Assignment week 8: Techno-economic Analysis

**Students name:**

**Teachers:** Arven Syla, Arbogast Nyandwi & Jonathan Chambers

**Objectives** **of** **this** **assignment:**

* Identify main parameters that shapes the economic viability (techno-economic assessment) of PV and batteries
* Evaluate the investment in PV and storage through modelling

**Group** **size:** 2 persons per group

# Submission date

The report has to be handed in on Wednesday 1 May 2024 17:00 at the latest. Please upload it on Moodle in the following directory: “EN-Methods for analyzing energy efficiency and renewable energy technologies”/ Method 8: Renewable energy balance and techno-economic analysis (25.04.2024)”. Only a single (MS-Word or pdf) file will be accepted. Any other (e.g., Excel) attachments will be ignored. When writing down your answers, please explain very briefly the main intermediate steps in the calculations. This will allow the teachers to follow the reasoning and thus award you points for the various steps. Please pay attention to the correct use of units and terminology.

**Debriefing:** The debriefing of the assignment will take place in the morning of Friday 3rd of May 2024.

# Part 1: PV System (without battery) for single house (30 pts)

1. **Please formulate the energy balance equations of the system 1 by writing the equation which establish** – 4 points:
   1. The relation between the PV panel output (E\_PVDC) and the PV useable energy (E\_PVAC) based on the conversion efficiency (eta\_inv)– 1 points

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* 1. The relation between the PV production (E\_PVAC), the PV self consumption (E\_PVd) and the PV energy export to the grid (E\_PVgrid) - 1 points

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* 1. The total electricity demand E\_d\_total as a function of E\_d, E\_EV  – 0.5 point

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* 1. How the total electricity demand E\_d\_total is satisfied by E\_PVd and E\_grid– 0.5 point

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* 1. Explain what do you think will E\_PVAC be equal to when electricity demand is higher or lower?– 1 points

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1. **Please calculate the following indicators** – 6 points**:**
   1. What the annual capacity factor of the PV installation (CF, using the annual PV generation in AC terms)? Please, compare with other technologies. – 2 points

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* 1. What is the percentage of PV which is self-consumed (SC)? (Indicate numbers only) – 1 points

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* 1. What is the electricity that is imported to the grid (E\_PVgrid)? (Indicate numbers only) – 1 points

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* 1. What is the percentage of PV which is self-sufficiency (SS)? (Indicate numbers only) – 1 points

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* 1. What is the electricity that is imported from the grid (E\_grid)? (Indicate numbers only) – 1 points

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1. **Please answer the following questions** – 5 points**:**
   1. Insert the plots (four) from the script – 2 points

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* 1. What are the main differences you can state between these seasons? What is the impact when charging EVs? What are the main factors that can affect PV generation, electricity demand, and other implications (such as imports, exports, production, consumption, SS and SC) please discuss them – 3 points

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1. **Please answer the following questions** – 2 points**:**
   1. What is the CAPEX of the PV system and the inverter? – 1 points

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* 1. What is the CAPEX that will further be replaced (after 15 years) ? – 1 points

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1. **Please answer the following questions –** 6 points:
   1. What is the equation and the annual revenue of the PV system? Compare to the original situation in which the house only buys electricity from the grid(Please use numbers in the beginning of the exercise) – 2 points

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* 1. What is the percentage of revenue due to PV self-consumption and due to PV export to the grid? – 1 points

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* 1. Repeat the calculations by reducing the export costs and import costs by 5 cents/kWh. Show and interpretate the differences! – 3 points

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1. **Please answer the following questions –** 7 points:
   1. What is the LCOE, LVOE and PBP of the PV system? (Indicate numbers only) – 2 points

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* 1. Compare and discuss the LCOE,LVOE and PBP of this system with other power generation technologies (i.e. wind, nuclear, coal)? Where this difference might come from? – 2 points

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* 1. Then repeat the calculations of LCOE by reducing the PV system expenditure costs by 20%. Interpret the differences! -1 point

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* 1. Which factors are not accounted and could have the biggest impacts on the LVOE of the PV system? – 1 point

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* 1. Seeing, LCOE, LVOE and PBP only, would you recommend to opt-in prosumers in an economical perspective? (be brief) – 1 point

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# Part 2: PV System (without battery) for single house (30 pts)

1. **Please formulate the energy balance equations of the system 2 by writing the equation which establish** – 2 points
   1. How PV electricity generation is used (include: E\_PVDC, E\_PVAC, eta\_inv, E\_charDC, eta\_conv) – 1 points

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* 1. How electricity demand is satisfied (include: E\_grid, E\_PVd, eta\_inv, E\_disDC, eta\_conv) – 1 points

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1. **Please indicate the following parameters** – 5 points
   1. Indicates PV energy export to the grid, **E\_PVgrid**(kWh); Electricity imports (or purchased) by the house - **E\_grid** (kWh) per year; and annual round trip efficiency, **eta\_bat**; self-consumption (**SC**); self-sufficiency (**SS**) and total number of equivalent full cycles (**EFC)**  – 3 points (results only)

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* 1. Please discuss the difference with the first exercise (question 2) for the system without battery.– 2 points

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1. **Based on the two representative days answer the following questions:** – 6 points
   1. Insert the plots (four) from the script – 3 points

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* 1. Discuss the main differences among the two days per season (production, consumption, imports/export etc)? Also the differences of battery charging and discharging? What is the impact of battery when compared without battery (from the first part of exercise) – 3 points

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1. **Answer the questions regarding to CAPEX of the battery:** – 2 points
   1. What is the equation to calculate the CAPEX of the battery? (Provide the equations and results) – 2 points

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1. **Answer the questions regarding to revenue of the battery:** – 6 points
   1. Formulate and calculate the annual revenue of the battery system (using the price data given in the introduction). Do not forget to include avoided imports and exports. – 2 points

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* 1. Please discuss the main parameters affecting the economic revenue drawn from the battery.– 2 points

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* 1. Discuss the implications of price changes (before prices (given at introduction) and after prices (exercise 5 and 6))! – 2 points

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1. **Answer the following questions related to economic viability of the battery:** – 7 points
   1. What is the LCOES, LVOES and PBP of the PV system? (Indicate numbers only) – 2 points

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* 1. Repeat 12.1 equation after the price changes? – 1 points

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* 1. Discuss the factors that are not accounted but could influence the LVOE? – 2 points

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* 1. Considering economic criteria, shall a prosumer invest in a battery under these assumptions? – 2 points

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1. **How can we increase/improve self-sufficiency and self-consumption apart of battery?** – 1 points

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1. **What evolution of parameters influencing economic viability of PV-coupled battery systems do you expect for the next 10-15 years? How would this affect the business case of PV-coupled battery systems in single houses? (You can use the bibliography given in Model to write your answer).** – 1 points

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