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# Potential of energy efficiency for a traditional Emirati house by Estidama Pearl Rating system

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**Abstract**

Buildings are consuming a high percentage of material resources throughout the world. Green building movements have emerged at a rapid pace since the beginning of the 1990s. The green building rating system developed by the Abu Dhabi Urban Planning Council as part of the sustainable development initiative was launched in UAE in 2010 on the name of Estidama, according to which a new building can score on seven different credit categories. This paper examined the Resource Energy (RE) credit category of the Pearl Rating system on an existing typical old Emirati house and concluded that the existing residential private building stock in UAE has a high potential of becoming Estidama certified. The total points achieved were 16 out of the maximum 21 points in the RE credit category. A number of retrofit strategies were applied in the form of insulation, passive cooling integration and onsite renewable energy generation using the Autodesk Revit® 2017 with Sefaira® 2017 plugin. Future recommendations for the existing building stock are addressed.



*Keywords:* Green buildings; sustainability; building energy; Estidama; energy efficiency

## 1. Introduction

In general, a building consumes 30-40% of energy and 12% portable water globally [1]. Buildings are the major electricity and water consumer in Abu Dhabi (capital of UAE), with 84.6% and 92.2% of total electricity and water

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consumption, respectively [2]. In order to make buildings and communities more sustainable, different green building movements which have specific standards and codes for sustainable development, were originated in different countries in the form of LEED (Leadership in Energy and Environmental Design) in US [3], BREEAM (Building Research Establishment Environmental Assessment Method) in UK [4] and Green Star in Australia [5], for instances. A similar sustainable development program named Estidama was launched in 2010 by the department of Urban Planning and Municipalities (DPM) in Abu Dhabi province of the UAE. It is the first program of its kind in the Middle East region. Estidama is not only a rating method, but it is also a vision and desire to achieve a sustainable way of life in the Arab region [6].

**Nomenclature**

| | |
|---|---|
| BREEAM | Building Research Establishment Environmental Assessment Method |
| EUI | Energy Usage Intensity |
| kWh | Kilo Watt Hour |
| LEED | Leadership in Energy and Environmental Design |
| LCA | Life Cycle cost Analysis |
| PV | Photovoltaics |
| PVRS | Pearl Villa Rating System |
| R | Mandatory credit requirements |
| RE | Resourceful Energy |
| RET | Renewable Energy Technology |
| U | Thermal transmittance |

The Pearl Rating system is a central component of Estidama program. It is the green building rating system developed under Estidama initiative and can be applied to communities, buildings and villas, with different requirements for each, with the scale of 1 to 5 pearl. The aim of the Pearl Villa Rating System (PVRS), which applies to villas only, is to promote the development of sustainable villas and improve quality of life. It encourages water, energy and waste minimisation, local material use and aims to improve supply chains for sustainable and recycled materials and products. According to the government policies all new villas must be designed to achieve a minimum rating of 1 Pearl, while Emirati villas (government funded) must meet at least 2 Pearls [7]. The PVRS aims to address the sustainability of a given development throughout its lifecycle from design through construction to operation. It provides design guidance and detailed requirements for rating a villa's potential performance in relation to the four pillars of Estidama, namely Environmental, Economic, Cultural and Social. The Estidama PVRS (Version 1.0) has seven credit categories on which a building can score, namely; IDP: Integrated Development Process, NS: Natural Systems, LB: Livable Villas, PW: Precious Water, RE: Resourceful Energy, SM: Stewarding Materials and IP: Innovating Practice [8]. These credits are similar in nature to the LEED credits (Location & Transportation, Sustainable Sites, Water Efficiency, Energy & Atmosphere, Material & Resources, Indoor Environmental Quality, Innovation. and Regional Priority) [9].

