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TECHNICAL ARTICLE

Assessing the Implementation of Renewable Energy Policy within the UAE by Adopting the Australian 'Solar Town' Program

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The environmental policies and the use of renewable energy are at the highest priority of the United Arab Emirates' (UAE) plans and strategies, and the implementation of clean energy in the country is one of the recent environmental practices that would require more studies and investigation. Conducting this study will offer some valuable analyses and results that could be taking into consideration in the implementation of renewable and solar energy programs further to enacting the environmental legislations and policies to achieve the UAE's target of reducing CO_2 emissions 70% by 2050. This study aims to explore the capability of implementing the solar panel (PV) system on a large scale by adopting the 'Solar Town' program and policies developed by some of the leading countries such as Germany and Australia. Further to this, Cost Benefit Analysis (CBA) was conducted to explore the benefit and the payback period of implementing this program. By calculating the CBA for each property within the community, it has been found that the PV energy system could cover an apartment's electricity consumption with a 1.1 kW surplus, while it can cover only 60% of a villa's electricity consumption.

Keywords: Renewable Energy; Implementing PV; Solar Town; Cost Benefit Analysis; UAE

Introduction

Background

Complying with Kyoto Protocol (1997), UN World Summit (2005), and the other United Nation agreements on Climate Change, a number of the developed countries founded and began the implementation of the Photovoltaic (PV) panels on large scale (UNFCCC, 1997; UN, 2005). One of the successful initiatives is the 'Solar Town' model for producing clean or solar energy on urban scale. The initiative of 'solar town' or 'solar village' was started in Germany in 1997 where the first solar village was established in Bavaria. Wildpoldsried the first solar village producing 321% clean energy more than its need, and the small agriculture village generating now $5.7 million from producing renewable energy every year by selling back to the national grid (Singh, 2015). The village with the population of 2,600 produces renewable energy using different systems inspired by the village council decided to bring built revenue by building a new industry and over fourteen years, the community equipped nine buildings with solar panels and installed seven windmills (REN21, 2015). Moreover, 190 houses in the village have PV panels on their rooftops in addition to three small hydro power stations. This industry developed a number of small businesses to service the installation and the operation of such renewable energy technologies. Furthermore, the village council 'Wildpoldsried Innovative Richtungsweisend (WIR)', which means the 'Wildpoldsried Innovative Trend', has set through this initiative while the council aimed to provide and create small businesses to the local surrounding areas. The village that is known as 'Klimaschutz' (the Climate Protection) obtained a number of national and international awards for its role in environmental protection, and the village council hosts a tour to explain their experiences to the other village's council and visitors.

The Chinese have their interesting experience in establishing the solar towns, 'Rizhao' one of China's solar-powered cities. The city with 3 million population located in the north of China has a unique appearance as most of the building rooftops and walls covered with small solar panels, and 99% of the households use solar water heaters, most of the streets and traffic signals as well as parks are lit by using the photovoltaic cells (Xuemei Bai, 2007). In Rizhao (the Sunshine City), 0.5 MW is produced for water heating and used by more than 0.5 million square meters of solar panels that are distributed on building walls. Because of the limited funding capacity, the Chinese government invested in the renewable energy industry instead of subsidizing the end users; this subsidy covers research and development of the renewable energy industry. The aim of the Chinese government is increasing the efficiency and the use of renewable energy, and decreasing the

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cost of each unit. Xuemei Bai (2007) stated that this achievement was the result of three combined key factors: (1) a government policy that encourages and financially supports solar energy use, research and development, (2) local industries of solar panel that provides the opportunity and the variety of sizes and improved products, and (3) the strong political and city's leadership that adopts the creative and new environmental initiative. However, the Chinese government started the implementation of solar panels on the governmental buildings, and some of the governmental authorities provided free installation of solar panels to their employees, which led Rizhao to be one of the top ten cities in China with respect of the air quality, and is selected by the Environmental Protection Agency (EPA) as a model of the Environmental Protection City. This achievement has a positive reflect on the city from different aspects; environmentally, socially and economically. Further to the clean environment that has been achieved, the social aspect has been improved as the number of visitors has increased by 48%, economically a number of well-known and respectful universities in China have chosen 'Rizhao' to open new campuses, which has provided new opportunities for the city residents, and new people for living and working.

On the other hand, the United Arab Emirates (UAE) has committed to contribute positively to the global environmental issues and concerns by driving and promoting the initiatives that encourage reducing the use of fossil fuels, which is also supported by the new regulations promoting the use of renewable energy. This study investigates the ways to adopt some of the successful international policies, such as the Australian policy and program, a large scale installation of PV panels and the 'Solar Town' initiative within the UAE local context.

Australian 'Solar Town' Program

Beside the Australian contribution to the Climate Change, the Australian government has commitment to the second round of Kyoto Protocol by reducing the Greenhouse Gas (GHG) emissions 20% by 2030 and 30% by 2040. To achieve this target, the Australian government and the Department of Environment have issued a number of policies and decisions that would serve this aim, and one of the main approaches was to increase the use of renewable energy. After an extensive consultation and careful consideration, they decided on a new target of renewable energy, which should be produced right away. According to the Department of Environment (2015), the new target aimed at producing renewable energy to supply 23.5% of the electricity demand by 2020, by doubling the current renewable energy generation to reach 33,000 GWh in 2020. The Australian Minister for the Environment stated that this target will increase the renewable energy industry further to achieve the main target of reducing the GHG emissions. In order to achieve this targeted amount of renewable energy production, the Australian government approached two types of scale; the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES).

The Australian environmental policies and contribution to actions on Climate Change was mainly through reducing the GHG emissions, and in line with the concept of Clean Air, one of the 'Cleaner Environment Plan' targets, while the 'Solar Town' (ST) program is one of the large scale renewable energy systems that aimed at producing a large amount of clean energy (Bond, 2011). This is in addition to promoting the sense of ownership and the responsibility against the environment and engaging the locals and communities with the LRET. The ST program run in two rounds, the 2014–2015 round and the 2015–2016 round. The Australian government allocated $2.1 million for the two rounds to support the community's management and/or organization to install the renewable energy technologies on the specific buildings to support the other or the whole community buildings, and at the same time, to provide clean energy through the use of PV panels and hot water systems specifically (Australian Government, 2018).

