

APPENDIX E

Case studies

CASE STUDY 1: University Classrooms

CASE STUDY 2: Solar Photovoltaic Power for Public Schools in Lebanon

CASE STUDY 3: Biodiesel in UAE from McDonald's Waste Oil

CASE STUDY 4: Aramex Dubai Logistics City: LEED Gold Certified with Philips Lighting

CASE STUDY 5: Aqaba Residence Energy Efficiency (AREE)

CASE STUDY 6: The Arab Organizations Building in Kuwait

CASE STUDY 7: Central Bank of Lebanon Goes Green

CASE STUDY 8: Dubai Festival City Hotels: Energy Efficient Landmark

CASE STUDY 9: Eco-Friendly Stadiums in Qatar

CASE STUDY 10: Energy-Saving Lamps in Lebanon

CASE STUDY 11: Energy Efficiency Retrofit for a Hospital

Case Study 1

University Classrooms

Large classrooms for computer training at a Lebanese university are equipped with 36 of 4x36 W TFL8 lighting fixtures. Night time illumination levels reached 600 LUX when all lights were ON. IESNA and CIBSE requirements require generally a maximum of 300 LUX for such applications.

One suggested option was to ask the students to energize 4 out of 6 lighting circuits (the 36 fixtures being zoned into 6 circuits). Delamping was also suggested as an alternative. Delamping was adopted because LUX readings have shown that de-energizing 2 tubes from each fixture would result in more uniform lighting levels than switching off two circuits out of 6.

Consequently, two tubes from each other fixture in staggered order were de-energized by disconnecting their ballasts. Readings were now lower than 400 LUX. The annual energy savings from this intervention were estimated at 2400 kWh which translates into 8400 kWh or 0.72 ton of oil-equivalent (TOE) of primary energy based on Lebanon's electric utility conversion efficiency. Avoided CO₂ emissions were 2.4 Tons. The payback period was 1 month.

Case Study 2

Solar Photovoltaic Power for Public Schools in Lebanon

Reliable energy is critical for economic growth, social development, fiscal sustainability, and regional and global integration. Indeed, several studies undertaken by the World Bank in many countries show a very clear correlation between access to energy and gross domestic product (GDP) growth.

Although Lebanon is 100% electrified, most regions of the country, mainly near the borders, suffer from very long electricity black-out periods and have very low voltage levels, which doesn't enable them to use electrical appliances or even enjoy adequate lighting levels.

While generally an inconvenience for everyone, for children these black-outs can have negative effects, particularly on their education. Since public schools cannot afford adequate alternative energy sources, children have no access to sufficient lighting or to reliable power to permit the use of classroom technologies.

With a mandate to deploy sustainable energy projects in Lebanon, the country energy efficiency and renewable energy demonstration project for the recovery of Lebanon (CEDRO), which is managed by the United Nations Development Program (UNDP), initiated in 2010 projects for the installation of solar photovoltaic (PV) systems in 25 public schools and community centers in Akkar, Bekaa, and in the South. Kherbet Selem public school in the south of Lebanon was selected for the pilot project.

The solar PV system is designed to supply power to the school independent of the grid. However, it is connected to the grid to allow the system's batteries to be charged when they are low on stored energy. In the future, a feed-in option will be installed to allow the solar PV system to supply power to the public grid during school days off or when there is power surplus.

The installed solar PV system consists of three mono-crystalline modules and has a capacity of 1800 Watt-peak (W_p). The solar modules comprise of cells that produce electrical direct current (DC) when exposed to sunlight. The electricity produced is stored in batteries and then converted to alternating current (AC) by an inverter. The batteries will supply essential power load to the building in the event of a grid power failure. The amount of power supplied will be sufficient to meet the load requirements of all necessary electrical equipment. In addition, more efficient lighting fixtures have been installed to provide the same required illumination for classrooms and offices, while consuming less energy.

