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Green Energy Applications in Potential Green Communities (Egypt2030)

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Abstract

The concept of sustainability has gained significant attention worldwide, with a focus on finding solutions to environmental, social, and economic challenges. In the context of Egypt2030, this paper explores the importance of green energy applications in promoting sustainable development within Green Communities. These communities are designed to incorporate strategies that prioritize green buildings, integrated water systems, pedestrian-friendly design, urban forestry, and waste management practices. The study emphasizes the significance of proper planning at the neighborhood level to ensure the long-term viability and reduced environmental impact of sustainable communities. It highlights key factors such as population density, alternative transportation systems, community agriculture programs, water reuse strategies, and green building techniques, all of which contribute to achieving sustainable development goals.

Renewable energy plays a crucial role in the development of green communities. The paper emphasizes the integration of renewable energy sources and the proper selection of alternative fuels and electric vehicles to minimize greenhouse gas emissions, combat climate change, and reduce air pollution. Furthermore, it underscores the importance of selecting appropriate energy storage methods to create a balanced, emissions-free, and sustainable community.

In conclusion, this manuscript underscores the significance of incorporating green energy applications into the planning and development of Green Communities in Egypt2030. By prioritizing renewable energy, sustainable neighborhood design, and efficient energy storage, these communities can contribute to a greener and more sustainable future.

Keywords

Sustainable & green communities; Renewable energy; Egypt SDGs 2030

1. Introduction

Green sustainable communities prioritize environmentally friendly practices, and sustainability, while promoting community and social well-being. Incorporating green spaces and alternative transportation options, they aim to enhance air quality and protect natural resources by reducing CO2 emissions and waste [5][6][7]. These communities prioritize pedestrians and cyclists over cars by using smart transportation systems, including infrastructure, telecommunications, and energy [7]. Key elements of green sustainable communities include using natural building materials, solar panels, and smart HVAC systems. Green architects are finding innovative ways to reduce resource use and lower greenhouse gas emissions [7]. Sustainable communities incorporate eco-friendly practices, which can result in money-saving natural resource systems. Additionally, buildings in green sustainable communities are often solar-powered, and may even be LEED-certified, which is desirable for tenants [7]. Rooftop gardens and green spaces are also common features of these communities. Supporting technology is integrated into sustainable communities to foster sustainable urban development. Smart cities are creating sustainable places with clean technology, parks and pathways, and urban sustainability principles. Eco-cities around the world are developing demonstration communities to showcase the latest in green technologies and practices [7][6][8]. Sustainable communities provide a range of environmental benefits while fostering a sense of community and social well-being. Furthermore, sustainability can lead to better education and enhance aesthetics while improving access to desirable amenities [7]. Incorporating renewable energy into green sustainable communities is essential to achieving a low-carbon economy and reducing greenhouse gas emissions. Renewable energy can be integrated into buildings, transport, industry, and power systems in green sustainable communities [9]. Incorporating renewable energy into these areas brings benefits such as cleaner air, improved living spaces, and modern services to cities [9]. Cities have a significant role to play in the transition to a low-carbon economy, and renewable energy can help achieve this goal [9]. A report examines the technologies that cities can use to incorporate renewable energy into green sustainable communities [9]. The report also highlights best practices and policies that cities can adopt to bring about a renewable energy future, including the potential for urban communities to scale-up renewables by 2030 [9]. Renewable energy sources can be used for cooling systems, heating, cooking, appliances, electricity generation, and water and space heating and cooling in green sustainable communities [10][9][11]. Furthermore, electric mobility and biofuels can be implemented as sustainable transport options in green sustainable communities [9]. Integrated urban energy systems can also be created to incorporate renewable energy into green sustainable communities [9]. Renewable energy offers an efficient solution for sustainable communities as they do not require much additional energy expenditure once they are built [10]. In contrast, coal is highly inefficient in terms of usable energy, with only 29% of its original energy value being converted into usable energy [10]. Wind power, on the other hand, offers a significantly higher return on its original energy input, with a 1164% return on usable energy [10]. Incorporating renewable resources in green sustainable communities can be helpful, particularly in regions with varying availability and quality of renewable resources, and local governments can incorporate renewable energy options to meet their goals [10][12].

2. Green Communities Characteristics

Green communities share several key characteristics that set them apart from traditional communities. These comm-unities prioritize energy efficiency and may incorporate features such as solar panels, geothermal heating and cooling systems, and green roofs.

In addition to sustainable building practices, green communities often feature pedestrian-friendly design with sidewalks, bike lanes, and public transportation options. They may also include green spaces such as parks and

community gardens, which provide numerous benefits for residents and the environment [13].