The Australian government has set a clear reference to explain the policies and guidelines, and the application procedure for this program; the second round has been improved by the lessons learned from the first round. The government measures the success of the program by the number of the installed systems and the reduction in GHG emissions. They are committed to be fair in distributing funds and studying the case of each community. The funding was provided for only one of the two offered systems: (1) Solar (PV) panels or (2) Solar hot water system, and after closing the applications for the first round, 20 applications were successful under the first round with funding around $300k (Australian Government, 2018).

Environmental Actions in the UAE

The UAE cities (or Emirates); Abu Dhabi and Dubai have started a serious and rapid steps toward positive contribution to the climate change issues, and as part of the Abu Dhabi Vision 2030 that is already becoming one of the top ten future sustainable cities (DPM, 2019), the capital of the UAE created the local green rating scheme, the Pearl Rating System (PRS) in order to drive the city toward World Sustainable Capital (WSC). It is well known that one of the most important policies for clean environment is the 'Green Building Codes and Regulations'; Green Building Regulations and Rating Systems were developed to eliminate or reduce the negative environmental impact through adopting high environmental standards in design, construction, operations and demolition (GBCA, 2015). This could be achieved by adopting the sustainability attitude in the construction main elements; site selection, energy and water efficiency, operating and management practices, materials and resources management. Furthermore, Dubai rolled out a new building rating system called 'Al Saafat' in 2018, which was developed and issued by Dubai Municipality (DM) as part of the Dubai Strategic Plan 2030 to introduce Dubai as a model of green and healthy city, which follows the highest standards for the sustainable developments (DM, 2019). Since 2012, the implementation of the 'Green Building Regulations and

Specifications' of DM became a mandatory requirement for all buildings in the Emirate, and obtaining the 'Green Building Certificate' became a condition to obtain the 'Building Permit' (BP). One of the major requirements in this code is the installation of a renewable energy system, i.e. Solar PV on the roof of all new projects in Dubai.

The UAE has a great opportunity to benefit from the sun's solar energy according to the location and the weather characteristics of the country. In this study, Dubai was chosen to explore the capability of adopting the 'Solar Town' program. The program goal is to increase the installation and utilization of renewable energy on urban scale through developing a partnership involving the different levels of; governmental authorities, local community master developers, local community management, building owners, householders further to the construction, industry and business sector (MESIA. 2015).

'Shams Dubai' Initiative

In December 2014, 'Shams Dubai' (SD) initiative was enacted by H.H. Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum, Crown Prince of Dubai and Chairman of the Dubai Executive Council. SD is one of the smart initiatives that supports the vision of H.H. Sheikh Mohammad bin Rashid Al Maktoum, Vice Minister and Prime Minister of the UAE, the Ruler of Dubai, to lead Dubai into the World Smartest City. The initiative aims to encourage the use of renewable energy by producing the electricity required for the water heater in villas and other types of buildings. The legislation regulations and the guidelines of connecting to the smart grid is operated by Dubai Electricity and Water Authority (DEWA). The initiative encourages householders and building owners to install PV panels to generate their own electricity on site, and the surplus is exported to DEWA's network by connecting these renewable systems to the grid using a smart meter (DEWA, 2018).

During an interview with the manager of solar system program in the headquarters building of DEWA at Al Jadaf, Dubai, the manager stated that the authority issued a list of approved consultants and contractors to work within this program, and she added that this list is on increase as there is a larger number of consultants and contractors will be evaluated in order to participate in this program. The householder or the building owner should follow a number of steps to get the final approval from the authority to install the Feed-in Tariff solar system. The authority started to proceed with a number of applications, and the program is under development day by day. The program is working according to the feed-in-tariff policy concept, the employee in DEWA Al Quoz, Dubai identified the prices of electricity in the city and the way of calculating the energy produced on site by the consumer. The employee mentioned that DEWA does not pay back for the electricity produced, but rather the amount of the production will be reduced from the consumption amount. In addition to the positive economic and environmental effects of this initiative, it started encouraging new businesses of solar panels sector, selling and maintaining. In the meeting with one of the approved contractors, 'Solar Land Technical Services', the engineer stated that there are some of the projects where the initiative has been installed, and people started to be interested in using renewable energy and solar panels on their roofs to reduce their bills. Hence, this study and the cost-benefit analysis would provide the householders and the building owners a clear perspective of the impact of the use of the renewable energy on the consumption, electricity (i.e. DEWA bill), and the positive environmental impact (DEWA, 2019).

Materials and Methods

This study adopted various methods such as case study, interviews, and field observation to obtain the study aim and objectives. The Australian experience in developing the 'Solar Town' initiative was investigated and the policies issued by the Australian Government (Department of the Environment and Energy) for this program were further studied to explore the related policies, and how the ST program could be implemented in the UAE/Dubai based case study (**Figure 1**). The methodological framework shows the three particular methods undertaken in this study, namely; literature review, observation and interviews, and case study, which allowed for data collection. The research explored the potential of applying PV systems on the three property types within the selected residential community. In addition, cost benefit analysis has been conducted to provide an evaluation of the environmental impact of the suggested scenarios.

Cost Benefit Analysis Method

The Cost Benefit Analysis (CBA) model used to evaluate the feasibility of any investment or project by comparing the total calculated costs with the benefits expected from this investment. It is one of the tools that is used to analyse and assess the feasibility of environmental projects, and it is importance for the decision maker to quantify the advantages (benefits), and the disadvantages (costs) of any project (Alberini, 2010).

The first step of CBA starts with identifications of all costs including non-recurring costs, operational costs, development costs, and recurring costs. The next step is the identification of benefits, which refers to all return or outcome from the alternative system (Pehnt, 2006). Generally, it is in dollars or local currency, and the benefit covers the following categories; recurring benefits, non-recurring benefits, and non-quantifiable benefits. CBA policy varied with type of project or element estimated the main target of this estimation, sometimes, it is a rather complicated procedure because of some items are not traded in markets or some benefits are non-quantified benefits, which needed special valuation techniques (Rolfe, 2011).