The back-up batteries are required to provide uninterrupted power supply in the case of a grid failure. Therefore, the solar PV system will work as the school's own generator and will supply the essential load. When solar radiation is low, power will be withdrawn from the public grid to charge the batteries. When the school is not occupied, during 3 months of the year, it will be possible for the solar PV system to feed renewable power into the public power grid.

Case Study 3

Biodiesel in UAE from McDonald's waste oil

Neutral Fuels, a company specialized in energy-efficient operational solutions, has begun to produce biodiesel by converting vegetable oil from local McDonald's restaurants in the United Arab Emirates. The biodiesel produced is used to fuel McDonald's logistics trucks, and can be used by any normal diesel engine. The oil received from McDonald's is the waste from food preparation, and therefore reduces carbon emissions by 60 to 80% as compared to traditional diesel fuel.

This biodiesel program is not the first of its kind, as it is already in operation by McDonald's in Germany, the UK, and areas in Brazil and

the US. The process works better in the UAE, though. Robin Mills, a Dubai-based energy analyst, explained in an interview with the BBC that the danger of biodiesel is that there is the possibility of it clogging up, forming a gel and eventually freezing at low temperatures. Of course, low temperatures are not a problem in the UAE, thus eliminating this risk.

One problem the country does face is that the UAE subsidizes the price of fuel at the pump, making it harder for companies like Neutral Fuels to compete and make a profit. Nonetheless, chairman of Neutral Fuels Karl Feilder takes this as an opportunity “to be even more efficient and even more competitive.”

The UAE is the world’s eighth largest oil producer, rendering it quite surprising that the biodiesel project is gaining support. Other restaurant chains are beginning to express an interest in the program as well.

"Nowadays companies are becoming more environmentally conscious and they want to, as much as they can, be environmentally sustainable," says Abdulla Al Jallaf, managing director of Neutral Fuels in Dubai, which became the first commercial producer of 100% biodiesel in the Middle East. The operation has been supported by Dubai Government’s Department of Economic Development (DED). McDonald’s is currently Neutral Fuels’ only client and the project is restricted to the UAE, but there are hopes to expand the project across the wider region.

Case Study 4

Aramex Dubai Logistics City: LEED Gold Certified with Philips Lighting

As a 29-year old global provider of comprehensive logistics and transport solutions in more than 54 countries, Aramex understands the importance of warehousing within the wider supply chain, and the environmental footprint of those facilities. The company is investing in cutting-edge green technology to ensure meeting customers’ storage requirements and inventory management needs with minimal carbon footprint. Dubai Logistics City emerged as one of Aramex’s key facilities to become energy efficient under “A LEED Gold Certified” project, in partnership with Philips.

The challenge was to provide a simple yet smart lighting solution to meet the application requirements, while consuming 40% less energy than stipulated by ASHRAE standards. The project required luminaries-based, stand-alone lighting controls for occupancy detection in the warehouse area and daylight optimization in the offices.

Philips made an intelligent selection and customization of standard luminaries. For the lighting controls, it customized the standard TMX204

luminary with an occupancy sensor in the warehouse area to provide the ideal scenario: light when and where needed. The Smartform TBS460 luminaries in the office spaces have been fitted with Luxsense controllers, which save energy by automatically regulating the luminary in accordance with the level of daylight available. Fugato Compact and Performance downlights with PL-R lamps were used for circulation areas.

Dubai Logistics City project reflects Aramex's continuous commitment to reduce its carbon footprint, optimize power consumption, and raise awareness among other activities in its 307 locations around the globe.

Both Aramex and Philips are AFED corporate members.

Case Study 5

Aqaba Residence Energy Efficiency (AREE)

The initiative to build a pilot scale energy efficient residence in Aqaba aimed to demonstrate the advantages of sustainable building in Jordan. The Aqaba Residence Energy Efficiency (AREE) design was selected to inspire improvements in the environmental performance of buildings. The building design addresses the efficient use of resources in building construction and in water and energy consumption.

