

Case Studies:

Feasibility Study of Zero Energy House in Nablus-Palestine

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Abstract: In the last years, 20% world's population has seen rapid growth that has profoundly altered their routines and quality of life. People paid a significant price for this improvement. A high usage of energy, derived from fossil fuels, increased carbon dioxide and emissions out into the air, causing global warming and damages the environment. As a result, new construction ide-as must be reconsidered. The challenge for emerging sustainable cities is to expand in accordance with tomorrow's lifestyles, while also creating a better relationship between environment and humanity and reestablishing lost interpersonal contacts. One approach is to design and build (ZEH), which minimize the pollution effect and the use of non-renewable resources. The coming factors should be examined in particular: the use of renewable and recyclable materials; improving building energy efficiency; introducing improved efficient energy systems that use alternative and clean sources etc. In this study a house of 200 square meter house of two stories was studied and it was occupied by four persons. To make this house zero energy, we will first construct the following renewable energy systems on the 115 m2 flat roof, followed by the installation of a solar water heating system. Finally, we will build a solar power system. and the following adjustments will be made to increase energy efficiency, for that Ret-screen software was employed and used for this simulation. The results showed that results showed a zero energy home of savings of 222 tons of co2 emmission a saving of 222845 ILS in fuel. The total savings were 311715 ILS. The results showed shows that the impact on the NPV is stronger for the "initial cost than that for the fuel cost base case.

Keywords: Energy efficiency, zero energy home, renewable energy system, sustainability, energy effi-cient homes, building energy simulations.

1. INTRODUCTION

Net Zero Energy home case study in Nablus is presented here in West bank city of Nablus. Nablus is 40 km from Jerusalem north. The goal was to design houses that integrate energy resource and energy efficient technologies in order to lessen their environmental effect. A net zero-energy home (NZEH) is described in this paper as a dwelling that uses as much energy as it generates over the course of a year. In short, the overall goals of this paper are firstly to create a clear vision and approach to home building in Palestine and increase the capacity of the national housing and renewable energy industry sectors secondly to produce high-quality product across the country over time [1]; Thirdly to achieve market acceptance of low-impact housing by the NZEH in Palestine. Buildings have a large influence on both energy consumption and the environment. This paper is unique in this field in Palestine in general and in the literature as a general case. [2] Fourthly to described the utilization of twelve years consumption of gas and evaluate performance of an existing residential building using RET screen. Developed RET screen Small Hydro Project Model [3] Fifthly gals were to make complete pre-feasibility studies with financial analysis [4] and propose a new sustainability approach to the building design process. Earlier researchers worked on designing the energy building reduction components to see if it was

possible to reach a net-zero energy building. Both the commercial and residential buildings consume more than forty percent of primary energy and approximately seventy percent of electricity in the United States [5]. The United States Department of Energy (DOE) has set a lofty target of research and development basis for cost-effective zero-energy commercial buildings by 2025 [6]. Most self-built low energy houses are one-of-a-kind, and the suggested designs need detailed study to predict their future energy and performance, which is highly reliant on their design and location. Building simulation may serve as a reference for this performance and be used to evaluate various design choices for optimization, using RET-screen expert software a design of the house was conducted where manipulation of the building materials, equipment, appliances building envelope, heating and cooling equipment and also the working schedules during the heating and cooling seasons, all this taking into consideration the location and the weather data all over the year by calculating the degree days, Also simulating the PV system using the solar radiation and the wind speed. The zero-energy home may or may not be linked to the power network.

