

# Hydrogen Infrastructure Development in Sweden – *exploring various future pathways*

Offshore wind and hydrogen conference

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# Government assignment to the Swedish Energy Agency to coordinate the work with hydrogen in Sweden

Among the tasks:

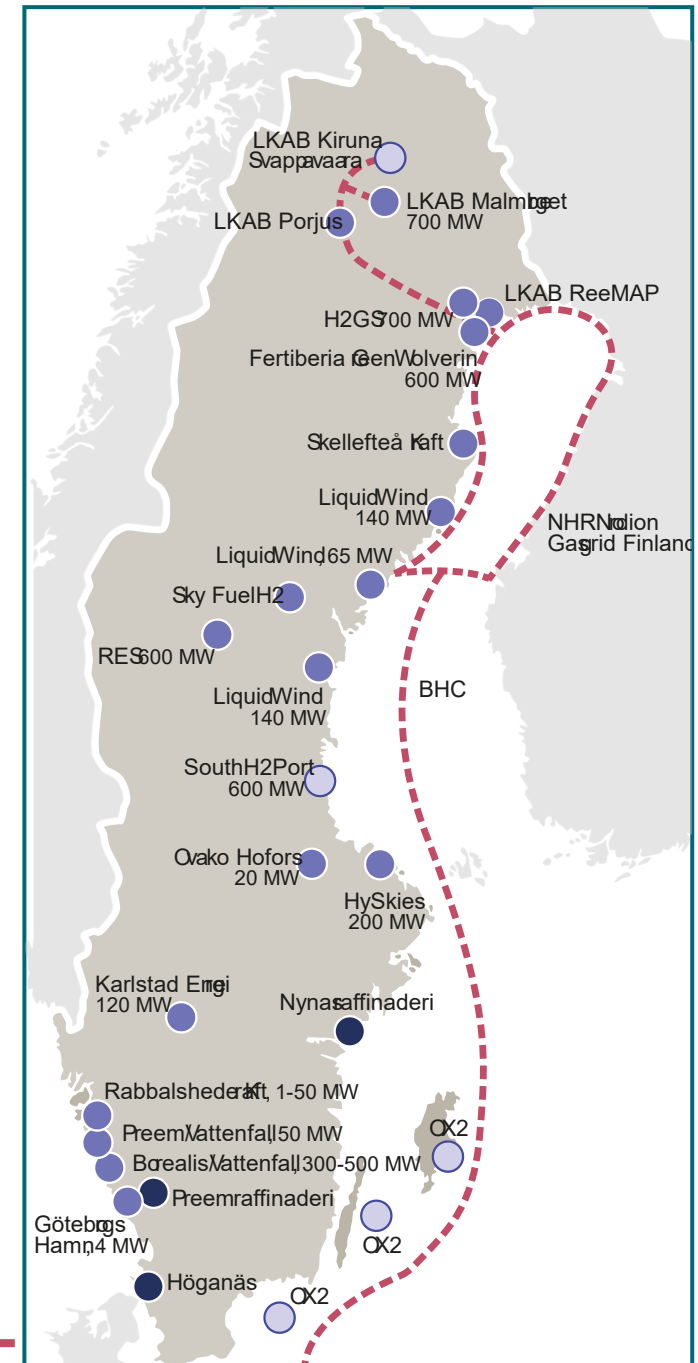
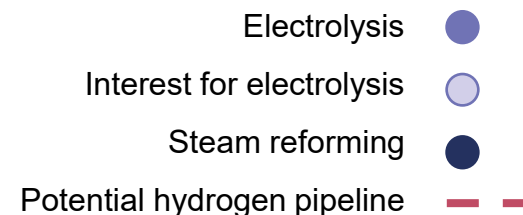
- Analyse how the hydrogen infrastructure can be developed in synergy with the electricity system and the energy system at large, in different scenarios with clusters or with more extensive pipeline infrastructure

