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

|  |
| --- |
| <insert here> |

* 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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |  |
| --- | --- |
| <insert here> | <insert here> |

* 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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

* 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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

# 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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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)

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |  |
| --- | --- |
| <insert here> | <insert here> |

* 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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |

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

|  |
| --- |
| <insert here> |