criterion was only analysed for the equipment listed in **Table 1**. In **Table 2** it is presented the temporal deviation of the peak consumption of each equipment from the daily global peak consumption, which was the measure of the load diagram criterion.

Table 2: Deviation from daily peaks (hours)

Equipment	1st peak (≈11 am)	2nd peak (≈8 pm)
Microwave oven	0	2
Refrigerator (with or without freezer)	0	-
Electric stove/oven	2	-
Vacuum cleaner	2	-
Water heating	2	3
Washing machine	2	0
Television (plasma, CRT or LCD)	2	-
Lighting	2	3
Computer (desktop or laptop)	2	-
Dishwasher	2	-
Clothes dryer	2	4
HVAC	4	5
Separate Freezer	N/A	-

Taking into account the four criteria, it can be concluded that the lighting systems, the washing machine, the refrigerator, the microwave oven, the television, the computer and the dishwasher are the equipment which have a higher probability of being ranked in the first positions of the decision analysis procedure, corresponding to the most suitable equipment to be analysed. In the opposite way, the printer, the stereo system, the dehumidifier, the washing/drying machine, the central vacuum cleaner and the separate freezer represent the set of equipment with no particular relevance to this

study. Among the other equipment, the potential is relatively indifferent. However preference should be given to HVAC systems (electric heater, heat pump, air conditioner and fan) followed by the remaining: clothes dryer, electric boiler, electric stove, vacuum cleaner, iron, electric oven, DVD player and radio. Regarding the microwave oven, despite its relevance to this study it was excluded from further analysis due to lack of available data.

Energy Saving Behaviors

In this section, the most common energy saving behaviours associated with each equipment are presented. Energy saving behaviours related to lighting systems are related to turning off the lights when not necessary, replacing inefficient light bulbs, which can reduce up to 80 % of the lighting energy consumption of a household, using sensors and/or light intensity regulators, and using daylight instead of artificial light.

Associated with the washing machine, the most common saving behaviours are the use of low temperature cycles, the use of the total capacity of the washing machine and the deviation of its usage to off-peak periods. In fact, the difference between washing at 30 and 60 ºC implies a consumption increase of 200 to 400 %. Shifting the usage of the washing machine to off-peak periods, in spite of not contributing directly to energy savings, contributes indirectly by reducing the daily peak demand at the country level.

The refrigerator is the equipment to which the largest number of different behaviours can be applied. The most common are related to its operating temperature, the number of times and period of door openings (for each time a door of a refrigerator with freezer/combined refrigerator-freezer is open for 10 seconds, its energy consumption can increase from 0.2 to 2 %), the non-existence of a layer of ice in its internal surfaces (a layer of ice higher than five millimetres can increase the consumption to around 30 %), its location (surrounding environments with less 5 ºC reduces the refrigerator's consumption up to 30 %), the habits of unfreezing and do not keeping warm food inside it (keeping warm food inside it can increase its consumption from 10 to 15 %). Moreover, behaviours related to its maintenance, such as keeping the seals, the condenser and the auxiliary ventilator in good operating conditions can be seen as saving behaviours.

Associated with the television and computer there are two similar behaviours which should not be confused. One of them consists of interrupting the equipment operation when not necessary (either by turning it off completely or leaving it in stand-by mode), and the other consists of actually switching off the supply, avoiding the stand-by mode. The stand-by mode consumption can represent around 30 % of the electricity consumption of the equipment.

The behaviours associated with the dishwasher are related to using low temperature washing cycles, fulfilling its total capacity, allowing natural drying by skipping the drying phase and deferring its usage to off-peak periods. In fact, the electricity consumption of a 60 ºC cycle exceeds by 30 % that of a 50 ºC cycle, and interrupting the washing process before the drying process, allowing a natural drying, can reduce up to 50 % the electricity consumed per cycle.

Table 3 summarizes the described behaviours and categorizes them according to the type of load they represent: investment dependent loads (INV), deferrable loads (DEF), loads responding to changeable parameter settings (PAR) and loads prone to energy conservation actions (CON).

Table 3: Common behaviors and types of loads associated with each by type of equipment

	Energy Saving Behaviour	Type of load
Lighting systems	Turning off the lights when not necessary	CON
	Replacing inefficient light bulbs	INV
	Using sensors and/or light intensity regulators	INV
	Using daylight instead of artificial light	CON
Washing machine	Using low temperature cycles	CON
	Using at full load	CON
	Deferring the usage to off-peak periods	DEF
	Replacing for a more efficient one	INV
Refrigerator	Adjusting the operating temperature	PAR
	Reducing the number of times and period of door openings	CON
	Removing the layer of ice in the internal surfaces	CON
	Changing the location	CON
	Avoiding placing warm food inside	CON
	Keeping the seals, the condenser and the auxiliary ventilator in good operating conditions	CON
	Replacing for a more efficient one	INV
Television and Computer	Interrupting the operation when not in use (either by switching it off or leaving it stand-by)	CON
	Switching off the supply (avoiding the stand-by mode)	CON
Dishwasher	Using low temperature cycles	CON
	Using at full load	CON
	Allowing natural drying by skipping the drying phase	CON
	Deferring its usage to off-peak periods	DEF
	Replacing for a more efficient one	INV

Regarding energy saving behaviours associated with loads prone to energy conservation actions, **Table 4** present the average adoption rate obtained from the studies reviewed. The average values were determined by using as weighting factor the sample size considered by each individual study. Accordingly, the sample size presented in **Table 4** corresponds to a virtual sample size which corresponds to the sum of the samples sizes of each individual study. In terms of the individual studies, the samples sizes referring to number of households were converted to number of individuals, by considering an average of 2.6 individuals per household. Studies using different scales of adoption frequency of a certain behaviour (e.g. from always to never or from most times to rarely) were combined by considering the cumulative values up to the middle point of the scale (e.g. from always to sometimes). As a result of such considerations some information was lost.

According to **Table 4** the energy saving behaviours with more room for improvement are using low temperature cycles in both the washing machine and the dishwasher, followed by using the dishwasher at full load, switching off the supply of the television (avoiding the stand-by mode) and turning off the lights when not necessary.

It is important to note that this values may not represent the Portuguese reality mainly for two reasons: i) the studies reviewed analysed samples with quite varied characteristics and ii) the answers provided by the respondents of each individual survey correspond to what they claim their own behaviour to be, which may not correspond to their reality.

Table 4: Loads prone to energy conservation actions: adoption rate of behaviours and virtual sample size

Equipment	Energy Saving Behaviour	Sample size	Adoption rate (%)
Lighting systems	Turning off the lights when not necessary	4332	62
Washing machine	Using low temperature cycles	1092	16
	Using at full load	11577	83
Refrigerator	Closing the refrigerator's door quickly	731	96
Television and Computer	Interrupting the operation when not in use (switching it off or leaving it stand-by)	814	95 (PC), 88 (monitor) and 97 (TV set)
	Switching off the supply (avoiding the stand-by)	All the population	57 (TV set) and 90 (PC)
Dishwasher	Using low temperature cycles	1014	14
	Using at full load	10015	56

The following paragraphs present, the behaviours associated with loads prone to energy conservation actions, more detailed values of adoption rates obtained by the different studies.

Lighting Systems

Several studies reported conclusions about the habit of turning off the lights when not necessary. In one of them it was concluded, that 62 % of the respondents almost always adopt this behaviour (Energaia, 2011). Other studies present similar values. For example, Rebelo (2011) concluded that 57 % of the respondents claim to almost always turn the lights off when leaving a room and it becomes empty. However, in another study slightly higher values were found, varying from 75 to 85 % (ADENE, 2011). When analysing the adoption rate of the complementary of this behaviour, i.e., leaving the lights on when nobody is in the room, the values seem to be in agreement with the referred previously. According to Rebelo et al. (2011), 61 % claim to almost never leave the lights on when nobody is in the room (Rebelo et al., 2011). According to the approach used by János (2011), on average the respondents often turn off the lights when leaving a room for more than 5 minutes or before leaving it, and they claim it to be probable to try to behave in that way in the next 2 months.

