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Sustainable Architecture and Urban Planning trough Exploitation of Renewable Energy

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Abstract: The exploitation of renewable energy technologies in architecture engineering and urban planning, offer the opportunity to diminish energy dependence, ensure efficiency and reliability, reduce pollutant emissions, and buoyant socio economic development. The aim of this paper is to present the importance of the state-of-the-art renewable energy processes and renewable technologies exploitation in architecture engineering and urban planning, and review the last literatures on sustainability as an essential need for today's societies. Also, future trends for developing cost-effective renewable energy sources utilization in the way of sustainability in the long-run and mitigation of greenhouse gases emissions are discussed.

Keywords: Renewable Energy Economics, Renewable Energy Technologies, Sustainable Architecture, Sustainable Urban Planning

1. Introduction

The rapid change in technology and lifestyle, have led to a dramatic increase in electricity demand, which can face urban planners and architectures with the challenge of ensuring the sustainable and clean electricity production. With today's cutting-edge, renewable energy technologies must propound the sustainability culture in architecture engineering and put forward with the necessary plans in urban planning. For instance, the European energy supply objectives 20-20-20 by 2020, where 20 stands for a reduction of 20% of greenhouse gas emissions, increasing energy efficiency by 20%, and 20% production of electricity from renewable energy source, compared to 1990 levels, respectively [1]. Electricity generation has relied in large-scale, integrated and centralized energy production, high technology, and capital intensive. In this context architects and urban planners by adequate understanding the renewable technologies application and two-way interaction between electricity demand and production; can help to achieve the national and international targets for energy security of supply. Balance between economic, environmental and social dimensions are factors to ensure sustainability, in which to meet the present needs without a decline of the future demand [2]. The concept of sustainable energy development has introduced based on these pillars [3]:

- Technical sustainability;
- Economic sustainability;
- Institutional sustainability;
- Environmental sustainability;
- Social sustainability;

The environmental awareness, public pressure and increased cost of the nonrenewable source lead to have

tendency toward renewable energy technologies [4]. Technically sustainable system is expected the output of the physical infrastructure of the input source, which economically is cost effective and affordable. The social sustainability measures the acceptability and accessibility of energy supply by all in the society. The environmental sustainability deals with the negative impact of energy use on society and tries to change positively. The Institutional sustainability defines the level of local participation in the management of the energy system. More details about sustainable energy pillars are detailed in [5].

2. Sustainable Electricity Supply

The Electricity has counted the basic necessity in modern society, and sustainable electricity supply requires balancing economic growth and prosperity with the preservation of the natural environment [6]. The sustainability concept intimates that how to use the source in a way that does not compromise the ability of future generations to meet their needs [7, 8]. The sustainability concept for efficient energy supply needs to satisfy these conditions [9]:

- All energy must come from sustainably managed renewable resources.
- Energy must be distributed and used with highest efficiency.

Those energy sources that does not satisfy these criteria and demolish the interactions between mankind and nature are not sustainable energy resources. That most hydropower, solar energy technologies, wind power, ocean energy or geothermal installations harvest renewable energy in a sustainable way [9]. In general agreement, the exploitation of renewable energy technologies and efficiency concepts are known the twin pillars of sustainable energy supply [10]. Globally, an enormous attention is being paid to switch to renewable energy source and consider the sustainability dimensions from technological innovation to its implications for greenhouse gases emissions, energy costs reduction, and dependence on technologies with catastrophic potential [11]. However, the transition from nonrenewable energy production to renewable sources in a sustainable way will take years. For this purpose, the transition to sustainability depend on the below constraints [6, 9] to be considered for architectural design and urban planning:

- Produce, transmit and use energy in an environmentally responsible manner.
- Enhance the reliability and quality of power supply.
- Reduce costs by improving operating efficiency and business practices.
- Assess availability of hydropower, wind, sun, geothermal heat and biomass.
- Investigate climatic conditions for harvesting solar, wind and biomass.
- Evaluate topology along shorelines for harvesting ocean energy.
- Estimate availability of land and sites for renewable energy installations.
- Propose political leadership with sound visions.

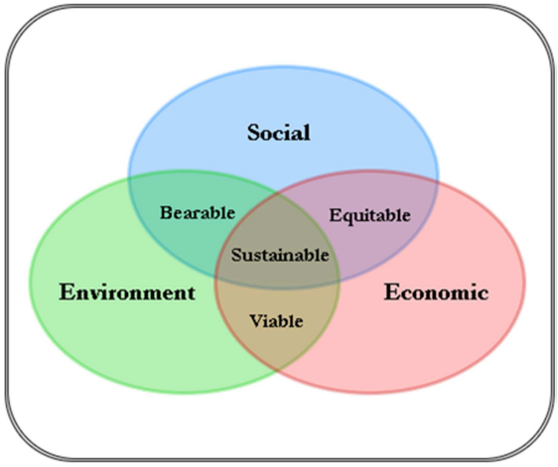

Figure 1. *Pillars of a sustainable energy design [12, 13].*

The most common issues for sustainable energy design are the integration and balancing approaches of economic growth, environmental protection and social equality dimensions of energy; shown in Figures 1 and 2. [7, 12, 13].