The net-zero energy project provides a comprehensive answer to the current environmental difficulties confronting business and residential buildings. On-grid net zero energy residences generate renewable energy on-site in an amount equal to

or more than the entire yearly energy usage of the building. The net component indicates that the facility may utilize energy from a utility grid (electricity) at some periods of the day (or night) but contributes renewable energy to the grid at other times [7]. Over the course of a year, this balance equals out. Palestine is an occupied area with limited resources and no control over energy or natural resources or even the data. It is not allowed to produce fuel search for oil or even wind or solar energy. The information and the weather stations are very limited to the areas controlled by the occupation which makes this study the first of its kind. Researches in this area is a monopoly for the occupation. [8] conducted a study Potential Zero energy building in Palestine. They made the study without using a simulation program. Also they did not add a feasibility study or environmental evaluation. Their study did not include adding a PV system. Their study was more a redesign for an existing building. [9] conducted a study for testing Low Energy Residential House: Combining Different Strategies in Palestine. The author studied a building using Design Builder an

This study was considered a reference for architects to design low energy buildings. Again, the study conducted a descriptive-analytical approach. [10] conducted a review of the green building sector in Palestine in terms of research issued, governmental and non-governmental bodies concerned with the development of this field, also to provide a review of the most important projects implemented as green building in Palestine, also the obstacles prohibiting adoption of green building. But none of the studies conducted was about simulation using RET screen, and as described a comprehensive environmental or economical aspect. Very few studies on the NetZero buildings for Palestine region can be found conducting a review which makes this study as a reference in this field for the first time.

2. Materials and Methods

The Ret-screen software was used for the simulation purposes and for that purpose a few assumptions and approaches were done. Data from RET screen local weather stations were used for the solar and weather data in Jerusalem as the closest ground weather station that matches with the weather condition although it was 40 KM far no other weather station with such a good match to Nablus mountainous nature is closer. Only 1 degree Celsius is the difference between the tow cities. Both cities has the same nature of wind speed solar radiation material nature of buildings etc. so we are going to assume similar data for booth cities for the purpose of the study. The local building materials were used for the definition of the loads and the cooling and heating load calculations, also the local electricity and Lpg tariff also were used together with the water prices. For the data of the equipment the data in the software library were used and sometimes the data from local market were also used. A 20-kW photovoltaic system were installed, a heat pump for heating and cooling were considered which saved in initial cost for the system. Improvements in the building envelope were done with regards to insulation for roof and walls, also in window and doors improvements and leaks in order to reduce the energy consumption. Also, a replacement of lighting fixtures was done, appliances have been replaced some times and scheduling in operation for appliances and heating and air-conditioning were considered.

By using the gas bill information and Northern electricity distribution company tariff beside the information collected about

the construction cost for windows doors enhancement of the building envelop and the appliances together with the scheduling of operation for the equipment, the gas consumption rate of the residential building was analyzed. Units and fuel rates were inputted, interest rate, time span for the system was also defined, carbon taxes or intensives were included. Heat pump for cooling and heating was introduced instead of heating using LPG boiler, Electric water heater was replaced by Solar water heater and heat pump in winter. The investment in the cooling was zero because the cooling was done using the same apparatus which is heat pump. 7 kw peak PV system was also introduced.

2.1 Data preparation

After the data was collected it was analyzed using RET Screen Expert software. With which, the weather information; the longitude and latitude, the climate belt, the building elevation, the heating and the cooling design input temperature, and finally the earth temperature amplitude. Data collected was for both the climate data location and the facility location to achieve the best result in the preparation of the data, the following two steps were taken. The first part of the software presents the facility information where all the necessary information like the facility type, type of building, facility name, address, were included. This was followed by the benchmark information where information like the home area, the Energy intensity in the building, the lower and higher benchmark of the home, the energy base case, and the proposed case of the energy use intensity were reported, all other parameters were automatically calculated and filled based on the initial facility location information provided by the software and the bench mark to reach the desired net zero energy.