In this study, the case study apartment is similar to the rest of the building apartments in condition and average consumption, and therefore the calculation is conducted on one apartment as an example of the other 24 apartments, which makes up the whole building block. For the calculations, both costs and benefits identified as follows:

Cost covers:

- Solar panel cost (material and installation).
- (DEWA) meter and approval cost.
- Cleaning and maintenance cost (will be neglected according to MESIA, 2014), and the low services cost could be integrated with other community services and cleaning cost.

Benefits include:

- The reduction in the electricity bill amount.
- In addition to the environmental benefits of reducing the CO_2 emission by reducing the use of standard energy (fossil fuel) resources.

Case Study and Data Collection Methods

To adopt the Australian 'Solar Town' initiative in the UAE, the emirates of Dubai was chosen to explore the capability of implementing this program, and a CBA is conducted for the feasibility of implementing this program on an apartment, and at the building's level. The urban planning of Dubai is based on dividing the corridor city into districts, neighbourhoods and communities. Most of these communities are managed by the 'Master Developer' or 'Management Company'. In order to conduct a CBA, a community in Dubai was selected, the neighbourhood is consisting of number of buildings, the consumption of one apartment is assessed as well as the feasibility study of installing PV panels is evaluated. Furthermore, the CBA of implementing PV panels on the other types of properties in the community have been conducted and analysed. The selected community was chosen to examine the opportunity of implementing the ST program in the 'Emirates Hills' neighbourhood, developed by 'Emaar'. The community consists of two types of properties: (1) Villas, and (2) Apartments as part of Mid-rise buildings. The mid-rise buildings are G + 3 and G + 6 storey blocks; and a G + 3 building is used in this study to assess and evaluate the implementing of PV panels and connection to the grid. According to the Emaar Community Management (ECM) system, the mid-rise buildings' air conditioning depends on the chillers for cooling water and the total consumption of water heater, lighting, and other usages that are separated from the chillers, district cooling system consumption, as the developer is responsible for the water cooling electricity consumption and the owner is paying an annual service fee to the master developer, in this case to 'EMAAR' toward such a service.

A feasibility study is undertaken to assess and evaluate the implementation of a renewable energy technology, in this case a Solar (PV) system and the calculation of the payback period for installing PV panels. One apartment from a G + 3 mid-rise building is selected, and the results are multiplied by 24 apartments in order to calculate the system operation of the whole building block. The total

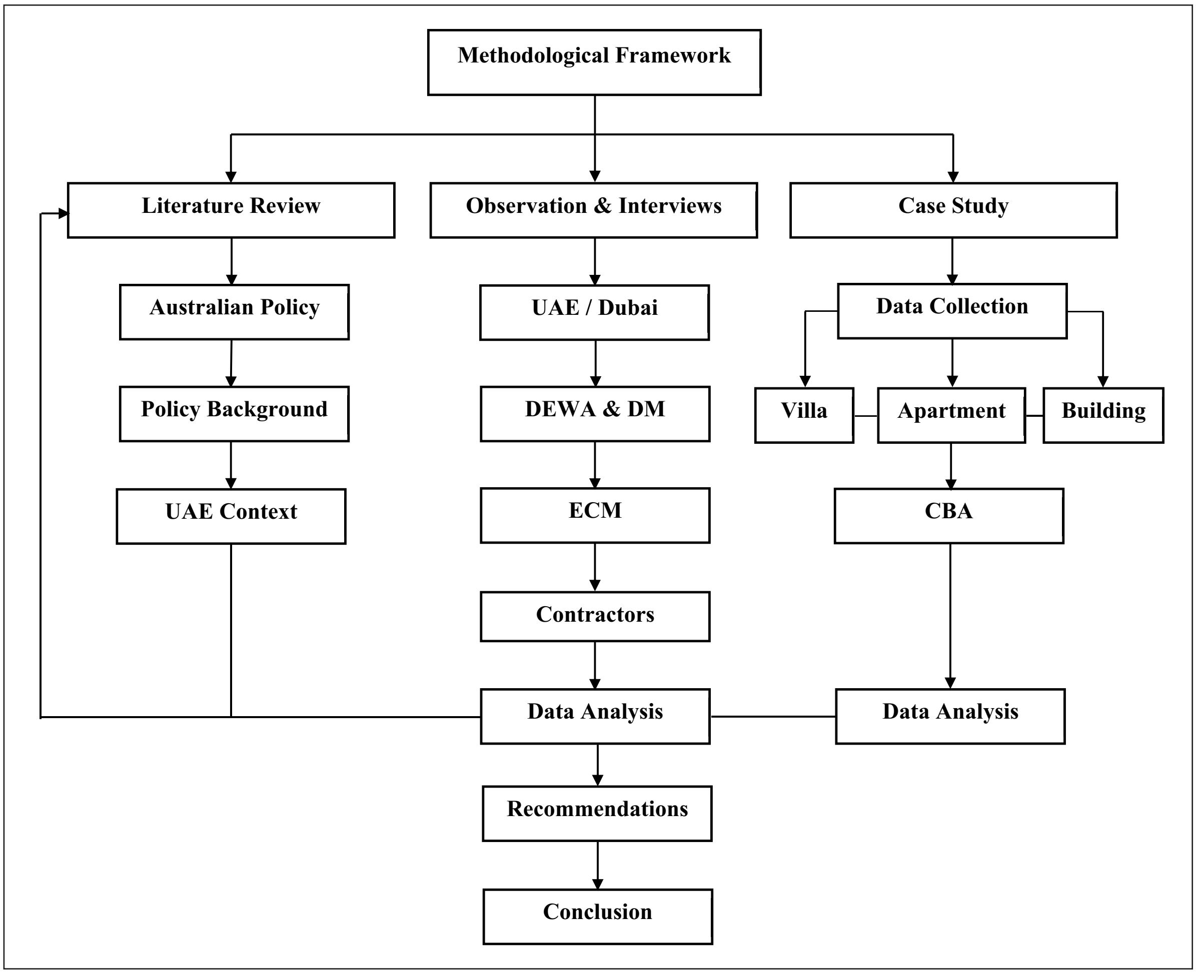

Figure 1: Methodological framework of this study.