2.1 Sustainable Housing in Green Communities:

One of the key features of green comm-unities is sustainable housing. This includes homes that are built with eco-friendly materials, have energy-efficient appliances, and utilize renewable energy sources such as solar power. In addition to reducing carbon emissions, sustainable housing also promotes healthier living environments by using non-toxic materials and improving indoor air quality [14].

Figure 1. Sustainable House - An eco-village in Florida

The above figure (Fig.1) combines some sustainable features:

- cover the roof area as wide flat space with solar collectors.
- Using the attached vehicle parking as charge station.
- Use the LED lighting fixtures to lumine the inter spaces.

2.2. Smart Transportation in Green Communities:

Another important aspect of green comm-unities is smart transportation. This includes promoting alternative modes of transportation such as biking, walking, and public transit, as well as encouraging the use of electric vehicles [15].

By reducing reliance on cars, green comm-unities can reduce traffic congestion, air pollution, and noise pollution while promo-ting physical activity and community engagement.

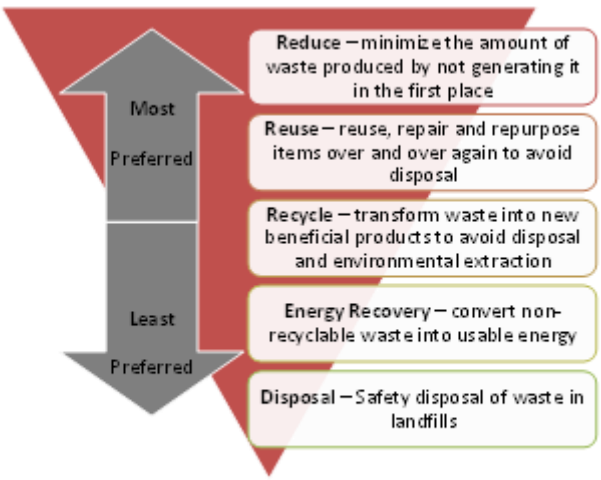

Figure 2. Waste Management Hierarchy

Waste Reduction and Recycling Programs

Green communities also prioritize waste reduction and recycling programs. This includes composting, recycling, and reducing overall waste by promoting sustainable consumption habits.

By reducing the amount of waste sent to landfills, green communities can reduce greenhouse gas emissions and conserve natural resources while promoting a more sustainable way of life [16].

3. Challenge of Creating Green Communities

Despite the many benefits of green communities, there are also challenges involved in creating them. One challenge is the higher upfront costs associated with sustainable building practices and infra-structure, which can make it difficult to attract developers and investors [17]. Another challenge is the need for community engagement and buy-in, as residents may be resistant to changes in their neighborhood or skeptical of the benefits of sustainability. However, with proper planning and

investment, these challenges can be overcome to create thriving, sustainable communities [17].

4. The Future of Green Communities

As the world becomes increasingly urbanized and climate change continues to threaten our planet, the need for sustainable communities will only grow. Green communities offer a promising solution to these challenges, providing a model for livable, environmentally friendly neighbor-hoods. In the coming years, we can expect to see more green communities being dev-eloped around the world, as governments, developers, and residents recognize the benefits of sustainable urban development [18]. By prioritizing sustainability and comm-unity well-being, we can create a brighter future for ourselves and future generations.

4.1. Case Study of Green Communities

Green communities can be found all over the world, from urban centers to rural areas.

4.1.1. District of Vauban, Germany

Vauban, is a district south of the city center of Freiburg, Germany. It is a "model district for sustainable development" built on the site of a former French military base. that prioritizes sustain-able transportation options and energy-efficient buildings [19].

Figure 3. Vauban, Germany

4.1.2. BedZED - London, UK

Another example is BedZED, a zero-carbon development in London, UK that incorporates renewable energy sources and sustainable building materials. These communities serve as models for sustainable urban development and demonstrate the potential for creating livable, environmentally friendly neighbor-hoods [20].

Figure 4. BedZED, UK

4.2. Comparison Study

A comparative study has been done between BedZed and Vauban, as shown in Table 1, to learn from their successful strategies.

