Design procedures for an average Saudi villa using integrated green building techniques

A. H. Besheer[1] & W. El-Hamidi[2]
[1]*Electrical Engineering Department, University of Tabuk, KSA*
[2]*Civil Engineering Department, University of Tabuk, KSA*

Abstract

Sustainable design or building "green" is an opportunity to use our resources efficiently while creating healthier buildings. This paper discuss general and initial design procedures and measures for designing a moderate sized residential Saudi villa using integrated green building concepts and strategies. Design factors such as orientation, house form, windows shape, as well as utilization of passive solar features, high levels of efficient insulation and taking advantage of natural cooling/heating and ventilation will be considered. Technological features will include applying alternative energy sources such as solar power, reducing water use, and using high-efficiency lighting and appliances to minimize electricity use. This work targets to integrate all design aspects (electrical – mechanical – architectural) in such a way that achieves at least a 50% reduction of common single family Saudi villa energy consumption working under Saudi environmental and climatic conditions.
Keywords: zero energy home, green building, renewable energy systems.

1 Introduction

According to [1], electrical power demand in Saudi Arabia is expected to grow higher to reach about double its current size over the coming 15 years. Saudi Arabia is expected to invest over SR 330 billion in new projects in the power sector between now and 2020. This will be spent on numerous areas of energy generation for example, increasing the Kingdom's electricity generation capacity to 80GW in order to meet future needs. Rapid economic and population growth, coupled with expanding industrialization and urbanization across Saudi Arabia, is fuelling this demand for power and putting considerable stress on existing

WIT Transactions on Ecology and The Environment, Vol 165, © 2012 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/ARC120041

energy systems. The rapidly growing world energy use has already raised concerns over supply difficulties, exhaustion of energy resources and heavy environmental impacts (ozone layer depletion, global warming, climate change, etc.). The global contribution from buildings towards energy consumption, both residential and commercial, has steadily increased reaching figures between 20% and 40% in developed countries, and has exceeded the other major sectors: industrial and transportation [2]. Growth in population, increasing demand for building services and comfort levels, together with the rise in time spent inside buildings, assure the upward trend in energy demand will continue in the future [3]. In Canada, Mexico, and the United States, commercial and residential building operations account for about 20, 30, and 40 percent of the primary energy consumption, respectively. They typically also account for 20 to 25 percent of the landfill waste and 5 to 12 percent of the water consumption. Figure 1 shows the world wide different sectors share for energy consumption. Emissions from the building sector are predominantly a function of energy consumption for diverse purposes that can be organized into three broad categories: public electricity use, direct fuel combustion, and district heating. The buildings sector – encompasses both residential and commercial (including institutional) buildings – accounts for 15.3 percent of global GHG emissions, including 9.9 percent for commercial buildings and 5.4 percent for residential; CO_2 accounts for nearly all emissions (Figure 2).

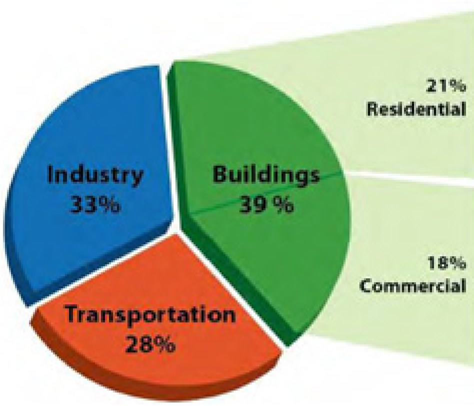


Figure 1: Worldwide sectors share for energy consumption.