amount of electricity consumption of each apartment covers water heating, lighting, air conditioning (AC) fan power, and other electrical technologies used. This consumption is excluding the chillers, air conditioning through district cooling system. The site observation showed that the building and roof design could allow the installation of PV panels, and the installation technique can offer advantages of providing shading to the chillers and increasing the cooling unit efficiency. Based on a report by the UAE Ministry of Environment and Water, the country's carbon emissions intensity for electricity generation is 600 g/CO_2 per kWh (MOCCAE, 2011). This means 1 kWh consumption of fossil fuel generates 600 g of CO_2 emissions while this amount could be reduced by the use of solar energy technologies (i.e. PV systems), which was further demonstrated by Martin (2006) in a study (Pehnt, 2006). Moreover, to calculate the reduction in CO_2 emissions and the payback period with the use of PV panels, the following equations have been used:

Equation 1: CO_2 Emissions PV–PP (kW) × 500 g/kW

Equation 2: Payback Period PV–PP × 500 g/kW × 365 × PP × 1000 kg/g

Where:

PV–PP = PV Panel Production (kW)
PP = Payback Period (year)

The data for the study were collected through the interviews with the people who are officially and directly involved in this program. The interviews cover people from authorities DM and DEWA, community master developer and management such as ECM, contractors and suppliers. During an interview with one of DEWA approved contractors, some of the data required for the CBA was indicated; the engineer mentioned that the average size of the panels used in Dubai is 1.9–2.0 m * 0.9 m. This panel normally produces 250 Watt where the cost of each renewable watt produced is 6.00 Dirham (AED), however according to the SD initiative, calculating the total amount of the energy produced in watts and deducting this value from the consumption value, means DEWA does not offer any price for the energy produced but rather the bill of the producer/consumer is reduced (Dubai Media, 2017).

Results and Discussion

The aim of this study was to assess the capability and feasibility of implementing solar panels, i.e. photovoltaic, on a community scale as a step toward adopting the 'Solar Town' model. The cost benefit analysis of installing solar panels on the selected case study community was evaluated on three levels accordingly with the types of property within the community: (1) Apartment, (2) Building (i.e. apartment block), and (3) Villa. **Figures 2** and **3** show the number of panels and the initial cost for each property in the community (including a block of apartments). As can be seen, the number of panels and consequently the initial cost for the villa is higher than the apartment initial cost.

Figure 4 shows the PV system production compared to the monthly consumption for each property type and as can be seen that the villa consumption is higher than the apartment consumption, as the villa consumption covers the total energy use including the AC consumption.

The results showed that the maximum production of each apartment is 4.0 kW, which is three times higher than the monthly consumption of 1.1 kW, and the rest of the clean energy produced is 2.9 kW that can be exported to the grid, taking into account that the consumption of an apartment does not include the AC consumption, according to the regulations of the 'Shams Dubai' program, and therefore DEWA would not pay back the surplus of the clean energy produced. The authority will transfer these "watts" to the next month consequently.

However, the calculation of the case study apartment consumption includes the electricity used for water heating, lighting, AC fan power, and other electrical technologies, and it excludes the electricity required by the chillers (through the district cooling system) as the

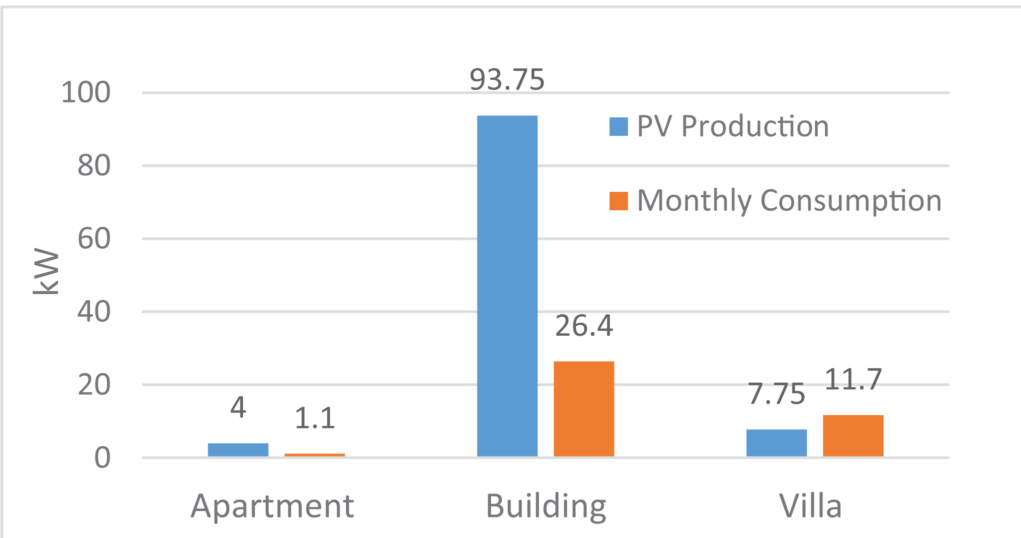

Figure 2: Total number of panels for each property.

master developer (Emaar) is providing this service against a specific yearly service fee calculated by the area (sqm).

The calculation of the proposed scenario of assuming that the owner has totally independent consumption of DEWA usage as well as the associated AC consumption (3.9 kW), it shows that installing PV panels would cover the total electricity consumption with a small surplus of 0.1 kW (**Figure 5**). In this case, the payback period for installing a PV system will be decreased from 7 years to 2 years (**Figure 6**).

The first proposal of installing PV panels on an apartment by the household (owner or tenant) would not obtain the maximum benefit from installing a PV system as it would not cover the total payment of electricity usage. Furthermore, alteration fee may be required from the owner to be paid to the developer as an additional fee. According to the second proposal of conducting a CBA on the whole building block scale, the developer takes the full responsibility to install PV panels on the building's rooftop. As shown by the calculations, the total cost of panel installations is less than the cost required for each apartment separately. This is due to non-separated meter required for each system by DEWA, consequently, and the payback period is less for the whole building system installation, and the reduction in consumption will be due to the electricity required for air conditioning (by the chillers), which is controlled by the developer. **Figure 7** shows the clean energy that can be produced by the whole building block, i.e. 93.75 kW with respect of the existing energy consumption of each apartment. This energy can cover the total building (24 apartments) monthly DEWA bill, and the variance of 67.35 kW can be used by the master developer to reduce the electricity demand required by the chillers.