Washing Machine

Some studies evaluated the behaviour associated with washing cycle temperatures of the washing machine. However, for this type of behaviour, it was observed that the results particularly depend on the sample. For example, one of the studies concluded that 61 % of the households habitually use low temperature washing cycles (between

30 and 40 ºC), whereas almost 20 % of them use 60-degrees washing cycles (Carvalho, 2013). However, in another study it was concluded, that only 12 % of the households use low temperature washing cycles (Energaia, 2011). Both studies contrast with a third study, which concluded that among all the households, 87% of them use washing cycles limited to 40 ºC (F. Ferreira et al., 2008). However, the participation in this last study was voluntary, probably biasing the results.

Several studies addressed the habit of using the washing machine at its full capacity. One of the studies evaluates this type of behaviour for different Portuguese regions. The variation among the regions is not significant, being the adoption rate of 21 %, on average (ADENE, 2011). Even lower, was the adoption rate of 9 %, obtained by Energaia (2011), which also evaluated different regions. On the contrary, Pinheiro (2008) concluded that 80 % of the respondents use the washing machine at its full capacity. However, this study is referent to a building complex in Lisbon, a strict sample, in opposition to the other two studies referred. Two other studies, besides evaluating the adoption rate of this behaviour, also considered its frequency of adoption. This fact, apart from hampering the comparison with the previous studies, may conduct to different results. Despite that, the results obtained in the two studies are reasonably in agreement: one of them concluded that 79 % of the respondents declare to always use the washing machine at its full capacity, 19 % sometimes and only 2 % of them claim to almost never use it full (Costa, 2011); the other concluded that around 85 % of the respondents declare to always use the washing machine at its full capacity and around 10 % of them to usually use it even if not full (A. G. Ferreira, 2009).

Refrigerator

Despite the large number of potential energy saving behaviours associated with the refrigerator, compared to the other energy services analysed, little information could be gathered. No studies were found concerning the habit of unfreezing food and storing warm food inside the refrigerator, as well as the habits related to the refrigerator's maintenance. Regarding the habit of opening the refrigerator's door, Rebelo (2011) concluded, that more than half of the respondents almost always close the refrigerator's door quickly when using it, avoiding keeping it open for long periods. However, this was the only study addressing energy savings behaviours specifically related to the refrigerator's use, as a result no comparison of values is possible with other studies.

Television & Computer

Considering the electric equipment in general, and not specifically the television and the computer, several studies presented values about the habit of switching off the equipment's supply (avoiding the stand-by mode). From the reviewed studies, the adoption rate of this type of behaviour varies between 35 and 61 %. However, in three of them, this range is shortened to values between 40 and 49 % (ADENE, 2011; Energaia, 2011; A. G. Ferreira, 2009). Two other studies evaluated the habit of leaving the equipment on stand-by mode instead of using the on/off button (Costa, 2011; Rebelo et al., 2011), i.e. the complementary habit of switching off the supply (avoiding the stand-by mode). The results presented are quite similar to the ones referred before. Assuming that "never leaving the equipment on stand-by mode" is

equivalent to "always switching off the supply", it is possible to conclude that between 31 and 36 % of the respondents usually switch off the equipment's supply (i.e., almost never, never or sometimes leave the equipment on stand-by mode).

Regarding the television individually, it is known that from the 7475656 televisions existing in the Portuguese households in 2011, 43 % of them were usually left on stand-by mode (INE, 2011), existing on average two televisions per household, as national statistics at country level show. When studies are targeted to small samples, different values may be obtained. According to Morais (2009), around 30 % of the respondents claim to switch off the television supply, avoiding the stand-by mode.

In the case of the computer, according to national statistics, from the 3102548 computers existing in the Portuguese households in 2011, only 10 % of them are usually left on stand-by mode, existing on average one computer per household (INE, 2011). Similarly to the case of the television, this value varies with the sample considered. Morais (2009) concluded that around 90, 70 and 50 % switch off the supply of the desktop, the monitor and the laptop, respectively, avoiding the stand-by mode.

Dishwasher

There are some studies concerning the dishwasher's washing temperature. However, similarly to the case of the washing machine, the adoption rate of a certain temperature considerably varies with the study. Besides, the different questions used in the surveys used by each study make it difficult to make a comparison among the values obtained.

For the sample analysed by Carvalho (2013), temperatures between 30 and 45 ºC are used by 35 % of the respondents. However, in other study it was concluded that only 12 % use low temperature washing cycles, not specifying the temperature values (Energaia, 2011). And in another study, it was concluded that 44 % use temperatures higher than 60 ºC (F. Ferreira et al., 2008).

According to the study performed by Ferreira (2009), the use of the dishwasher at its total capacity is a habit always adopted by around 60 % of the respondents, declaring only 5 % of them to usually use it even if not at full capacity. A slightly higher adoption rate was presented in another study, which concluded that 80 % of the users use the dishwasher at its full capacity (Pinheiro, 2008). However, in this study no frequency of adoption is referred, making it quite difficult to compare with the former. On the other hand, according to another study, only 9 % of the users claim to adopt such behaviour (Energaia, 2011).

Conclusions

The residential equipment with higher potential for actions targeting behaviour and a set of common consumers' behaviour related to each one were identified, for the Portuguese reality. To identify the most relevant equipment, four criteria were assessed under a decision analysis procedure. Considering these criteria, the results indicate that, among 25 different equipment, lighting systems, washing machine, refrigerator, television, computer and dishwasher are the equipment with higher

potential for actions targeting behaviour. Printers, stereo systems, dehumidifiers, washing-drying machines, central vacuum cleaners and separate freezers belong to the group of equipment with lower potential for actions targeting behaviour.

Different types of behaviour associated with the referred equipment were identified for the Portuguese reality. Studies which employed surveys launched in Portugal during the last years, addressing each behaviour, were reviewed. For the majority of the identified behaviours, studies were found with relevant information. However, most of the times that information varies significantly from study to study, mainly due to the sample considered by each one. Moreover, the use of different types of questions to obtain similar information, make the comparison among the studies a challenging task. From the identified types of behaviour, no relevant data could be collected regarding behaviours related to daylight use, the removal of the layer of ice in the internal surfaces of the refrigerator, interrupting the television and/or computer operation when not in use (either by switching it off or leaving it stand-by) and allowing the natural drying of dishes when using the dishwasher.

According to the data collected from the studies, the energy saving behaviours with more room for improvement are using low temperature cycles in both the washing machine and the dishwasher, followed by using the dishwasher at full load, switching off the supply of the television and turning off the lights when not necessary.

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Natural Ventilation as Passive Cooling Strategy Aimed at Summer Overheating Reduction in Heritage Buildings: The Case Study of Vleeshuis Museum in Antwerp (Belgium)

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The European Conference on Sustainability, Energy & the Environment 2014
Official Conference Proceedings

Abstract
The challenge of reducing energy demand for historic and heritage buildings, while improving people indoor comfort is widely recognized as common economic and scientific issue.

Historic buildings are not always equipped with mechanical systems for indoor microclimatic control, therefore the indoor climate is strongly dependent from outdoor environmental parameters and specific building dynamic behaviours. Due to the building permeable system, people and exhibits thermal comfort, might drastically change throughout the year or even during a specific day.

Energy and environmental improvement, also for existing buildings is properly considered as a priority within the European energy saving Directives. Nevertheless these design purposes have to be merged with the fundamental needs of building protection. In historical and heritage buildings, each energy retrofitting strategy should be based on the minimum intervention approach.

Reducing the internal summer heating load by increasing the natural cross ventilation or by allowing air mass exchange between different building parts, responds to the double aim of improving the indoor comfort for people and artworks while reducing the energy cooling demand. Furthermore the building architectural integrity may be retained.

