Sustainable Energy System Class Project 2024

Submission Date: 9 December 2024

Choose one topic for each group and develop a techno-economic or feasibility analysis for the project based on the details below. **Each group consists of 4-5 people**. The feasibility report and presentation are due one week before the final exam.

Topic 1

Techno-Economic Analysis of Hybrid Wind-Diesel

Project Objective:

- Students must conduct a comprehensive Techno-Economic Analysis on a standalone / off-grid hybrid system of wind and diesel. Students need to consider two scenarios of wind-diesel and wind-diesel-battery.
- Determine which scenario is the most economical.

Project Scope:

- The project involves the construction, operation, and maintenance phase.
- The project is in the district of Lembor, Manggarai Barat.
- The power plant will be able to electrify 900 households with simple appliances.
- A Special Purpose Company (SPC) will develop and implement the project using business model as IPP and tariff mechanism based on MEMR 4/2020 and Presidential Regulation 112/2022, respectively.

Task:

- Estimate electricity demand based on the given number of customers served.
- Hybrid system design (e.g., configuration, capacity) based on given wind speed, and electricity load, considering systems with and without battery energy storage.
- A comprehensive economic analysis, including capital costs, installation expenses, operational and maintenance costs, and potential revenue from electricity sales.

- Feasibility analysis includes business model, financial, fiscal incentives, and electricity tariff. In developing the scenario, please consider existing policies and regulations to accelerate the deployment of RE project from MEMR, MOF, MOEnv, and international agencies.
- Fiscal and non-fiscal recommendations.

Topic 2

Techno-Economic Analysis of Solar-diesel hybrid

Project objective:

- Conduct a feasibility study of a Solar-diesel hybrid scenario vs solar with battery. Determine the most economical scenarios.

Project Scope:

- The project involves the construction, operation, and maintenance phase.
- The project is in the district of Talaga Raya, Central Buton.
- The power plant will be able to for residential load 74,898 MWh/year
- A Special Purpose Company (SPC) will develop and implement the project using business model and tariff mechanism based on MEMR 4/2020 and Presidential Regulation 112/2022, respectively.

Commented [GS1]: cap = 45 MW, cf = 19%,

Task:

- Estimate electricity demand based on the given number of customers served.
- Solar system design (e.g., configuration, capacity) based on given solar irradiation and electricity load, considering hybrid system with diesel versus solar-battery systems.
- A comprehensive economic analysis, including capital costs, installation expenses, operational and maintenance costs, and potential revenue from electricity sales.
- Techno-Economic analysis includes business model as IPP, financial, fiscal incentives, and electricity tariff. In developing the scenario, please consider existing policies and

regulations to accelerate the deployment of RE project from MEMR, MOF, MOEnv, and international agencies.

- Fiscal and non-fiscal recommendations.

Topic 3

Techno-Economic Analysis of Low-carbon Buses vs. ICE Buses.

- We need to determine the **Total Cost of Ownership – TCO** (USD/km) for each bus technology, including ICE buses, specifically **diesel and LNG buses**, and low-carbon buses, specifically **electric and hydrogen buses**, over time (2020 – 2060).
- Determine **when** low-carbon buses can economically compete with ICE buses.
- Determine the **carbon footprint** for each type of bus (gram CO_2/km).

Project Scope:

- Students will analyze the techno-economic aspects of large buses with a capacity of approximately 60 seats, used for long-distance travel.
- We assume that all these buses are used on the island of Java, Indonesia; therefore, all energy prices used will reflect the prices specific to this region.
- The investment cost of new buses will change annually, following the learning rate.
- The TCO (Total Cost of Ownership) calculation must include elements of Investment, Fixed O&M (Operations & Maintenance), and Fuel Cost.
- We will use 2020 as the base year for data, with projections made in increments of every 5 years (2025, 2030, 2035, 2040, 2045, 2050, 2055, 2060).

Task:

The following are the steps that need to be carried out:

- Find the energy prices for the island of Java, including Diesel, LNG, and Hydrogen for the year 2020.

