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Photovoltaic and Solar-Thermal Use Case Application Comparison with Witness Simulation and DCF Analysis

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Abstract. In this work, we investigate a system of solar and thermal heat collectors in combination with local and electric net storage. The system is implemented in a Witness Horizon simulation model, allowing for the investigation and scenario analysis of different use cases. In a practical industrial application example use-case, using simulation and Discounted Cash Flow (DCF) analysis, the economic feasibility of the best system variant could be calculated. The developed model includes the local consumption and production profile, and it was evaluated by a DCF model after the dynamic energy modelisation with the generic industrial production system simulation model can be in future further extended to generic and more complex production systems, simultaneously integrating the DCF cost evaluation analysis and following direct economic optimisation as well as integrating it with the pro- duction portfolio theory approach by integrating diversified virtual production market aspects and market goal-oriented optimisation.

Keywords: Photovoltaic, Solar-Thermal, EU Green Deal, WITNESS Horizon, DCF Analysis

1. Introduction

In times of energy crisis and climate change, companies must position themselves more broadly and independently of the fossil energy market. Future investment is increasingly obliged to leave a sustainable footprint, which is demanded on the one hand by the market and on the other hand by politics, especially by the Green Deal of the European Union and the EUTAX regulation (see, e.g. [1]). In this context, photovoltaic and solar thermal technology are essential components. This work aims to achieve an economic correlation between the two technologies. Different scenarios with both technologies must be defined and simulated to achieve results for the profitability investment calculation. For the simulation, the program WITNESS Horizon is used, which is a common tool in industrial production and process simulation [2]. With the simulation results, a profitability calculation for investment, in this case, a Discounted Cash Flow (DCF) method, can be performed (for implementation, see, e.g. [3], [4]). Then, with the help of the results of the DCF method, a strategic decision can be made regarding the investment. In parallel, the EUTAX conformity must still be checked and proven.

2. Modelling and Simulation

2.1 Parameters and Models

At first, key parameters had to be defined for the modelling. The “local solar global radiation”, the “available area”, and the “system efficiencies” for the photovoltaic and solar thermal system were defined as key parameters as shown in Table 1.

***Table 1**: Key Parameters according to [5].*

Parameter	*Wert*	*Einheit*
Local solar (sun) global power (Graz, Austria)	1206	*kWh/m²*
Available area at parking house C&P Immobilien AG	1222	*m²*
Photovoltaic system efficiencies Solar Thermal system efficiencies	16,57	*%*
Local solar (sun) global power (Graz, Austria)	35,75	*%*

By using the key parameters, the corresponding Sankey diagram could be created (see Figure 1). In the Sankey diagram, the system boundaries of the model, which is mapped in the Witness Horizon for the simulation, are defined, as well as the associated losses along the value chain.

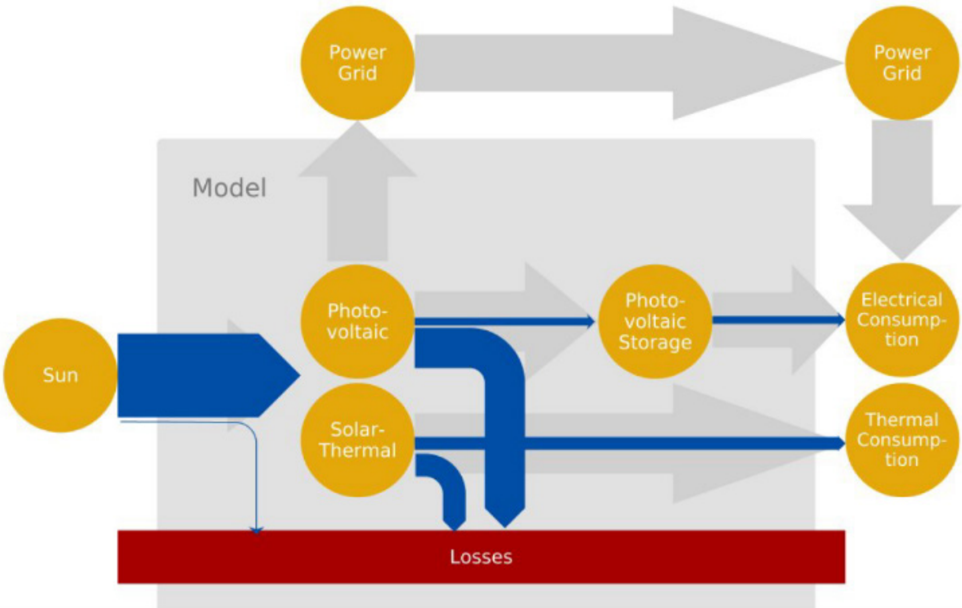

***Figure 1**. Model for simulation of comparison of photovoltaic and solar thermal (Model 2) [5].*

The Sankey diagram forms the basis for simulation in Witness Horizon (see Figure 2). Two paths serve as energy sources in WITNESS Horizon. The first path is the sun (Energy Globalpower), a free but dynamic resource. The second path is the electrical power grid (Energy PowerGrid), a static system that provides security for a permanent energy supply—the storage for photovoltaic works as an element between electric consumers and photovoltaic systems. The most economical storage size is a result of the WITNESS Horizon simulation. For the sun’s energy supply Energy Globalpower), the hourly arrival of solar power must be calculated using statistical values [6].