In the proposed contribution, Computational Fluid Dynamics (CFD) simulations are performed for investigating people and artworks thermal comfort enhancement after implementing passive cooling strategies.

Keywords: Passive cooling strategies, Heritage buildings, Museums, CFD simulations

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1. Introduction

Ensuring simultaneously optimal microclimate for preserving collections or embedded artworks[i] and thermal comfort for staff or visitors in heritage buildings and museums is still an unsolved conflict [1][2].

In such buildings type, artefacts and architectural envelope components, have been acclimatized to the indoor climate the building has from Centuries. Building materials, whether they appertain to artworks or constructive elements, have been adapted throughout the years to the specific building *historic microclimate*[ii].

If the *historic microclimate* is not taken into account during the whole design process, a completely different indoor quality may emerge after the refurbishment.

In this cases, the indoor climate variations induced by the new schedules and systems set points, can cause short and long-term fluctuations far from the ones previously experienced by the building[iii]. In such situations, the new conditions, although theoretically safer, might lead to temporary materials behaviour variations[iv] or either to their premature decay. For instance, the hygrothermal changes into an architectural enclosure, affects the materials seasonal drying cycles.

Materials after the retrofitting actions, might have different time-intervals for fully drying than the ones which would have had the same materials under the previous environmental indoor circumstances. This condition occurs mostly because of the equilibrium moisture content (EMC) alteration [3][4][5].

However, although the original *building historic microclimate* should not be drastically distorted, sometimes it is not adequate for ensuring people thermal comfort, therefore HVAC systems might be required.

Nevertheless, the documented drawbacks of HVAC systems [6][7], combined with the needs of: reducing installations energy cost, equipments invasiveness [8] and, considering at the same time, the main concern of non compromising the original microclimate, have currently raised the interest in implementing passive cooling[v] measures also in heritage buildings [9][10][11]. The option of preferring passive solutions before any mechanical ones is suggested by the EN 15251.2007[vi] .Indeed the Standard proposes to solve the problem of summer overheating firstly by means of passive solutions and only later by proposing active cooling technologies [12].

1.1 Passive Indoor Climate Management In Historic Buildings

The use of passive solutions such as the air stack effect, for natural building ventilation and overheating reduction was an already practised method during the past Centuries, before the customary use of mechanical installations [13][14]. Often historic buildings were equipped with integrated technologies for exploiting heat or mass flow to enhance the indoor climate comfort. Obviously in the past, only the accomplishment to thermal comfort for people was taken into account [15][16].

More recent successful passive cooling applications, seeking to reduce cooling loads by exploiting both: *solar* or *cold chimneys effect*[vii] with minimal initial economical investment, have been widely discussed by C. Ancay in [10]. In the documented

cases, the proposed cooling passive systems were based on straightforward design intuitions: the monitored basements, during summer, have shown air temperature far lower than the one in the upper levels, therefore the already existing air ducts (chimneys and shafts) have been reused as *solar chimneys* enabling an upwards air movement from the basement to the attic. In summer period, the air temperature in the attic rooms, was lowered by 14.5°C only by means of passive cooling strategies.

Proposition of adaptive ventilation systems, for improving indoor hygrothermal quality during short year periods in cold climates have been published by P. K. Larsen and M. Wessberg et al. in [17][18]. Furthermore examples of reusing existing architectural features for minimize the installations invasiveness and maximise the indoor quality in heritage buildings are discussed in [8][19].

Although, several case studies have proven the effectiveness of such passive solutions also with regard to heritage buildings, not every times a free running microclimate management is sufficient to ensure the compliance of microclimate requirements for collections preservation: such as controlling the short hygrothermal fluctuations.

Nevertheless, it has to be pointed out that a stringent indoor climate which doesn't admit any dynamic parameter fluctuations is not feasible and not energetically and economically sustainable [20][21][22]. The safer indoor environment is not the one with stringent theoretical temperature and relative humidity thresholds, but is the one iteratively controlled and rigorously evaluated in its short and long-term moisture-thermal dynamics.

Very often the damage to artworks is caused by improper or non-existing climate control. Therefore the activities aimed at controlling and certifying the indoor climate enable, by definition, a safer microclimate.

E. Neuhaus in [6] reported cases in which the threats to the collections were caused by the negligence of curators which did not regularly checked the hygrothermal parameters. If the physical environmental parameters are regularly controlled (frequencies over the time and their spatial distribution), optimal indoor quality may be ensured also by only implementing passive solutions; allowing in the same while, a consistent energy demand reduction, as largely documented by J. Kaferhaus in [23].

2 Research Aims and Methodology

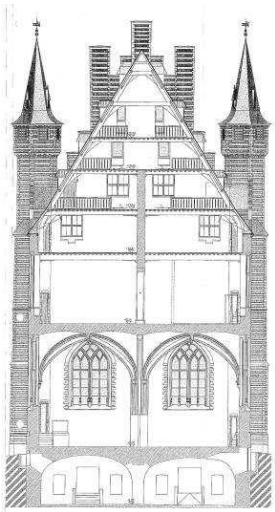
This study investigates possible passive solutions for lowering the overheating, often experienced by the hypogeum exhibition space of Vleeshuis museum during the summer period. Since the building has not air conditioning or mechanical ventilation systems, the people thermal comfort belongs to the adaptive theories [24]. However in the museum, due to the objects preservation and safety requirements, beside the people dress code, there are no other allowable adaptive behaviours. Indeed none window is operable, and fans for allowing air movement are not installed.

The research aims at proposing two passive cooling strategies and evaluating them on the basis of a general thermal comfort improvement.

In the next paragraphs, after a building description and a report on the current ITQ state, the passive strategies will be explained as well as the simulation methodology. Finally the ITQ after simulating the passive cooling strategies will be commented and final conclusions will be drawn.

2.1 Building Characteristics

The Vleeshuis Museum is a typical medieval Flemish slaughterhouse [25]. Although the original use destinations have changed across the Centuries, it is still possible to observe the original architectonic volume. The building was built with the following functions per level:



- The slaughter space was built in the basement level in order to allow the blood and waste disposal; currently it is used as exhibition space (object of this study).
- The covered market space, where the product was sold, is localized at ground floor; this space is currently used as main exhibition space.
- The merchant house, at the first floor, has big rooms and spaces for reception and trade activities. In this space, fireplaces were designed to increase punctually the indoor thermal quality; this level is mainly used either for temporary activities or for artworks storage.
- The upper levels (from the second to the fifth) were built for storing the products; currently these levels are used with offices functions (second floor) and artworks storage.

Image 2.1 Transversal section of Vleeshuis Museum

Although the basement level and the ground floor have the same surface (7.00m x 7.30m), the vertical proportion are completely different: 3.45m the maximum height in the basement level and 8.48m the maximum height in the ground floor. In basement level, high sensible gains from lamps, necessary due to the low day lighting, causes pronounced summer overheating.

The vertical distribution throughout the levels is ensured by five towers with staircases: one in each building corner and one extra tower in the middle of the South facade. The latter tower is the unique one connected to the basement level, therefore considered in the computational domain of the presented CFD simulations.

2.2 Indoor Thermal Quality Evaluation

The Vleeshuis Museum is not equipped with cooling and air mechanical ventilation systems and it has not centralized hygrothermal control, therefore during the hottest summer period, indoor temperature in the basement may reach peaks of 29-30°C.
Reasonably the Indoor Thermal Quality (ITQ) evaluation has been based on the adaptive theories[viii] [26] as considered within the EN 15251 [12].

