Comparative Analysis for Selecting a Renewable and Environmentally Healthy Energy Source for use in Buildings in the Arabian Peninsula, Especially Saudi Arabia

Dr. Ayman Mohammad Alkhatib
King Saud University

Abstract

There have been significant advances recently in developing renewable energy technologies. Most of these technologies focus on a centralized power generation solution. In this paper, we will review these resources-- Solar Power, Wind Power, Geothermal, Biofuel, Biomass, Hydro Power, Tidal Power, and Wave Power. We maintain that a distributed solution (multiple power generation localities) using Solar Panels for use in building is the most attractive solution for the Arabian Peninsula. This distributed model is not intended to be a replacement for fossil fuel or natural gas rather than an attempt to engage in exploiting an environmentally friendly, abundantly available energy resource in a way to supplement the ever increasing demand for energy and energy resources.

1.Introduction

Over the past decade, the ever increasing carbon emission, due to increasing energy demands, has been gaining a lot of attention worldwide in view of the projected need of fusel fuel. One way to positively impact the global environment is in utilizing renewable energy sources in buildings. In this paper, we shall:

1.Summarize the renewable resources currently used worldwide.

2.Discuss challenges of renewable resources.

3.Present the centralized power generation model vs distributed model for buildings.

4.Consider the geographical and local recourses available in the region.

5.Recommend solar panels for future use as appropriate renewable energy in buildings.

6.The recommended solar panel technology is based on a hybrid distributed and centralized models.

7.Propose the need of future research in building architecture and structural design in buildings to integrate the use of Solar Panels.

1.1 Solar Power

Solar power is by far the most available renewable energy source in the middle-east. It is capable of providing current energy demand. However, it is in the growing stages in terms of energy storage, power transmission, and on demand supply. Yet, it lends itself to be the best choice for current planning and future implementation.

1.2 Geothermal

Geothermal energy is extracted from heat stored in the earth. It has been used for space heating and bathing since ancient roman times, but it is now better known for generating electricity. Although it is cost effective, reliable, and environmentally friendly, geothermal wells tend to release greenhouse gases trapped deep within the earth.

1.3 Wind Power

Wind power, through wind turbines, produces about 1.5% of worldwide electricity, and is growing rapidly, having doubled in the three years between 2005 and 2008. The intermittency of wind seldom creates problems, when using wind power to supply a low proportion of total demand. This is mostly centralized solution

that is not recommended for the region since it is less predictable than Solar energy.

1.4 Bio-fuel Power

Bio-fuel is defined as solid, liquid or gaseous fuel obtained from relatively recently lifeless biological material and is different from fossil fuels, which are derived from long dead biological material. Agro-fuels are bio-fuels which are produced from specific crops, rather than from waste processes such as landfill off-gassing or recycled vegetable oil. Considering the water resources, this solution is more suitable in regions such as South America. In fact, Brazil has been successful in harnessing energy from sugar cane to produce ethanol, which is ultimately used for cars.

1.5 Biomass Power

Biomass refers to plant matter grown to generate electricity. For example, trash such as dead trees and branches, yard clippings and wood chips are bio-fuel. Industrial biomass can be grown from numerous types of plants, including switch grass, hemp, corn, poplar, willow, sorghum, sugarcane, and a variety of tree species, ranging from eucalyptus to oil palm (palm oil). Although fossil fuels have their origin in ancient biomass, they are not considered biomass by the generally accepted definition because they contain carbon that has been "out" of the carbon cycle for a very long time. Their combustion therefore disturbs the carbon dioxide content in the atmosphere. They are considered scarce and do not present a viable solution in the Middle East. It is centralized and unavailable for buildings.

1.6 Hydro Power

Hydro Power is electricity generated by gravitational force of falling or flowing water. It is the most widely used form of renewable energy. Worldwide, hydroelectricity supplied an estimated 20% of the world's electricity, and accounted for about 88% of electricity from renewable sources. It has been utilized where available. It is centralized and unavailable for buildings.

1.7 Tidal Power

Tidal power, also called tidal energy, is a form of hydropower that converts the energy of tides into electricity or other useful forms of power. It is centralized and unavailable for buildings.

1.8 Wave Power

Wave power is the transport of energy generated by ocean surface waves, and the capture of that energy for electricity generation, water desalination, or other forms of power. It is based on a centralized model with the world's first commercial wave farm based in Portugal. It is at the Aguçadora Wave Park, which consists of three 750 kilowatt Pelamis devices.

2.Challenges and Realities of Renewable energy

In his 2009 article [ref. 4], David MacKay, a professor of physics at the University of Cambridge, argues that we need to introduce simple arithmetic into our discussions of energy. "We need to understand how much energy our chosen lifestyles consume, we need to decide where we want that energy to come from, and we need to get on with building energy systems of sufficient size to match our desired consumption." kWh is kilowatt-hours, a measure or energy .