AREE is a three-floor, 420 m² building that includes a living room, a kitchen, a study room, a family room, six bedrooms, three bathrooms, a car garage, and a basement.

The summer temperatures in Aqaba rise above 40° C, and with hardly a need for heating during the winter, the design was focused on adopting passive cooling strategies. By design, heat accumulation is prevented in the summer and heat gain is optimized in winter. The architectural concept was formed by sun angle analysis, wind conditions, Red Sea views, and Jordan's common construction practices (plastered block work and stone cladding).

The architectural design is the first step to get to efficient use of energy, water, and materials. The orientation and layout of AREE optimize passive cooling. Spaces that are generally used for short periods (bathrooms, garage, corridors) are located on the southwest side, the hottest side of the house, creating a buffer that helps keep the main spaces cooler. To minimize the internal cooling load, the bedrooms face northeast. The main part of the building is finished in regular plasterwork mixed with straw to decrease heat transfer and reduce the use of cement. The use of plasterwork provides a nice texture that improves with ageing.

Natural ventilation is improved by carefully positioning the windows, doors, and ventilation openings below the ceiling and the main staircase, designed to work as a 'wind tower'. Movable shades prevent solar

warming in the summer time, but allow for solar heat to enter during the winter to minimize the need for heating.

Exterior and interior space is connected by a zone with recessed glass doors for optimal day lighting. This zone, housing the kitchen and dining area, connects both building volumes. The lower volume is clad with recycled stone procured from local stone companies. The roof garden on top of the lower volume contributes also to a lower internal cooling load achieved by the heat accumulation capacity of the 40-cm garden soil. This roof garden provides shading and has a beautiful view of the Red Sea.

The building envelope is the second step for environmental design and passive cooling strategy. Interior spaces are protected from solar heat through the use of improved insulation. The blocks of the cavity walls have a better insulation value because of the volcanic and perlite aggregates. The cavity is filled with insulation material. The most exposed building surface is the roof, and therefore it is also insulated, which is not a common practice in Jordan. Another new practice introduced is the insulation of the 'heat bridges' at the floor-wall connections. The sand filling of the north cavity wall and natural stonewall finishing increase the heat accumulation capacity of the building.

The building design and construction save 30% on the cooling load, compared to a conventional building. To ensure significant savings on electricity bills, efficient lighting systems have been installed as well.

The 'solar cooling' concept is based on hot water from solar panels providing thermal energy to the adsorption chiller, which provides chilled water to cool the interior. This is the first application of solar cooling in Jordan, and therefore there are challenges in achieving optimal performance. The local supplier is working on a second prototype. In the meantime, an imported adsorption chiller has been installed and is currently being tested.

The solar cooling system brings the total potential savings of electricity costs to 72%, compared to a conventional design. Taking in consideration additional investment costs, the expected payback time is less than nine years. To make AREE almost self-sufficient in energy supply, the option of photovoltaic (PV) panels for electricity generation was considered. However, the long payback time of around 14 years rendered this option uneconomical.

Reducing water consumption is essential for Jordan, a country with a very low annual per capita share of freshwater. AREE is the first project in Aqaba equipped with a dual plumbing system, separating grey and black wastewater. The grey water from showers and sinks is filtered by a constructed wetland and used for garden irrigation. Water-efficient plants and trees that are well adapted to Aqaba's climate were selected, minimizing the need for irrigation. Together with water-saving taps, toilets, and showerheads, the total estimated water saving is 51%.

All design and construction elements were easy to plan on the drawing board, but required a lot of discussion with the engineers and contractors on site. The biggest challenge for sustainable building in Jordan is the use of materials and the reduction of construction waste. Environmentally friendly materials are scarce and local suppliers are often unfamiliar with material specifications. Moreover, Jordanian contractors were not familiar with passive cooling strategies. The opportunities for learning have been immense, which bodes well for the dissemination of more sustainable building practices in Jordan.