2.2 Location and assumptions:

The house consists of two floors of 100m² each located in West bank city of Nablus north of Palestine on mounting Eibal at 35.2577481692464 longitude and 32.2319986450968 latitude at elevation of 726 m and because of the lack of the data in Palestine the nearest weather station used was Jerusalem Airport which is 35.22 latitude and 31.87 longitude and elevation of 756 m figure 1 shows the data from the weather station. The house is built ub of stone layer of 5 cm then concrete 5 cm layer after that halo Brik of 10 cm. the building is facing the four directions, it has windows of aluminum that are not very tight single glass and steel main door. The occu-pants are four people. The heating load was estimated to be 24 kw, and so is the cooling load, hot water load was estimated to be 5 kw for 4 members family. Cooling indoor conditions was 24 and 50% relative humidity, and the outdoor conditions was 5 degrees dry bulb and 76% relative humidity, and in summer the dry bulb temperature outside was 23 and the relative humidity was 60% indoor design summer conditions was 24 dry bulb and 50% relative humidity. Electricity rate was assumed to be 0.65 NIS per KWhr. And water 6.11 Nis /m³ flat rate. The LPG cost was assumed to be 5.5 NIS/kg. Led lux per watt was assumed to be 70 lux /w and for incandescent lambs the lux per watt was assumed to be 15. The base case was heating the building with LPG boiler under floor heating system and the hot water system was via electric water heaters, the re-placing systems were heat pump for heating and cooling and heat pump for hot water system and also solar water heaters. The windows and doors were assumed to be leaky and was replaced by tight ones the cost for the door and windows replacement were 15000 NIS. The fuel and electric billing system were as per the cost of May 2022. The used heat

pumps were phinex that has the attached catalog of 40 kw capacity. The air conditioning system was used using the same heat bum by adding fan coil system, and this has an incremental cost of 15000 NIS To replace the cooling system that was split units. A solar panel system of 50 kw system was proposed.

2.4 Building Envelope

The building envelope was defined and data were inputted for the base case and the modification that needed to be done in the envelope to enhance the efficiency of the building. This will define the loads that will be used for the calculation of the used fuel or electricity. The temperature, the schedule of operating, the occupancy etc.

2.5 Energy consuming equipment's

Equipment has to be also defined for the systems what system and what is the investment and operational cost, the seasonal efficiency, manufacturer, model number, quantity, savings

and costs that are encounter and any other relevant information for all the systems being used i.e. Heating, cooling, appliances, water heater, etc.

2.6 Power production installed systems

In this page we inputted the proposed system for power generation and all the information relevant to the system, the size the capacity, quantity, manufacturer data, name, model number and the initial and operation and maintain ace cost that will be encountered. This information will be related to the solar energy and weather conditions from the station to find out how much power will be produced all over the year. Figure 1 presented the daily solar radiation and air temperature per month that was used in the calculations. The data varies between 280 kwh/daym2 and 870 kwh/m2.day and the temperature variation was between 7 in December and 21 degrees centigrade in June.

Unit		Climate data location		Facility location		Source	
Latitude			31.9		32.2		
Longitude			35.2		35.3		
Climate zone			48 - Mixed - Dry				Ground+NASA
Elevation	m		759		0		Ground - Ground
Heating design temperature	°C		2.0				Ground
Cooling design temperature	°C		31.2				Ground
Earth temperature amplitude	°C		23.1				NASA

Month	Air temperature °C	Relative humidity %	Precipitation mm	Daily solar radiation - horizontal kWh/m ² /d	Atmospheric pressure kPa	Wind speed m/s	Earth temperature °C	Heating degree-days 18 °C	Cooling degree-days 10 °C
January	7.7	76.1%	41.73	3.37	96.3	3.2	11.7	319	0
February	8.2	73.4%	34.14	4.20	96.2	3.5	13.3	274	0
March	10.4	70.8%	22.02	5.30	96.0	3.7	17.5	236	12
April	15.1	58.6%	10.19	6.81	95.8	3.4	23.9	87	153
May	19.1	53.6%	4.72	7.83	95.8	3.6	28.3	0	282
June	21.4	56.0%	0.53	8.57	95.6	4.2	31.2	0	342
July	23.1	59.5%	0.07	8.40	95.4	4.5	33.7	0	406
August	23.1	64.4%	0.11	7.85	95.5	4.1	33.8	0	406
September	21.8	64.8%	1.29	6.73	95.8	3.6	31.2	0	354
October	19.1	63.5%	10.40	5.28	96.0	2.8	25.5	0	282
November	14.1	66.7%	17.10	3.74	96.2	2.8	18.8	117	123
December	9.7	73.5%	30.54	3.05	96.3	2.7	13.3	257	0
Annual	16.1	65.0%	172.84	5.94	95.9	3.5	23.6	1,291	2,361
Source	Ground	Ground	NASA	Ground	NASA	Ground	NASA	Ground	Ground
Measured at						m	10	0	