The energy security is concerned for a sustainable supply, which it defines as the accessibility of energy supply at an affordable price in an environmental friendly atmosphere [14]. In a global outlook, ensuring sustainability in architecture engineering is approached from a narrow interdisciplinary renewable energy sources. As an obvious, there is an urgent need for the smooth transition from traditional to a new sustainable architecture engineering based on appropriate sustainable criteria. In order to move to a sustainable building design and urban planning, there is need to apply the renewable energy approaches in architecture engineering based on the sustainability practice and technologies. The best practice for renewable energy technologies application is to initiate feasibility studies for combination of different renewable energy technologies with considering the technical and environmental barriers at the buildings and urban design and planning phases to find a reasonable solution. Besides, the sustainable architect design requires a firmly technical and technological approaches that yields the high standard of renewable energy application in architecture engineering. Which paves the way to integrate not only the technical and technological aspects, usually focused on economic, environmental, and social considerations.

In brief, in this study, the sustainability concept is aimed to develop the decision-making process and optimum use of the specific renewable energy source in architecture engineering and urban planning. The process is the life cycle analysis of the three elements (economy, environment, and society) of sustainability to evaluate the impact of these elements for the viable energy systems. Application and supply of the renewable energy technologies in the future buildings and urban areas allow to mitigate the carbon-intensive energy source and overcome the global warming emissions. The societies would adopt a lifestyle that growth the sustainability in housing and urban facilities.

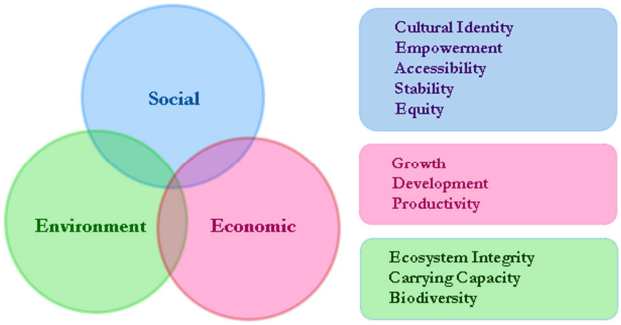

Figure 2. *Elements of the sustainable energy design.*

3. Type of Electricity Generation Sources

This all types of the energy sources are essential for every society with revert attention to economic and environmental restrictions in a way of energy technologies change over time. In principle, the energy sources categorize in primary and secondary energy sources. Primary energy sources (nonrenewable energy (fossil fuels): coal, crude oil, natural gas, nuclear fuel) are extracted or captured directly from environment. While, the secondary energy sources (renewable energy: hydropower, biomass, solar, wind, geothermal, and ocean energy) are produced or converted from the primary energy sources [15]. The energy triangle model illustrates the balance between three key dimensions; Figure 3 [16].

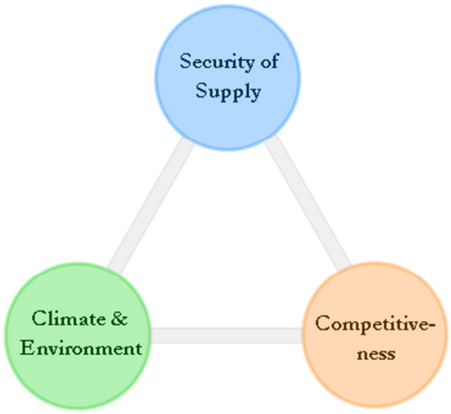

Figure 3. *Energy Triangle [16].*

4. Inexhaustible Electricity Supply

Throughout the world, everywhere and any architectural scenarios endowed with the renewable energy sources for inexhaustible electricity production and supply. These diverse sources of renewable energy have potential to provide all the electricity the nation needs many times over [17]. The renewable energy sources technical potential are limited due to availability and technical, economic and environmental constraints [17, 18]. In the last decades, the renewable energy technologies projects exceedingly invested and trying to revert attention for the production of less greenhouse gasses emission-intensive energy. If we suppose an architectural design or an urban plan as a project, from renewable energy integration point view there are many options [12]. Selecting the "best compromise project (renewable energy sources)" is a complex decision because of the following reasons [12]:

- Each project is evaluated according to several conflicting criteria (economic, social and environmental), that could be quantitative or qualitative.
- The consequences of projects have to be evaluated in the short, medium and long term horizons.
- The evaluations of each project are uncertain and may be imperfect (inaccurate and/or ambiguous and/or incomplete).
- Several unforeseen events out of control can occur over time and impact future evaluations of the projects.
- Economic, social and environmental impacts of projects must be considered simultaneously in the decision-making process.
- Many stakeholders with different points of view, eventually conflicting, will intervene in the decision.
- The resources available for projects are limited.

