

Eco-Friendly Buildings: The Central Factor in Transitioning to a Net Neutral Community

Abdul Salam Darwish

Phoenix Renewable Energy Centre, Manchester, UK

Abstract

The building sector is the world's largest contributor of global greenhouse gas emissions. More than 33% of global energy use is consumed in offices, homes, and other buildings. This figure is expected to double by 2030. It is imperative that new construction projects, and renovations to existing construction, are focused on eco-friendly building, which provides a low-cost means to battling climate change, reducing energy bills, and diminishing our reliance on fossil fuels. This paper will present the importance of urban planning in terms of eco-communities by discussing how building designs and materials can achieve energy neutrality. Consideration of climate must also figure prominently into eco-planning, emphasizing the most appropriate forms of renewable energy for the region. Many factors need to be considered when creating an energy efficient built environment, including: making the best technical use of local resources to avoid the costly (financially and ecologically) long-distance transportation of construction materials; determining the most optimum balance between harnessing natural sunlight and insulating the inside of a structure from its accompanying heat; and creating natural ventilation and air filtering through design rather than focusing on energy draining air conditioning systems. Of these three, the last may be the most important, as the highest percentage of household energy consumption is associated with the cooling and heating of living spaces. These aspects greatly affect quality of life and will not be forsaken. Their ecological adaptation is necessary in order for populations to adopt more sustainable lifestyles. The focus of this paper is balance: balancing the planet's and our communities' future needs with the sustainment of home comforts and quality of life; the balance of future urban development with renewable energies; the balance of ecological building design with high life-cycle materials and balance between people and nature.

Keywords: *eco-friendly, energy, climate change, design, balance, greenhouse gas emissions.*

1. Introduction

Over the last 150 years, much of the world has experienced some level of major industrial and technological revolution. Industry and technology have developed at a phenomenal pace. During this relatively short period, hundreds of individual fields (medicine, aviation, manufacturing, etc), have progressed more than over the entire previous existence of mankind. Progress was made earlier for the sake of progress and then for the sake of profit, mostly without any concern for the effects

such advances were having on other aspects of humanity or on the planet. However, we are now beginning to understand the importance of balancing these advancements with the future sustainability of our resources. If our current ways of interacting with our environment are allowed to continue unaltered, people all over the world will experience rapid and increasingly detrimental effects to their quality of life. One point of major concern is that as global greenhouse gas levels

* Corresponding author: darwish@renewableenergycentre.org

continue to rise, the planet's temperature will correspondingly rise, resulting in the melting of the polar ice caps and seriously altering global weather patterns. In fact, we are already seeing the evidence of these changes. A major consequence to this specific scenario is that ocean levels will rise and coastlines will significantly recede. Rising sea levels will be a catastrophe for every coastal nation on the planet, but especially in the Arabian Gulf, where the majority of the Gulf nations' populated areas lie along the sea line. If water levels rise as predicted, almost every major city along the Gulf, and possibly the entire territories of Qatar and Bahrain, much of Kuwait, much of the Saudi Gulf coast, and significant parts of the UAE will become submerged. Current estimates calculate that the world's built environments account for approximately one third of all global greenhouse gas (GHG) emissions whilst consuming 40% of the world's energy (UNEP SBCI, 2009). These figures are expected to nearly double by 2030 (UNEP Kyoto, 2008). That means that within the next 16 years, the *major* ecological threat to the populated regions along the coast of the Arabian Gulf is the world's new and existing buildings and built environments. This should provide a major incentive for the residents and governments of these nations to lead the way in terms of developing ecologically minded buildings, pertaining to both design and material, as well as eco-conscientious communities.

It is important to keep in mind that a built environment changes only periodically and even then, very slowly. A building constructed today will realistically still be standing and in use at least fifty years from now (Jablonska et al., 2010), possibly more. It is not expected that a newly constructed home or facility will immediately need to be renovated or updated. In fact, it is the feature of a well considered, designed and developed structure that it will need to be refurbished rarely, if ever. For this reason, for most of the world, only 1% of new construction is added to a built environment annually (Jablonska et al., 2010).

Only 10-20% of a building's lifetime energy consumption is derived from the energy used for its production: acquiring raw materials, manufacturing and transporting building supplies, construction, renovations and finally demolition (UNEP SBCI, 2009). This means that for any

house, office space, or commercial property, 80-90% of the GHG emissions it creates are derived during its operational phase: when the building is being heated and cooled, when lights and appliances are being used and when water and air is being filtered and supplied (UNEP SBCI, 2009).