Green building refers to the use of environmentally preferable practices and materials in the design, location, construction, operation and disposal of buildings. It applies to both renovation and retrofitting of existing buildings and construction of new buildings, whether residential or commercial public or private. Substantial research supports the health and productivity benefits of green features, such as day lighting, increased natural air ventilation and moisture reduction, and the use of low-emitting floor carpets, glues, paints and

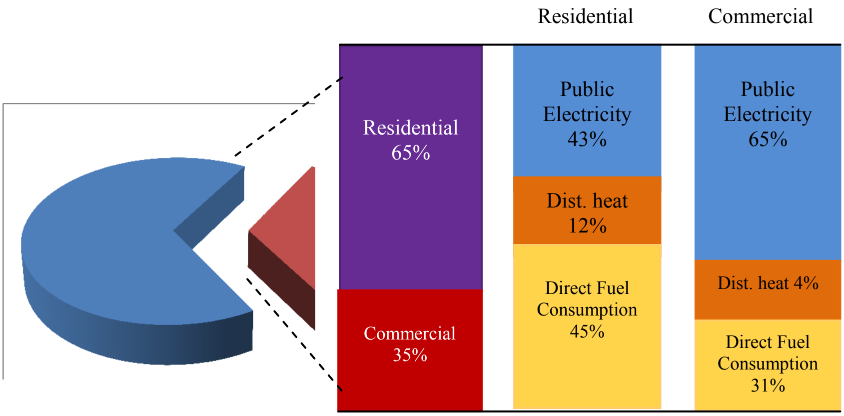


Figure 2: CO_2 from building use. (Source: US DOE, Building Energy Data book.)

other interior finishes and furnishings. The United States Green Building Council estimates that green building, on average, currently reduces energy use by 30 percent, carbon emissions by 35 percent, water use by 30 to 50 percent, and generates waste cost savings of 50 to 90 percent [2].

Zero Energy Homes (ZEH) are technically feasible today. If cost trends continue and research milestones are accomplished in solar energy and efficiency technologies, ZEH will eventually become economically competitive with conventional construction. Market penetration of highly efficient homes with renewable (for example solar) energy systems has already begun, and will continue in selected markets. Solar electric (photovoltaic) system costs have continued to decline while production continues to increase by nearly 30 percent annually. New, low-cost solar water heating designs are under development that will reduce costs and improve efficiency. At the same time, a portfolio of energy-efficiency improvements in appliances, building envelopes, windows, and mechanical systems is moving into the market. Combined, all of these elements suggest a potential to build practical ZEH with a significant market potential [4].

In Saudi Arabia, as a result of increased urbanization and rapid population growth, not only is the residential sector booming, but it also constitutes more than half of the country's energy demand [5]. In addition, despite the abundant availability of renewable energy sources, the use of sustainable energy technologies, such as solar photovoltaics (PV), is exceptionally rare in oil-rich Saudi Arabia [6, 7]. Hence, one of the key needs of the Kingdom is the need to create more energy efficient buildings within Saudi Arabia. The Kingdom is undergoing huge development and if buildings that are put up are zero carbon or more efficient than old structures, the country will take a huge step towards reducing the rapid escalation of its energy consumption. Figure 3 depicts the electrical energy consumption for different sector in Saudi Arabia.

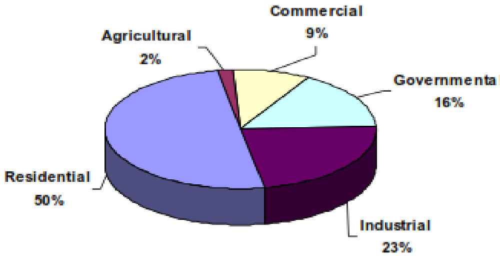


Figure 3: Electrical energy consumption in KSA.

Although some initiatives have recently taken by Saudi government in the field of energy efficiency and rationalization, wastewater treatment and awareness of the problem of water scarcity, the need for a collective and integrated policy to move towards the sustainable housing and building in the country is still highly desired. In this paper measures – that revolve around four elements of nature (Site, Water, Energy and Materials) – to achieve zero energy building using environment friendly green techniques are addressed and discussed. It is aimed at defining initial and tentative guidelines for the designer of a common type of Saudi residential villa that is more adapted with Saudi environment and culture.