In this context the renewable energy technologies are proved often cost-effective for rural and remote communities electrification where locates far away, populations are less, and demand for energy is low [19].

5. Renewable Energy

At the recent years, the use of renewable energy technologies has expanded rapidly. Renewable energy attributes the energy from natural sources that are replenished at a faster rate than they are consumed, including hydro, bioenergy, geothermal, aerothermal, solar, wind and ocean [20]. In other word, a source that constantly renew themselves or that are regarded as practically inexhaustible [21]. Renewable energy source are available everywhere human life, such as wind, hydro, tidal and wave energy, photovoltaic cells, solar thermal and bioenergy (biomass and biogas) contributes enormously our society, climate, and economy. Table 1. illustrate the renewable energy and their electricity production types [9].

Table 1. *Renewable Energy Sources.*

No	Energy Sources	Types of Technology	Type of Energy
1	Solar energy	Photovoltaic	DC electricity
		Collectors	Heating
		Concentrators	AC electricity
2	Wind energy		AC electricity
3	Hydropower		AC electricity
4	Ocean energy	Waves	AC electricity
		Tides	AC electricity
5	Geothermal	Low temperature heat	Heating
		High temperature heat	AC electricity
		Synthetic fuels	
6	Biomass	Low temperature heat	Heating
		High temperature heat	AC electricity
		Synthetic fuels	
7	Organic waste	High temperature heat	AC electricity

Despite the consensus agreements, still the world we are living in is steady polluting air and the greenhouse gases emissions are continuing in an umpteen quantity; the

renewable energy is the only hope for a sustainable energy resource for a greenhouses gases free atmosphere. The sustainability term for renewable energy defines to develop sustainability protocols for different forms of renewable energy over time with contemplating of these indicators [20]:

- Deployment diversity;
- Policy developments;
- Technology costs;
- Investment in renewable energy;

6. Renewable Energy Advantages and Disadvantages

Nowadays, each of renewable energy technologies has practical consideration that impact their deployment; as said [22], the old adage that "everything has its limits". The key distinguish of the elements of energy sustainability define in the following aspects [22]:

- Conservation;
- Development and utilization of renewables;
- Improvement of efficiency in generation, transmission, distribution, and utilization;
- Energy storage;

Perhaps, for development of sustainable framework the items as mentioned earlier have to come all into play as an overall sustainable plan. Each renewable energy source has unique advantages, and the overall renewable energy sources or technologies advantages and drawbacks can be listed as [19, 23-25]:

6.1. Advantages

- Abatement of global warming and reduce air pollution.
- Accelerate development and deployment of affordable low carbon technology solutions.
- The renewable energy technologies produce insignificant pollutant, so they are environmental friendly.
- Developing and exploiting renewable energy technologies helps to meet the millennium development goals in national and international perspective.
- Reducing safety risks from conventional energy source
- Spurring socio-economic development.
- Balancing the use of renewable and nonrenewable sources for future generation.
- The renewable energy technologies' operation is cost effective due to less maintenance.
- Renewable energy sources can be used for more than energy production purpose.

6.2. Disadvantages

- The renewable energy technologies describe with unpredictable behavior and variation in energy production within the time of demand due to dependency on the natural source.
- Still in large scale electricity generation from renewable energy source compare to traditional fossil fuel, and coal plants is not feasible.
- Renewable energy is not always technically viable to operate at all sites due to environmental nature and barriers.
- The spatial energy intensity or density of renewable energy sources is often low compared with most fossil fuel and nuclear energy sources. Large spaces are needed.
- The cost of energy from renewables is often not yet competitive in the marketplace.
- Often, the renewable energy technologies exploitation needs high capital investment.
- Some types of renewable energy use, destabilize the ecosystems.
- Some types of renewable energy sources have a negligible impact on daily life and health (for instance, noise from the wind turbines).
- Some types of renewable energies have potential of high-risk disaster.
- Some types of renewable energy are sensitive to natural disasters.

7. Renewable Energy Economics

The economic efficiency of renewable energy technologies and management are the subtle considerations for renewable energy practical application [26]:

- Economic efficiency of renewable energy systems;
- Politics and legal issues;
- Investment and financing;
- International trade and marketing;
- Standardization and interoperability;

Since, the price of nonrenewable sources continue to increase, reaching levels that threaten the economy, so there is need to seek alternative sources of energy [27]. The main objective of the sustainable energy integration in buildings and urban areas are the incorporation of renewable energy resources for achieving the energy efficient buildings. Residential loads or buildings consume about 42% of the total world annual energy consumption [28]. So, it makes the role of architects and urban planners significant for optimization of buildings and urban in the way of sustainability in the long-run and minimization of annual load consumption by considering effective techniques of world-wide accepted energy engineering approaches.