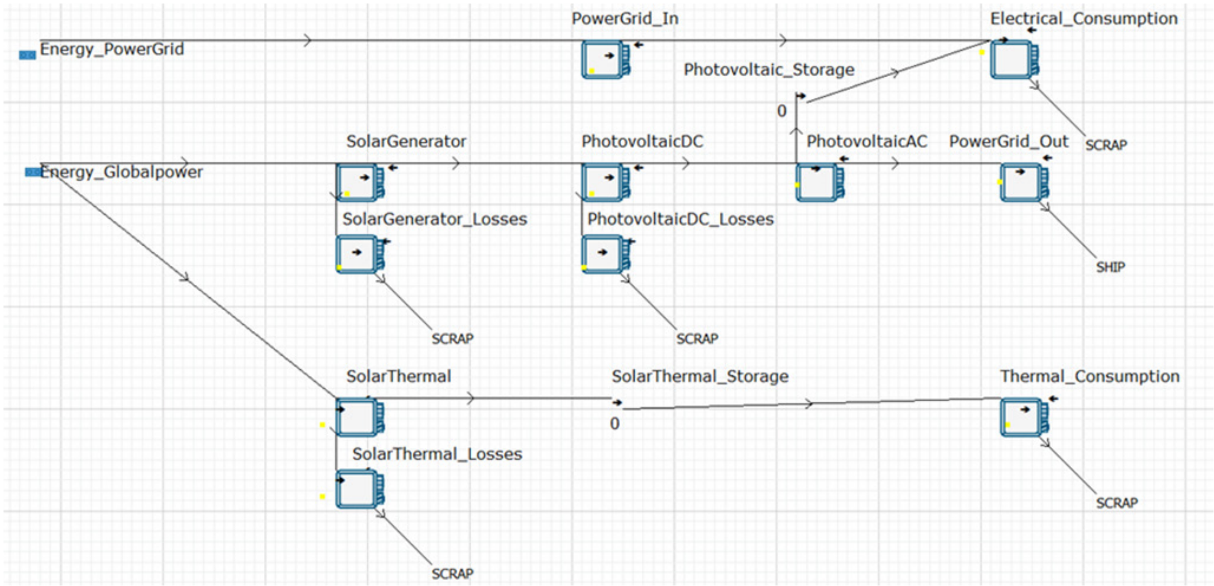

Figure 2. *Model and Simulation in WITNESS Horizon [5] (Model 2). The Witness files are also supplied at [7].*

2.2 Scenario Simulation

The results of the simulation are the electrical energy purchased from the power grid, the electrical energy surplus from the photovoltaic system, which feeds into the power grid and the electrical yield from the photovoltaic system for the own electrical consumers. The results of the previously mentioned values change depending on the photovoltaic storage size. Additionally, the result is the heat consumption. With the results of the different scenarios in the simulation, the DCF method calculation can be performed, and consequently, the most strategically economical decision can be made.

In Table 2 and Figure 3, the different scenarios are listed by five cases. In this Figure also the risk landscape (neutral/pessimistic/optimistic) is depicted, which means that the global situation is evaluated according to individual risk preferences.

2.3 Discussion

This risk evaluation can lead then in general, to the production portfolio analysis as deduced in [8], [9] and applied to an industrial application in [10].

The risk analysis in this work can similarly be applied to the new evaluation method, and gives hence a direction of how to decide with regard to risk.

The risk of sustainable energy systems is mainly determined by two factors: Firstly, the technological risk, which is primarily a factor of the maturity of technology. A mature technology will have no risk or at least a low and quite accurate and predictable one, as the technology is then reliable. Secondly, by the nature of the problem, we simply order by fossil or non-fossil, which means with regard to natural 'storage' capacity. The term fossil denotes that a natural source stores the property. Sustainable energy sources would have then to be of the nature of a flow, in our days of the syntropy source sun, which is correlated and causally linked to the surface property of the earth as one major influence factor.