## Mapping of announced hydrogen projects to:

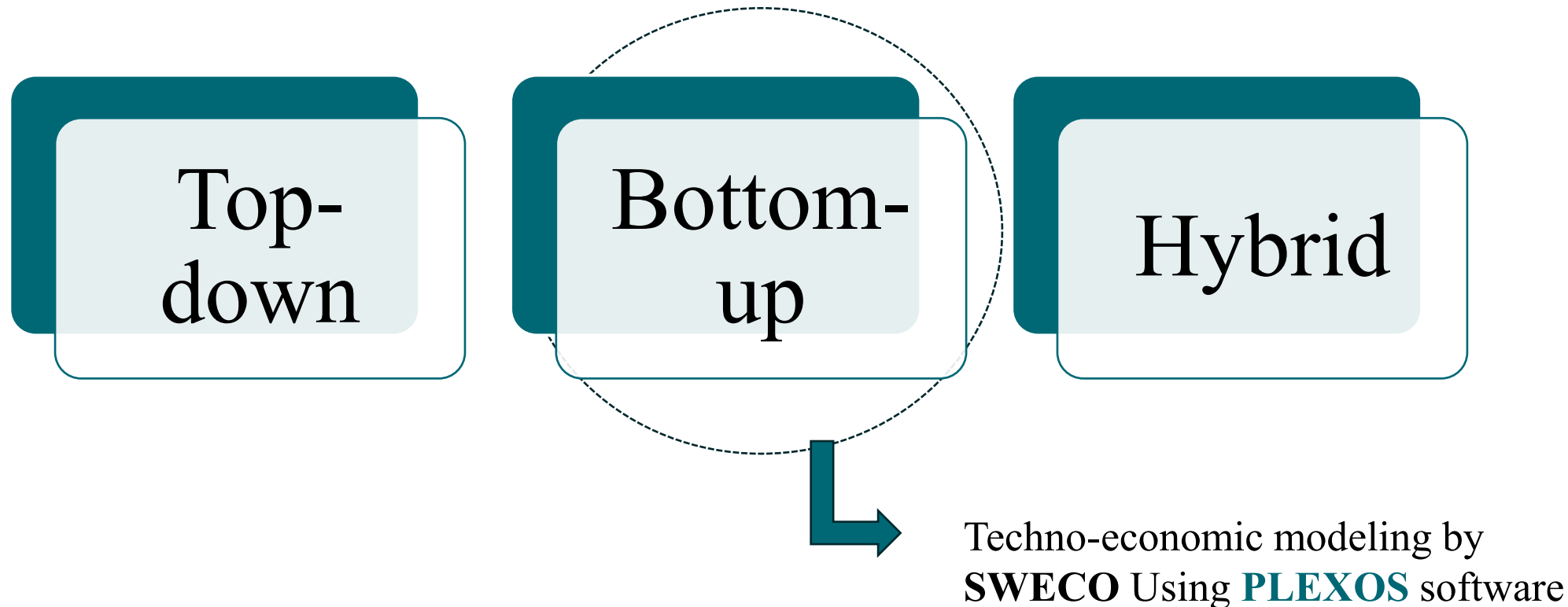
- Analyse the geographical distribution of the projects across the country
- Assess the alignment of hydrogen production with fossil-free energy sources.
- Examine plans for hydrogen production, utilization, transmission, distribution and storage

## Techno-economic analysis to:

- Investigate the need for energy transmission and identify opportunities for socioeconomically optimal development.



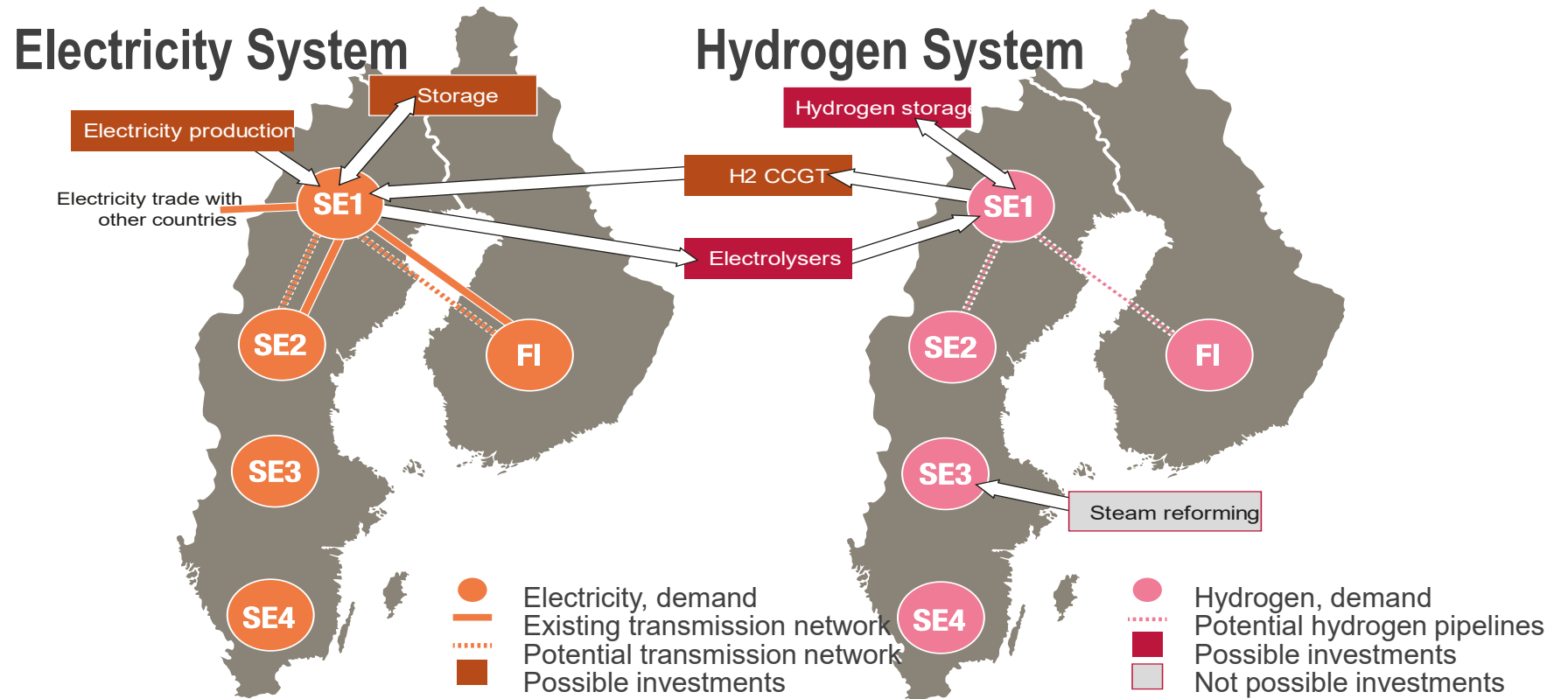
# Different approach to analyze pathways for infrastructure development