The cost for renewable energy technologies have declined steadily, for instance the average price of a solar panel has dropped almost 60% since 2011 [17, 29]. So, it is another reason for renewable energy technologies application in buildings and urban as a plenty of opportunities. It is conceivable to reduce the buildings' energy consumption by sustainable building design through appropriate application of renewable energy technologies. Also, it is more economical in energy consumption to look the feasible enhancement techniques such passive measures, natural or hybrid ventilation rather than air conditioning; can dramatically reduce primary energy consumption [28, 30]. So, the jointly

mixed renewable source provide to enhance the overall system efficiency and reliability for a stable cost-effective system operation. The hybrid PV system application for rural and remote areas is an outstanding examples [17, 31, 32].

8. Global Warming

Green energy technologies are a subset of renewable energy source that provides environmental friendly energy with a trivial environmental impact; such as solar, wind geothermal, biogas, biomass, and hydroelectric source.

However, the recent advanced technologies provides irrefutable benefits for mankind. On the other hand, these technologies are overloading our atmosphere with global warming emissions and steadily drive up the planet's temperature that cause unexpected environmental and climate changes. The emission of greenhouse gases and their mitigation to climate change comes into global focus. According the reports [33], electricity production and consumption emiten Giga Tonnes, or approximately 37% of global emissions. The air pollution emitted by nonrenewable source has directly harmful impact of our daily life and health. Among the greenhouse gas emissions, these gases have the lion's share in warming the earth by absorbing energy that act like a blanket insulting the earth [34]:

1. Carbon Dioxide (CO_2);
2. Methane (CH_4);
3. Nitrous Oxide (N_2O);
4. Chlorofluorocarbons (CFCs);
5. Hydrofluorocarbons (HFCs);
6. Hydrochlorofluorocarbons (HCFCs);
7. Perfluorocarbons (PFCs); and
8. Sulfur Hexafluoride (SF6);

The share of global emitting are vary for different electrical power generation sources such as coal-fired power plants have the majority of emissions; while, the wind and nuclear power plant release respectively less than coal-fired plants. Somehow, the global warming emissions life cycle associated with renewable energy, including manufacturing, installation, operation and maintenance; dismantling and decommissioning are minimal [17, 35]. Table 2 and Figure 4 show the emission rates from different electricity generation sources [33].

Table 2. *Greenhouse gases emissions from different energy sources [33].*

Technology	Tonnes CO_2/GWh		
	Mean	Low	High
Lignite	1054	790	1372
Coal	888	756	1310
Oil	733	547	935
Natural Gas	499	362	891
Solar PV	85	13	731
Biomass	45	10	101
Nuclear	29	2	103
Hydroelectric	26	2	237
Wind	26	6	124

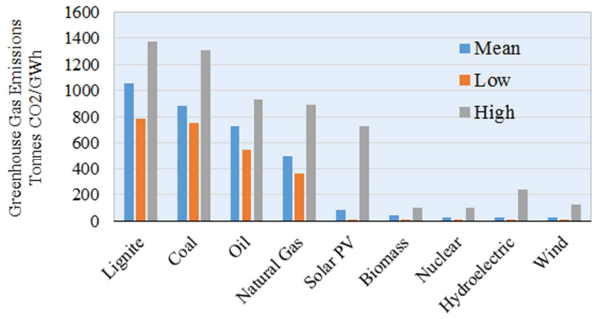

Figure 4. *Graphical Representation of the Greenhouse Gases Emissions.*

Tables 1 and 2 show the lifecycle emissions of natural gas and coal plants are approximately 15 and 30 times greater than a nuclear plant. The awareness of the best renewable technologies and their appropriate application in architecture engineering and urban planning reduce energy usage and enhance carbon footprint [36]. So, the renewable energy is the only inevitable option for energy security and global warming mitigation [37]. Recently, the energy consumption and carbon footprint reduction is of growing interest to individuals (architectures and urban planners), organizations, and governments [38].

9. Conclusion

This study is hinted the role of architects and urban planners in seizing the opportunities of renewable energy technologies exploitation to maintain a sustainable community. The application of such methodology might improve the overall energy performances and reduce the greenhouse gas emissions. Besides, the latest literature review in this study, focused on the importance of deployment of renewable energy technologies for life-style change in the way of long-run comfortable life. Also, this paper is highlighted the main points for architects and urban planner as a precise guideline.

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