Previous studies on residential energy improvements according to the rating system, e.g. energy and atmosphere credit category in the LEED rating system was tested in European countries. The improvements were mapped with points and variations were found depending on local conditions. It was concluded that more benefits are expected from this credit category if improved insights about on-site real applications are provided [10]. In Malaysia, the LEED rating system for Homes (LEED-H) was tested on three existing Malaysian green homes (GH). It was found that it did not comply with 12 mandatory prerequisites out of 23 as outlined in LEED-H [11]. Energy Conservation Measures (ECMs) were implemented in ten villas in Abu Dhabi and the villas were monitored for a year. It was found that percentage of savings varied from 14.4% to 47.6% in the total electricity consumption. However, the study was not linked with PVRS and its credit categories [12]. One such study was performed for a villa building in Abu Dhabi. It was found that there was an improvement in the energy reduction by 31 % for the chosen villa building from the base case [2]. However, it was not interpreted into credit category points.

In the current paper, a case study of a typical old Emirati residential villa building is examined with respect to the RE: Resourceful Energy credit points. The energy performance is mapped with credit points achieved to find the

potential of energy improvement for the existing villa buildings on the score sheet of PVRS. The residential sector has always dominated the construction industry in the city. In addition, sustainability has been emphasized on the new residential buildings as 83% of the new buildings built in 2015 in Abu Dhabi were residential [13]. The current traditional residential building stock has not been addressed before with respect to sustainability as studied here.

## 2. Building Characteristics

The selected building is an old traditional Emirati residential villa located in Al Hayer (Abu Dhabi Province). Fig. 1 shows the location of the selected building in both city and site map. The model was drawn in Revit® 2017. The total site area was 828 $m^2$. The plan consists of twelve bedrooms, seven bathrooms, a living area, one male hall, one female hall, two stories, a pantry and a kitchen as shown in Figs. 2, and 3. It is built to accommodate eleven people [14].

## 3. Methodology and Results

The software used for the analysis was Autodesk Revit® 2017 [15] alongside a plugin of Sefaira® tool [16] which specializes in cloud-based computing solutions for high-performance building design. The maximum total credit points achievable is 90 in PVRS out of which the RE: Resourceful energy credit can score maximum of 21. There are two possible methods of claiming points either through the Prescriptive method or the Performance method. Performance method was used in the methodology of the current study [8]. The Resourceful Energy (RE) credit category has achieved the sub credits mentioned in Table 1.


Fig. 1. Location of` the building in city (left) and in site map (right)