Since built environments comprise such a large and ever-increasing portion of the world's total GHG emissions and since the majority of those emissions are derived from a building's life cycle, this is obviously the area of urban development where meaningful and long-term change must immediately be implemented, if we are to positively affect GHG levels within this century (UNEP SBCI, 2009).

The Middle East is in a unique position and is blessed with the fortune of being able to choose its destiny. Fifty, even thirty years ago, most of the Middle East's current urban landscape was non-existent. Cities in the UAE, Qatar, and Bahrain have sprung into their current form virtually overnight. This is very liberating in the fact that our Middle Eastern countries do not find themselves bogged down by the historical considerations and pre-existing layout of European countries. In terms of eco-friendly and green urban design, there is an unobstructed and fresh canvas to work upon. This fresh canvas then presents Gulf region nations with the capacity to develop their cities not just to meet present needs, but with a forward-thinking mindset. With a little bit of extra planning, and a little bit of creative innovation, the Middle East can develop entire environmentally conscientious landscapes that will produce benefits which will multiply many times over, well into the next century.

2. Eco-Communities are Key

Arabian Gulf countries do not currently employ eco-designs and considerations into their new construction planning, as a matter of policy or regular practice. There is a huge dependence upon carbon resources, above and beyond that required in other regions of the world, even to obtain such basic survival necessities such as fresh water. For most of this area, water is supplied through desalination plants, which rely on a massive consumption of petroleum fuels. Furthermore, public transportation options are limited, increase-

ing the use of fossil fuels to power high volumes of individual vehicles. These are only a few of the challenges that Gulf building and community planners will need to overcome in order to implement a sustainable and eco-friendly way of life for the area's residents. In order to accomplish this goal, however, Middle Eastern urban developers will need to keep the following main considerations in mind.

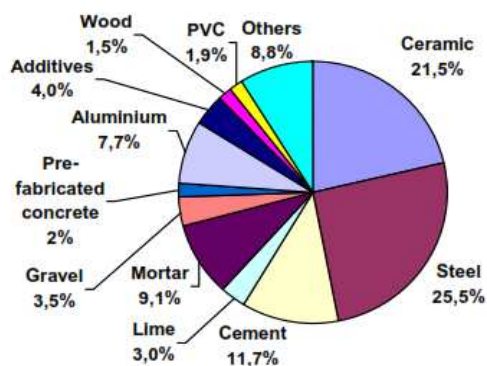
It is not sufficient to adopt or encourage only individual low-scale eco-friendly building incorporations. This statement is not meant to discourage the individual or minor changes, but in terms of *country-level* contributions to the *global goal* of significantly reducing GHG emissions, a handful of homes in each neighborhood with solar panels, or one beautifully designed entirely green office building per city center, simply does not provide any measurable impact, nor does it increase the quality of an eco-conscientious lifestyle for the majority of the population. In order to gain measurable and significant GHG reductions that meet country level goals for contributions to global goals, eco-friendly designs must be carefully planned for and incorporated on community-wide levels. The majority, if not all, of the built environments in an area must incorporate eco-positive designs and modifications. Net neutrality will be less expensive and more easily managed on the community level. Psychologically, community members are also more likely to be invested in the effort of achieving the goal and in holding each other accountable for maintaining the goals, once achieved. It is more difficult and initially expensive for one building to achieve neutrality than for a group of buildings to meet a goal collectively. That is to say, if only one building is designed to be self-sustaining, then that individual building must generate enough power (through solar panels or wind turbines or geo-thermal piping) to meet all of its energy needs, whilst also having the facilities to generate the power it needs from these sources and to recycle its wastes, and so on. For instance, that one building must be appropriately oriented towards the sun or wind, with no obstacles or the risk of future obstacles. Such impediments make it less likely then, that the individual building owner or builder will exert much effort towards eco-design. On the other hand, if ten buildings located together over several

blocks have the goal of energy sustainability, then they can collectively work towards meeting their goals by borrowing and lending energy and resources and by sharing responsibilities. Maybe two of the buildings receive a lot of sunlight and can produce the majority of the energy needed for all of the buildings. Then a recycling station for use by all of the buildings will only take up space in one of the structures, and so on. Pedestrian centers can be built between the structures and large awnings stretched over this space can provide shade that protects all of the buildings from being exposed to too much heat. By sharing the efforts, each individual building will lower its own responsibility and expense and be more likely to successfully meet the overall emission reduction goals.