In the third proposal of installing PV panels on villas within the community, the total clean energy production could be directly reduced by the total electricity consumption since the total consumption covers all the electricity consumed by the villa including the AC consumption. **Figure 8** shows that the renewable energy produced by a villa can cover

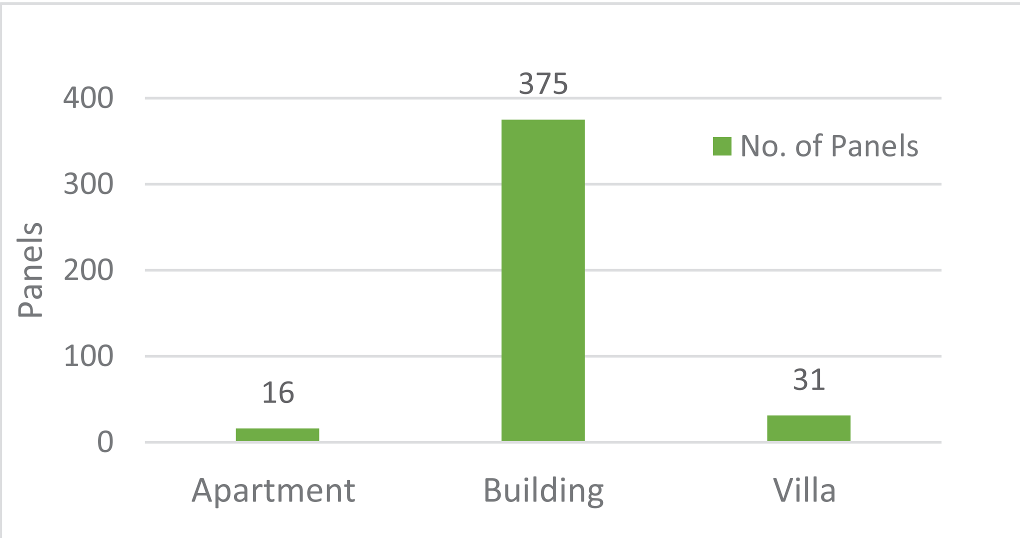

Figure 3: PV system initial cost for each property.

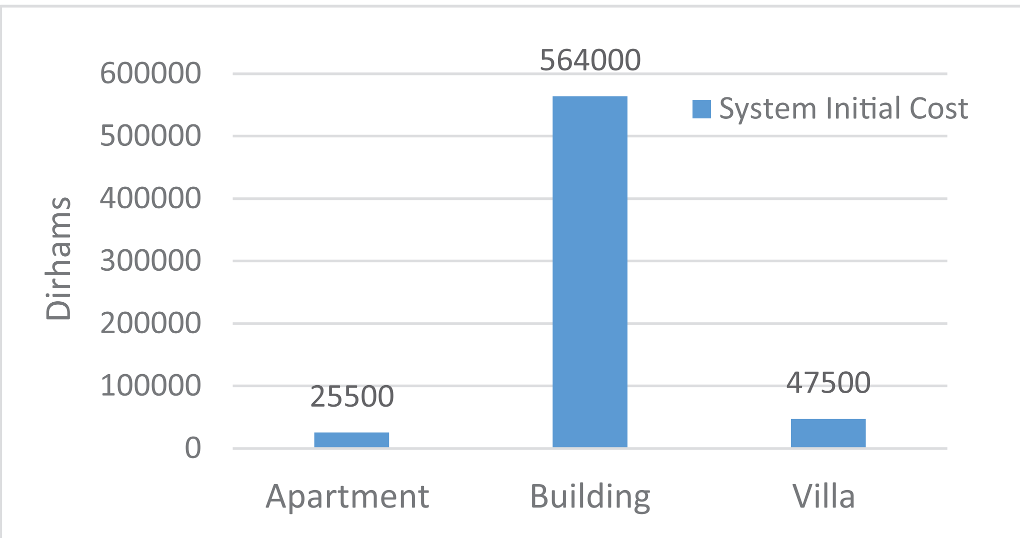

Figure 4: Total PV production compared to monthly energy consumption for each property.

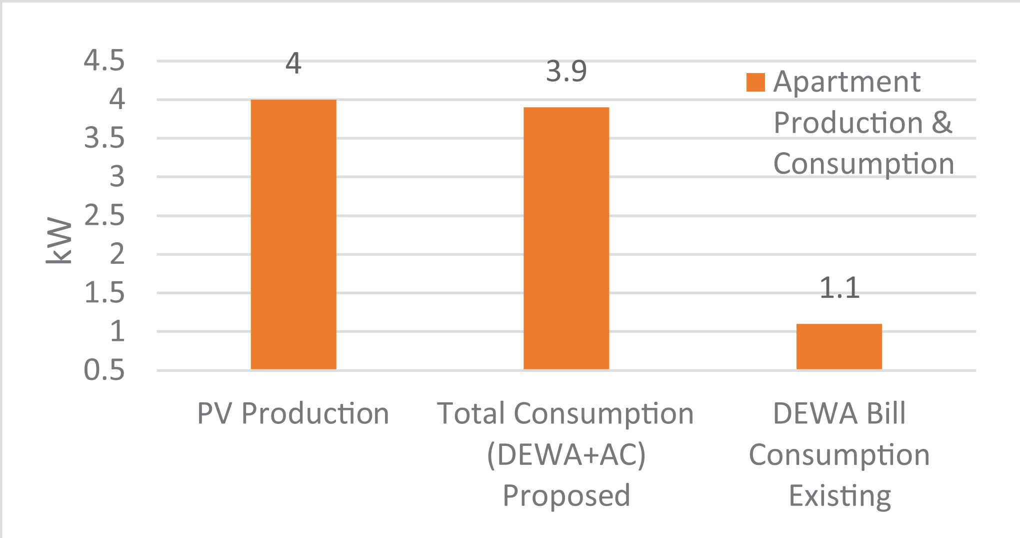

Figure 5: The apartment total electricity consumption and proposed PV production.