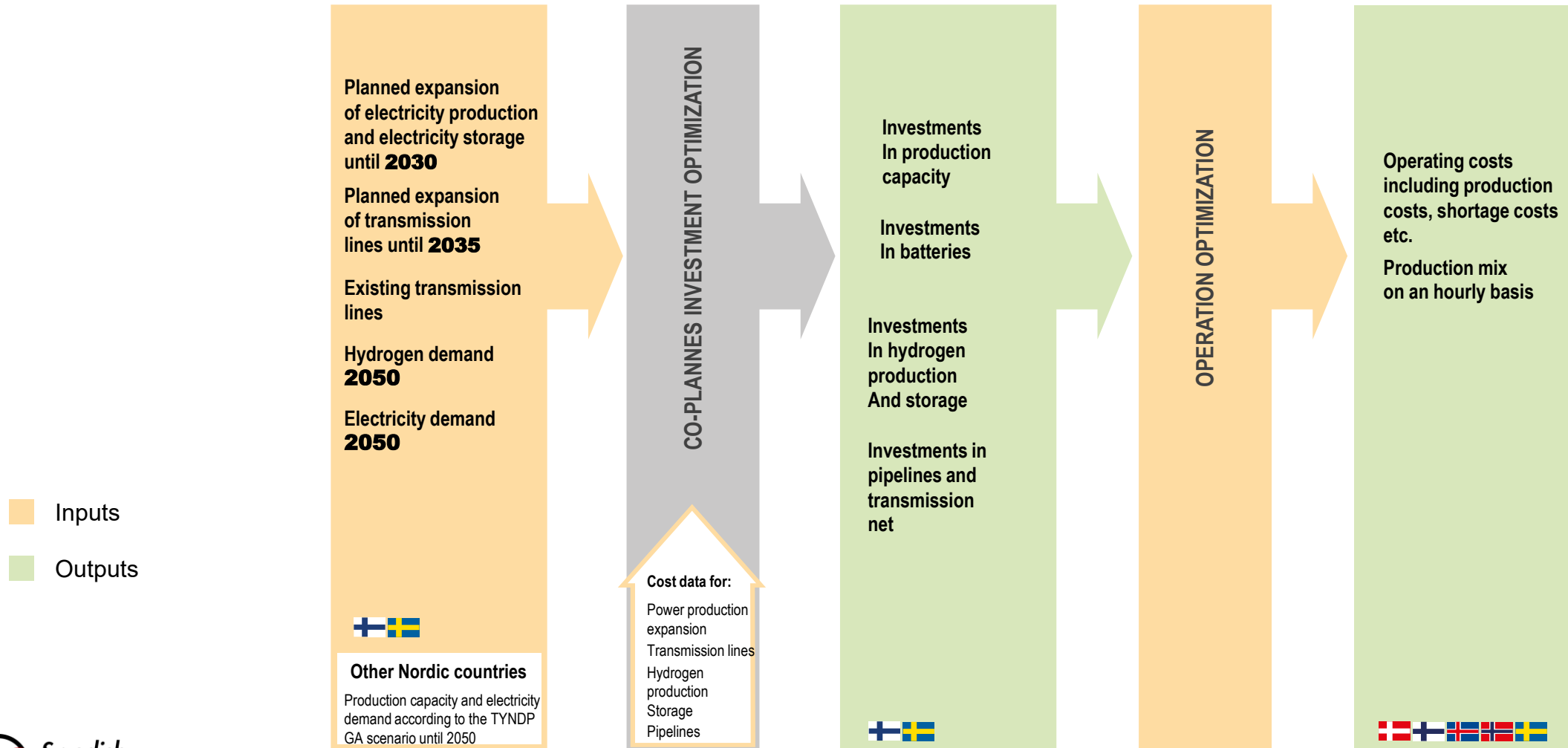
# The energy systems that the modelling optimizes



*The model does not capture infrastructure needs within electricity bidding areas*