Table 1. Comparison Study between BedZED and Vauban neighbor-hoods

	BedZed	Vauban
City in which low carbon experiment developed	London	Freiburg
First phase completion	2002	2007
Systems involved	Buildings, waste, water, energy, transport	Buildings, waste, water, energy, transport
Carbon production in city (tones per capita/annum) a	12.5c	8.5d
Carbon production in city (tones per capita/annum) a	0.51f	0.5g

Cultural innovation	Zero carbon; Zed and One-Planet concepts	Solar city concept
Structural innovation	Low carbon technologies and urban design (the Zed system)	Low carbon technologies; Local code for improved energy performance in buildings; institutions for co-provision
Innovation in practice	One-planet sustainable lifestyle concept; One-planet framework for managing development	Co-provision (energy, housing and built environment); collaborative planning

5. Alternative Energy Strategies

Alternative Energy Strategies have become an increasingly important topic of discussion and debate as the world seeks to reduce its carbon footprint and transition towards a more sustainable energy future.

5.1. Benefits of Renewable Energy

Generating energy that produces no greenhouse gas emissions from fossil fuels and reduces some types of air pollution.

Diversifying energy supply and reducing dependence on imported fuels.

Creating economic development and jobs in manufacturing, installation, and more [21].

5.2. Types of Renewable Energy

5.2.1. Solar Energy

The sun has been generating energy for billions of years and is the ultimate source of all the energy and fuel we use today. Humans have used the sun's rays (solar radiation) to heat and dry meat, fruit and grains for thousands of years. Over time, technology has been developed to harvest solar heat for heating and convert it into electricity. Solar photovoltaic (PV) devices, or solar cells, convert sunlight directly into electricity. Small photovoltaic cells can power calculators, watches and other small electronic devices. By arranging many solar cells in a photovoltaic module and several photovoltaic modules in a photovoltaic

array, it is possible to generate electricity for the whole house. Some large installations of photovoltaic power plants can span several acres and generate electricity for thousands of homes [22].

Figure 5. Solar (PV) Independent Power Product, Aswan- Egypt

Figure 6. Wind Farm, Zafarana- Egypt

5.2.2. Wind Energy

Winds are caused by the sun's uneven heating of Earth's surface. Because the Earth's surface is made up of different types of land and water, it absorbs heat from the sun at different rates. An example of this uneven warming is the diurnal wind cycle.

Wind energy is mainly used to generate electricity. Pumping windmills were once used across the United States, and some are still used on farms and ranches, primarily to provide water for livestock [23].

5.2.3. Hydroelectric Energy

Hydropower was one of the first energy sources used to generate electricity.

Since the source of hydroelectric power is water, hydroelectric power plants are often located on or near water sources. Water flow and changes in elevation (or slope) from one point to another determine the energy available in moving water. In general, the greater the flow of water and the higher the slope, the more electricity a hydroelectric plant can produce [24].

Figure 7. Aswan High Dam, Aswan- Egypt

5.2.4. Geothermal Energy

Geothermal energy is the heat inside the earth. Geothermal energy is a renewable energy source because heat is continuously generated inside the earth. People use geothermal energy to bathe, heat and generate electricity.

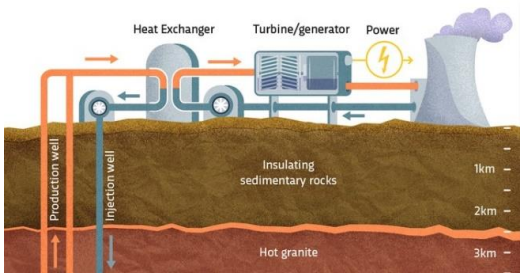

Figure 8. Geothermal Energy Diagram

Scientists have found that the temperature inside the Earth is about 10,800 degrees Fahrenheit (°F), as hot as the surface of the Sun. The temperature of the mantle ranges from about 392°F near the mantle-crust boundary to about 7,230°F near the mantle-core boundary. Rocks and water absorb heat from magma deep underground. Rock and water deep in the ground have the highest temperatures [25].

5.2.5. Hydrogen Energy

Hydrogen is a clean fuel that generates just water when used in a fuel cell. Natural gas, nuclear power, biomass, and renewable energy sources such as sun and wind may all be used to make hydrogen. These characteristics make it an appealing fuel choice for transportation and power production applications. It may be utilized in automobiles, housing, portable power, and a variety of other applications.

Hydrogen is a type of energy carrier that may be utilized to store, transport, and transfer energy from other sources.

Today, hydrogen fuel may be manufactured in a variety of ways. Natural gas reformation (a thermal process) and electrolysis are the most often used technologies nowadays. Other approaches include solar-powered and biological processes [26].

5.2.6. Biomass Energy

Biomass has been used since humans first started burning wood to prepare meals and stay warm. Today, wood is the most abundant biomass energy resource. Food crops, grassy and woody plants, agricultural or forestry leftovers, oil-rich algae, and the organic component of municipal and industrial wastes are among the other sources. Even landfill fumes (which contain methane, the primary component of natural gas) may be used as a biomass energy source [27].