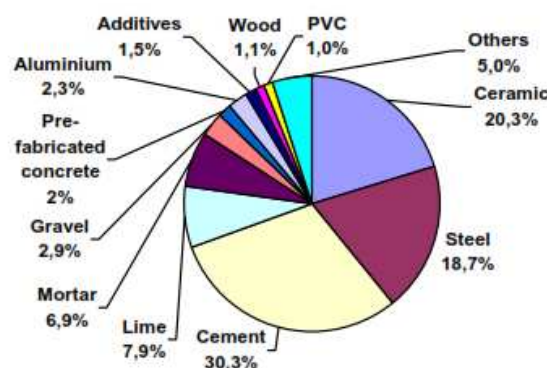
2.1 Building Materials

Developers in Arabian Gulf countries will need to remove themselves from the Western mindsets of building designs and materials and think on how those designs might be altered to be sustainable and energy neutral. The ecological impact of construction materials can be significantly reduced by encouraging the use of the best eco-innovation in production plants and substituting the use of finite natural resources for waste generated in other manufacturing processes, thus resulting in increased competition to produce more eco-efficient products (Ignacio et al., 2011).

Other attempts, to migrate only the individuals in a community towards more eco-friendly construction and practices, have met with varying levels of minor success. Countries in the West have attempted everything from incentives to penalties in order to coerce their populations into the direction of eco-conscientiousness. Research and experimental eco-communities throughout the world are proving that providing a group with overall goals and the means to achieve those goals collectively, yields higher rates of success and better attitudes about participation and contribution. In this way, eco-communities offer better balance for people to cooperate towards the GHG reduction goals, than when they feel they are carrying these burdens by themselves. This balance, between the individual and the community, is a key factor.



Contribution of primary energy demand for the manufacture of the materials needed in the construction of 1 m² (gross floor area) (Cuchí, 2007).



Contribution of CO₂ emissions associated with the manufacture of the materials needed for the construction of 1 m² (gross floor area) (Cuchí, 2007).

Figure 1: A comparison of building materials. Energy demand vs. CO₂ emissions

(Note: The high impact of commonly used materials such as steel, cement and ceramics is notable)

Importing building materials into the Gulf region is expensive. Often high-quality and eco-conscious materials are more expensive. It can be argued that any positive gain from the extra effort of producing building materials in an environmentally sound way might be cancelled out by the waste produced in transporting them to the local area. Remember, however, that all of the effort and pollution created in acquiring, manufacturing, transporting and constructing materials only accounts for less than 10-20% of a built environment's overall lifetime of GHG emissions. It is better than to possibly create a little bit more GHG emissions in the manufacture and delivery of high quality eco-materials that will then operate efficiently throughout the lifetime of the building. Material production can significantly be reduced by encouraging the use of the best eco-innovation in production plants, and substituting finite natural resources for the materials made from the waste generated by other manufacturing processes.

Business policies that focus on acquiring and building with such materials would result in an increase in competition to produce more eco-efficient products (Ignacio, et al., 2011). Similarly, there must also be a focus on so-called 'life-cycle' materials. A prime example is aluminum, which is extremely durable and versatile and can be repeatedly recycled, using only a tiny fraction (5%) of the amount of energy needed for its initial

production. Aluminum can be used with a wide variety of alloys, has a long life, low maintenance costs, and improves a building's energy performance by either conducting or reflecting heat. (Association, 2006) It is also an ideal material for achieving air-tightness, which is essential in the battle to reduce GHG emissions by affecting heating and cooling energy expenditures. Aluminum is versatile and particularly suited for the Gulf climate. It functions equally well to maintain thermal comfort by reflecting heat away or by harnessing solar radiation as a conductor in photovoltaic cells (Association, 2006). Table 1, illustrates the criteria for eco-neutral materials to be considered for use in the UAE and similar countries.

3. Energy Neutrality and the Arabian Gulf

A district or community can be considered energy neutral if, on an annual basis, a net energy import is not necessary from outside the district, in order to offset the energy consumption within the district (Jablonska et al., 2010). For the purpose of this paper, a building is considered to be energy neutral when its energy demand is met or offset by locally renewable energy resources (preferable on-site or nearby). This can also be referred to as "energy self-sufficiency" (Jablonska et al., 2010). When a

building or community produces more energy than it consumes, it has a surplus and can export that (green) energy. When the demand for energy is higher than the amount created through renewable resources, then other, usually carbon based energies must be imported (Jablonska et al., 2010). Avoiding this latter scenario is the ultimate goal. Long-term studies of six test communities in the Netherlands prove that with proper planning and implementation, this is entirely feasible for all aspects of community functioning, except for running private vehicles (Jablonska et al., 2010). In order to determine how best to offset a building's energy consumption, we must first understand where and how it uses and loses that energy.