Figure 1 Daily solar radiation- horizontal (KWH/m2day) and air temperature per month and facility data

3. Results and descussion

This report was performed using RET screen software. The key results is presented in Table 1 below, a saving of between both cases and 358223 KWh electricity. This saves 232845 ILS in total because the base case has a cost 213790 ILS that was reduced to -19055 ILS. Table 2 Project verification the consumption of propane was reduced to zero using heat pump and solar energy technology together with heat pump cooling and the reduction in the electricity consumption was also reduced using the effeminacy enhancement procedures, in building envelope and appliances used together with the equipment for heating and cooling with a variance of -101% the propane was reduce to zero consumption and the electricity was reduced to -9332 kwh.

Table 1 Summery electricity and fuels.

Summary - Electricity and fuels							
Fuel type	Fuel type		Base case		Proposed case		Savings
	Fuel rate	Fuel consumption - unit	Fuel consumption	Fuel cost	Fuel consumption	Fuel cost	
Electricity	ILS 0.65	kWh	328,907	ILS 213,790	-29,316	ILS (19,055)	358,223
Total				ILS 213,790		ILS (19,055)	ILS 232,845

Table 2 Project Verification

Project verification				
Fuel type	Fuel consumption - unit	Fuel consumption - historical	Fuel consumption - Proposed case	Fuel consumption - variance
Propane	kg	23,144	0	
Electricity	kWh	1,270,475	-9,332	-101%

The cumulative cash flow was shown in figure 6 below where it was spread over fifteen years taking into consideration all the costs. The climate data obtained for the location of Nablus city was obtained from the ground station located in Jerusalem 40 Km north to Nablus. But the weather is very similar to that in Jerusalem figure 2 presented the data collected from that station plotted.

Table 3 presents the savings that were achieved using the energy reduction majors

Together with the efficient appliances and heating cooling technologies and power generation.

Savings						
	Heating kWh	Cooling kWh	Electricity kWh	Total kWh	Plan kWh	Variance %
Base case	307,942	126,001	176,766	610,709	108,651	462%
Proposed case	21,900	5,845	-37,077	-9,332	0	
Fuel saved	286,042	120,156	213,843	620,041	108,651	471%
Fuel saved - %	92.9%	95.4%	121%	102%	100%	

