Report on Bachelor Thesis

Institute of Economic Studies, Faculty of Social Sciences, Charles University

Student:	**Tomáš Doležal**
Advisor:	**Milan Ščasný**
Title of the thesis:	**Economics and Return on Investment of Photovoltaic Power Plant on houses in the Czech Republic**

OVERALL ASSESSMENT

Short summary

The thesis evaluates the financial performance of a small-scale residential photovoltaic (PV) plant. This assessment is performed on one case plant using ROI and the payback period. The financial performance is assessed for a PV project with/without battery storage and with/without a subsidy provided.

Contribution

Evaluation of the financial performance of an investment project presents a trivial economic analysis. Still, it can be useful if it relies on multiple performance measures and\or includes a sensitivity analysis of the key factors to assess comprehensively a project. These factors may include CAPEX for different project components, options for a replacement by the more efficient panel, prices of electricity, and consumption profiles). Using a PV at home is related to the role of consumers to be ‚prosumers' that will have many consequences on consumption profile (including the possibility to store or share electricity, using heat pumps, charging their electric vehicles) which is not discussed in the model at all. Financial performance might also be enriched by the economic assessment, performing CBA, to consider the overall social costs that would be very relevant to assess the socially desirable public support. Neither of these is done in this thesis. Although some key factors are discussed (qualitatively), no sensitivity analysis is performed (except comparing the case with/without a battery and with/without a full subsidy).

A review of some cost components, including their technical characteristics that determine the financial performance of a PV, is only the contribution of this thesis.

Methods

Financial evaluation relies on computing the payback period and the return on investment (ROI). However, no details on the model are provided (except that it was written in Phyton). This is not satisfactory. For instance, which cost components were included, how the costs were treated if the lifetime of the particular component was shorter than the lifetime of a PV and if the lifetime of the replaced component exceeded the lifetime of a PV (e.g., were the salvage costs considered?); how revenues were calculated; which discount rate was used etc. The most crucial part in computing the ROI is forecasting the cash flow from the investment; this would need to be describe in detail in the thesis.

The thesis shall rely on multiple measures of the financial performance analysis to provide a more comprehensive evaluation of a project such as NPV, LCOE, or IRR. At least, the financial analysis should perform a sensitivity analysis on various levels of subsidy and electricity prices.

Moreover, I find several issues in the chosen approach to perform the financial analysis, including:

First, I guess *'investment income'* should read as revenue flow or the cash flow generated from a project, and, again, I can only guess that it was calculated as electricity generated multiplied by

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electricity price (D02d or linearly extrapolated from 2009-2024). On page 18, it is noted that the predicted price increase „was added both to the bought and sold electricity price." So, my question is how bought and sold electricity was calculated since both electricity generation from a PV and electricity consumption follow certain time profiles which differ across seasons. Obviously, the time profile of electricity generation and consumption will affect the share of electricity that is used at home, that is sold, and that needs to be bought from the grid. The prices of electricity for the latter two differ and may vary over time. This issue needs to be elaborated more in the model used.

Second, the author's assumption on the predicted price of electricity should be better justified. Why D02d was chosen? Shall we assume the same price for electricity bought and sold? I am concerned about the linear extrapolation using the data for the 2023-2024 period since they were affected by the geopolitical situation; a robustness check should be carried out, at least excluding the 2023+ data. Still, many studies predict electricity prices. For example, at least research performed by colleagues from Charles University predicted electricity prices for the Fit-for-55 policy using the macro-econometric E3ME model and the TIMES-CZ model (of course, there are other studies). Moreover, the price of electricity consists of regulated and non-regulated components, and the prediction should discuss both of these components (maybe the regulated component might go down or remain constant, while the non-regulated part of the tariff may go slightly up).

Third, what is the income from the installation of a PV project? Following a note on page 6, I doubt revenues from sold and costs of bought electricity are only considered. I think the revenues for both ‚no-project' and ‚a PV project' should be calculated and compared, and the difference shall be used in computing ROI, implying that electricity generated from a PV and consumed at home has its shadow price. Still, I can see there may be three different prices of electricity: one for electricity sold (that could be zero or even negative), another for electricity bought from the grid (much higher), and the last would be the shadow price for electricity generated and used at home. Note: there are also different pricing regimes, first that each kWh sold and bought are priced, and second, when only a difference between the sold and bought are priced; these regimes might define the scenarios to be analysed in the financial analysis. Note (a hypothetical case): what income would be if home demand for electricity is fully satisfied by electricity generated and no kWh would be sold?

Fourth (related to the third), as correctly described in the thesis in Section 2.2.3 (although it should not belong to Photovoltaic History), an off-grid system with a single-phase inverter presents an alternative to an asymmetric power inverter. Since the costs of the inverter represent the high share of the overall costs of a PV system (42,500 CZK), it might be very useful to evaluate this option.

Fifth, I guess the information derived from a solar radiation map is used to compute electricity generation by the hour or 15 min (after seeing the Excel file, I guess this analysis was performed in very detailed time resolution, but the model description in the thesis is missing). How this information is used in the model should be described, including how the electricity generation time profile matches the electricity consumption profile.

Sixth, I do not understand the role of inflation in the model and in the performed financial analysis, which should rely on the costs and revenues expressed in real terms (ROI should not consider inflation). Moreover, if *„the price of inverters remained almost the same in the past 10 years"* (page 16), then in real terms, its price went down and further, I do not understand what adjustment is done, referring to this text *„thus the same price adjustment for inflation is assumed in 15 years"* (page 16) (btw, why the price is adjusted for inflation in 15 years if the lifetime of a PV project is 30 years?).