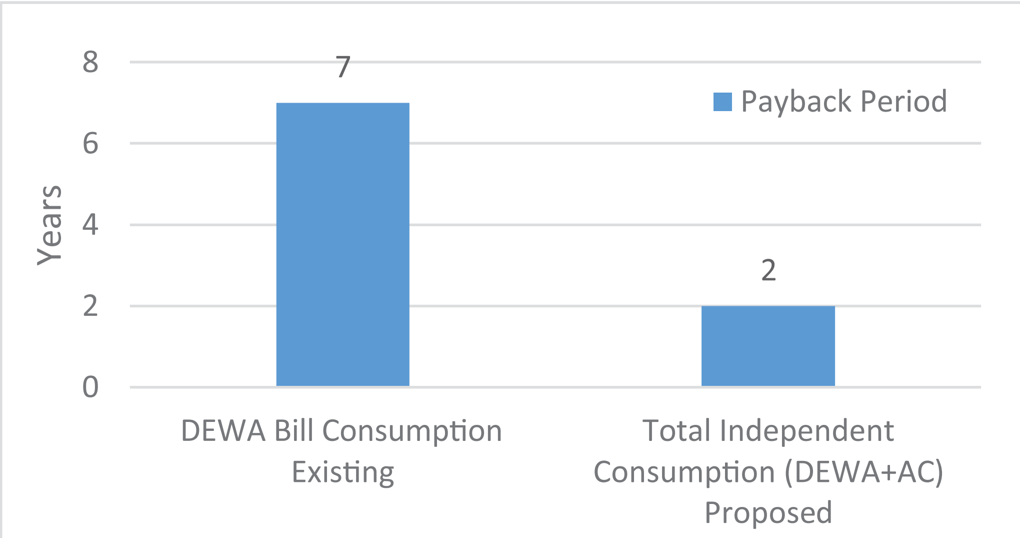

Figure 6: Payback period for the apartment with the proposed scenario of total electricity consumption.

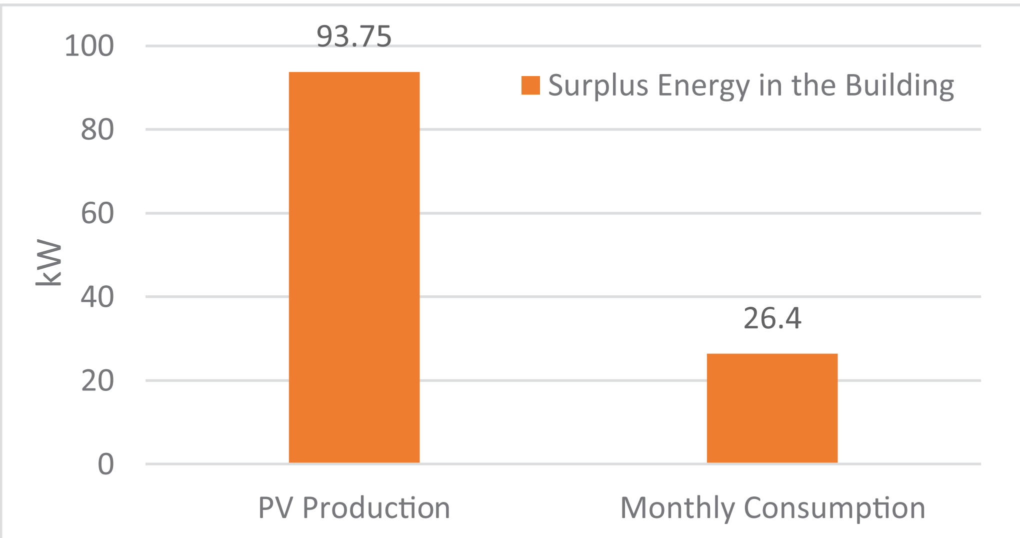

Figure 7: The surplus energy of the building with PV panels.

up to 60% of the monthly consumption, and the rest (up to 40%) of the consumption is covered by DEWA. In other words, the onsite energy can reduce the villa's electricity bill by up to 60% if the villa uses the maximum available area on the rooftop to install a PV system. This result provides an indication that some actions are required to increase the use of renewable energy by the villa owners.

However, it should be noted that the calculations conducted according to the maximum area available on the rooftop to maximize the benefits from solar energy, and it is optional for the developer or the villa owner to use less area and to install less number of panels. **Figure 9** shows the variation among the energy surplus calculated for each property.

Furthermore, there is no major variation in the payback period between the different types of community properties; according to the calculations, and the villa has the less payback period of 6.6 year than the apartment, which is 7 years, taking into account that the apartment's consumption is only through DEWA (i.e. partial consumption). On the other hand, the total building payback period is 6.5 year, which is less than the individual apartment payback period of 7 years as the initial cost for the building PV system installation is less than the individual apartment system installation (**Figure 10**). The variation in payback period between the apartment, the building and the villa is related to the availability of area on the rooftop; where the number of PV panels can be installed in the villa, the apartment and the building are as follows: 31, 16, and 375 respectively.

Table 1 presents a summary of the calculations as the results, which are further analysed and discussed in the paper.

More than the CBA of installing PV panels on the community properties, an environmental impact calculation and analysis have been conducted to determine the environmental impact of using renewable energy technologies. The calculation was conducted according to the reduction in CO_2 emissions that can be obtained by using the calculated number of PV panels

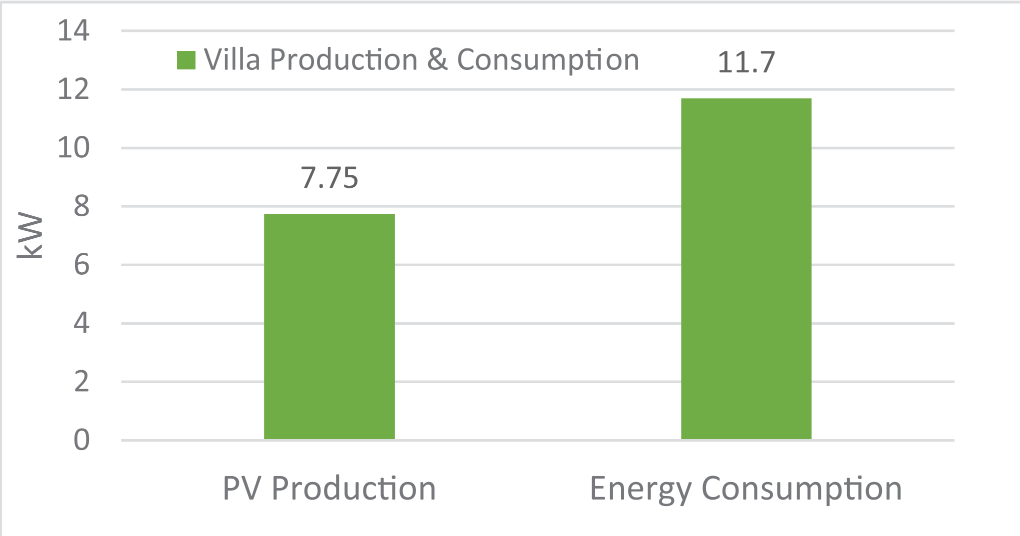

Figure 8: The villa PV production and energy consumption.