Table 3 Savings KWH between base case and proposed case for each measure

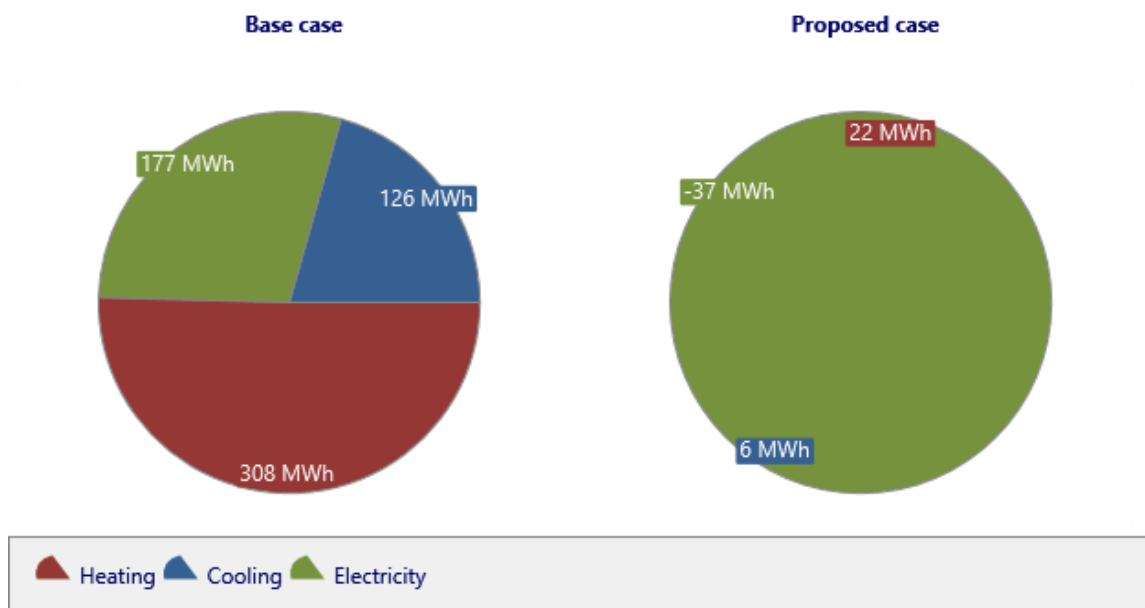


Figure 2 Pi chart Fuel saving in KWH per application

In Figure 2 a pie chart for the fuel saving in KWH per application was illustrated where the heating load consumption of 308 MWH per year was totally saved, and a 126 MWH per year of cooling load savings were also saved the reaming is a 177 MWh conservation of electricity usage were conserved and an extra 6 MWH were also produced.

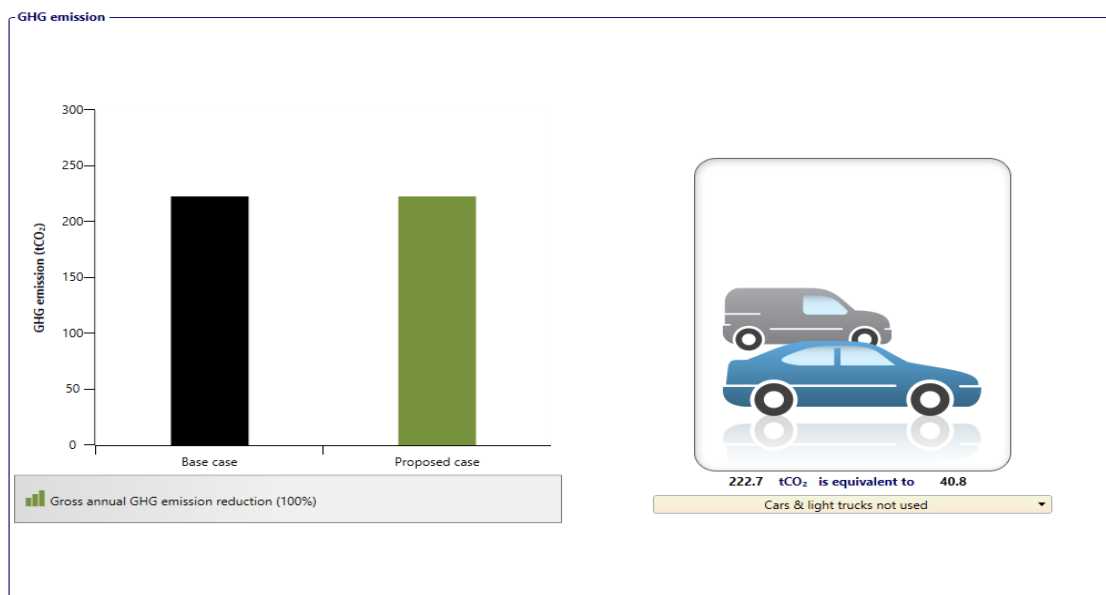


Figure 4 GHG and equivalent Tons of CO2 saved in the facility

Figure 4 above illustrates the total greenhouse gases saved as per the taken measures and their equivalent tons of co2 gas in tons per year a zero emission can be seen with total of 223 tons of co2 were save which is very good it can be compared to 41 cars that are not used, or 520 barrels of crude oil saved or 77 tons of waste recycled. Figure 5 shows a typical house hold production of co2 emotions per house hold per year, in this figure we see that 12.5 tons of co2 is produced per house hold which is around the number that was originally in the base case, this number was reduced to zero in the proposed. Financially wise the systems are very feasible as can be seen in figure 5. For an investment of 111279 ILS the total annual savings for this house were 311715ILS the pretax equity was 989% and simple payback period in average less than 1 year. It is shown in figure 8 that the risk in the initial cost is higher the operation and maintainace cost and the debt interest and fuel cost of the base case then the fuel cost of the proposed case and finally the debt ratio. The analysis shows that the impact on the NPV is stronger for the “initial cost than that for the fuel cost base case.