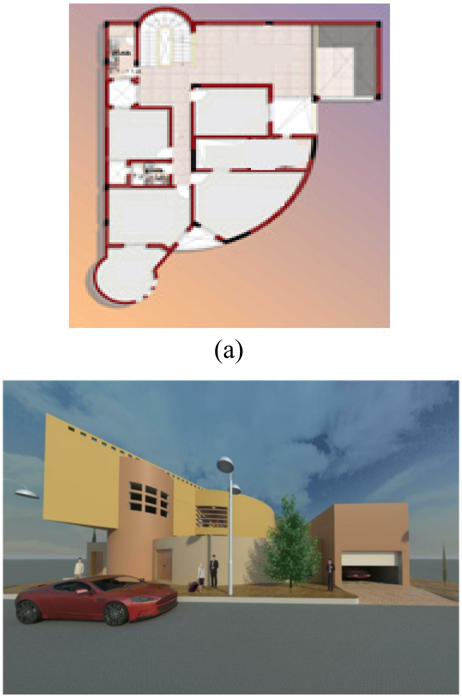
2 The prospective test villa case study

The selected residential test villa is situated in Tabuk area – which is recently witnessed rapidly growing residential and commercial activities – located near the Red Sea (coordinates are 28° 23' North, 36° 35' East). Figure 4 shows Location of Tabuk. Meteorological data in table 1 indicates that exploitation of solar energy is economical in Tabuk area.

Figure 4: Location of Tabuk (source: Google Earth).

Table 1: Solar energy and surface meteorology [8].

Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Insolation, kWh/m²/day	3.34	4.33	5.38	6.41	6.81	7.52	7.35	6.88	6.02	4.75	3.61	3.06
Hours of sunshine, hrs	10.5	11.45	11.96	12.5	13.3	13.7	13.2	12.5	12	11.49	10.9	10.4
Clearness, 0–1	0.54	0.59	0.60	0.63	0.62	0.67	0.66	0.65	0.64	0.60	0.56	0.53
Temperature, °C	8.25	10.06	14.13	19.84	24.61	27.30	28.97	29.53	27.47	22.50	15.66	10.23
Wind speed, m/s	4.71	4.71	5.17	4.99	4.95	4.96	4.62	4.59	4.59	4.75	4.60	4.45
Precipitation, mm	10	3	7	3	3	0	0	1	0	6	13	6
Wet days, d	0.6	1.0	0.7	0.5	0.7	0.1	0.0	0.1	0.0	0.7	0.5	0.8



(a)

(b)

Figure 5: Drawings of the case study residential test villa: (a) floor plan and (b) elevation.

WIT Transactions on Ecology and The Environment, Vol 165, © 2012 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)

The test villa building comprises of two floors, with a built floor area of 150 m^2 and a total land area of 300 m^2. Figure 5 illustrates the floor plans and elevations of the case study. The prospective test villa case study will incorporate many measures designed to make it more efficient. This includes a reflective roof system, advanced windows, an interior duct system, wider overhangs, more efficient lighting, a high efficiency air conditioning system and propane used for major appliances which commonly use resistance electricity (range, dryer and heat). For comparison, a control house with an identical floor plan and located on the same geographical area and working under the same climatic conditions but without the efficiency features will be constructed.

3 Measures for achieving green design for Saudi villa

ZEH is the term used for a home that optimally combines commercially available renewable energy technology with the state of the art energy efficiency construction techniques. In a ZEH no fossil fuels are consumed and its annual electricity consumption equals annual electricity production [9]. A number of zero energy homes and buildings have been built, tested and reported throughout the world [10–12]. In almost all of such demonstrations the renewable energy sources consist of photovoltaic cells, solar water heaters, and geothermal heat pumps. In [9], a hybrid energy system consisting of photovoltaic, wind turbine and micro-hydro is suggested as another possibility. In the following sections, various measures and procedures for designing green single family Saudi villa are put forward. To the author best of knowledge, this villa is the first implemented Saudi building that will be built taking into account the recent green building techniques. Hence, the aim is to develop tentative measures for achieving such sustainable building that can be used and followed through the different designing and implementation phases for this villa.