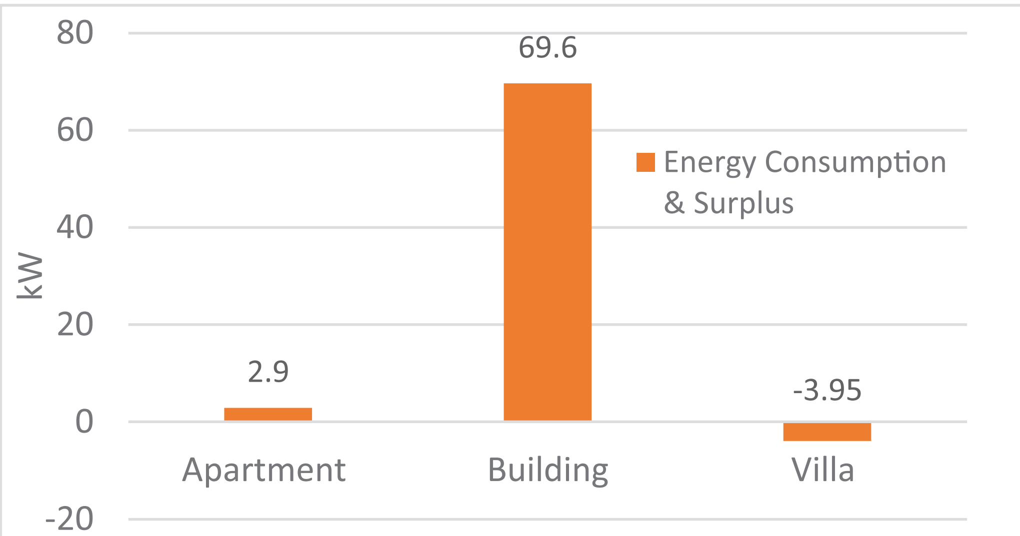

Figure 9: PV energy surplus for each property.

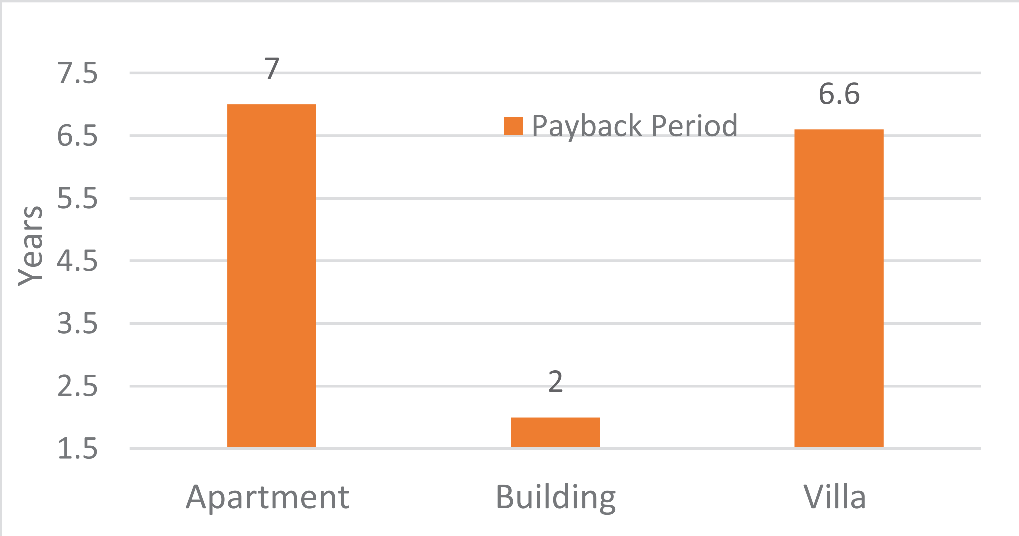

Figure 10: The payback period for each property.

Table 1: Summary of the existing case calculations.

Property Type –	PV Production kW	Monthly Consumption kW	Number of Panels –	Surplus kW
Apartment	4	1.1	16	2.9
Building	93.75	26.4	375	69.6
Villa	7.75	11.7	31	–3.95
Property Type –	**Initial Cost of System Dirhams**	**Payback Period Years**	**CO_2 from PV g (gram)**	**CO_2 Reduction by using PV**
Apartment	25,500	7	400	2000
Building	564,000	6.5	9375	46875
Villa	47,500	6.6	750	3900

for each property, comparing the emissions occurred by using the fossil fuels for the same amount of energy produced. The calculation shows that installing PV panels on the building's rooftop to serve the whole building block has much more environmental impact than the use for one apartment or villa scenario, which makes sense as the area of PV panels would be much more when using the building's rooftop, and the number of panels will be installed is much higher than the number of panels will be installed on the apartment or the villa. The reduction in CO_2 emissions for the type of property; apartment, building, and villa are as follows: 46,875 g, 3,900 g, and 2,000 g respectively (**Figure 11**).

Conclusions and Recommendations

This study evaluated the capability of implementation the Australian program 'Solar Town' within the local context of Dubai, and explored the barriers of implementing the program on urban level. The evaluation of implementing PV panels has been conducted on three levels according to the community property type; (1) apartment, (2) building, and (3) villa. The results showed that installing the system by the apartment would not provide the optimum benefit from the energy produced onsite as the surplus energy, which is about three times higher than the consumption, would be exported to DEWA and calculated toward the next month's bill, while the apartment pays a large part of the energy consumption (e.g. AC) to the master developer as part of their service fee.