2.2.1 People Comfort

The thermal classification in EN 15251, is based on the calculation of the operative temperature for three category intervals against the exponentially weighted running mean of the daily mean external air temperature. The exponentially weighted running

mean outdoor temperature (θ_{rm}) is calculated from the formula (1)[ix] as reported in [12].

$$\theta_{rm} = (1-\alpha)(\theta_{rd-1} + \alpha\theta_{rd-2} + \alpha^2\theta_{rd-3} \dots) \quad (1)$$

where:
θ_{rm} = running mean outdoor temperature for today
θ_{rm-1} = daily mean external temperature for the previous day
θ_{rm-2} = daily mean external temperature for the day before, and so on.
α = constant between 0 and 1 (0,8 recommended value)

In the EN 15251 is stated: "*the level of* (people) *adaptation and expectation is strongly related to outdoor climatic conditions*"[x]. Basing the comfort expectations on the outdoor temperature in its dynamic profile instead of a given interval, may lead to a less expensive energy management. Therefore acceptable indoor temperature thresholds have been calculated on a dynamic profile throughout the whole monitored period (July- August 2013) on the basis of the six equations reported in *Table 2.2.1.1* taking into account the calculated mean outdoor temperature.

	COSTANT	CATEGORY I	CATEGORY II	CATEGORY III
UPPER LIMIT	$\Theta i\ max = 0{,}33\theta_{rm} + 18{,}8\dots$	+2	+3	+4
LOWER	$\Theta i\ max = 0{,}33\theta_{rm} + 18{,}8\dots$	-2	-3	-4

Table 2.2.1.1, Acceptable indoor design temperatures for buildings without mechanical ventilation in [12]

NB the design upper and lower temperature ranges reported in Table 2.2.1.1, are expressed in operative temperature instead of air temperature; however within the EN15251 the air temperature might be considered as design temperature[xi] when the surface components temperature do not differ significantly from the air temperature[xii] (temperature difference lower than 4°C) and when the occupants are involved mainly in sedentary activities and they may adapt their dressing code[xiii]. The three categories correspond to different level of comfort expectations, from high (I) to moderate (III). To allow the indoor thermal quality (ITQ) certification, two basic statistical indexes have been introduced: Performance Index (PI) and Failure Indexes (FI). The first (Pi) expresses the percentage (of time) in which the monitored parameter is within an acceptable interval; the second (Fi) expresses the percentage (of time) in which the monitored parameter is out of the acceptable interval. The Failure Index is composed by two deviation indexes for temperature and two for relative humidity[xiv]. Failure warm (Fwi) and Failure cold (Fci) express whether the temperature is higher than the upper category level or lower than the lower category level. Failure superior (Fsi) and Failure Inferior (Fii), represent whether the Relative Humidity is higher than the upper category level or lower than the lower category level.

2.2.2 Collection Wellbeing

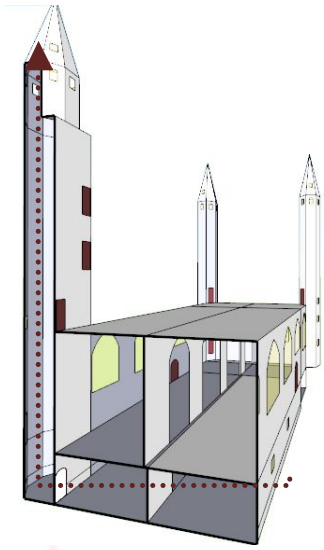
In order to consider a ITQ certification methodology comparable to the one discussed for people comfort, three hygrothermal category intervals have been defined for certifying the microclimate quality with regard to collections wellbeing. The three categories, reported in *Table 2.2.2.1* classify the microclimate quality on the basis of air temperature (T) relative humidity ranges (RH) and their maximum daily fluctuations (Δ).

	Temp (C°)	RH (%)	Δ Temp (C°)	Δ RH (%)
I CATEGORY	19-21	50-55	1,5	6
II CATEGORY	18-24	40-60	1,5	6
III CATEGORY	17-27	≤40; ≥60	1,5	6

Table 2.2.2.1, Hygrothermal categories Artworks

The first two categories represent respectively optimal and acceptable hygrothermal quality level, while the third represents a risky environment. Therefore a Pi higher than 0 in this category represents the percentage of time in which the exhibition spaces have risky indoor climate.

3 Passive Strategies



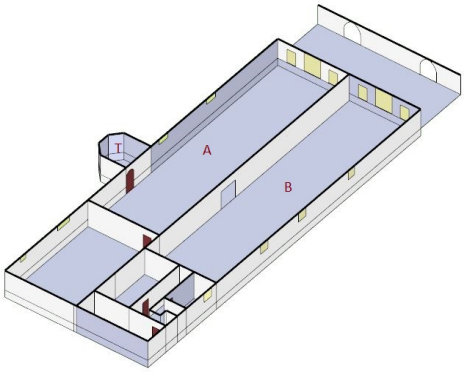
On the basis of the research aims already discussed in 2, two passive scenarios for reducing the summer overheating have been simulated and evaluated in this contribution. In Image 3.1 the three-dimensional representation of the building section shows the research hypothesis, as below explained[xv].

In the first configuration (1), the tower connected to the basement is considered as solar chimney; this configuration may reduce the basement air temperature by air stack effect and thermal buoyancy between the upper tower part and the lower basement part. The above described chimney effect is coupled with basement cross ventilation. Indeed the windows from the North facade[xvi] of the basement level are kept opened[xvii] seeking to enhance the indoor air velocity. In the second configuration (2), the same windows are closed. The air velocity and the relative humidity increase, as a direct consequence of the natural ventilation rise, may pose a problem either for people comfort or for artworks preservation. Therefore both the parameters have been controlled during the strategies evaluation.

Image 3. 1, Three-dimensional representation of Vleeshuis Museum; South oriented tower and exhibition spaces: ground floor and basement level.

4 CFD Methodology

For this study, *VE2014* (Virtual Environment) and its integrated CFD computational module *MicroFlo* was used. The CFD software uses the primitive variable approach, which requires the solution of the three velocity component momentum equations together with equations for pressure and temperature (conservation equations). The set of conservation equation is, linearized and discretized according to the discretization of the computational domain. The whole computational domain is subdivided in finite non overlapping and contiguous volumes constituting a geometrical grid; for each volume the conservation equations are expressed as linear algebraic equations. Hence solved on a iterative calculations. For investigating the fluid flow, in the specific case, the k-ε turbulence model has been taken into account[xviii].



4.1 Computational Domain and Modelling Assumptions

In order to reduce the calculation time, the computational domain, has been geometrically simplified: the two exhibition spaces are considered as parallepiped 2.75 high[xix] and the south oriented tower is considered as unique cave structure.

Image 4.1.1; Three dimensional representation of the basement level; South oriented space (A), North oriented space (B); South tower (T)

The exposition space is divided in two, namely A (South oriented) and B (North oriented) by a continuous bricks wall 100 cm tick, see Image 4.1.1. The presence of a large opening in the middle of the wall allows the continuous mass flow through the spaces; while the operable door of the tower allows the controlled mass transport through the exhibition spaces and the tower. A summary of the geometrical characteristics for the simulated spaces is reported in Table 4.1.1.

GEOMETRY SUMMARY	Max. Length (m)	Max. Width (m)	Max. Height (m)	Volume (m^3)	Floor Area (m^2)	Floor Perimeter (m)	Window Area (m^2)	Windows
Exhibition -1 A	25.00	7.20	2.75	629.885	179.981	64.47	7.792	5
Exhibition -1 B	27.00	7.20	2.75	678.750	193.934	68.35	8.222	6
Tower South	3.30	3.40	30.09	329.824	10.899	12.64	6.816	14

Table 4.1.1;Geometrical characteristics summary computational domain

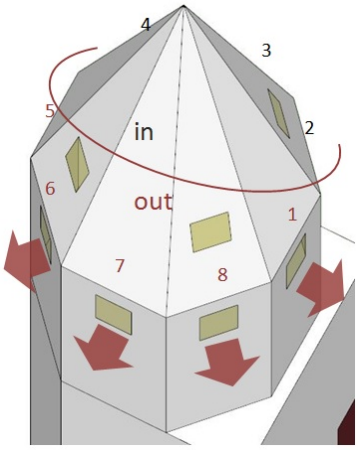
The computational domain for the CFD simulation has been gridded considering 0.10 m grid spacing (homogeneously distributed).