3.1 Measures for energy production

In this study, due to the abundant solar energy in Tabuk region, the source of electricity in the intended single family Saudi residential villa will be photovoltaic system which produces electricity from solar energy as depicted in Figure 6. The Direct Current (DC) electrical output from a PV system is converted to Alternating Current (AC) power by an inverter. The AC power can be used in the home or fed back into the power grid. In the simplest system, power sent into the utility grid causes the home's electric meter to operate in reverse. In a ZEH, the power taken from the utility is designed to be equal to the power sent back by the PV system annually.

The major solar system components that will be used in this project are solar charge controller, inverter, battery bank, auxiliary energy sources and loads appliances.

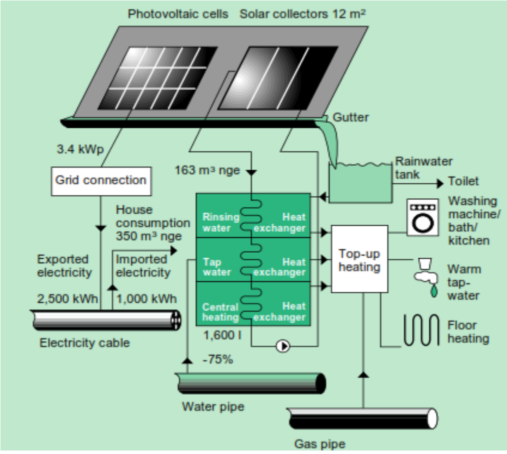


Figure 6: Schematic of the photovoltaic and solar heating systems.

PV module: converts sunlight into DC electricity. **Solar charge controller**: regulates the voltage and current coming from the PV panels going to battery and prevents battery overcharging and prolongs the battery life.
Inverter: converts DC output of PV panels or wind turbine into a clean AC current for AC appliances or fed back into grid line.
Battery: stores energy for supplying to electrical appliances when there is a demand.
Load: are electrical appliances that connected to solar PV system such as lights, radio, TV, computer, refrigerator, etc.
Auxiliary energy source: is diesel generator or other renewable energy sources.
The sizing of PV system components in this project will be split into four tasks. These tasks will be performed via gathering and calculating the appropriate data and information for the following design issues:

- **The PV modules sizing, where it includes:**
  - Calculate total Watt-hours per day for each appliance used.
  - Calculate total Watt-hours per day needed from the PV modules.
  - Calculate the total Watt-peak rating needed for PV modules.
  - Calculate the number of PV panels for the system.
- **Inverter sizing**
  - The inverter size should be 25-30% bigger than total Watts of appliances.
  - In case of appliance type is motor or compressor then inverter size should be minimum 3 times the capacity of those appliances and must be added to the inverter capacity to handle surge current during starting.
- **Battery sizing**
  - The battery type recommended for using in solar PV system is deep cycle battery. Deep cycle battery is specifically designed for to be

discharged to low energy level and rapid recharged or cycle charged and discharged day after day for years.

- The battery should be large enough to store sufficient energy to operate the appliances at night and cloudy days. To find out the size of battery, calculate as follows:

$$\text{Battery Capacity (Ah)} = \frac{\text{Total Watt} - \text{hours per day used by appliances} \times \text{Days of autonomy}}{0.85 \text{ x } 0.6 \text{ x nominal battery voltage}}$$

where “Days of autonomy” is the number of days that you need the system to operate when there is no power produced by PV panels.

- **Solar charge controller sizing**

According to standard practice, the sizing of solar charge controller is:
Solar charge controller rating = Total short circuit current of PV array x 1.3

$$\text{Solar charge controller rating} = I_{sc} \times 1.3$$

where I_{sc} is the total short circuit current of PV array.