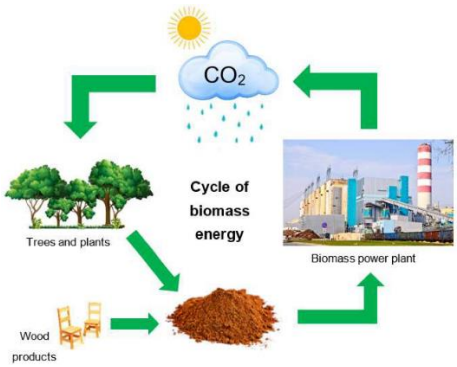

Figure 9. Biomass Energy Diagram

5.2.7. Ocean Energy

The oceans cover approximately 70% of the Earth's surface and are considered one of the largest sources of renewable energy. Additionally, ocean waves are the largest untapped source of renewable energy on Earth. Ocean waves have enormous energy and have the potential to contribute to vast amounts of renewable energy around the world. Ocean-transmitted energy, especially ocean waves, has several significant advantages over other renewable energy sources, such as: High resource availability, high utilization, low environmental impact, and resource predictability [28].

Figure 10.- Ocean/ Wave Energy, port of Pecém – Brazil

In addition, the power density of wave energy is greater than that of solar and wind energy. On average, ocean waves can generate an energy density of over 100 kW/m, much higher than solar and wind intensities. Meanwhile, the global wave energy potential is estimated to be as high as 10 TW, and the annual wave energy is estimated to be as high as 93,000 TWh. For these reasons, ocean waves are a renewable energy source that promises to reduce reliance on fossil fuel power generation [28].

5.3. Advantage and Disadvantage of Renewable Energy

The following Table2 shows the advantages and disadvantages of renewable energy resources to guide the researchers how to get the most beneficial use of renewable energy resources:

Table 2. Pros and Cons of Renewable Energy

ADVANTAGES	DISADVANTAGES
Renewable energy won't run out	Renewable energy has high upfront costs
Renewable energy has lower maintenance requirements	Renewable energy is intermittent
Renewables save money	Renewables have limited storage capabilities
Renewable energy has numerous environmental benefits	Renewable energy sources have geographic limitations
Renewables lower reliance on foreign energy sources	Renewables aren't always 100% carbon-free
Renewable energy leads to cleaner water and air	
Renewable energy creates jobs	
Renewable energy can cut down on waste	

6. EGYPT SDGs 2030

Vision 2030 for Egypt is a milestone on the path of inclusive development, identifying well-being and prosperity as the main economic goals to be achieved through sustainable development, social justice and balanced, geographical and sectoral growth. A sustainable development strategy involves three main dimensions; economic, social and ecological [29]. Sustainable

development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Each of the 17 Sustainable Development Goals (SDGs) has specific targets to be achieved by 2030[30]. To achieve these goals, all partners must work together; governments, civil society, private sector and people. Everyone should play a defined role in the plan to achieve the stated goals.

Figure 11. Sustainable Development Goals (SDGs)

6.1. Potential Local Green Community (Al Rehab City)

Al Rehab city is located in the New Cairo area, which is about 20 kilometers east of Cairo. It is a master-planned community that was developed by the Talaat Moustafa Group, with total area around 10 million m2 planned to accommodate 200 thousand residents, Al Rehab is designed to accommodate 32,385 Apartment and 3741 Villas. Moreover, Al Rehab enjoys a fully integrated services plan including but not limited to commercial markets, shopping malls, Food courts, offering educational mix from International, National, and experimental Schools, A Sporting and Social Club, 4 Medical Centers, An Internal and external Transportation Network, Banks and Money Exchange Services. The city is divided into 10 phases, each of which is a self-contained district with its own schools, hospitals, commercial centers, and parks.

The city is designed to be a green community, with a focus on sustainability [31]. There are a number of green features in the city, including:

A network of green spaces, including parks, gardens, and pedestrian areas.

A commitment to water conservation, with rainwater harvesting and greywater recycling systems being used.

A use of sustainable materials in construction, such as recycled materials and low-VOC paints.