Case Study 6

The Arab Organizations Building in Kuwait: An Example of Modern Eco-friendly Architecture

Among glass high-rise buildings that have invaded the Gulf countries stands a unique building in Kuwait: the Arab Organizations Headquarters Building, a model of modern environmentally-friendly construction. The building, which is home to the Arab Fund for Social and Economic Development, adapts the traditional Arab house design which is built around a courtyard. Therefore, all the offices in the building overlook the spacious central courtyard which carries nature inside. The splendor of the interior is not reflected on the exterior of the building which is seen from a few kilometers as a massive cube of gray granite covering 54,000m², and dotted with deep slanting openings on all sides.

As you enter the building, which was completed in 1994, you feel like swimming in the light. You do not feel any draft blowing from air conditioners, nor do you feel any disturbing heat. Special insulation and lighting systems have created, inside the building, a temperate and comfortable environment. This eco-friendly building consumes less than half the quantity of energy used in any other glass building of the same size. In addition to having all these environmental qualities, the building is an embodiment of modern architecture with all its advanced technologies.

Upon entering the building, a visitor is overwhelmed by its grandeur, extensive dimensions, and lofty heights. One can sit calmly for hours in the waiting room with nothing to hear but the trickle of water from the fountain and nothing to see but stunning scenes around. Attention is immediately drawn to the left side where there is a great waterfall over a Moroccan, light-colored, hand-made mosaic wall.

On climbing the marble stairs that lead from the Moroccan waiting room to the first floor, one would start to hear a melody coming from above mixing the twittering of birds with the gurgling of water. Once on the first floor, your eyes are caught by extended greenery, bright light and

ample space. This is the building's main courtyard, an architectural feat manifesting both artistry and power.

Walls and partitions on all floors are made of glass, making it possible for anyone standing at one end of the building to look through to the opposite end easily.

A critical design challenge was to exclude excessive exterior heat while retaining natural light. This was achieved after a careful study of the sun's rays that reflect on the building throughout the year. The windows were designed in directions that do not allow direct sunlight into the building, and artificial lighting was made in a way that gives daylight effect without shades. The glass wall of the courtyard is unobstructed from the north to allow light in while blocking direct sun rays.

The concept, design and execution of the Arab Organizations Headquarters Building is a striking proof of the success of employing modern architectural techniques adapted to local environments at an age when imitation and copying prevail.

Case Study 7

Central Bank of Lebanon Goes Green

The Central Bank of Lebanon (BDL) is subsidizing green loans, which consumers can apply for at an affordable interest rate of about 2% over the cost of funds. Managed by commercial banks, the loans were initially meant to support eco-friendly industry and agriculture, but have been extended to support green construction, eco-tourism, and even the renovation of existing facilities to preset environmental standards. To broaden the scope of the initiative, BDL and the United Nations Development Program (UNDP) have agreed to establish the National Energy Efficiency and Renewable Energy Action (NEEREA) to finance energy efficiency, renewable energy, and green building projects across Lebanon.

To facilitate collaboration, BDL and UNDP signed a Memorandum of Understanding (MOU) on June 14, 2010. Using the MOU as a framework for cooperation, DBL and UNDP seek to bring in international donors and organizations to support NEEREA. The two bodies will also organize awareness-raising and capacity-building programs targeting Lebanese commercial banks and consumers to promote energy efficiency and renewable energy projects.

To facilitate loan processing, NEEREA will develop a set of criteria to assess the technical eligibility of green loan applications. These criteria will be used to provide technical validation and certification to potential green projects submitted to BDL through the Lebanese Center for Energy Conservation (LCEC), hosted at the Ministry of Energy and Water.

In parallel, the European Union has signed a €15 million grant contract with BDL and the soft loan program *Kafalat*, geared at providing financing to small and medium size enterprises (SMEs) that want to invest in energy efficiency and renewable energy technologies.

NEEREA is expected to leverage investments in the range of US\$500 million in the coming few years in order to finance projects with interest rates as low as 0% and repayment periods reaching 14 years, with variable grace periods.