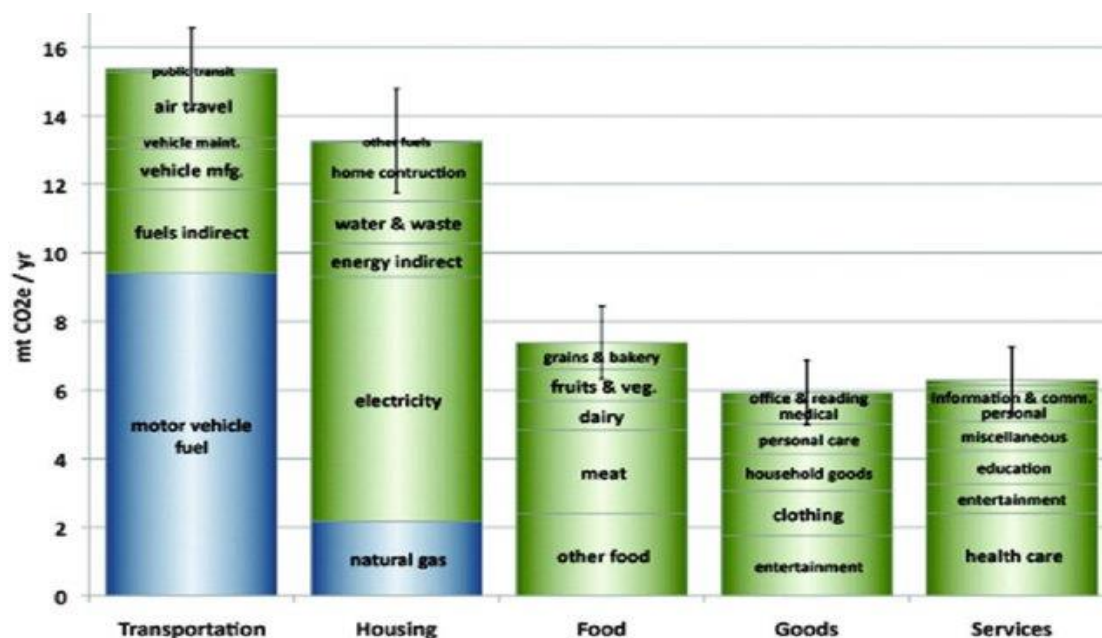


Figure 5 Total carbon emissions of a normal US household 48 tonsCO₂ year [8]

The cash flow for this investment can be shown in figure 6

Costs Savings Revenue				Financial viability			
Initial costs							
Incremental initial costs	66.8%	ILS	74,279				
Balance of system & miscellaneous	33.2%	ILS	37,000				
Total initial costs	100%	ILS	111,279				
Annual costs and debt payments							
O&M		ILS	-12,755	Pre-tax IRR - equity	%	989%	
Fuel cost - proposed case		ILS	-6,066	Pre-tax IRR - assets	%	298%	
Debt payments - 15 yrs		ILS	7,505	Simple payback	yr	0.34	
Total annual costs		ILS	-11,316	Equity payback	yr	0.1	
Annual savings and revenue							
Fuel cost - base case		ILS	311,715				
Total annual savings and revenue		ILS	311,715				