The exhibition spaces are equipped with halogen lamps from 100W (dimmer constantly set at 50%) and small lamps 50W (dimmer variously set), furthermore neon lamps 48W are installed in the showcases. The current sensible heat gains from the lighting system are modelled as uniformly distributed temperature increase on each space surface; the radiant fraction for the specific lamps has been considered 0.45. Since this study aims at generally assessing the hygrothermal characteristics of the exhibition space, no punctual heat sources have been modelled.

People metabolic activity in the museum is reasonably low, sensible heat gains and latent heat gains per person are considered respectively 67W and 50W[xx], the exhibitions spaces are considered with a occupancy factor 0.5. However, the people activity incidence in the whole temperature increasing especially during the summer period in the basement level is negligible.

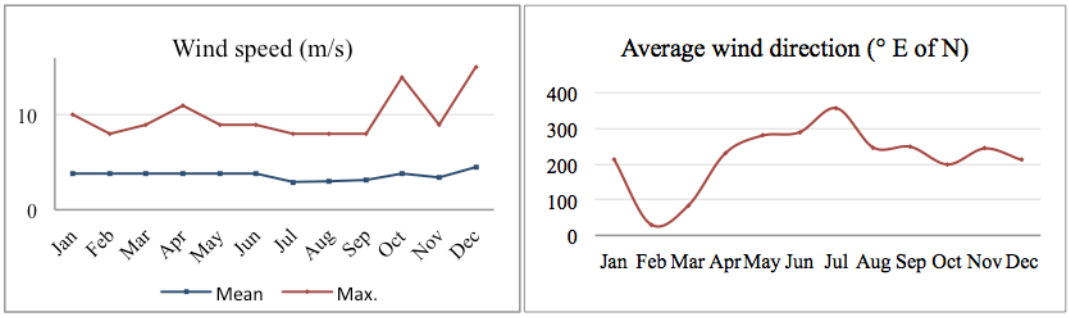
4.2 Passive Solutions

The average wind direction during the summer period in Antwerp is W-NW, while the average wind velocity during the same period is 4m/s, with possible peaks of 8m/s, see Graph 4.2.1 and Graph 4.2.2. For this study, a specific day during the monitored period (31st July 2013) has been considered with the aim of testing the effectiveness of both the proposed passive cooling solutions during typical summer conditions.



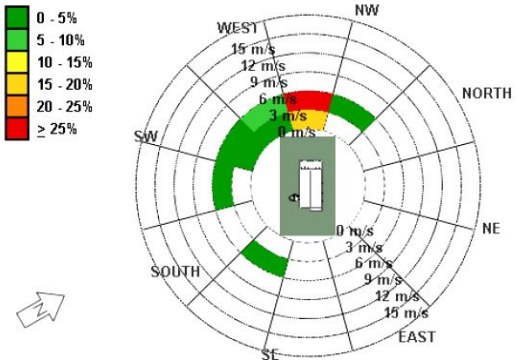
For a better understanding of the impact of external ventilation on the building, a wind rose diagram is proposed in Image 4.2.2. The highest wind frequency, for the selected day has orientation W-NW and air velocity between 3 and 6m/s. On the basis of this diagram it is possible to detect which tower window(s) should be used, as outlet, during the CFD simulations. Although more convenient for the geometrical and physical configuration of the solar chimney, the windows on the roof are not operable, hence with the aim of delivering more realistic scenarios, solely the contribution of the windows: 5,6,7,8;1 (See image 4.2.1) has been considered in *MicroFlo*. The air-flow rate through the windows non directly exposed to the ventilation (5-6-7-8-1) was therefore investigated for evaluating the air flow rate.

Image 4.2. 1; South tower Vleeshuis Museum, detection of outlets; the windows on the roof are not operable

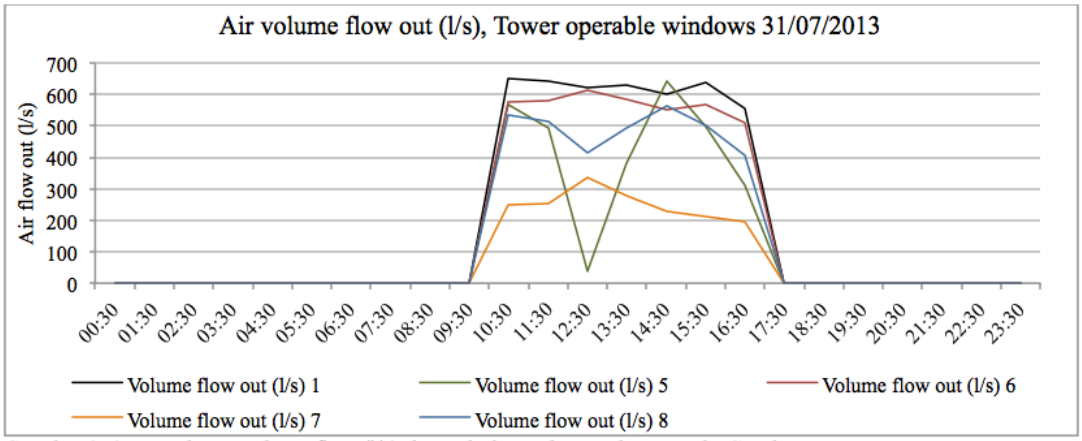


Graph 4.2.1(left) -Graph 4.2.2 (right) Monthly wind direction- Antwerp 2013 (left side), Monthly wind speed and peaks- Antwerp 2013 (right side); from Meteonorm V7.0.22.8.

Image 4.2. 2; Wind rose- Average wind direction and frequency at the studied site during 31 July 2013

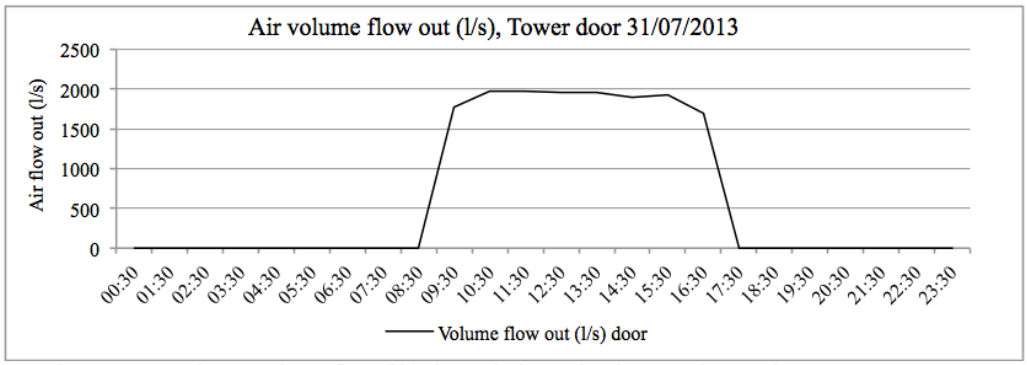


The flow rate for the different modelled window is plotted in Graph 4.2.3. The highest air flow frequency is from 9.30 in the morning to 17.30 in the afternoon. This condition allows a good natural ventilation during the museum opening hours (10.00-17.00), but it does not allow night ventilation. Although night cooling has been proven high effective among the passive cooling techniques to lower the indoor daytime temperature [27], it cannot be applied to the specific case since it is not possible to leave windows open during the nights in the studied museum. Three of the five investigated windows (1,6,8) have high air flow rate (>400l/s), for the whole time interval, while two of them (7,5) have lower or discontinuous ventilation.



Graph 4.2. 3; Hourly air volume flow (l/s) through the outlet windows on the South tower

As the South oriented tower is connected to the basement via an operable door. The air flow rate through the door, during the same time period considered for the windows, is plotted in Graph 4.2.4. Through the door, up to 2000l/s can be blown out from the basement by exploiting the natural stack air effect. The surface opened percentage for the door has been simulated equal to 100% for the entire studied interval of time. Obviously this percentage may be reduced if the air velocity in the basement level will result too high.