Case Study 8

Dubai Festival City Hotels: Energy Efficient Landmark

InterContinental & Crowne Plaza hotels in Dubai Festival City comprise 814 rooms, with over 2 kilometers of static external façade lights and more than 35,000 indoor light points. The existing lighting installation was inefficient, causing high maintenance costs, high rates of heat release from lit lamps, and high energy consumption.

To identify opportunities for switching to energy saving solutions, Philips performed a lighting audit at the premises. The audit results have revealed that the old installation could be replaced with a more efficient lighting system that would ensure long term safety, while preserving the ambience of the rooms and corridors by using the appropriate lamp for the right application.

For interior lighting, a direct replacement with light-emitted diode (LED), CFL-I, and energy saving halogen lamps was offered based on the application requirements and location (burning hours, light levels, and dimming needs). This solution has reduced heat generation, which in turn reduced the cooling load, and has improved the quality of light especially in the corridors. Maintenance costs have become minimal due to the long lifetime of the new lighting installation, particularly the LED technology.

Likewise, a feasibility study of outdoor lighting demonstrated that maintenance-free LED I-Color Accent is the perfect alternative to the cold-cathode tubes. Flexibility of control, provided via an easy plug & play system, allows playing any color-changing effect in line with the type of event taking place on the premises.

InterContinental and Crowne Plaza in Dubai Festival City are setting the benchmark for one of the region's best practices in green technology. Aiming to reduce their carbon footprint, the hotels are expected to cut down their CO₂ emission by almost 2 million kg/year and achieve an 80% reduction in the energy costs incurred by lighting.

Case Study 9

Eco-Friendly Stadiums in Qatar

Qatar won its bid to host the 2022 World Cup Finals, but will players and spectators be able to endure the scorching Doha summer? And who will later, in this tiny country, make use of stadiums built to accommodate tens of thousands of spectators? And what will the magnitude of this tournament's ecological footprint be? Qatar pledged to have a carbon-free tournament but the question is whether it will be able to fulfill its promise.

Qatar undertook to use and develop eco-friendly technologies that could later be adopted by other countries. After the end of the finals, the stadiums will be contracted by dismantling some parts and shipping them to, and reassembling them in, other Asian countries. This will help keep the spirit of Qatar 2022 alive across the continent. Visitors from all over the world will enjoy Arabian hospitality and leave Qatar with a new understanding of the region.

The main challenge facing the organizers is to overcome the extreme desert heat in summer when the finals are taking place. Providing a comfortable environment inside the stadiums requires too much energy, especially for cooling. Two solar energy technologies shall be applied simultaneously to guarantee a convenient and carbon-neutral environment for all players, fans, administrators, and the media. The first technology is the photovoltaic system that converts sunlight into electricity. The second is the solar thermal system that uses heat captured from the sunrays. The system's collectors transmit and store energy to be used on the days of the matches to cool the water which, in turn, cools the air down to 27° C. Cold air shall be carried, through tubes, to the ground of playing fields and under seats to cool players and watchers alike. Though these two systems are not new, it is the first time they are used in combination with each other.

The roofs of the stadiums shall be retractable to comply with the FIFA regulations which might require matches to be played in open air. Roofs shall be closed during the days before the matches to keep the temperature in the stadiums at 27° C. When there are no matches in the stadiums, the solar equipment shall transmit electricity to Qatar's main grid, and receive its power from the same grid during matches, making the stadiums carbon neutral.

These cooling technologies shall be made available to other countries that have hot weather, so that they may also host major sports events.

Engineers at Qatar University's Mechanical and Industrial Engineering Department produced a design for an artificial cloud that is remotely controlled, so that its location may be changed depending on the position of the sun. Such a cloud shall hover above the stadium and overshadow

all fans sitting to watch the game. The cloud consists of a mixture of light carbon and helium, and the solar energy will keep it floating in the air.