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Seventh, the price of electricity is based on different tariffs for different volumes of electricity consumed. Is it reasonable to drive the electricity bill for heavy and light electricity users assuming the same price, see Section 3.1.9 (page 16).

Eight, *„there is not much maintenance or cleaning needed after the installation because rain together with the tilt of the roof provides enough cleaning effect*" (page 16) contradicts Section 4.1.2 which argues that *„solar panels collect significant dust and pollen particles over time, which are in most areas not washed completely by rainfall…. ".* Should these costs (or the effect on efficiency) be accounted for in the model?

Last, the author criticises the use of „a certain value with confidence intervals" on the ground that these values „would be made on assumptions that do not have to hold" (page 18). I think the author does the same; he is using assumptions that need not hold since no one knows the future. Could the author say that his assumptions about the future that he used in his model will definitely hold?

Literature

I acknowledge that it would be challenging to review the literature on each component of a home PV. The thesis reviews the CAPEX & OPEX and lifetime for every critical component, primarily relying on one or a few sources. I would appreciate it if the thesis would focus on one or a few factors in more depth and perform then a sensitivity analysis on the chosen factor.

Literature that provides an overall picture of photovoltaics and energy system modelling is missing. For instance, there are several studies and papers that model decarbonisation scenarios and pathways, including my work; then, it would also be very useful to review the MAF reports on adequacy that is annually prepared by ČEPS and its modelling of the unit commitment in the power sector by PLEXOS model. If this literature was reviewed, the author need not conclude that „all the installed solar capacity have no effect in reducing the number of power plants running on non-renewable resources" that is not true.

Many studies perform a financial analysis of PVs; only a few are cited.

Manuscript form

The thesis has a very low standard. This presents the most critical comment and my reason for not accepting this thesis for the defence.
The text is not clear in many places; some sections are not finalised, and in some subsections, there is not relevant text (for instance, 4.1.2 Without subsidies that includes a one-paragraph on efficiency decrease due to dust and pollen; 2.2.2 Photovoltaic Power Potential describes efficiency or the load factor, not potential), or there is even no text in some subsections (4.3). Figures and tables are blurry or badly edited. The exposition of the results is not satisfactory; the text is hard to read and follow. Appendix A is blank. Overall, the thesis seems to be a working draft, not finalised.

Overall evaluation and suggested questions for the discussion during the defense

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Although financial analysis does not present a very sophisticated approach in economics, it might be a useful and acceptable topic for a bachelor thesis if it is based on the assessment of multiple measures and if it discusses the role of key factors in more depth, for instance, through a sensitivity analysis. This has not been done in this thesis. The main issue with this thesis is that the model used is not sufficiently described, requiring its readers to make their guesses about the model used; the model should be described in the thesis (including a description of how information is described in Section 3 is finally used in the model). I also have several issues with the approach used, and I consider this as the main shortcoming of this thesis method. My evaluation of its content is, therefore, around D.

However, the manuscript form has a low, very low, quality; the main issue of this thesis is that it is not finished. I guess a draft version of the thesis has been submitted since at many places texts is not placed at right place (sub-section) and at another places a text is completely missing. In my opinion, a thesis should not be submitted at this stage of writing. For that reason, unfortunately, I must downgrade my evaluation of this bachelor thesis and consider it does not fulfill the standard required on thesis that may be defended.

In my view, the thesis does not fulfill the requirements for a bachelor‘s thesis at IES, Faculty of Social Sciences, Charles University, I do not recommend thsi thesis for the defense and suggest a **grade F**.

I am convinced that after finalising the manuscript, placing text at right places, adding texts in sub-sections that are now blank and after improving financial assessment, this thesis would do fulfill the requirements for a bachelor‘s thesis at IES, and I would not have any objectoion for recommending it for the defense.

SUMMARY OF POINTS AWARDED *(for details, see below):*

CATEGORY		**POINTS**
Contribution	*(max. 30 points)*	15
Methods	*(max. 30 points)*	5
Literature	*(max. 20 points)*	13
Manuscript Form	*(max. 20 points)*	1
TOTAL POINTS	*(max. 100 points)*	**34**
GRADE	**(A – B – C – D – E – F)**	**F**

NAME OF THE REFEREE:* *Milan Ščasný

DATE OF EVALUATION:* *27 August 2024

Mgr. Milan Ščasný, PhD.

Digitálně podepsal Mgr. Milan Ščasný, PhD.
Datum: 2024.08.27 18:07:11 +03'00'

Referee Signature

EXPLANATION OF CATEGORIES AND SCALE:

CONTRIBUTION: *The author presents original ideas on the topic demonstrating critical thinking and ability to draw conclusions based on the knowledge of relevant theory and empirics. There is a distinct value added of the thesis.*

METHODS: *The tools used are relevant to the research question being investigated, and adequate to the author's level of studies. The thesis topic is comprehensively analyzed.*

LITERATURE REVIEW: *The thesis demonstrates author's full understanding and command of recent literature. The author quotes relevant literature in a proper way.*

MANUSCRIPT FORM: *The thesis is well structured. The student uses appropriate language and style, including academic format for graphs and tables. The text effectively refers to graphs and tables and disposes with a complete bibliography.*

Overall grading:

TOTAL	**GRADE**
91 – 100	**A**
81 - 90	**B**
71 - 80	**C**
61 – 70	**D**
51 – 60	**E**
0 – 50	**F**