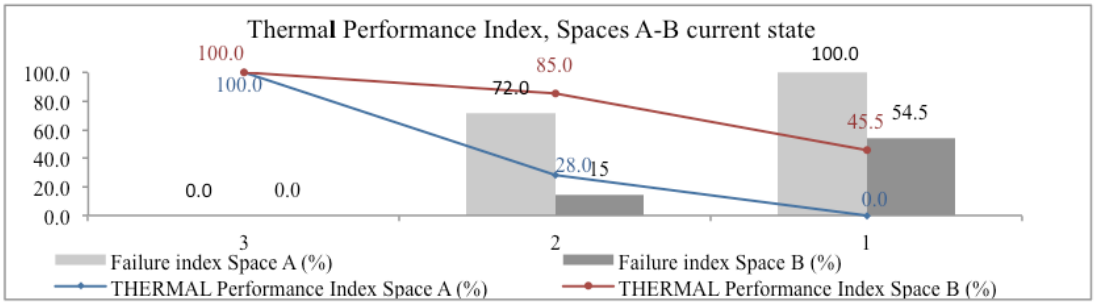
Graph 4.2. 4; Hourly air volume flow (l/s) through the outlet door on the South tower

5 Results Discussion

The ITQ has been verified before and after the passive cooling strategies for both the exhibition spaces (A,B) and both the proposed passive cooling solutions (1,2) either with regard to the artworks *comfort*[xxi] or to people thermal wellbeing. For sake of brevity, the solely first solution will be further discussed as been found the most performing[xxii].

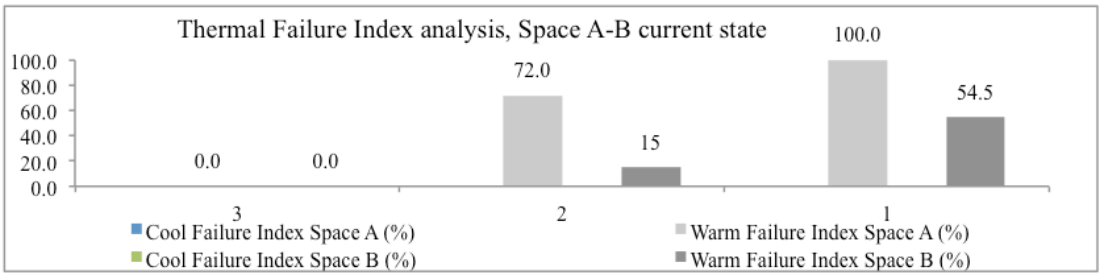
5.1 Thermal Improvement for Artworks, Results Discussion

The current thermal quality certification considering the categories proposed in 2.2.2[xxiii], is plotted for space A and B in Graph 5.1.1. The optimal microclimate (I) is reached for less than half the period in space B (45.5%) and never in space A. The scan thermal quality is consequence of both high internal sensible gains and spaces orientation. Acceptable microclimate (II) is reached for 85% of time in space B and for 28% of time in space A.



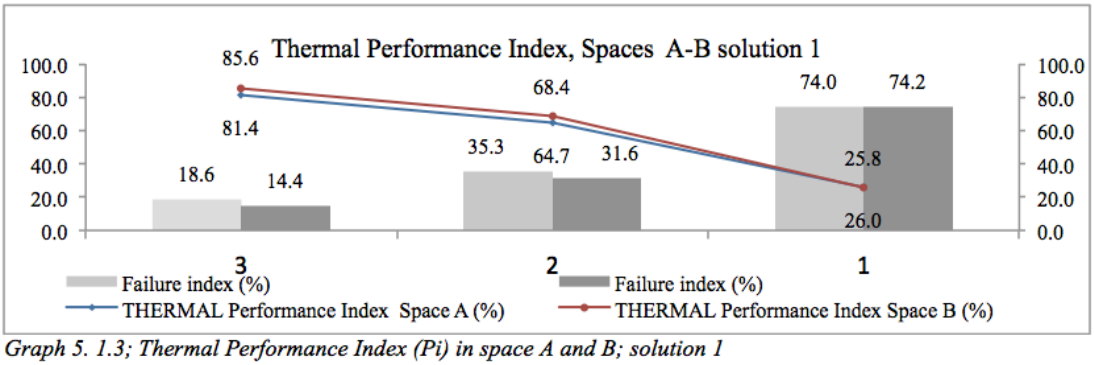
Graph 5. 1.1; Thermal Performance Index (Pi) in space A and B; current state

By breaking down the general Failure index, in the specific deviation indexes, becomes clear, as plotted in Graph 5.1.2, that the real cause of indoor discomfort is given by the high indoor temperature.



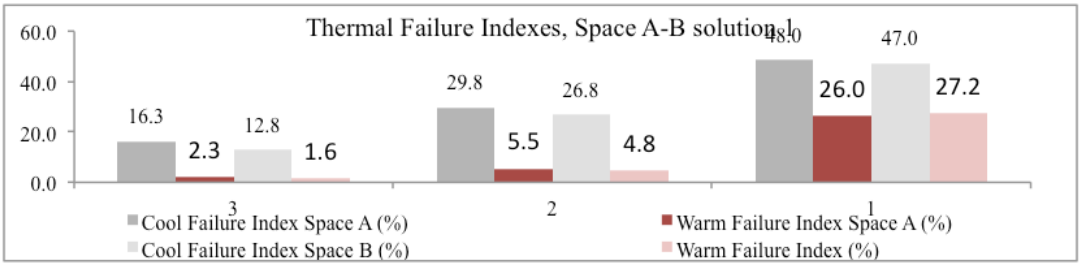
Graph 5.1. 2; Thermal Failure Index (Fi) in space A and B; current state

The indoor thermal quality after the simulations, if analyzed by considering the artworks thermal needs, shows a general improvement, (see Graph 5.1.3). Indeed, beside the increasing of thermal discomfort in space B, the Pi values for space A show an unmistakable quality enhance. The frequency of time in which the indoor air temperature falls into the risk category (III) is reduced in both the exhibition spaces, producing an overall increase of thermal quality.



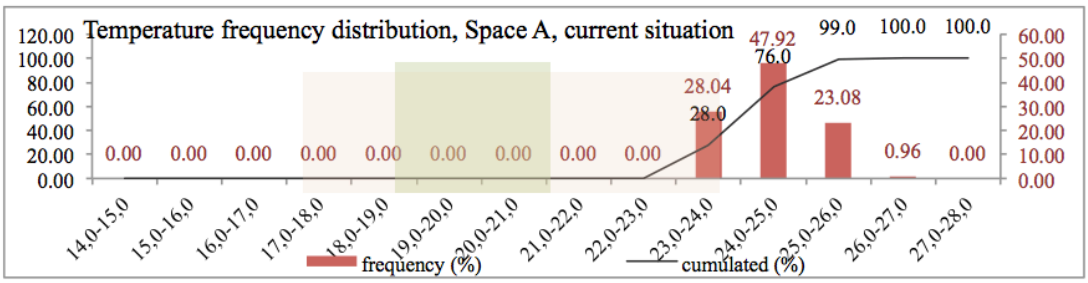
Graph 5. 1.3; Thermal Performance Index (Pi) in space A and B; solution 1

After the passive scenarios implementations, however, a slight discomfort for artworks caused by too cold temperature, on the basis of the intervals given in Table 2.2.2.1, may occur. Indeed after the strategies implementation, the composition of the general Failure index (Fi) is not longer given merely by the Failure warm index (Fwi), as it was in the current state, but mostly by the Failure cold index (Fci). Although there is a general thermal improvement, it might happen that the air temperature sometimes is too low; See Graph 5.1.4.