- Project energy prices for Java from 2020 to 2060, including Diesel, LNG, and Hydrogen. The yearly increase or decrease in projected prices can follow the projected percentage changes in crude oil prices (crude oil price projections are available in the World Energy Outlook 2023 document from the IEA).
- Find the investment cost (USD) and Fixed O&M cost (USD/km) for each type of low-carbon bus and fossil-fuel bus for the year 2020.
- Assume the average distance traveled by one bus per year based on literature studies and annualized capex (USD/km).
- Find data for learning rate, lifetime, and efficiency for each type of bus.
- Project the investment costs for each type of bus from 2020 to 2060 (using the learning rate formula or changes in investment costs based on literature studies).
- Calculate the TCO (USD/km) by adding annual investment cost + Fixed O&M + Fuel cost for 2020–2060.
- Present the TCO in a line graph format.
- Find the carbon footprint for each type of bus.
- Define the total carbon emitted each year for each type of bus.
- Analyze the results and give the recommendations based on these results.

***Clearly state and cite all data used and assumptions made for the calculations!**

Topic 4

Techno-Economic Analysis of Electric Stove vs. Gas Stove.

Project Objective:

- We need to determine the **Total Cost of Ownership (TCO)** for each stove technology, including Gas Stove, specifically **LPG and natural gas stove**, and **electric stove** overtime (2020 – 2060).
- Determine **when** electric stove can economically compete with gas stove.
- Determine the **carbon footprint** for each type of stove (gram CO_2/km).

Project Scope:

- We will analyze the techno-economic aspects of household stoves.
- We assume that all these stoves are used on the island of Java, Indonesia; therefore, all energy prices used will reflect the prices specific to this region.
- The investment cost of new stoves will change annually, following the learning rate.
- The TCO (Total Cost of Ownership) calculation must include elements of Investment, Fixed O&M (Operations & Maintenance), and Fuel Cost.
- We will use 2020 as the base year for data, with projections made in increments of every 5 years (2025, 2030, 2035, 2040, 2045, 2050, 2055, 2060).

Task:

The following are the steps that need to be carried out:

- Find the energy prices for the island of Java, including LPG, Natural gas via Gas Networks, and Electricity for the year 2020.
- Project gas prices for Java from 2020 to 2060, including LPG, Natural gas via Gas Networks. The yearly increase or decrease in projected prices can follow the projected percentage changes in crude oil prices (crude oil price projections are available in the World Energy Outlook 2023 document from the IEA).
- Project Electricity Price from 2020 to 2060. You can use the regulated price from the government.
- Find the investment cost (USD) and Fixed O&M cost (USD/PJ) for each type of stove for the year 2020.
- Assume the average usage of cooking services per stove per year based on literature studies and annualized capex (USD/PJ).
- Find data for learning rate, lifetime, and efficiency for each type of stove.
- Project the investment costs for each type of stove from 2020 to 2060 (using the learning rate formula or changes in investment costs based on literature studies).
- Calculate the TCO (USD/PJ) by adding annual investment cost + Fixed O&M + Fuel cost for 2020–2060.
- Present the TCO in a line graph format.
- Find the carbon footprint for each type of stove.

- Define the total carbon emitted each year for each type of stove.
- Analyze the results and give the recommendations based on these results.

***Clearly state and cite all data used and assumptions made for the calculations!**

Topic 5

Techno-Economic Analysis of Low Carbon Hydrogen Produced from Solar PV direct to the grid vs. Solar PV with battery

Project Scope:

- The project involves the investment of the project, operation, and maintenance phase.
- Assume a production capacity of 20 MMSCFD for hydrogen options.
- PEM electrolyzer for hydrogen production.

Task:

Develop a techno-economic or feasibility analysis of the project consisting of:

- Electricity demand estimation given hydrogen production capacity (20 MMSCFD)
- Design conceptual systems for each option, including:
    - PEM electrolyzer
    - Solar PV capacity for low carbon hydrogen
    - Battery storage capacity

- A comprehensive economic analysis, including investment cost (direct to the grid and with battery storage), installation expenses, operational and maintenance costs, and potential revenue from product sales.
- In conducting economic analysis, consider replacement cost for equipment which lifetime is shorter than the project's lifetime.
- Feasibility analysis includes business model, financial and fiscal incentives, and product price.
- Fiscal and non-fiscal recommendations

Clearly state and cite all data used and assumptions made for the calculations