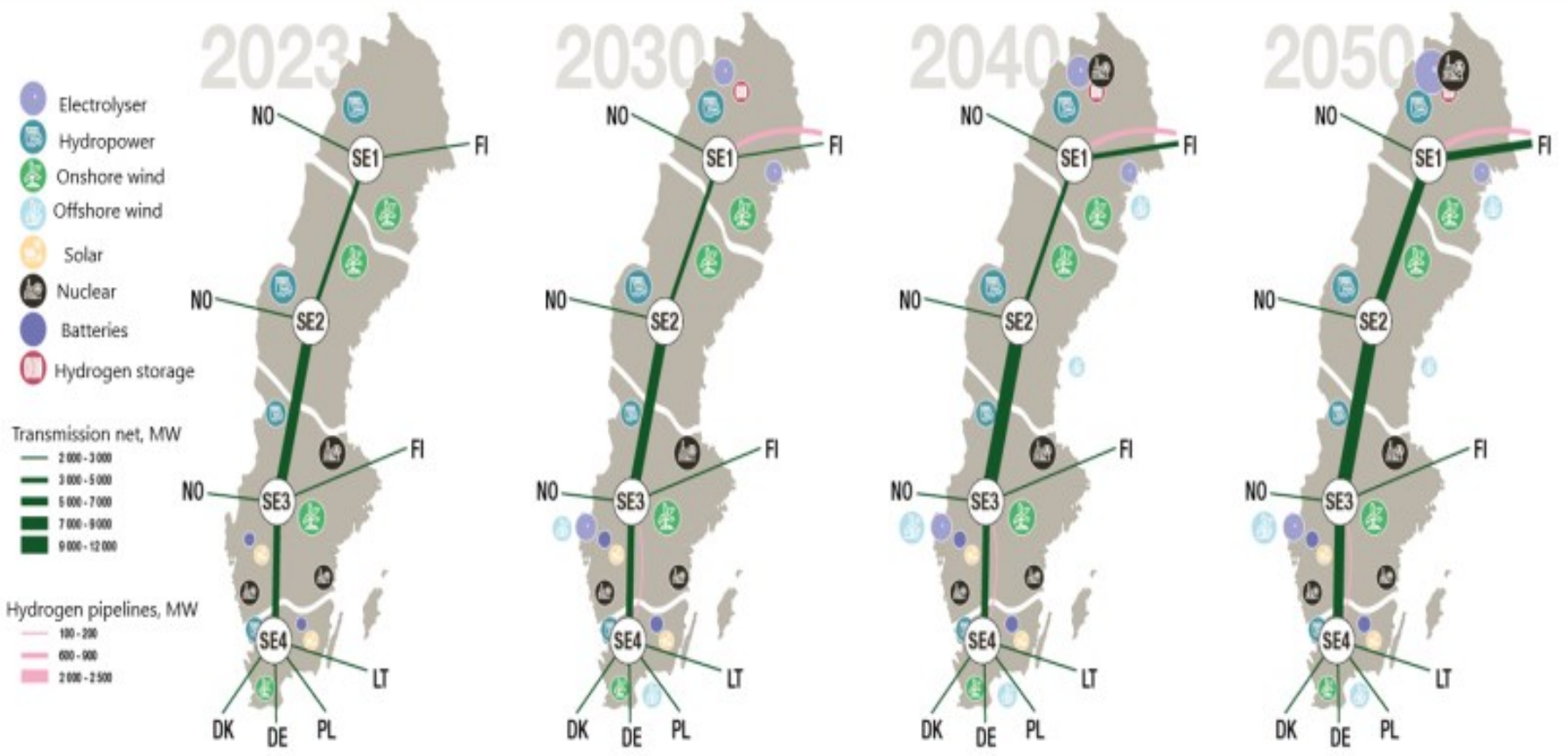


# The inputs and outputs of the co-planned energy system in the modeling



# Development of the energy system to 2050- Reference scenario

➤ The Reference scenario is based on the Swedish Energy Agency’s **Long-term scenario “High electrification”**



## Sensitivity analysis

- Reference
- Lower Electricity and Hydrogen Use
- Limited expansion of onshore wind in SE1
- New nuclear 2035
- Lower pipeline, higher transmission net-CAPEX
- Higher pipeline, lower transmission net-CAPEX
- Higher electrolyzer, lower storage costs
- Lower electrolyzer, higher hydrogen storage costs