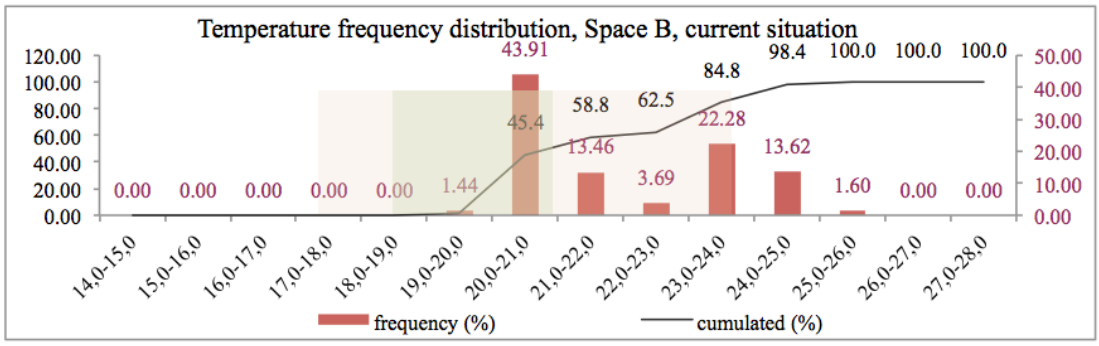


Graph 5.1.4; Thermal Failure Index (Fi) in space A and B; solution 1

In order to study more in details the temperature descreasing in the exhibition spaces, the cumulated frequency of the air temperature, for space A and B, before the passive cooling proposition is plotted in Graph 5.1.5 and 5.1.6. In the above mentioned graphs, the green and yellow squares indicate the optimal and acceptable indoor air temperature (categories I and II). In the current situation, it is evident the shifting of the air temperature frequencies from the safety ranges. In space A, during up to 72% of time, the indoor temperature is out from the acceptable microclimate thresholds; while in space B the temperature deviating from the acceptable interval is 15.2%.

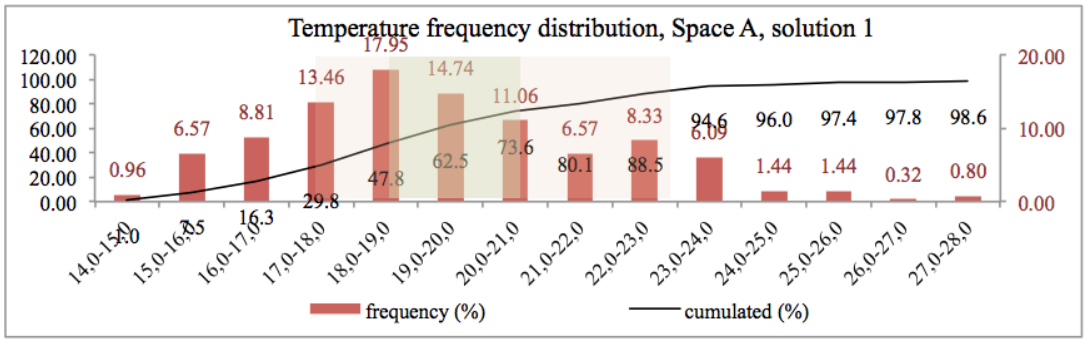


Graph 5.1.5; Frequency distribution space A current state; Indication of first category (green) and second category (yellow)

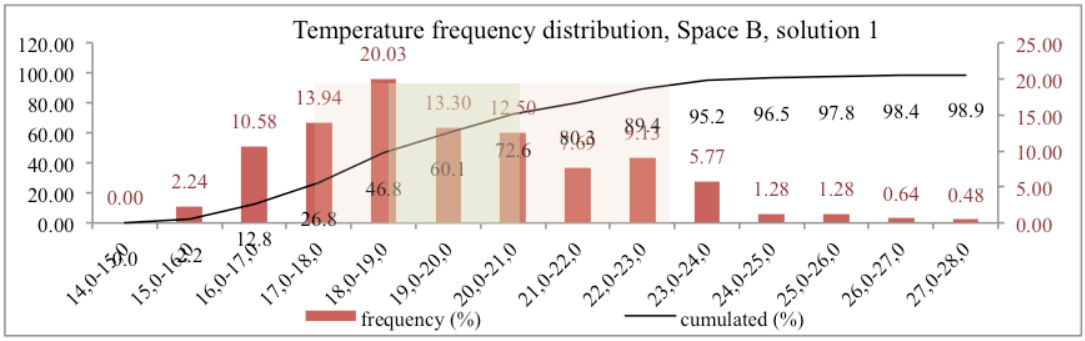


Graph 5.1.6; Frequency distribution space B current state; Indication of first category (green) and second category (yellow)

The Graph 5.1.7 and 5.1.8 show the temperature deviation after the passive cooling strategies simulation. The temperature deviation from the safety interval is reduced up to 26.4% in space A and 5.9% in space B, this shows the high potential of passive cooling strategies in reducing the daily temperature overheating.



Graph 5.1.7; Frequency distribution space B simulations; Indication of first category (green) and second category (yellow)



Graph 5.1.8; Frequency distribution space B simulations; Indication of first category (green) and second category (yellow)

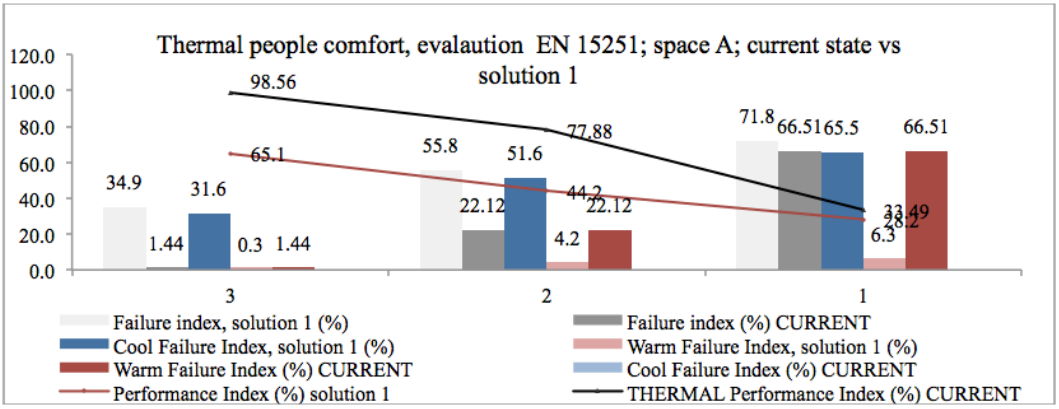
However the general overheating reduction is not the unique factor to be analyzed when evaluating passive cooling scenarios effectiveness. Indeed, the consequent relative humidity and air velocity increase may raise the risk of humidity damage and people local discomfort. The uncontrolled humidity increase is generally the biggest backward of passive technologies and it has to be evaluated case by case. The problem may be solved by installing vents opening systems, equipped with loggers for external-internal temperature and specific or absolute humidity control, as documented by Kaferhaus in [23]. In Table 5.1.1 the percentage of relative humidity out from the safety range (II category) is reported with regard to space A and B in the current state and after the CFD passive cooling strategy 1 simulation.