In one day we consume food with chemical energy to stay alive that amounts to about 3 kWh per day. Taking one hot bath uses about 5 kWh of heat. Driving an average car 100 kilometers uses 80 kWh of fuel. With a few of these numbers in mind, we can start to evaluate some of the recommendations that people make about energy. In his paper, David MacKay maintains that the European lifestyle uses 125 kWh per day per person for transport, heating, manufacturing, and electricity. That is equivalent to every person having 125 light bulbs switched on all the time. The average American uses 250 kWh per day, 250 light bulbs. The numbers for energy consumption for the Middle East is expected to be within 80 to 130 kWh per day. In his paper, David MacKay, concludes that among all the renewable energy-supply technologies, the two with the biggest potential today are solar power and wind power. In Europe, especially the northern part, wind power is more attractive alternative. However, in The Middle East Solar is by far the more reliable and stable source of renewable energy.

3.Centralized Vs Distributed Methods

The Centralized power generation and distribution model is shown in Figure 1. This model is the current implantation almost in every region worldwide. In the case of wind power generated energy, which fit the centralized solution, a large scale wind farms are typically connected to the local electric power transmission network.

The largest centralized solar power plants in the world are solar thermal plants, but recently multi-megawatt photovoltaic plants have been built. Completed in 2008, the 46 MW Moura photovoltaic power station in Portugal and the 40 MW Waldpolenz Solar Park in Germany are characteristic of the trend toward larger photovoltaic power stations. Much larger ones

are proposed, such as the 550 MW Topaz Solar Farm, and the 600 MW Rancho Cielo Solar Farm in the U.S. In his paper [ref4], David MacKay, concludes that, all renewable energy recourses deliver only a small power per unit area, so if we want renewable facilities to supply power on a scale at all comparable to our consumption, those facilities must be big.

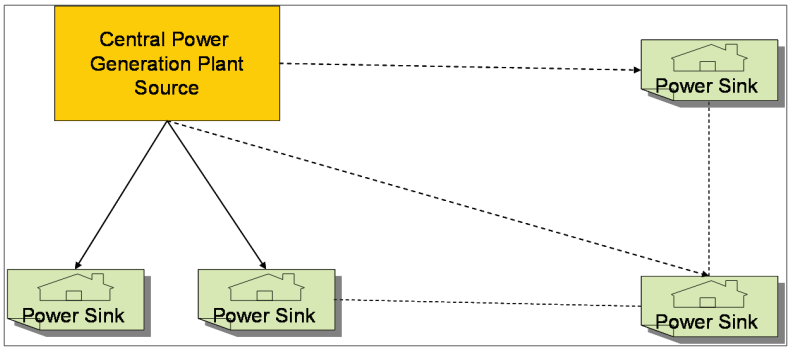

Figure 1: Centralized Power Generation and Distribution

Quasi-Distributed solutions are currently in use in residential building to supplement the current resources, with the most common being used for water heating. In addition, photovoltaic are starting to being installed in the states of Arizona, California and Oregon in the United States. The pure distributed model is shown in Figure 2. It requires that each power consuming structure has a local renewable power generation unit, or in this case as we argued Solar Panels. In terms of available technology this model is realistic once a reliable solution to the energy storage problem is realized. For a practical solution a hybrid model is needed.

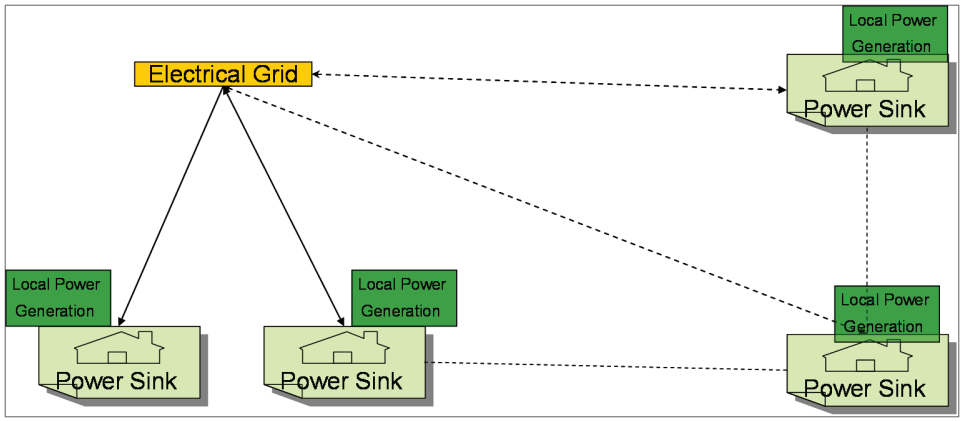

Figure 2: Distributed Power Generation and Sharing Model

4.Solar Panels and the Hybrid Solution

Given the fact that to supply 42 kWh per day per person from solar power requires roughly 80 square meters of Solar panels, the distributed model is clearly the better choice for future planning. In the distributed model each power consumer is a power producer as well. At this point in time in history, we are far from realizing the fully distributed power generation and sharing model.

The hybrid model, as shown in Figure 3, is the most attractive model to move toward a distributed model solution due to the challenges in controlling and storing solar produced energy. The hybrid model does not require that all power consuming structures have a local

renewable power generation unit. The energy storage issue is handled in the centralized power generation plant. Future advances in storage technology could present an opportunity to move more toward a fully distributed model. In either case, building architecture and structural design must integrate the energy storage feature of solar panels in buildings. The same way buildings evolved to accommodate for indoor pluming, central heating, and air conditioning.