Figure 5 cost saving table

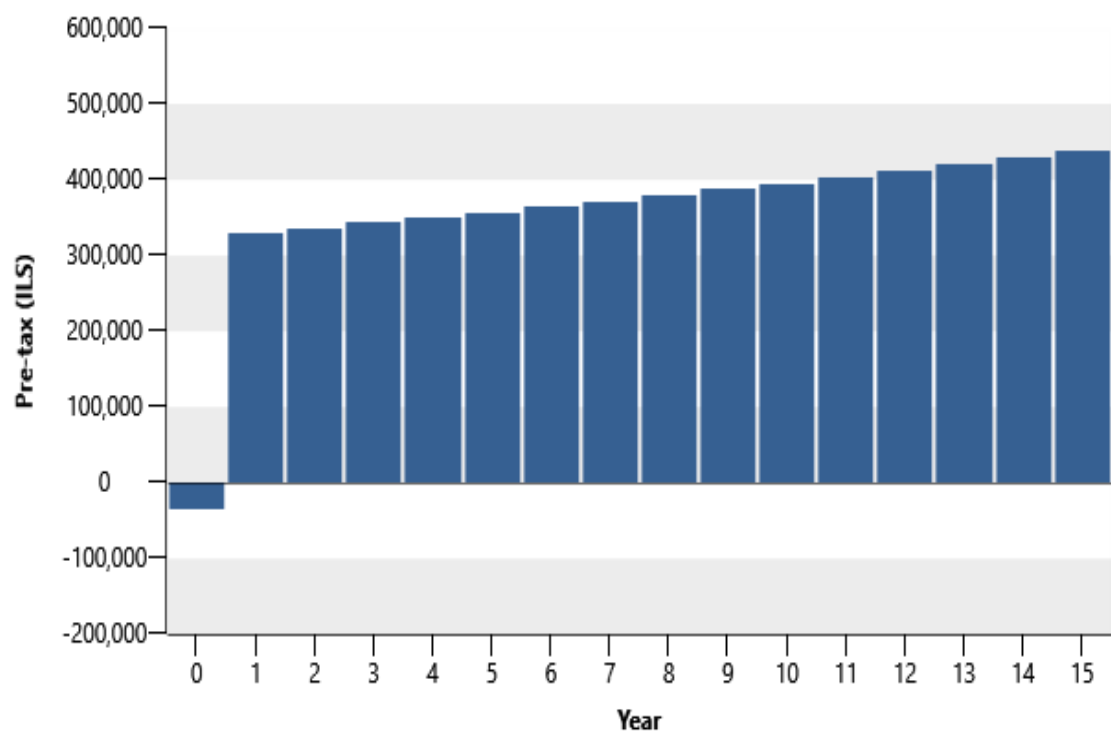


Figure 6 Cash flow diagram for the investments

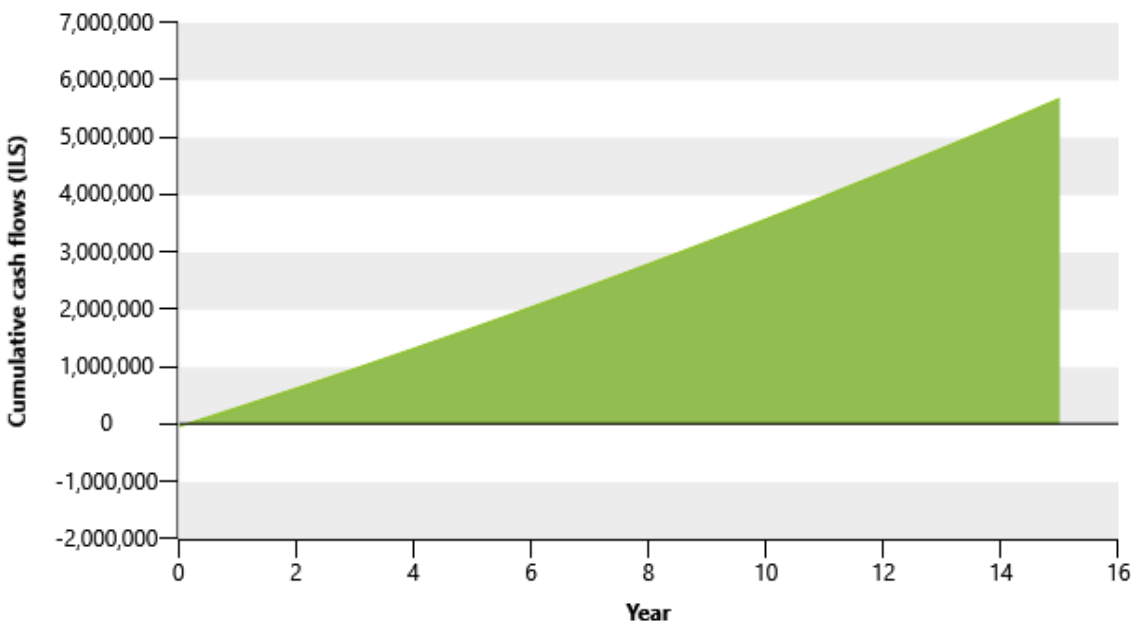


Figure 7 cumulative Cash flow diagram for the investments for 15 years

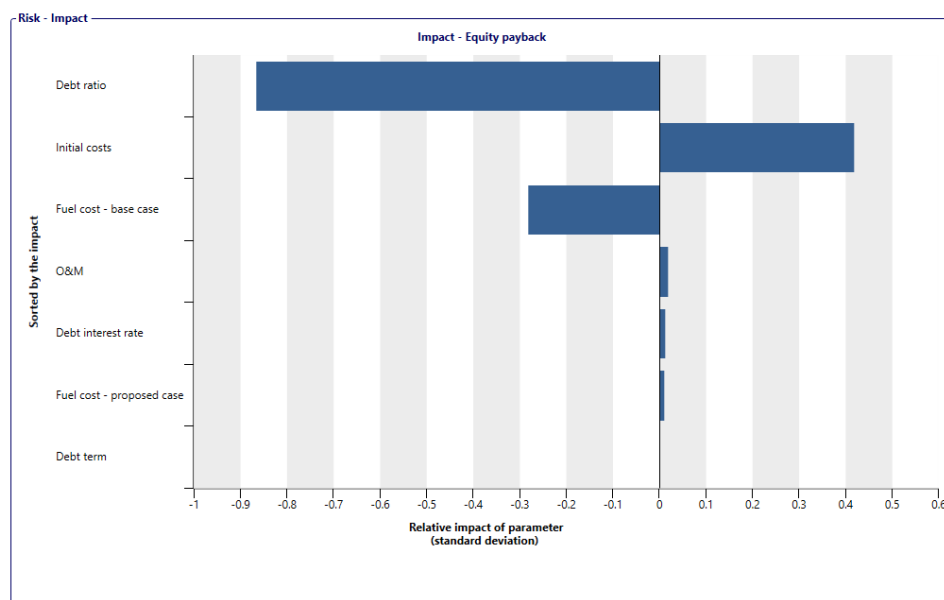


Figure 8 Impact of risk on pay back RETScreen

4. Conclusion

In conclusion a 200m² home in west bank city of Nablus were studied and investigated to have an application of NetZero energy home for the first time in Palestine. The system was simulated using RET screen, the purpose was to reduce the cost and the emission of the systems used in the house to reach a sustainable zero energy home. The study suggested imprudent in the building envelop and operating schedules. The location was cold so less savings in the cooling was encountered. In power generation a system of 7 kW peak was installed. The heat pump heating and cooling system were introduced to have one efficient system. Appliances were also searched. The results showed that results showed a zero-energy home of savings of 222 tons of co2 emission a saving of 222845 ILS in fuel. The total savings were 311715 ILS. The results showed shows that the impact on the NPV is stronger for the "initial cost than that for the fuel cost base case. Which is in favor of getting into the investment for a zero-energy home although only few measures were changed. The more the applications and renewable energy resources are used the more the investment became feasible, the more the emissions are reduced.

Supplementary Materials: The rescreen report is available and attached with the research.

Declaration of Competing Interest

The author declared that there is no conflict of interest.

Acknowledgments

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Appendix A

RET Screen Report.

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