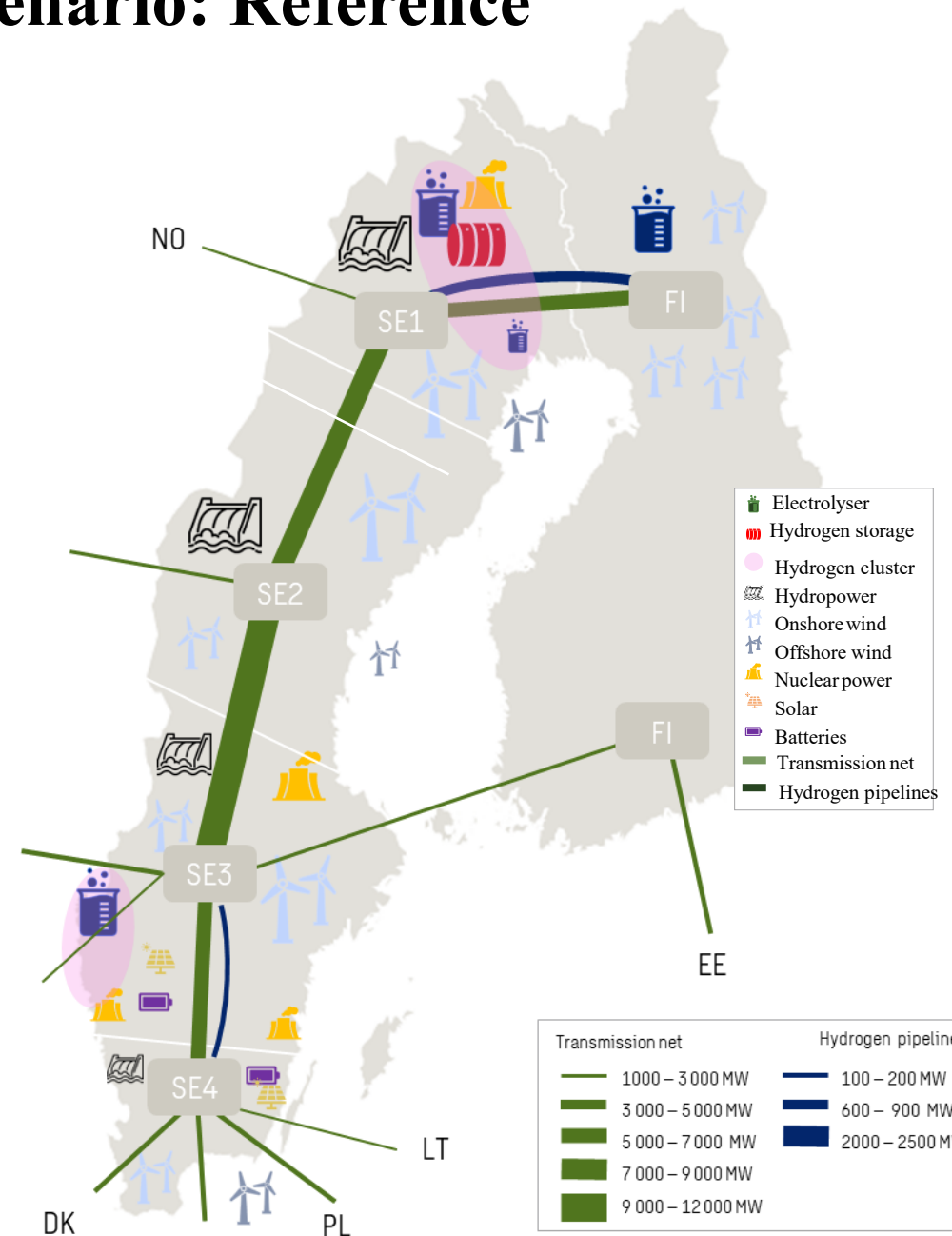
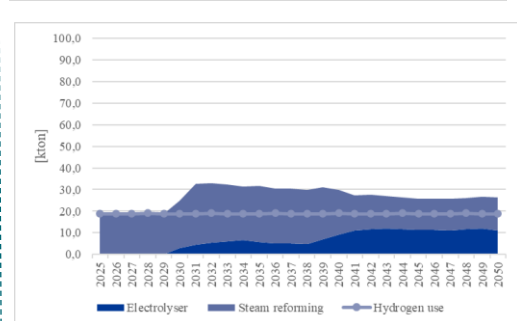
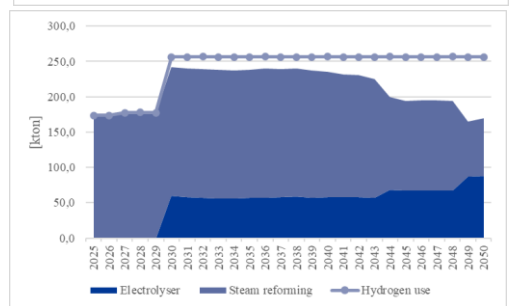
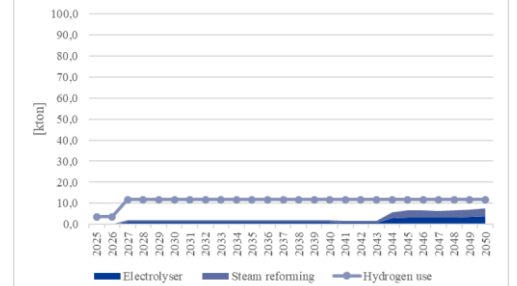
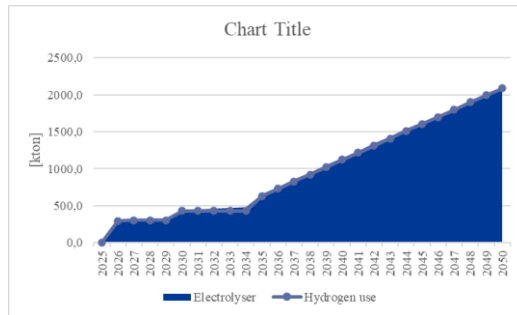
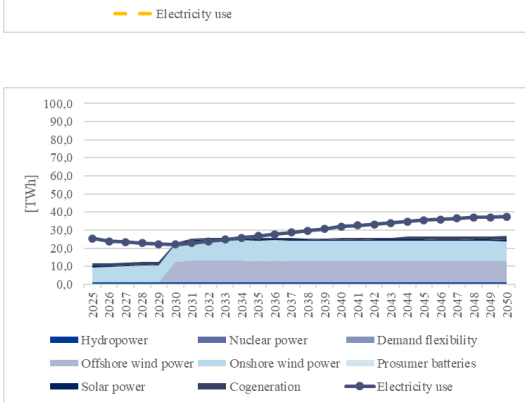
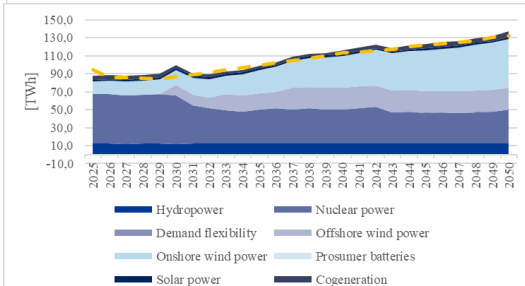
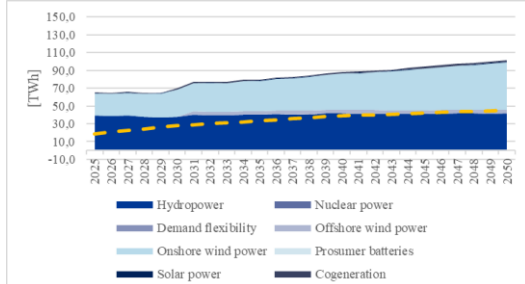
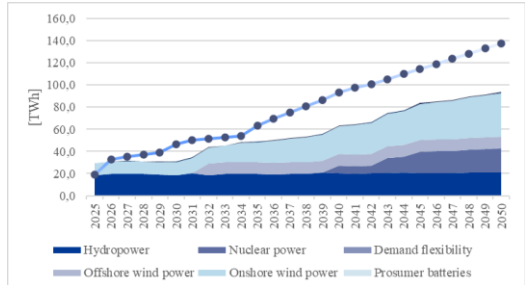
## key Indicators