	SPACE A	SPACE B
Current state	49.60%	57.00%
CFD solution 1	69.80%	69.90%

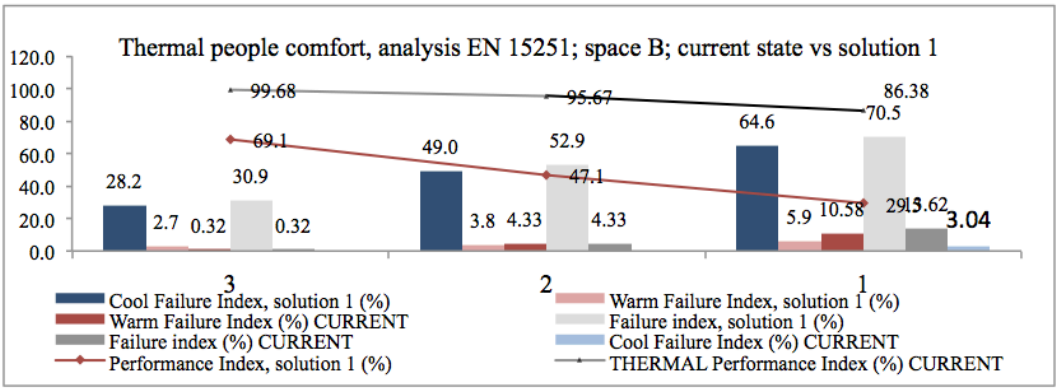
Table 5.1.1; Frequency of relative humidity deviating from the safety levels (II category); current space and after the CFD simulation

The increase of relative humidity deviation from the safety level due to the passive solution simulation is up to 20.2% in space A, however the temperature amelioration in the same space is up to 45.6%. Therefore the passive cooling strategies should be selected on the basis of building priorities and incidence risk evaluation.

5.2 Thermal Improvement for People, Results Discussion



Graph 5.2.1; Thermal Performance Index (Pi) analysis EN 15251, space A current state versus solution 1



Graph 5.2.2; Thermal Performance Index (Pi) analysis EN 15251, space B current state versus solution 1

The methodology presented in 2.2.1 has been applied for evaluating the people thermal comfort before and after the passive cooling strategies simulation. In Graph 5.2.1 and Graph 5.2.2, the Performance Index (Pi) and the Failure indexes (Fi) for each of the three comfort categories, before and after the intervention, are plotted for space A and B. By decomposing the Failure index it is possible to evaluate the discomfort causes before and after the scenarios proposition.

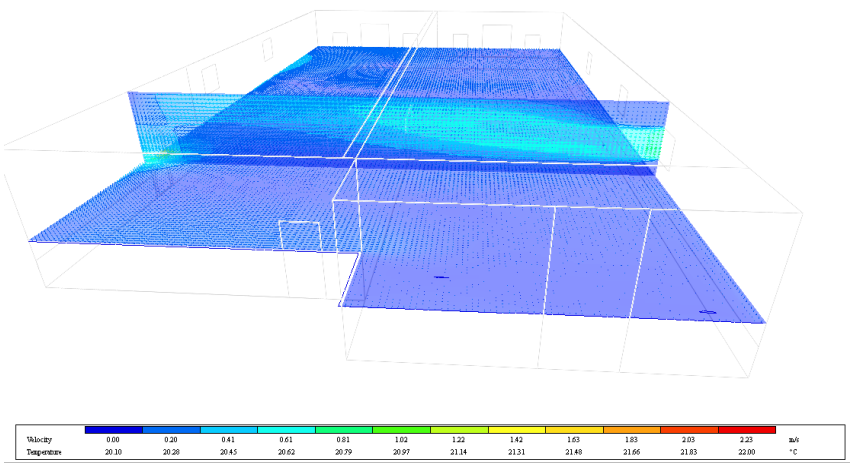


Image 5.2.1; Vertical and horizontal plans for air temperature and velocity tracking

The thermal discomfort (Fi), for the building current state, is caused by the too warm temperature; while in strategy 1, the (Fi) is mainly composed by high (Fci) percentages. In scenario 1, the (Fwi) is reduced up to zero.

The graphs explain the high effectiveness of the studied solution, indeed its adoption may results in a too incisive indoor temperature reduction. As discussed in 5.1 the air velocity increase has to be evaluated as a potential cause of thermal local discomfort, in Image 5.2.1 a combined vertical-horizontal plan sections shows the most perturbed part of the exhibition spaces, namely the connection between space B and A. The air velocity and temperature tracking are displayed on a vertical and horizontal plan (1.10 m high). The North facade windows are kept opened (solution 1). The air velocity field distribution shows values ranging from 1m/s and 0.2m/s. The highest air velocity occurs near the inlet and outlet (windows and tower door) while the lower air velocity is found at people legs level. In both the spaces no air stagnation occurs, the natural ventilation ensures, indeed, perfect air flows mixing. According to the plotted results for solution1, the air velocity does not generate local discomfort as the maximum velocity in the central part (where the visitors and collection are) is 0.81m/s. Higher velocity are reached only in specific boundary spots, for instance where the open windows are.

6. Conclusion

The presented study, although ongoing, delivers interesting results on the effectiveness of passive cooling strategies for lowering the summer overheating in historic buildings.

The proposed strategies have been investigated by means of Computational Fluid Dynamic (CFD) simulations and evaluated with regard to people thermal comfort (on the basis of adaptive theories) [28] and collection optimal microclimate. The indoor climate after the cooling strategies implementation is characterized by air temperature picks reduction: the temperature has been found even lower than the comfort thresholds calculated on the basis of the free running mean outdoor temperature.

However, as a consequence of the temperature reduction a sharp relative humidity increase was found. If the relative humidity increase is considered harmful for the collections or for building materials preservation, the installation of a metering systems on the automatic windows opening ironmongery might be a solution [23]. However the opportunity of investigating passive cooling scenarios before designing any air conditioning systems, especially in heritage buildings where there is the problem of installations integration, should be considered (see EN 15251), the first design option. The results of this research may be updated according to still ongoing research activities.

References And Notes

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[i] Embedded artworks: not movable works of art, such as: frescos, painted wooden ceilings or interior walls.
[ii] Building historic climate defined as climatic condition in a microenvironment where a cultural heritage object has always been kept, or has been kept for a long period of time (at least one year) and to which it has become acclimatized; in EN 15757:2010; Terms and definitions, pag 5. in [29]
[iii] An extensive description of the historic microclimate variation disadvantages, is reported in [3]
[iv] Physical, chemical and mechanical material behavior variations can be caused by the new boundary conditions.
[v] Passive cooling and heating strategies for retrofit design are proposed by Calderaro et. al. in [11]
[vi] The standards proposes to exploit natural ventilation, for reducing the summer overheating, before selecting any mechanical strategy, chapter 6.1 [12]
[vii] In the warm or solar chimney, the external air is drawn into the room, an upward air movement is obtained. In the cold chimney, the air is lead from the basement to the upper rooms; in [14].
[viii] Adaptation: Physiological, psychological and behavioral adjustment of building occupants to the interior thermal environment in order to avoid discomfort. In naturally ventilated buildings these are

often in response to changes in indoor environment induced by outside weather conditions, in Terms and definitions, EN 15251.2007 [12]

[ix] In: *Terms and definition; External Temperature, Running Mean* in [12]

[x] In Building without mechanical cooling, paragraph 6.1.2; EN15251

[xi] Instead of Operative Temperature

[xii] Recommended criteria for thermal environment, Annex A; EN 15251.2007 [12]

[xiii] Annex A.2 Acceptable indoor temperatures for design of buildings without mechanical cooling systems; pag 27 EN 15 251.2007

[xiv] The deviation indexes for Relative Humidity are only used during the microclimate evaluation for artworks wellbeing.

[xv] NB The upper floors are excluded from the CFD computations.

[xvi] Worth of mention: the basement level has splayed windows, different in dimension according to the facade orientation. The openings from outside correspond generally to the street level. With the exception from the West and South-West facades, where the street inclines.

[xvii] The simulated surface opening percentage is 50%

[xviii] Considering the extra equations referring to turbulence kinetic energy and turbulent viscosity.

[xix] The exhibition spaces are 0.65m lower than the reality as they have been interrupted before the vault.

[xx] From Table 6.2 Benchmark allowances for internal heat gains in typical buildings; Internal heat gains-Section 6; CISBE Guide A 2006

[xxi] The authors, with artworks comfort, mean optimal microclimate condition for avoiding hygrothermal stress in artwork materials

[xxii] With higher Performance Index in the first and second category.

[xxiii] Results of current situation refer to the simulations of the exhibition space without the implementation of passive retrofitting strategies.

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