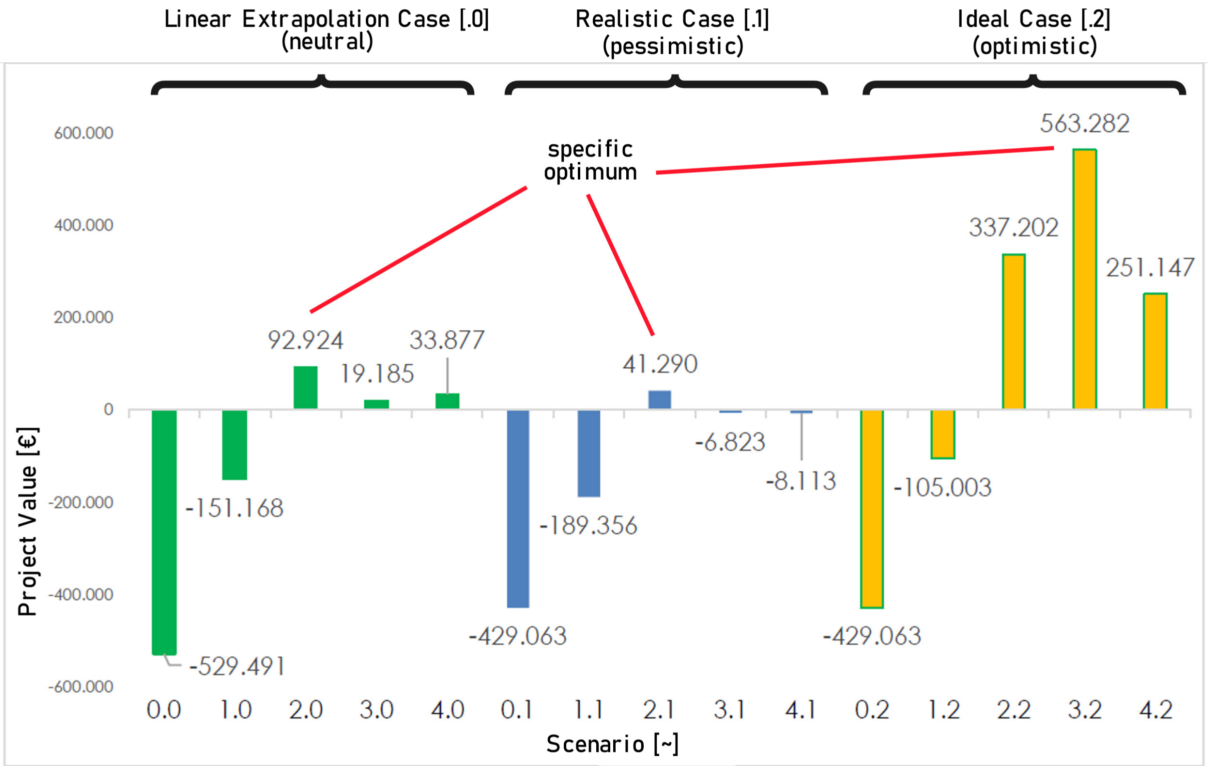

***Figure 3**. DCF project valued of different scenarios in the risk landscape (neutral/pessimistic/optimistic) (see also [5]).*

***Table 2**. Scenarios*

Scenario	*Description*
[0.]	without investment 270 [kWh/a]
[1.]	photovoltaic + storage + solar thermic 230 [kWh/a]
[2.]	photovoltaic + photovoltaic storage 230 [kWh/a]
[3.]	photovoltaic + storage net 230 [kWh/a]
[4.]	photovoltaic + photovoltaic storage 270 [kWh/a]

Finally, with regard to Figure 3, a clear decision can be based on the local solution, as this is implicitly used in the model, as well as the actual potential investment and operating costs. The negative value of doing nothing shows clearly that investment is always more profitable, which means practically going the entrepreneurial way towards energy production, which is implicitly prescribed by the nature of the decentrality of sustainable energy sources, and hence efficiency advantage in the case of a decentral installation. The great quest for now and the future is shown by the kind of storage. This mainly influences the overall productivity and is very sensitive to this factor.

So, it seems to make sense, that there should be rational decisions with regard to societal and with this political decisions. The optimal decision is not only a question of technology, as we can see from this example, but also of optimal political control. This means that the political process is part of the optimisation problem and clearly not independent. Better political systems, with regard to overall system efficiency, will then have an evolutionary advantage, whatever this means practically.

According to systems theory, this means that, to achieve higher total productivity, there has to be low-cost flexibility and the possibility of interest-driven and rewarded influence, which means that there is a high multidirectionality or high degree of back-couplings of the system in different system scalings (cf. also [11]).

3 Conclusion and Outlook

In this paper, we have introduced Witness models for the simulation of solar thermic and photovoltaic installations together with a DCF evaluation. The results show that the strategic change toward energy harvesting in one or several economic directions makes sense even in today's challenging economic situation. There is a strong dependency on the environmental, political, and market situation with regard to costs of storage, be it the electric net system or the electrochemical accumulator system, and the size of these systems. To do nothing is the most expensive option. Finally, it can be seen that there will be clear socioeconomic advantages of national or political economies that take into account the interests of the population and all other involved energy consumers as well as producers, especially with regard to low risk and hence also concerning the long term risk situation and stable, sustainable energy sources.

Data availability statement

The data in this paper can be found mainly in two sources. In the work of Karl Gaugg [5] and in the GitHub repository [7]. There the electronic data for the Witness simulation model are accessible.

Author contributions

This paper is based on the previous work of Karl Gaugg in [5], and he has prepared Sections 1, 2.1 and 2.2 for this work. In Section 2.3 Bernhard Heiden, Bianca Tonino-Heiden and Volodymyr Alieksieiev have contributed equally. All the authors have written the rest of the paper equally distributed and done the proofreading in the same way.

Competing interests

The authors declare that they have no competing interests.

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