- Expansion costs
- System costs
- Shadow prices
- Development of transmission networks and hydrogen pipelines
- Electrolysis and steam reforming
- Energy storage - batteries and hydrogen storage
- Hydrogen use in the power sector
- Production mix

# Electricity use and production

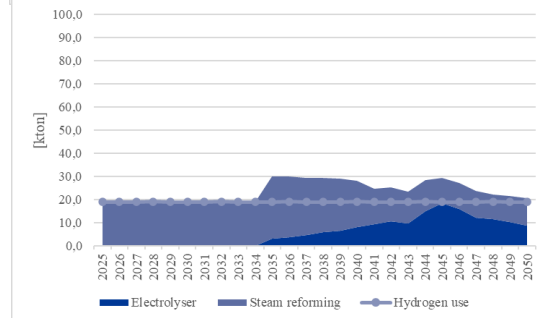
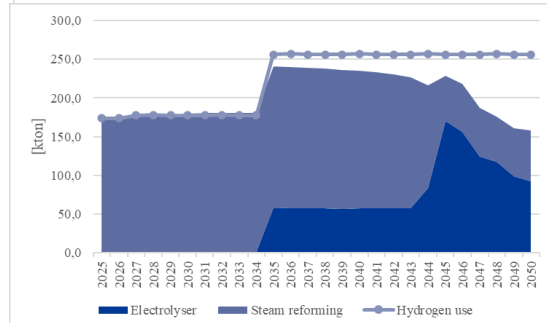
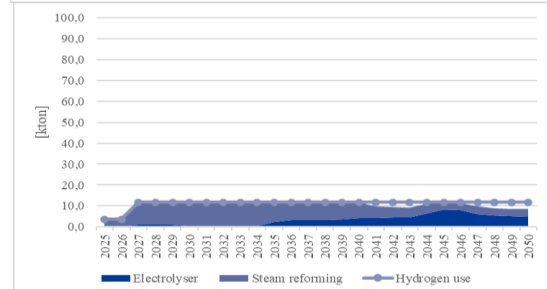
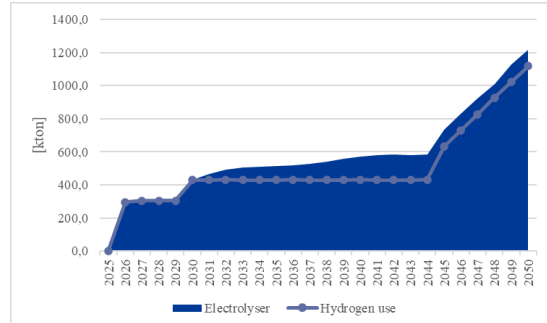
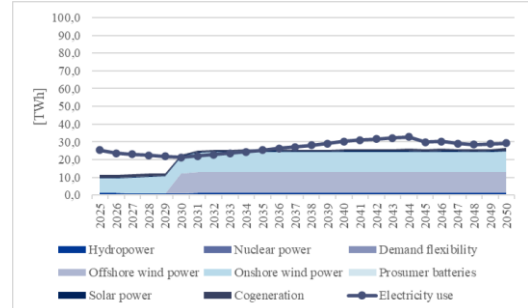
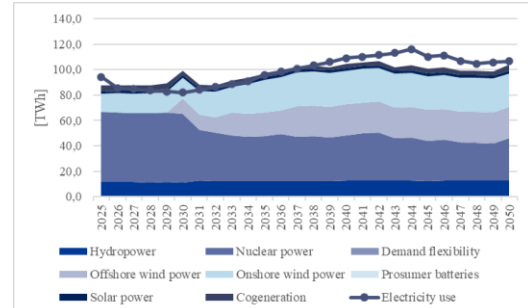
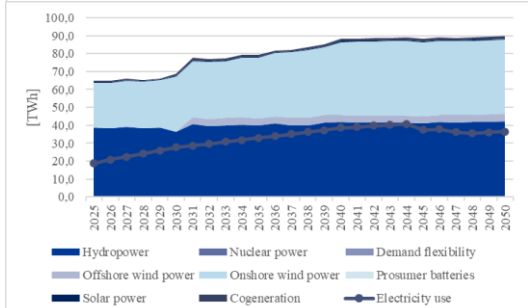
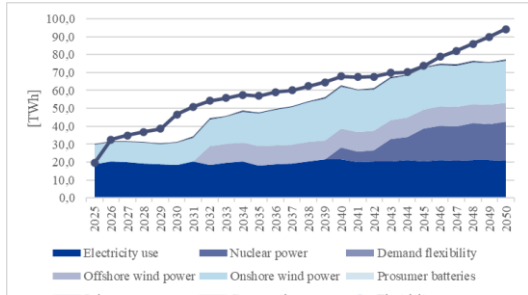
# Hydrogen use and production