Figure 12. Al Rehab City

Al Rehab City is still under development, but it has the potential to be a model for sustainable urban development in Egypt. If it is successful, it could inspire other cities to adopt more sustainable practices. So, the city can develop and invest in the green elements, such as:

- Prioritize renewable energy: The city can install solar panels and wind turbines to generate electricity. It can also promote the use of electric vehicles and other renewable energy technologies.
- Promoting public transportation: Al Rehab city can invest in environmental friend public transportation systems to reduce the number of cars on the road, by use electrical shuttle buses. It can also encourage the use of bicycles and walking by increase the awareness between the road users.
- Waste Reduction: Al Rehab can develop programs to reduce types of waste. It can also encourage recycling and composting.

6.2. Potential Green Energy Applications for Residential Green Communities (Al Rehab City)

There are many different types of renewable energy applications that can be used, such as:

- Solar energy: Solar panels and other solar applications can be installed on rooftops and other sunny areas to generate electricity. Solar energy is a clean and abundant source of energy that is well-suited for Al Rehab City, which is located in a sunny region.
- Wind energy: Wind turbines can be installed in areas with strong winds to generate electricity. The map below indicates the topographic contour and levels for Al Rehab city location. The elevated location (+230m-to-+270m height above sea level) and wind directions can be benefits supporting use this type of renewable energy.

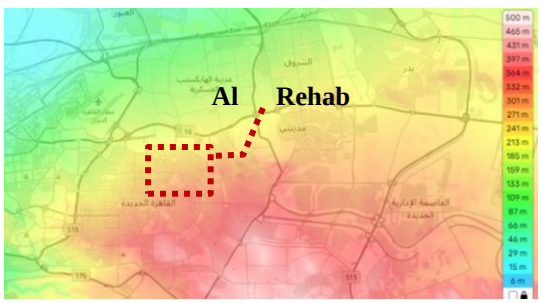

Figure 13. Topographical map for Cairo area

Wind energy is another clean and abundant source of energy that could be used in Al Rehab City.

The generated energy from renewable sources can be used to run and serve landscape lighting and irrigation systems, providing sustainable and cost-effective solutions. Moreover, harnessing renewable energy for these purposes helps reduce reliance on non-renewable resources and minimizes the environmental impact associated with traditional energy sources. This shift towards using generated renewable energy in landscape lighting and irrigation not only promotes sustainability but also supports the overall goals of maximizing land productivity and preserving agricultural areas.

Figure 14. Street solar lights

Also, the vehicle charge stations can provide and supply energy for the new generations of environment friend vehicles.

The specific renewable energy technologies that could be used in Al Rehab City will depend on a number of factors, including the availability of resources, the cost of the technology, and the environmental impact. However, all of the technologies mentioned above have the potential to play a role in making Al Rehab City a more sustainable community.

Conclusion

In view of the strong development of green societies, in-depth theoretical research is of particular importance. According to the concept of green society and development, building society, this paper presents a definition of sustainable development of green society and environmentally friendly renewable energy systems. It also proposes the implementation of green energy applications in Al Rehab City as a case study to illustrate the practical aspects of achieving sustainable development goals in green communities.

By examining the case study of Al Rehab City, we can draw important conclusions about the application of green energy in green communities and its contribution to achieving sustainable, as follow:

Green energy has a wide range of applications to be used in green communities. it's not necessarily to be the most expensive and more efficient one. the selection of the applications must comply with existing infrastructure.

The implementing green energy applications can cover the installation of renewable energy systems like solar panels, wind turbines, and other technologies that generate clean and sustainable electricity. This reduces reliance on fossil fuels, decreases greenhouse gas emissions, and promotes the production of eco-friendly power sources. that can be implement for example by replace the tradition street lights with solar one and run the irrigation system for green areas.

Also, energy-efficient practices and technologies are prioritized in green communities. This includes the use of energy-saving appliances, LED lighting, insulation, and intelligent energy management systems. These measures effectively decrease energy consumption, lower carbon footprints, and reduce overall utility expenses.

By incorporating renewable energy and energy-efficient technologies, green communities such as Al Rehab City actively contribute to addressing climate change and diminishing air pollution. This proactive approach safeguards ecosystems, biodiversity, and human health by mitigating environmental impacts.

The green energy applications emphasize the responsible utilization of resources like water and materials. Sustainable water management strategies like rainwater harvesting and wastewater recycling can be implemented to minimize water consumption. Additionally, recycling and waste management programs play a crucial role in limiting resource depletion and waste generation.

Finally, the adoption of green energy applications not only brings about environmental benefits but also creates economic opportunities and employment. Furthermore, energy-efficient measures yield long-term cost savings for residents and businesses through reduced energy bills.

Also, Implementation and adding the renewable energy applications can be done gradually and by phasing to the power network and other utilities to reduce the reliance on tradition grid network.

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