Table 1

Criteria for Eco-Neutral Materials to be considered for use in the UAE

Eco Criteria	Material And Technical Solutions
Eco-standards and regulations	– International LEED standard and local building regulations
Eco -Technology for tropical climate	– Renewables (Solar, wind) – Control Mechanisms – Double Glazed windows and doors to reduce heat absorption
Eco Architect	– Green Roofs – Aluminum Cladding – Air circulation – Direct sunshine lighting
Environmental	– Reduced water consumption
Eco-Communities	– Introducing the Eco community measures experimentally and modelling
Eco resources	– Encourage local manufacturing seeking local raw materials reducing none recycled waste
Eco materials	– High quality eco materials finite natural resources will have long life cycle – Eco-innovation in production plants, – Eco-efficient products through business competition – Low maintenance costs materials (e.g. Aluminum)

(Ignacio, et al., 2011)

A huge proportion of the average building's energy expenditure comes from heating and cooling the interior spaces. This is particularly so in the case of arid environments like those found in the Middle East or in very cold climates. While current building cooling (heating) methods require large amounts of energy to produce the artificially cooled or heated air, this expenditure is compounded by the loss of such air through poor building construction, materials, and insulation. Even more energy is then used to force the cooled or heated air into different parts of the structure. Furthermore, this aspect of a building's function never declines in importance and its efficiency only decreases over time.

3.1 Adapting Building Design and Construction to Achieve Energy Neutrality

Building design must also think outside the box, moving away from the tried and true “ducting and forced air” method of heating and cooling, to more environmentally appropriate and ecologically sound systems. Currently popular methods for space heating and cooling are extremely inefficient, wasteful, and make up the largest portion of a built environment's GHG emissions (Jablonska et al., 2010). Many methods can be applied to the design of a building in order to alter its functionality. For most of the time, people have not had the means to artificially alter their environments as we do now. Yet ancient civilizations were able to design buildings in such a way that heat was reflected (or absorbed where needed such as for heating water), light and shade were utilized for maximum benefit, and airflow was directed in such a way so as to circulate air within and around a structure. Our ancestors were at balance because they used the elements to their advantage and figured out the best uses for local resources. They were often the only ones available.

While technology is wonderful, it sometimes makes us lazy in terms of our creativity. One of the major obstacles to be overcome in the global battle to reduce GHG is the battle to fight our own mentality in favor of just continuing to do things the way we are or have been doing them. We must be willing to accept those ideas that might seem strange if they have the potential for weaning our dependence on fossil fuels and unheeded energy consumption. For instance, in very cold climates some buildings are now constructed with double

walls set a meter apart. Between these walls natural straw is used as an insulator. The straw traps heat in and significantly reduces the amount of inside heat that is lost to the outside environment (over conventional construction methods). Obviously straw is not a native resource to the Gulf environment and walls of such thickness would be difficult to maintain on tall, multi-storied buildings, but it may be possible to take these ideas and apply them to the challenges of living in a hot climate. In those cases where a building is only a couple of stories tall, perhaps thick walls filled with sand as insulation will absorb the outside heat while maintaining coolness inside. Light pipes are ideal for directing sunlight through thick walls and can be used to direct sunlight into the corners of a room rather than to have a wall of windows that would overheat the house. This method, along with light wells, which can also be used to direct sunlight into the central areas of the home, can help to eliminate the need for electric lights during daytime hours.

3.2 Applying Renewable Energy Sources to Achieve Energy Neutrality

There are so many options for applying renewable energy resources towards the goal of eliminating carbon dependence. In the Middle East the sun is both the most plentiful resource to be tapped and the biggest challenge to overcome. Obviously solar panels are the first things that come to mind when considering renewable resources in the sunny, arid climates. Creativity in their application might serve the dual purpose of harnessing solar energy, whilst protecting a structure from becoming too overheated by the sun's heat. One way this could be achieved is by applying solar collection cells vertically to the walls that absorb most of a building's direct sunlight.