# Scenario: Reference

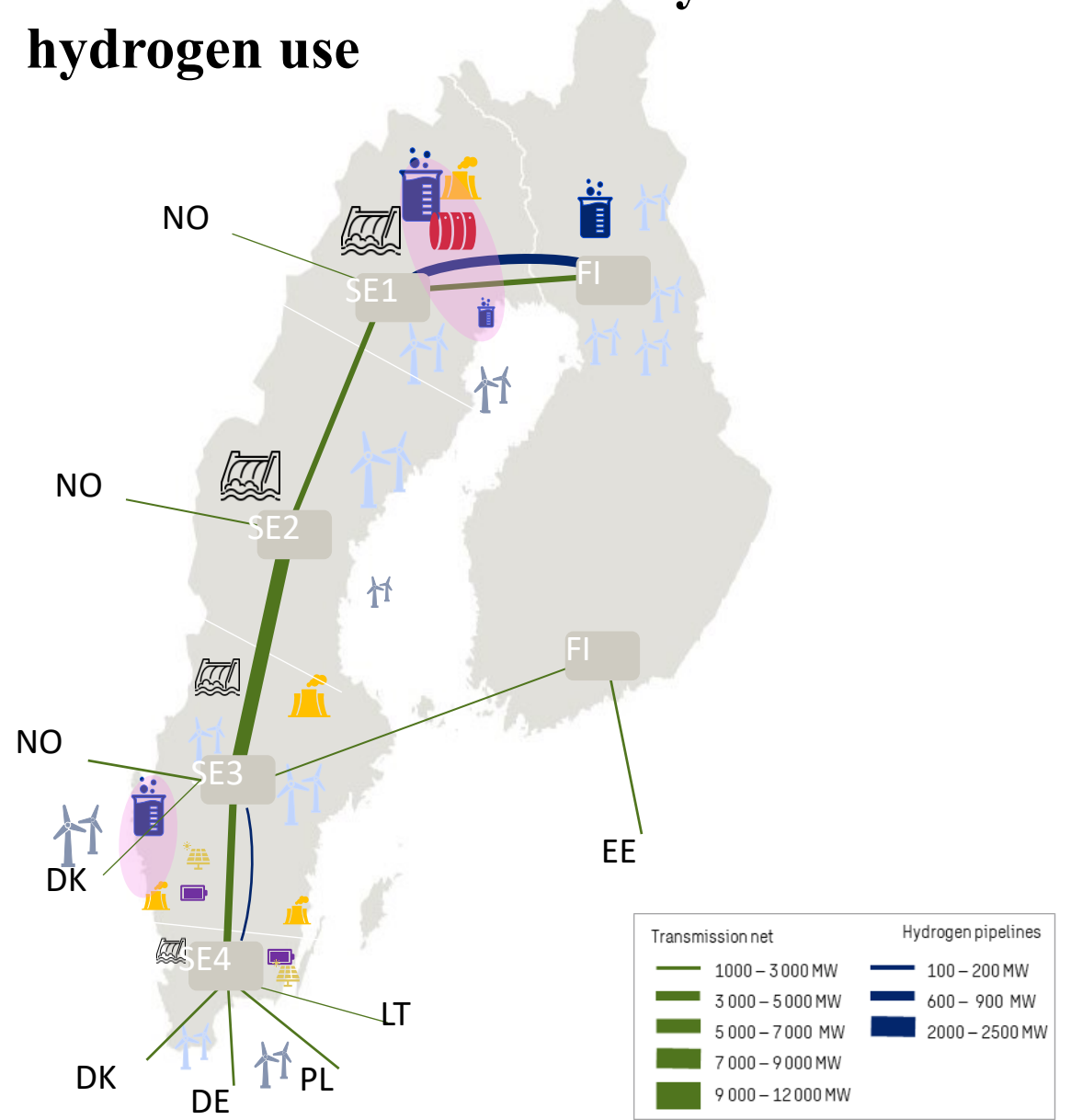




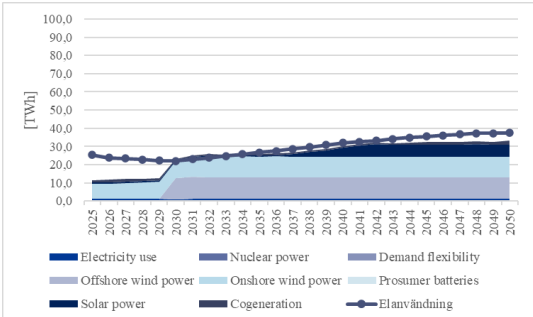
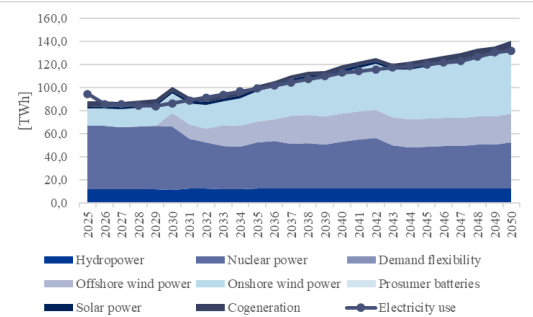
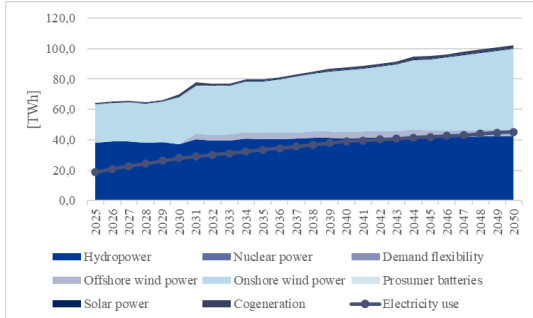
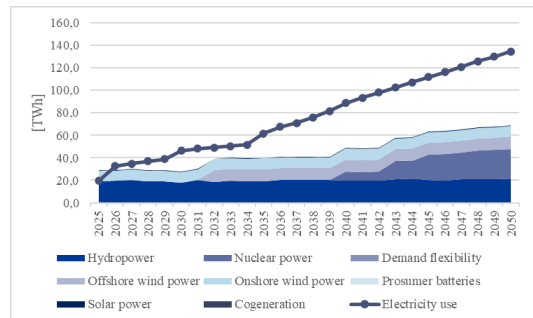