3.2 Measures for energy efficiency

Improving energy efficiency is the most effective option to mitigate GHG emissions in the building sector. Energy efficiency is part of a larger set of requirements which ZEBs should fulfill prior to offsetting their energy consumption from on-site renewable energy production. By adopting such requirement the low-quality ZEBs with high energy use and oversized on-site energy producing systems will be eliminated. For example, lighting electric load was reduced by almost 80% in [13] by using of 15 W compact fluorescent light (CFL) instead of 75W R-lamp incandescent bulb. The average life time for this type of bulb is 10,000 hours of use rather than 2,000 for a standard incandescent lamp. Some of the essential measures for energy efficiency for the prospective single Saudi family villa are as follows:

- Replace regular incandescent light bulb with a compact fluorescent light bulb. This kind of bulb uses 60% less energy than a regular bulb.
- Choose the most energy efficient appliances when making new purchase.
- Don’t leave appliances on standby mode to avoid energy loss.

Solar energy can also be harnessed for space and water heating. The most common system is a solar domestic water heater. Components of a typical solar water heating system include a rooftop solar collector, depicted in Figure 6, and a hot water storage tank. Water that runs through the roof-mounted solar collector is heated by the sun and stored in a hot water storage tank. Back-up electric or gas water heating is usually provided for periods when hot water demand exceeds system output, such as during long periods of cloudy weather.

3.3 Measures for water consumption rationalization

In [7], the estimated water consumption rate of 498 LCD represented an average Saudi household water consumption rate. This figure reflects the high consumption rate of the water if it is compared to the European average of 200 LCD. To reduce such high domestic water consumption, some measures and modifications were mentioned in literature [7] and are listed here as follows:

- Use of low-flow tap aerators in the kitchen (9 Litres/min), bathroom (6 Litres/min) and showerheads (9 Litres/min)
- Use of Dual-flush (6/4 Litres) cisterns
- Use of Efficient washing machines (49 Litres/min)
- Use of grey-water system, which collects 90% of the bath and shower waste in order to supply toilet cisterns

There is a range of other ways to further reduce water consumption, some of which require a sensible use of water. Examples of sensible behavioural changes include reducing shower times and turning off the taps when brushing teeth or shaving. Moreover, instead of using a running hose to wash a car, a trigger hose or even a bucket with a sponge should be used.

3.4 Measures for sustainable buildings architecture

A well-insulated thermal envelope without thermal bridges is a passive way to obtain a low heat/cool demand and improved thermal comfort. There are two key ways to a well-insulated building shell; high levels of insulation with minimum thermal bridges and airtight constructions. Typical insulation materials exists, including aerated concrete, light clinker, cell glass, expanded polystyrene (EPS), extruded poly-styrene (XPS), polyurethane, perlite, cellulose fibres, fibre boards, woodcrete and mineral wool. A study commissioned by the European Insulation Manufacturers Association, [14] reveals that by applying a good level of thermal insulation to the buildings in Europe, the target of the Kyoto Protocol could be easily achieved.

3.5 Building insulation

Building insulation is one of the components towards an energy efficient building envelope. It serves as the outer shell to protect the indoor environment as well as to facilitate its climate control. Effective residential building insulation reduces heat ingress into the building thereby lowering power consumption for air conditioning dramatically for the consumer. In harsh, dry desert with great temperature extremes like Saudi Arabia, more than 80% of the total heat gain is due to direct solar radiation and the rest is due to temperature difference between the exteriors and interiors. Thus to reduce the overall Relative Heat Gain (RHG), it becomes necessary to curtail the incoming solar radiation. This is typically achieved by the use of opaque insulation for walls and roofs and the use of solar control glass with high performance solar coatings. In a building it is estimated that 20% of the solar heat gain comes through the roof and 15% through the walls, and the remaining from the windows, doors, occupants, ground and other heat sources like appliances, etc. Through calculations it can be established that heat gain from a roof alone reduces by almost 87% through application of a good insulation material such as 50mm Extruded Polystyrene (XPS) thermal insulation. It is possible to reduce heat gain by 70% by proper use of insulation in the building envelope thereby reducing power consumption required to cool the interiors. It is estimated that with a 70% reduction of heat load, the savings accrued through reduced electricity costs are quite dramatic. As mitigation measures, Air conditioning and building insulation are areas where maximum reduction in greenhouse gases can be achieved in the building sector at low costs. Figure 7 depicts building insulation for the roof and wall that may be used in the prospective case study Saudi villa. The gain from using proper building insulation materials can be summarized as follows:

- Lower energy consumption for cooling and heating resulting in energy savings.
- Lower HVAC equipment sizing resulting in capital costs savings.
- Enhances indoor temperature and air quality thereby resulting in better health and productivity for the occupants.
- Enhances building marketability to the owners.