Qatar's pledge to adopt the green building standard was part of its national 2020 vision, and not solely to support its World Cup bid. If the Green Building Council and construction companies succeed in implementing environmental principles during the next few years, Qatar might witness, by 2022, the development of highly-advanced building technologies. Yet the great challenge will be to shift these technologies from sports spectacles to everyday life.

Case Study 10

Energy-Saving Lamps in Lebanon

On March 10, 2010, the Government of Lebanon approved the national action plan submitted by the Ministry of Energy and Water (MEW) to allocate US\$9 million to finance energy conservation programs in the country. The allocation was diverted from a budget initially assigned to subsidize diesel fuel. One of the main goals of the plan is to replace, free of charge, 3 million incandescent lamps, with 3 million compact fluorescent lamps (CFL) in households across Lebanon, at a cost of US\$7 million.

CFL lamps have been demonstrated to have lower power consumption than incandescent lamps while costing less over their lifetime. They also provide effective illumination. The replacement program will be part of an effort to phase out incandescent lamps. One million residential electricity subscribers, out of a total of 1.4 million, will benefit from this plan and will take part in this first-of-its-kind Clean Development Mechanism (CDM) project. The initiative is accompanied by an awareness campaign urging the public to adopt energy conservation measures.

The project is rolled out as per the Clean Development Mechanism (CDM) procedures in order to claim CO₂ reduction credits. The savings according to CDM calculations are 970 GWh of electricity, equivalent to US\$181 million. CO₂ emissions will be reduced by 806,000 tons. In addition, the project will reduce the load demand by 160 MW of capacity at peak load. The reduction in peak load demand translates into crucial savings for the government's public budget. The public will benefit from reduced air pollution emissions as well as from lower energy bills.

Distribution of the CFLs has already started in October 2010, and will be completed in 6 phases. Public stakeholder consultation meetings have been conducted in each area of the country while simultaneously conducting an awareness campaign. The lamps are being distributed across Lebanon through municipalities and in collaboration with collectors of electricity bills at Electricité du Liban (EDL).

Case Study 11

Energy Efficiency Retrofit for a Hospital

The Centre Hospitalier du Nord (CHN) is a private hospital with 140 beds, located in Zgharta, North Lebanon. Due to frequent power cuts, 75% of the hospital's electrical energy demand has to be produced by generators. The total energy bill was over €270,000 in 2006. The CHN decided to conduct an energy audit that resulted in the following recommendations:

- Improved maintenance of air-conditioning (AC) equipment.
- Energy efficient lighting.
- Thermal insulation of the roof.
- Demand management system (software for peak shaving and control/monitoring).

After implementing the above measures in 2007, the hospital now saves 20% of its overall energy consumption. This corresponds to an annual saving of €55,000 of energy costs and a yearly reduction of 410 tons of CO₂ emissions. The needed investment did not exceed €60,000. The payback time being estimated at slightly above one year, the used technologies are replicable in most hospitals and similar buildings in Lebanon and in other countries in the region, even without any external financial assistance. CHN has already decided to use the positive experiences of this pilot project for a new hospital building in Jounieh, a coastal city north of Beirut.

Energy in Lebanon

Lebanon is extremely dependent on energy imports— about 97% of all energy had to be imported in 2005. Buildings are the second biggest energy consumers with a share of about 30%, with transport coming in first place and industry in third place. With the sharp increase in world market prices for energy, and with energy prices subsidized in Lebanon, the national electricity company **Électricité Du Liban** (EDL) alone absorbed 21% of the state budget in January 2008 (L'Orient Le Jour, 11/03/08). Moreover, people suffer from frequent power cuts due to insufficient and obsolete power plants and distribution lines and have to bear significant additional costs for private generators.

At the same time, a large potential for energy efficiency and for the use of renewable energies stays untapped in Lebanon. The building stock and particularly new buildings usually do not integrate technologies such as thermal insulation of the building envelope, energy efficient lighting, or solar water heaters. The project in Lebanon shows that with additional investments of 10-20%, energy consumption can be reduced dramatically by up to 60%.