Solar powered air conditioning systems, or so-called "Chinese air conditioners" are used predominately in Asia. They are far superior to window units by creating their own energy rather than consuming massive amounts of electricity and draining city wide electrical grids during high temperature days. Furthermore, in addition to operating optimally in temperatures ranging from -15°C – 55°C, they also heat and filter water, on-demand, thus eliminating the extreme amount of energy wasted by conventional Western multi-gallon hot water heater tanks. They save between

30-50% of electricity used on conventional cooling systems and 70% or more of the energy used to heat hot water. These systems do not waste valuable window real estate, are not unsightly, do not cause energy leakage through instillation, do not freeze in winter, and eliminate water scale buildup common to tank systems (SolarFirst, 2014).

A wind cone is a revolutionary concept to our modern thinking but examples of wind towers can be found throughout ancient architecture. In the most basic terms, a tall tower is constructed as a central part of a structure. It is designed in such a way that it draws in air and pushes the air to a subterranean level, where it is cooled naturally and then cycles back up through the structure, transferring the cool air as it passes back out of the tower. The headquarters building for the new Masdar City project incorporates modern examples of wind towers.

Table 2

Solutions for Achieving Energy Neutrality

Purposes	Net Neutral Designs
Cooling	– Increased thermal efficiency to reduce need for air conditioning – Reflective outer materials, protective roof or awnings, thicker walls, natural insulations
Environment	– Increased urban waste production – Wastewater/ Grey water treatment – Sustainable urban drainage – Rainwater harvesting – Vacuum sorted underground waste removal – Well lit, safe, and well-drained walkways, especially over or under major roads and as access to public transportation – Maximum water efficiency including low-flow toilets, on demand sinks and showers, high efficiency washing machines and dishwashers – Indoor plant air filtration
Technical	– Energy ONLY from renewable sources: – Solar panels, wind turbines, geothermal ducting, biomass fuel generation
Ventilation	– Wind Cones

Rooftop gardens and wall gardens are nice ecological features, not only for their ascetic value or for the fact that plants clean carbon dioxide out of the air and replace it with fresh clean oxygen, but because they absorb and convert the sun's heat energy and create a better heat reflective surface than traditional heat absorbing asphalt tiles or tar pitch. Wall gardens, which climb vertically up a building's walls or are incorporated into design into walls that feature steeped levels, serve better than reflective glass not only by capturing the sun's energy, but by not reflecting its heat back out between the buildings, which in turn raises the urban environment temperature increasing the buildings' energy effort to cool the insides. They insulate and bring greenery and plant life into the urban landscape. This aids in the mental balance between man and nature, which can sometimes be lost to city-dwellers.

Table 3

Sustainable Neutral Carbon Community Developments

Measures	Action
Create Direct Incentives	Encourage customers to install renewable energy technologies by helping reduce high equipment costs
Adopt Feed-In Tariffs	More capital to the market, and more renewable energy implementation technology used in the new green buildings
Offer Loans for Energy Efficiency and Renewable Energy Systems	Allowing consumers to spread up-front equipment costs over the life of a loan
Create Clean Energy Financing Program	Long term fixed cost loans
Improve Renewable Energy Access Laws	Protecting the rights of property owners to install solar systems
Engage the Utility	Work with the power supplier to promote energy efficiency
Improve net-metering rules	Net metering encourages customer investment in renewable energy
Encourage the Recycle and Reuse Wastewater	Suitable for cases where large amount of power needed to import water.

(Shanghai Manual)

Wind is also a major natural resource to be tapped and turbine technology is constantly developing. The latest wind turbines don't actually have propellers at all but look more like large doughnuts or satellite dishes. This could be a better functioning option in sandy environments where blowing sand could damage and increase maintenance costs on moving turbines. The new design also eliminates noise and light flicker concerns and makes this a more acceptable option for urban landscapes where those complaints caused concern for implementing older turbine technology. Solutions are shown in table 2.

4. Sustainable Energy Community

A sustainable energy community is a community that is developed through planning and organized policies for the implementation of renewable energy systems towards the goal of creating and ensuring the community's future functionality and comfort. "A planned community can consume about 45% less land, cost 25% less for roads, 15% less for utilities and 5% less for housing," (Burchell, et al., 1991). Measures presented to encourage sustainable and neutral carbon community developments are summarized in Table 3, below.