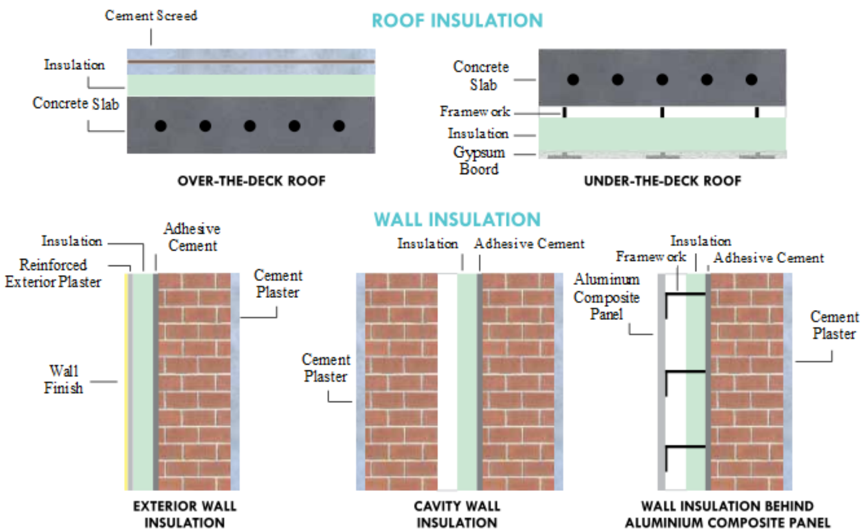


Figure 7: Recommended building insulation for the roof and wall.

3.6 Green materials

The choice of materials and products used in a building play an important role in the “Greenness” of a project and has a major role in energy savings, indoor environment and can reduce the environmental impact of building construction. The construction industry has developed materials which are stronger and many times lighter compared to traditional used materials, whereby reducing the quantity of material used. Recently, number of companies is using nanotechnology to add special characteristics to product surfaces, which can be anything from stain-resistance and color durability to self-cleaning, improved hardness and scratch-resistance, corrosion and UV resistance, and improved thermal performance. Two nano-particles that stand out in their application to construction materials are titanium dioxide (TiO_2) and carbon nanotubes. The former is being used for its ability to break down dirt or pollution and then allow it to be washed off by rain water on everything from concrete to glass and the latter is being used to strengthen and monitor concrete. Coatings made from nano-particles can be unusually tough or slippery, or exhibit unusual properties, such as changing color when current is applied or cleaning themselves when it rains. Hybrid Materials with desired properties and products like Nano Solar Paints provide unimaginable benefits [15].

Hence, when choosing a building material, the following measures and guidelines should be followed:

- Design for long life and adaptability, using durable low maintenance materials.
- Ensure materials can be easily separated.
- Avoid building a bigger house than you need. This will save materials.
- Modify or refurbish instead of demolishing.
- Ensure materials from demolition of existing buildings and construction wastes are re-used or recycled.
- Use locally sourced materials when possible (including materials salvaged on site) to reduce transport.
- Select low embodied energy materials (which may include materials with a high recycled content) preferably based on supplier-specific data;
- Avoid wasteful material use.
- Specify standard sizes; don’t use energy-intensive materials as fillers.
- Some very energy intensive finishes such as paints, often have high wastage levels.
- Use efficient building envelope design and fittings to minimize materials (e.g. an energy-efficient building envelope can downsize or eliminate the need for heaters and coolers, water-efficient taps allow downsizing of water pipes, etc).