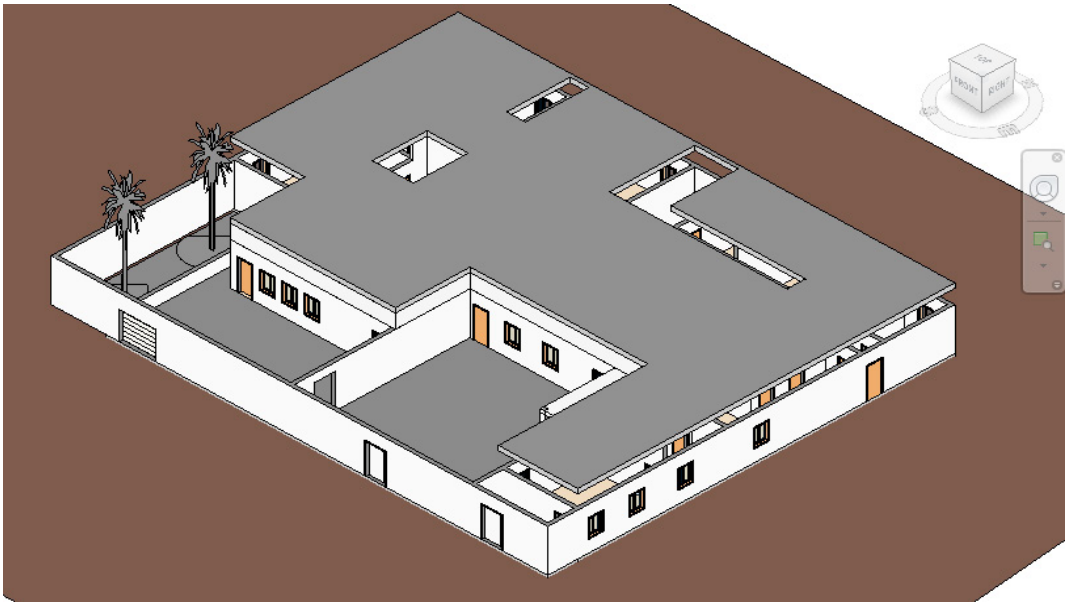

Fig. 2. Traditional Emirati villa drawn in 3D in Revit® 2017

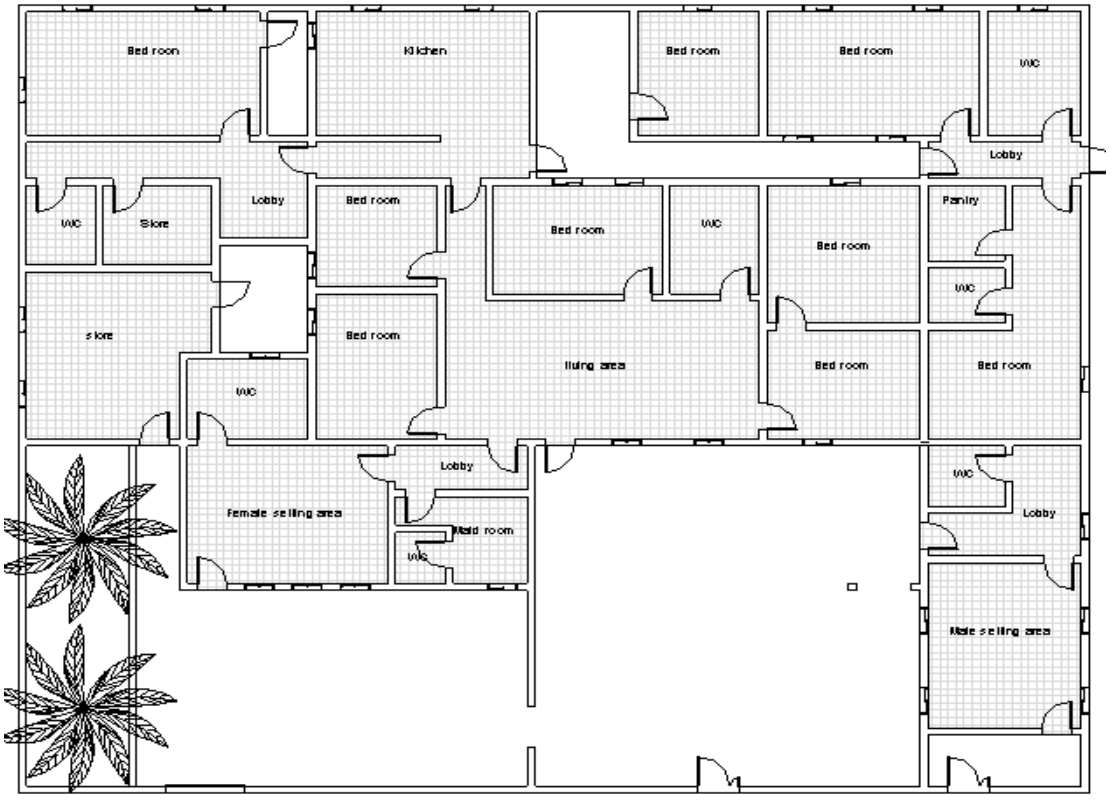


Fig. 3. Plan of a traditional Emirati house Revit® 2017

Table 1. RE: Resourceful Energy credit category

| Credit Code | Credit Title | Villas |
|---|---|---|
| RE-R1 | Minimum Energy Performance | R |
| RE-R2 | Energy Monitoring | R |
| RE-R3 | Ozone Impacts of Refrigerants Systems | R |
| RE-1 | Improved Energy Performance | 8 |
| RE-2 | Cool Building Strategies | 6 |
| RE-3 | Renewable Energy | 7 |
| | **Total** | **21** |

R stands for mandatory credit requirements, it does not have any points and a building can score only on an optional credit achievement, e.g. RE-1, RE-2 and RE-3.