According to the economics literature, this represents a type of 'market failure' or 'systematic failure', which requires a governmental intervention to produce or improve the environmental policy to regulate the relation among the stakeholders; master developer, apartment owner and/or tenant, in order to remove the barriers that impedes the large use of renewable energy and solar panels, and to increase the use of clean energy on urban and communities level in Dubai.

Therefore, a scenario was suggested to find the impact of installing PV panels on the case study apartment to cover the total consumption (DEWA + AC). The results showed that the PV energy generation could cover all the consumption of the apartment with small surplus and less payback period of 2 years, but comparing

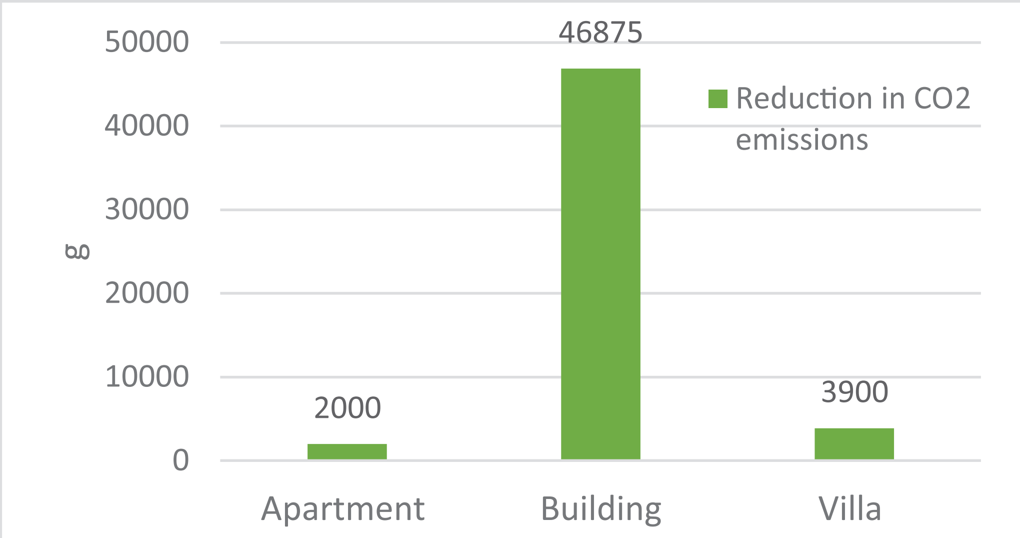

Figure 11: Reduction in CO_2 emissions by the use of PV panels for each property.

to the villa, the PV energy production could cover only 60% of the villa total consumption. This result supports the concept that the high dense areas (with apartment blocks) are less in energy consumption as they are protected against solar exposure and gains. The obstruction of optimizing the benefits obtained by the apartment owner or tenant from installing a PV system is indicated as one of the barriers that limited the use of PV panels on large scale. This problem could be overtaken through improving and developing regulations and policies that involve all stakeholders. The urban fabric of Dubai city consists of developed neighbourhoods and communities; this could support the implementation of the program, as the master developer or the community management could implement the program on large scale directly. This is one of the Australian policy conditions for implementing the program and providing funding, as the building should be owned or operated by one owner or organization. However, the application of this program needs a cooperative effort from the authorities, community developers and individual owners. Furthermore, installing the system by the master developer on all community buildings and other facilities within the community would provide opportunities to maximize utilization of the available area and to generate renewable energy on large scale, further to reducing installation fees when compared with individual system fees. In this case study, the master developer is responsible for the AC (chillers) consumption, and generating from renewable energy on large scale would provide economic and environmental benefits for the developer, since the developer could use the produced energy to cover the energy consumed by the chiller plants, enhancing the community outdoor environment, in addition to the non-quantifiable benefits mentioned before such as enhancing the organization image. Some suggestions could be recommended in setting and organizing the relation between the master developer and the unit owner, which are as follows:

- The developer takes the responsibility of the whole system installation to obtain the maximum benefit from the solar energy applicable to produce according to the available area, and to use this energy to reduce non-renewable power required to operate the chiller system units. This would meet the concept of the Australian 'Solar Town' program, since one of the conditions of this initiative is that the property should be owned or operated by one owner or an organization.
- The mentioned suggestion requires to develop a policy from the master developer to organize the relation between the apartment owner and the master developer. In this case, an addendum could be issued from the master developer 'Emaar' to be added to the primary environmental policy, which can be developed in the direction of maximizing the energy efficiency and reducing the negative environmental effects.
- Producing renewable energy by the developer should affect the monthly amount of 'services fee' paid by the owner to the developer, and the developer should reduce service fees related to the air conditioning and chillers system.
- The developer would improve the environmental policy in order to cover all the property types within the community and to maximize the installation of solar (PV) panels where applicable by covering other community buildings and facilities.
- The apartment owner "independently" would install a number of panels that can cover the existing monthly consumption, in this case, 4 panels (1000 W) could cover the monthly consumption excluding the air conditioning consumption.
- Developing a policy by DEWA to pay back the owner for the surplus energy produced (Feed-in-Tariff), in order to encourage the unit owners to invest in the sector, and to benefit from the maximum area available, as increasing the production of renewable energy would have a long term positive environmental effect by reducing carbon dioxide emissions.

Moreover, the results showed that installing the system by the villa owners would directly affect the electricity bill as the onsite energy produced will cover 60% of the total monthly consumption and would decrease the depending on standard electricity. However, all calculations were achieved by calculating the maximum area available for each property and reducing the area provided for PV installation that would consequently reduce the number of panels and the energy produced. The payback period and the reduction in CO_2 emissions were estimated for all property types, and the building, i.e. apartment block, has the least payback period according to the number of panels that can be installed and the maximum utilization of the energy produced, while the apartment has the highest payback period as the apartment owner would not be able to obtain the maximum benefit from the energy produced. The CO_2 emission calculations showed that the building offered the highest reduction in CO_2 emissions according to the lager area available for the number of PV panels that can be installed. Finally, the renewable energy sector in the UAE is a new and promised sector, and further research are required to increase, encourage and develop the use of renewable energy.

Competing Interests

The authors have no competing interests to declare.

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