Journal of Multidisciplinary Engineering Science Studies (JMESS)
ISSN: 2458-925X
Vol. 9 Issue 4, April - 2023

Modeling Small Scale Photovoltaic Systems: A guide to identify operational and financial risk factors for their success.

A case study from Berat, Albania

Matilda SHEHU[1)]
Dept. of Finance, University of Tirana, Economics Faculty, matildatola@feut.edu.al

Urim BUZRA[2)]
Dept. of Physics Engineering, Faculty of Mathematics and Physics Engineering
, Polytechnic University of Tirana, Tirana, Albania, rimibuzra@yahoo.com

Saimir TOLA[2)]
Dept. of Mathematics Engineering, Faculty of Mathematics and Physics Engineering, Polytechnic University of Tirana, Tirana, Albania, saimir_tola@yahoo.com

Leonard Abazaj[3)]
University of Tirana, Economics Faculty alumni
leonard.abazaj@gmail.com

***Abstract*—There is an on growing interest among households and companies to secure their electricity supply and to lower their electricity bills. In countries, like Albania but not only, that rely heavily in hydropower electricity production or fossil fuel, there is a need to diversify energy production resources. Solar power has a lot of potential; due to our geographical area, residential PV shows the same interest as PV farms. In tourism areas especially, where cultural preservation and a steady electricity supply is needed, rooftop photovoltaics are an optimal solution.**

The aim of this study, is to assess primarily the impact of the financial design in the success of residential PV in a specific radiation area. Our research shows that the investment should be supported by policymakers and financial institutions by subsidies and preferential interest rates.

Keywords—Photovoltaic (PV), electricity, financial modeling, SAM, Berat

I. INTRODUCTION

Photovoltaics development has a positive impact in achieving a steady supply of electricity without relying heavily on the general transmission system; though contributing to the development of tourism. (Baschieri, September 2020). In areas where the radiation is good to optimal but the terrain is scarcely flat, or it competes with agriculture (Martijn van der Pouw, 2022), residential PV are an interesting choice.

Our area of interest is the town of Berat1, for which we provided solar radiation data in TMY 30 series, hourly resolution.

[1] Berat is an area with tourism potential in Albania, protected by UNESCO as a cultural heritage site.

The data was elaborated by using NREL SAM2. SAM enables us to model and evaluate electricity output performance and financial cash flows associated with the project. The cash flows include initial investment and O&M costs. These projects contribute to economic development and have a political impact on the community. (Gilbert E. Metcalf, Discussion Papers Series)

Although SAM provides several generic models to residential photovoltaics, we believe that PV Watts is the most suitable to our analysis; for (1) it models the output of every brand of on grid photovoltaic system (PV systems) in the specific area and (2) it is simple to use; (3) reliable modeling of PV shading to PV output. For investment decisions we have used NPV criteria (Ross, 2008)

II. SIMULATION

Generic and financial assumptions are listed in the table below, for the initial simulation:

Generic Parameters		Financial model	
System Capacity	10 kwh	Deposit (IBI)	20%
PV model	Standard	Project Economic life	25 years
Inverter efficiency	96%	Interest rate	5%[3]
DC/AC	1.2	Loan Maturity	25years
Estimated loss	14.08%	Inflation rate	2.5%[4]
Demand Model	Hourly resolution[5]	Taxes	zero[6]

[2] SAM (system advisor model) is an open data software developed by NREL. The version used for this paper is 2020.2.29

[3] We assume the interest rate will not change for this type of financing product

[4] This is an assumption of the average expectations on inflation before Ukraine- Russian conflict

A. Financial modeling simulation results

Below are the results of PV production and cash flow simulation based on our initial assumptions.

	Values
Yearly output (year 1)	16,714 kwh
Capacity factor (year 1)	19.10%
Energy rentability (year 1)	1,671 kwh/kw
LCOE l(nominal)	14.00 ¢/kwh
LCOE (real)	10.71 ¢/kwh
Electricity bill no PV (year 1)	$1,800
Electricity bill with PV (year 1)	$363
Net savings (year 1)	$1,437
NPV	($6,765)
Payback	21.3 years
Discounted payback	N/A
Investment	$26,300
Equity	$5,260
Debt	$21,040

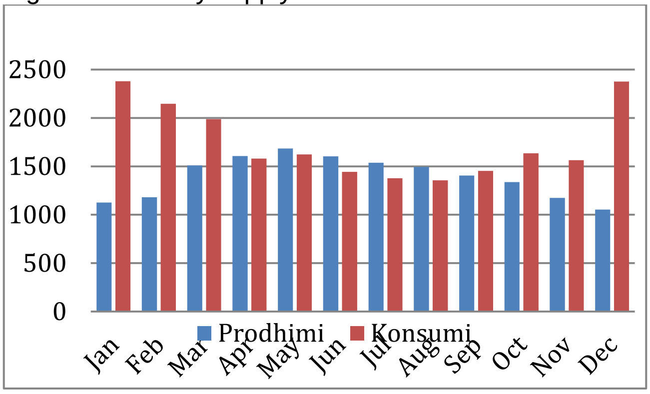
Generated with SAM

Our initial simulation suggests that the proposed model is financially not sustainable since there is a negative NPV of 6,765 $. The two main issues that arise are:

(1) Is our system sustainable in terms of demand & supply?
(2) Do we need to review financial parameters for the project to break even?

The following graph compares energy demand and energy production from PV.