The transformation towards an Energy Sustainable Community can be achieved by:

- Increasing the community's awareness for energy consumption and problems.
- Involving the community over all social levels, from end-users to regional decision makers to government and super-governmental organizations.
- Gaining public acceptance for renewable energy systems through the use of energy technologies and emphasising that the technologies will not detrimentally affect quality of life and comfort.
- Implementing continuous financial support and other significant incentives to encourage the development of new projects.

4.1 SMART Technologies and Intelligent Transport Systems

SMART technologies and Intelligent Transport Systems (ITS), in particular, can positively impact the development of a sustainable community by providing cleaner, safer and more efficient public transportation systems. These systems reduce vehicle congestion and its resulting negative externalities that is, fuel consumption, while simultaneously adding the benefits of increased comfort and adding valuable time (as community members are free to otherwise utilize their time whilst riding on these transportation systems). In order to implement a reduced energy consumption/emissions policy, planner should consider the following three factors: demand management, traffic management and city access restriction (European Commission Report, 2013). Planers should also consider employing automated systems to eliminate human error and increase efficiency. Smart ticketing will provide fast and easy services, saving time and energy and maintaining a SMART public operation and increased mobility.

References

- Association, E. A. (2006), The home of the aluminium industry in Europe. Retrieved from European Aluminium Association: <http://www.alueurope.eu/> (Accessed 16 February 2014)
- Burchell, Robert W. and David Listokin., (1991), *"Fiscal studies for the Governor's Commission on Growth in the Chesapeake Bay Region"*, Baltimore, MD Maryland Office of Planning
- Cuchí A, Wadel G, Lopez F, Sagrera A. Guía de la (2007), *eficienciaenergética para los administradores de fincas*. 1st ed. Barcelona: Fundación Gas Natural; 2007. pp 10-11
- European Commission Report (2013), *"Mobilizing Intelligent Transport Systems for EU Cities"*, Brussels SWD 527, Available at: [http://ec.europa.eu/transport/themes/urban/doc/ump/swd\(2013\)527-communication.pdf](http://ec.europa.eu/transport/themes/urban/doc/ump/swd(2013)527-communication.pdf) (Accessed 18 February 2014)
- Ignacio, ZabalzaBribian, et al. (2011), "Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluations of the eco-efficiency improvement potential", *Building and Environment*, Volume 46, Issue 5, pages 1133-1140
- Jablonska, B. et al. (2010), "Transition to Sustainable Energy Neutral Districts before 2050: Innovative Concepts and Pilots for the Built Environment", Available at: http://eusmartcities.eu/sites/all/files/docs/bestpractice/Paper%20AES2010_Transition%20to%20Sustainable%20Energy%20Neutral%20Districts%202050a.pdf (Accessed 28 February 2014)
- SolarFirst (2014), "Solar Water Heater Power Air Conditioner with Energy-saving and Eco-friendly", Retrieved from globalsources: <http://solarfirst.manufacturer.globalsources.com> (Accessed 7 March 2014)
- Shanghai Manual – A Guide for Sustainable Urban Development in the 21st Century, Available at: http://www.un.org/esa/dsd/susdevtopics/sdt_pdfs/shanghaimanual/Chapter%206%20-%20Green%20buildings.pdf (Accessed 18 February 2014)

5. Conclusion

Careful consideration to building and community design is essential for Gulf countries to help in transition from a carbon energy based urban foundation to one that incorporates sustainable practices and renewable energy resources. However, it is necessary for this transition to occur if country level goals towards global greenhouse gas emissions are to be achieved. It is by embracing the future and the change it brings, that we will achieve a balance between ourselves, our lifestyles, and our environment. Our planet is in a phase of rapid transition, directly caused by our carelessness. Through the ideas and adaptations presented in this paper, we can ease this evolution with the best possible outcomes. SMART technologies and intelligent systems are one of the key factors for the transitioning of a net neutral community in the UAE and similar countries.

UNEP, United Nations Environment Programme (2008), “The Kyoto Protocol, The Clean Development Mechanism and Building the Construction Sector”, Available at: <http://www.unep.org/sbci/pdfs/BuildingsandCDMreporte-version.pdf> (Accessed 3 March 2014)

UNEPSBCI, United Nations Environment Programme Sustainable Buildings and Climate Initiative (2009), “United Nations Environment Programme Buildings and Climate Change: Summary for Decision Makers”, Available at: <http://www.unep.org/sbci/pdfs/sbci-bccsummary.pdf> (Accessed 28 February 2014)