### *3.1. RE-R1 Minimum Energy Performance*

The Thermal transmittance (U) values used for the building elements in this credit category are listed in Table 2. These are the minimum standards for insulation according to the Estidama villa rating system [13]. The total energy load was found to be 164,585 kWh per year or 189 kWh/m$^2$/yr (Energy Usage Intensity – EUI) as shown in Fig. 4. This was taken as a Baseline building energy performance for the model. The Baseline external heat gain was 106.35 kWh/m$^2$/yr.

Table 2. Building element profile

| Building Element | U Value (W/m$^2$K) |
|---|---|
| Walls | 0.32 |
| Roof | 0.14 |
| Façade Glazing | 2.2 |
| Floor | 0.15 |
| Infiltration rate | 0.35 ACH |
| Solar Heat Gain Coefficient (SHGC) | 0.4 |

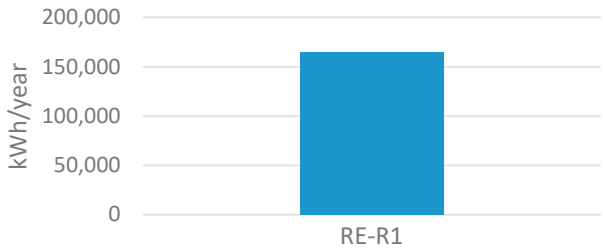


Fig. 4. Total energy load for the building

### 3.2. RE-1 Improved Energy Performance

The same methodology outlined in RE-R1 was used with further percentage reductions in the proposed building by taking some energy conservation measures. The lighting power density was taken as 3.9 W/m$^2$ as strategy of green lighting [17]. The total cooling load for the year became 105,218 kWh per year having an EUI of 127 kWh/m$^2$/yr. A percentage drop of 36% was found from the baseline, as shown in Fig.5 resulting in claiming 6 credit points. Consequently, an improvement between 30% and 40% results in 6 credit points as per the Estidama villa rating system [8]. This was taken as Proposed Building Energy Performance.

Percentage Improvement = 100 × (Baseline Building Performance (kWh/yr) – Proposed Building Performance (kWh/yr) ÷ Baseline Building Performance (kWh/yr) = 36%

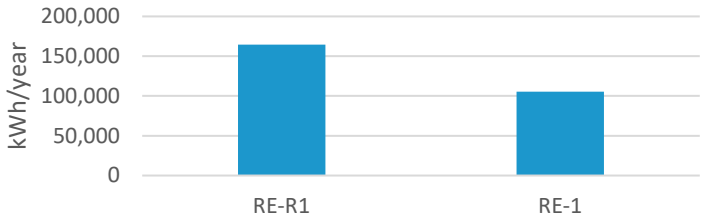


Fig. 5. Comparing base case building performance with proposed case building performance

### 3.3. RE-2 Cool Building Strategies

Further improvements were made in design in the form of external shading devices (0.55 m) both vertically and horizontally. Also, natural ventilation system was chosen for the desired months and profile was made in Sefaria. The external heat gain performance was 54335 kWh/m$^2$/yr (EUI). This has resulted in 60% improvement as shown in Fig. 6 in the External heat gain performance compared to the External heat gain performance of the Baseline building in RE-1. According to the rating system, 5 points were achieved [8].