Figure 1- monthly supply and demand

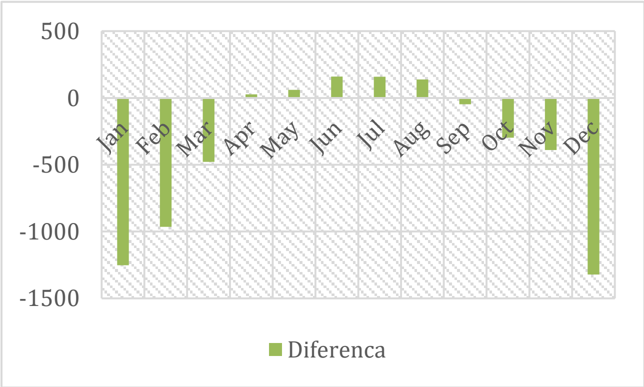


Source: Authors Calculations

As we can see there is a significant mismatch between supply and demand, resulting in energy deficits and supplies. The conclusion here is that the system does not fully support the household's demand for electricity. Still we have to rely on the general production system.

The next graph quantifies these deficits (positive/negative) monthly.

Figure 2- Monthly deficit supply/demand



Source: Authors Calculations

To summarize, the expected average production is 16,714kwh and the average supply is 20,921kwh, with a deficit of 4,207kwh.

The initial financial plan does not support financial sustainability in these conditions; so we rely on parametric simulation to identify the minimum initial credit support (IBI) for the project to break even, or have a positive NPV for the household.

B. Parametric Simulation

We run the parametric simulation in terms of the IBI; or the credit support that should be provided for the individual to make PV affordable. We choose the IBI as the simulating parameter; for the main financial support for this investment in real practice is deposit subsidy.

By subsidizing 6,838$, or 26%, the following parameters change:

(1) cost of the investment to 19,462$ from 26,300$;
(2) payback from 21.3 to 14.8 years; and
(3) the reduction of LCOE to 10.95¢/kwh (nominal) and 8.38 ¢/kwh (real).

[5] We have modeled the yearly electricity demand on hourly resolution for a sample two story house with two families living in it, with average income.
[6] We assume as an incentive no tax on electricity sales or any other aspect whatsoever

	Values
Yearly output (year 1)	16,714 kwh
Capacity factor (year 1)	19.10%
Energy rentability (year 1)	1,671 kwh/kw
LCOE l(nominal)	10.95 ¢/kwh
LCOE (real)	8.38 ¢/kwh
Electricity bill no PV (year 1)	$1,800
Electricity bill with PV (year 1)	$363
Net savings (year 1)	$1,437
NPV	$39
Payback	14.8 years
Discounted payback	22.6 years
Investment	$19,462
Equity	$3,892
Debt	$15,570

Generated with SAM

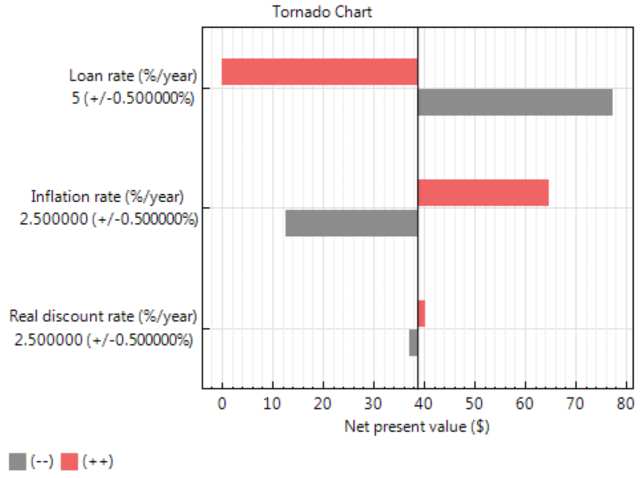
The data suggest that the minimal financial support for this project should be at least 26% to 30% deposit subsidy. This is a common practice supported by the business experience in countries that have developed PV technology to household use.

C. *Sensitivity Analysis*

The sensitivity analysis helps to identify the main sources of risk to the project.
The operational risk is defined by the system output which is influenced by radiation. Apart from IBI, we try to identify other financial risk sources.

Here we focus on financial aspects, like loan rate, inflation rate and real discount rate.

Figure 3: Tornado Chart



Source: Authors Calculations

From the chart we see that the project NPV is heavily influenced by changes in loan rate and inflation.

So for every 0.5% change in loan rate the NPV changes +/- 40$. This can help policymakers to support green finance products by subsidizing them to maintain an adequate interest rate; discriminating by the region.

III. Conclusions:

The spreading of PV for electricity production will help households to have a reliable energy supply with a minimal cost for the next 25-30 years. It will be beneficial to communities especially, in areas with tourism potential.

This technology is not accessible without subsidy from the government or other financial support mechanisms, like deposit subsidy.

Green Finance products should take into consideration the area potential of electricity production, and residents income to design adequate products to support PV technology development.

REFERENCES

Baschieri, M. M. (September 2020). COMPREHENSIVE FINANCIAL MODELING OF SOLAR PV SYSTEMS. *37th European Photovoltaic Solar Energy Conference and Exhibition.*

Gilbert E. Metcalf, 2. (Discussion Papers Series). "The Economics of Energy Security," ,. Department of Economics, Tufts University 0790, Department of Economics, Tufts University.

Martijn van der Pouw, C. R. (2022). Agrivoltaics: Combining solar panels and agriculture into a win-win resul. *https://www.statkraft.com/newsroom/news-and-stories/2022/agrivoltaics-combining-solar-panels-and-agriculture/.*

Ross, W. J. (2008). *Essentials of Financial Management, Chapter 9.* MCGrawHill Irwin.

Saimir Tola , Alfred Daci , Gentian Zavalani , "A Simulation of an Elastic Filament Using Kirchhoff Model," Mathematics and Statistics, Vol. 10, No. 1, pp. 25 - 34, 2022.