Project 2 (PRO 2) Description

Jagruti Thakur, Shravan Kumar, Filippo Padovani

Introduction

Effective planning and optimization of dispatch in district heating systems is essential due to the complexity of managing multiple energy sources, storage options, and fluctuating demand. Various resources like biomass, solar thermal, and industrial excess heat must be coordinated with storage technologies to ensure efficient operation. Optimizing dispatch improves energy efficiency, reduces costs, and helps balance supply with demand in real time, while integrating renewable energy and maintaining system flexibility. As district heating systems evolve, advanced dispatch planning becomes increasingly important for reliable, cost-effective, and sustainable energy distribution.

Step 1-Base case

- Design a basic optimization model dispatch to meet heat demand for 1 full year.
- Consider Load 1 from the given file and in addition choose any one more profile from the provided dataset - Justify
- Identify the sources to meet demand, number of sources (should be at least 3 different technologies)
- Define technical and economical features of the chosen technologies in the model and justify your choice.
- Perform optimization for one full year
- Answer the following questions
  - What is the technology mix chosen for dispatch to meet the demand?
    - Mention in terms of capacity and energy for the whole year
  - What is the fuel usage vs heating demand met by each technology?
  - Evaluate the seasonal variation
    - Mention the changes in seasonal variation in technology allocation and discuss

The overall aim of this step is:

To design and implement a basic optimization model for dispatch that meets heat demand in Stockholm over a full year, utilizi ng selected demand profiles and justifying the choice of technology sources.

Step 2-Future Scenario

- Develop a future scenario of 2030 (For example, based on government targets and policy, worst case scenario, extreme events scenario….)
- Forecast the demands
- Resize the sources to meet the demand and run step 1 again
- Compare the results from step 1 and 2

The overall aim of this step is:

- To develop a future scenario for 2030, forecasting demand and resizing sources to meet this demand, and then rerunning the op tim ization.
- The aim is to compare the results from the initial optimization with those of the future scenario to analyze seasonal variati ons in technology allocation and capacity, assessing their impact on overall energy production and demand fulfillment throughout the year.

Step 3- Storage

- Add two storage technologies to the base case and future scenario and revaluate the results
  - One storage should be diurnal and another should seasonal storage
  - For example, hot water tank, borehole, aquifer etc.
- Compare the results with and without storage for both scenarios

The overall aim of this step is:

- To evaluate the impact of integrating two storage technologies—diurnal (e.g., hot water tank) and seasonal (e.g., borehole or aquifer storage)—into the optimization model. This includes comparing the results from the initial optimization with those of a future scenario for 2030, assessing how the addition of storage influences technology allocation, capacity, and overall energy production and demand fulfillment throughout the year.

Step 4 - Cost based minimization

- Add the 5 demand profiles and resize the whole network
- Add atleast one source as CHP and heatpump.
  - CHP will operate based on electricity prices to meet either heating demand or electricity demand for heat pumps
- Re run the model for base case and future scenario with storage
- For optimization, consider optmizing alpha value=electricity production/heating production

The overall aim of this step is:

- To design and implement a basic optimization model for dispatch that meets heat demand in Stockholm over a full year, utilizi ng five demand profiles, resizing the entire network, and justifying the choice of technology sources, including at least one Combined Heat and Power (CHP) system and a heat pump.
- To evaluate the operational dynamics of the CHP system, which will function based on electricity prices to balance heating an d electricity demands, and to assess its impact on overall system performance.

Step 5- Emissions based optimization

- Perform above steps for minimizing emissions
- Compare Step 4 and Step 5 results

The overall aim of this step is:

- To evaluate the operational dynamics of the CHP system, which will function based on electricity prices to balance heating and electricity demands, while focusing on an **emissions-based optimization objective function** aimed at minimizing the overall carbon footprint.

Data

- Load Profiles- Check in canvas
- Source for heating technologies
  - Technology Data for Generation of Electricity and District Heating | The Danish Energy Agency

Grading Matrix

	E (Step 1)	D (Step 2 in addition to Step 1)	C (Step 3 in addition to Steps 1, 2)	B(Step 4 in addition to Steps 1,2,3)	A (Step 5 in addition to Steps 1,2,3,4)
ILO3: Model, ILO4: Evaluate, ILO5: Analyze	Perform one year dispatch optimization and analyse the results. **The optimization model** will evaluate the effectiveness of cost minimization, taking into account factors like fuel prices, operational limitations, and environmental considerations. Third, the **analysis and interpretation** of results will be graded on how thoroughly cost allocations, dispatch of plants plant and the role of renewables, if any are examined. Additionally, the ability to identify **potential improvements** in dispatch strategies—such as increasing efficiency, reducing costs, or lowering emissions—will be important. Finally, the overall **clarity and justification** of the results, along with well-reasoned recommendations for improvement, will be a crucial aspect of the evaluation.	In addition to step 1, **design a future scenario** to assess growing heating demand and analyze the need for increased resources. This scenario should explore different energy demand trends evaluating how these factors impact future dispatch strategies. Finally, the overall **clarity and justification** of the results, along with well-reasoned recommendations for improvement, will be a crucial aspect of the evaluation.	In addition to step 2, a critical component of the model will be incorporating **storage solutions**, including both **short-term and long-term thermal storage**, to enhance grid flexibility and manage supply-demand imbalances effectively. These storage technologies should be evaluated for their impact on dispatch optimization and overall system reliability. Finally, the overall **clarity and justification** of the results, along with well-reasoned recommendations for improvement, will be essential in the grading.	In addition to step 3, The model should integrate **five demand profiles**, and **resize the network** to meet all demands. They must include at least one **CHP** and a **heat pump**, with the CHP operating based on electricity prices to balance heating demand and electricity supply for heat pumps. The model should be **re-run for both the base case and future scenario**, incorporating storage, to evaluate system performance under changing conditions. Clarify how to manage these dynamics and analyze results, and provide clear, justified recommendations for improvement.	In addition to step 4, The model should be **re-run for both the base case and future scenario**, incorporating storage, with a focus on **emission-based cost minimization** to reduce environmental impact. Clarify how to manage these dynamics and analyze results, and provide clear, justified recommendations for improvement.

Q&A Sessions – LABs

- Four Q&A sessions

w45	Friday	2024-11-08	13:00	15:00	Lab	M23, Brinellvägen
w46	Friday	2024-11-15	10:00	12:00	Lab	M38, Brinellvägen
w47	Friday	2024-11-22	15:00	17:00	Lab	M36, Brinellvägen
w48	Wednesday	2024-11-27	15:00	17:00	Lab	M38, Brinellvägen

- Upload pre-final report by Dec 2, 2024
- Exam: presentation on Dec 5 and Dec 6 (2.5 credits)
  - I will add slots to calendar, please sign up
- Final report submission on Dec 20, 2024 (0.5 credit)

- Sign up for groups by 4 pm today
- Calendar slots for exam- please sign up
- Change in exam times

w49	Thursday	2024-12-05 08:00	12:00	Exam	V01, Teknikringen
w49	Friday	2024-12-06 13:00	17:00	Exam	B23, Brinellvägen