Percentage Improvement = 100 × (Baseline Building External Heat Gain (kWh/m$^2$) – Proposed Building External Heat Gain (kWh/m$^2$) / Building External Heat Gain (kWh/m$^2$) = 60%

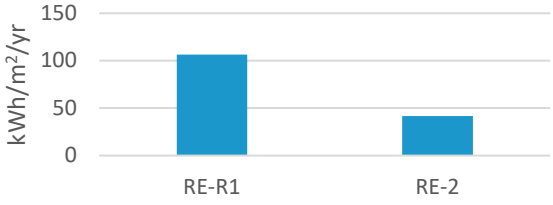


Fig. 6. Comparing base case building EUI with proposed case EUI

### 3.4. RE-3 Renewable Energy

For this credit, the only onsite Renewable Energy Technology (RET) source selected was Photovoltaics (PV). PV watt calculator [18] was used. The specifications for PV panels were taken from Sunergy Solar (a local supplier) [19]

and 25% of the roof space was used. It resulted in total onsite energy of 35,837 KWh from the PV panels which accounts for 21% of the total proposed building energy performance (105,218 kWh per year) as shown in Fig. 7. According to the rating system, 5 points were achieved [8].

Percentage Onsite Renewable Energy = 100 × ∑ Annual Energy Generated from Onsite Renewable Energy Technologies (kWh) / Proposed Building Energy Consumption (kWh) = 34 %

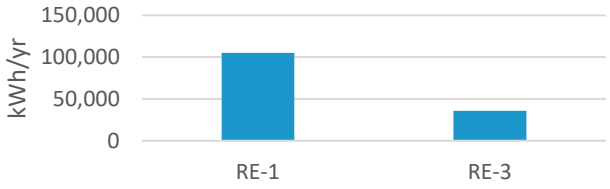


Fig. 7. Comparing proposed case energy load with onsite Renewable Energy production

Table 3. Total RE credit points calculation

| Credit Code | Credit Title | Points achieved | Max Points |
|---|---|---|---|
| RE-1 | Improved Energy Performance | 6 | 8 |
| RE-2 | Cool Building Strategies | 5 | 6 |
| RE-3 | Renewable Energy | 5 | 7 |
| | **Total** | **16** | **21** |

### *3.5. RE-R2 & RE-R3 Energy Monitoring and Ozone Impacts of Refrigerants*

These two mandatory requirements could not be simulated during the building simulation like the other credits because RE-R2 is about installing energy sub meters which should be capable of monitoring energy consumption. RE-R3 is about promoting those refrigerant systems that has minimum impact on the environment [8].

## 4. Conclusions and recommendations

The total number of points achieved were 16 out 21 in the RE credit category as listed in Table 3, i.e. a traditional Emirati house has a high potential of scoring in the building energy category if proper retrofitting is accomplished. Finding the building materials and adjusting the U values of the building elements as per the minimum requirement of Estidama for the existing buildings will be interesting because some of the energy efficient building materials are not available in local market and has to be imported which can increase the cost of retrofit. Also, claiming points through Natural Ventilation in certain months depends on wind direction and speed as described in [20]. Other passive strategies like introducing green walls can also decrease the external heat gains in hot arid climate as shown in [21]. Therefore, these points can vary from case to case depending on the site conditions. Life Cycle Cost Analysis (LCA) study can be carried out for the whole building to find the payback period for the existing buildings after completing the major improvements though one such study has been accomplished in 2014 [22] even though it was not a residential private unit. Other credit categories study can also be accomplished to find out how much it scores in totality out of the total score (90). Only PV study was taken as an onsite Renewable Energy Technology (RET). Other RET sources such as, Wind turbine, Solar thermal collector and Geo thermal, impact can be studied too. The UAE government has a regulation of one Pearl Rating to be achieved for new private building and two Pearls for new government buildings. In order to convert the existing buildings into sustainable ones, green building regulations integration during retrofitting is now inevitable though the government has launched a project of 3000 non-residential buildings to be energy retrofit under Tarsheed program [23]. Exciting times ahead for the building energy sector as existing building stock will be addressed.

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