3.6.1 Windows design

Windows are still the least insulating part of the thermal envelope with a heat loss coefficient that is typically 4 to 10 times higher than the one of other thermal envelope elements. At one time this lead to the use of very small window areas at the expense of the daylight level, but concurrently with development of improved insulating glazing, the size of typical window areas has again increased. Windows are built up of a number of components (glass, gas filling, spacer, frame) that can be combined so that in each case the window meets the requirements for insulation properties, daylight conditions, solar shading, noise reduction, etc. Most glazing choices involve a trade-off between the requirements for air conditioning, space heating and electric lighting. For instance, clear glass lets in lots of visible light and solar heat, thus reducing the need for heating and electric lighting, although it increases the need for cooling relative to reflective glass. Chromogenic glazing has the potential to improve performance in both parameters [14].

In Saudi Arabia climate, building windows may consider as an effective source of heating and cooling loads. Generally, a low Solar Heat Gain Coefficient (SHGC) is needed to keep out the sun's heat and a low conductance or U-value (Btu/hr ft^2 – °F) is important to reduce the design cooling load.

The most common windows used in Saudi homes do not meet these needs well. Typically, windows are single pane clear glass with aluminum frames (SHGC = 0.875, U = 1.1). For the prospective residential Saudi villa, a spectrally selective glazing will be chosen. This refers to a window unit which transmits much of light in the visible portion of the solar spectrum, but limits transmission in the infrared and ultraviolet portions. Sungate 1000 is a low-E glass product with Argon gas fill. The product has a SHGC of only 0.38, but with a daylight transmittance of 73%. The center-of-glass U-value is 0.24 Btu/hr ft^2 – °F; we reduced heat transmission through the window frame by specifying white thermally broken vinyl frames (overall U-value= 0.35). The improved glass had a major impact on air conditioning sizing [13]. Related to how the building envelope is designed, is also how the building is placed in the local context, following measures should be adopted:

- A building should always be designed with attention to passive solar issues, such as orientation and sitting, glazing size and location, natural ventilation, as well as shading strategies.
- Positioning of windows should be in strategic locations so as to capture sunrays, but avoid glaring, and also to capture air while ensuring the building's structural stability.
- The builder should also consider the use of energy efficient materials, such as high-efficiency windows, insulation, bricks, concrete, masonry, as well as interior finishing products.

3.7 Site and energy chain planning

It is not only the building itself that has an influence on the energy efficiency. The location and the context into which it is placed, and how the surroundings are planned, also play important roles. The building design and the construction techniques have to be in accordance with the local environmental conditions. This means paying attention, among others, to the local climate, prevalent winds and urban fabric, so that individual buildings will be able to fit well (individually as well as collectively) within the spatial structure of the place and be less resource intensive by exploring issues such as natural daylight and passive cooling/heating, according to the local requirements [14]. Individual buildings may also contribute to enhance urban green areas, not only on the surface, such as on the roofs and ground, but also vertically on the envelope. There are now interesting examples of buildings that have developed vertical gardens, which not only contribute to balancing energy use in their interiors by minimizing cooling loads, but which also help to reduce pollution and urban warming. Vertical gardens can also help in carbon sequestration processes. In summary, in order to minimize the environmental impact, the following measures should be taken into consideration:

- A residential or commercial district should consume as little energy and produce as little waste as possible.
- This can be achieved by placing buildings close to each other,
- Taking advantage of existing infrastructure,
- Ensuring a functional public transportation system right from the beginning
- Having a system for the sorting of waste that is easy for the end-user.
- Locally available renewable energy sources should be utilized and the whole energy chain should be taken into account already in the planning phase.