5.Regional Consideration and Architectural Requirements

Solar energy is readily available and predictable resource in the Middle East. Most of the current use is in buildings utilizing it for water heating. Solar energy is most fitting for the Middle East, especially photovoltaic in its Hybrid distributed model as shown in Figure 3. In Figure 4, an attempt to add solar panels on a roof of existing building is shown which is called retrofitting. A novel architecture that accounts for solar panels placement and cultural and traditional customs in the Middle East is invaluable for future buildings.

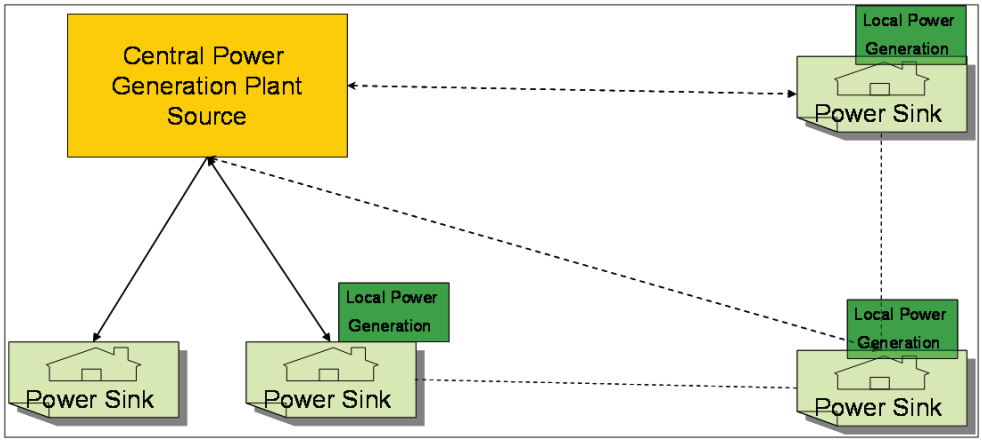

Figure 3: Hybrid Power Generation and Distribution Model.

Each choice of renewable energy requires a unique architectural solution in buildings when we follow the Hybrid model. In fact, Solar panels may provide the most challenge and opportunity for novel building designs. This is a new topic that shall start a new research area in architecture for placement of the solar panels. In fact, the following questions must be addressed in lieu of the hybrid model planning: (1) How can we architect buildings (Residential, Commercial, government) to integrate solar power for future planning? It includes building architecture shape and design with cultural consideration. (2) What are the structural solutions needed with the new novel design architecture in terms of Energy efficiency. (3) How and who will be responsible to resolve issues of the power generation, energy storage, and maintenance consideration in the new architected buildings?

6.Conclusion

We conclude that a distributed solution using Solar Panels for use in building is the most attractive solution for the Arabian Peninsula. This is an

environmentally friendly, abundantly available energy resource that will supplement the ever increasing demand for energy. The Solar panel distributed solution for use in buildings gives rise to new questions and research topics that need to be addressed by the Architecture and Structure Community.

Figure 4: Solar Panels as an Addition to Existing Building.

References

[1] https://store.solar-electric.com

[2] http://www.wakapidia.com

[3] http://en.wikipedia.org/wiki/Solar_power

[4]http://www.cnn.com/2009/TECH/science/05/13/mackay.energy/index.html

[5]http://www.withouthotair.com/ , David MacKay , Sustainable Energy -without hot air

دراسة تحليلية لاختيار مصدر طاقة متجددة وصديقة للبيئة للاستخدام في المباني في المنطقة العربية وعلى الأخص في المملكة العربية السعودية

الدكتور أيمن محمد الخطيب
جامعة الملك سعود

ملخص:

تم مؤخـرا إحـراز تقدم مهم في مجال تقنيات الطاقـة المستدامة.معظم هذه التقنيات تتبنى حـلا مركزيا لتوليد الطاقة. في البحث الحالي تم مراجعة الأشكال المختلفة لمصادر الطاقة ومن أهمها الطاقة الشمسية، طاقة الرياح والطاقة الهيدروليكية وغيرهـا. تم التأكيـد أن الحـل الموزع (مولدات طاقـة محلية) باستخدام خلايـا الطاقة الشمسية هو الحـل الأمثل للمنطقة العربيـة. الحـل المطروح لا يهـدف أن يكون البديل للطاقة المستخدمة حاليا من بترول وغـاز وإنما هو حل مؤازر ومتمم لتلبية الطلـب المتزايـد علـى الطاقة وذلـك باستخدام مصادر طاقة وفـيرة ومتجددة وصديقـة للبيئة. وكون هذا الحـل هو الأمثل للاستخدام في المباني فإن ذلك يستدعي معالجة المشاكل المعمارية والإنشائية الناجمة عن اعتماد الحل الموزع لتوليد الطاقة ليكون قادرا على التأقلم مع المتطلبات الطبيعية والاجتماعية.