4 Conclusion

This paper presents a tentative road map for any sustainable building design in the form of single family residential villa by integrating different green building techniques and measures. The main contribution of this paper is two folded. It is considered as a comprehensive design plan that will be followed by the engineering design office in charge of constructing the prospective case study residential Saudi villa in Tabuk area. From the other hand it offers a general guidelines and procedures that should be taken into consideration by any other designer of sustainable building. It involves the investigation of alternative building designs that utilize appropriate design and technological innovations to reduce its energy consumption and impact on the environment. The paper puts forward the essential measures of various design aspects for green Saudi villa working in Tabuk area. In conclusion, it is recommended for any green building to have the following features [15]:

- Building constructed with Fly Ash based cement RMC and Autoclave Aerated Concrete (AAC) Blocks.
- Double glazed windows with low-e coating.
- Rain water harvesting
- Adequate design air- conditioning system.
- Solar thermal water heating system for hot water generation.
- Use of day lighting resulting in reduction of life cycle cost on energy front.
- Energy efficient lighting (lamps with electronic ballast, high efficient luminarie).
- Water saving techniques and water efficient landscaping.
- Sewage treatment plant and waste water recycling.
- Smart, rapidly renewable and certified materials.
- Eco friendly house keeping chemicals and practices.
- Carbon dioxide monitoring

References

[1] Ramzy R. Obaid and Anwar H. Mufti, Present State, Challenges, and Future of Power Generation in Saudi Arabia. Proc. of IEEE Energy 2030 Conf. Atlanta, GA USA, 17-18 November, 2008.

[2] Green building in North America opportunities and challenges, the Secretariat of the Commission for Environmental Cooperation (CEC), 2008 ISBN 2-923358-47-3.

[3] Luis Perez-Lombard, José Ortiz and Christine Pout, "A review on buildings energy consumption information", Elsevier Energy and Buildings Vol.40, 2008, pp. 394–398.

[4] "The potential impact of zero energy home", NAHB Research Center, Inc. Report No. EG5049_020606_01.

[5] Al-Shehri, Abdullah (2008) "Electricity Industry in Saudi Arabia: An Overview", In Saudi Water and Power Forum, Jeddah, 1-4 November 2008.

[6] Al-Saleh, Yasser, Paul Upham and Malik, Khaleel (2008) "Renewable Energy Scenarios for the Kingdom of Saudi Arabia". Tyndall Centre for Climate Change Research, Working Paper 125. Available from: http://www.tyndall.ac.uk/publications/working_papers/twp125.pdf

[7] Taleb Hanan and Pitts Adrian (2009) "The Potential to Exploit Use of Building-integrated Photovoltaics in Countries of the Gulf Cooperation Council", Renewable Energy. Vol. 34, No.4, pp. 1092-1099.

[8] http://www.gaisma.com/en/location/tabuk-sa.html

[9] M. T. Iqbal, "A feasibility study of a zero energy home in Newfoundland", Elsevier Renewable Energy 29 (2004) 277–289.

[10] Parker DS, Dunlop JP, Barkaszi SF, Sherwin JR, Anello MT, Sonne JK. Towards zero energy demand: evaluation of super efficient building technology with photovoltaic power for new residential housing. In: Proceedings ACEEE Summer Study on Energy Efficiency in Buildings, vol 1; 2000, pp. 1207–23.

[11] Reijenga TH. Energy efficient and zero-energy building in the Netherlands. In: International Workshop on Energy Efficiency in Buildings in China for the 21st Century, CBEEA, Beijing; December 2000.

[12] Gilijamse W. Zero-energy houses in the Netherlands. In: Proceedings of Building Simulation '95. Madison, Wisconsin, USA, August 14–16; 1995, pp. 276–83.

[13] Danny S. Parker, James P. Dunlop, Stephen F. Barkaszi, John R. Sherwin, Michael T. Anello, and Jeffrey K. Sonne, "Towards Zero Energy Demand: Evaluation of Super Efficient Building Technology with Photovoltaic Power for New Residential Housing" http://cgec.ucdavis.edu/ACEEE/2000/PDFS/PANEL01/228.pdf

[14] "Buildings and Climate Change: Status, Challenges and Opportunities", United Nations Environment Programme, 2007.

[15] "Volume 7", www.inspiredgreen.in