# Electricity use and production Hydrogen use and production



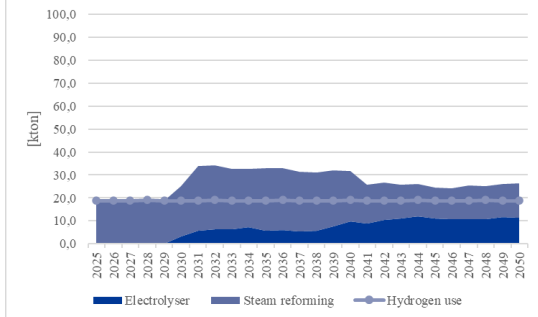
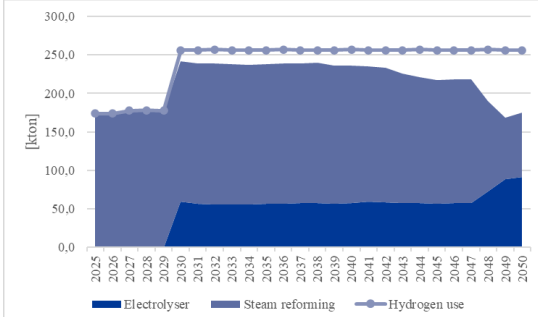
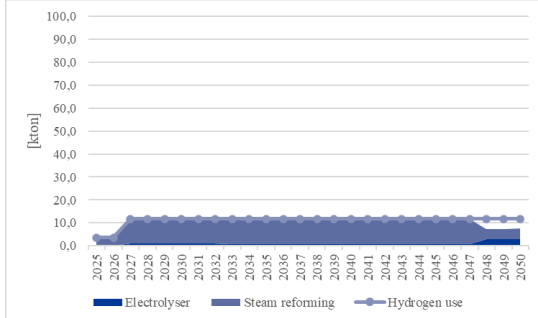
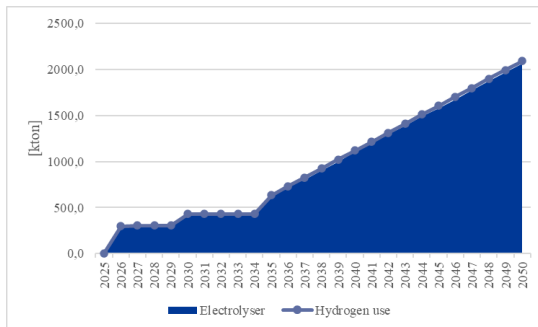
# Scenario: Lower electricity and hydrogen use



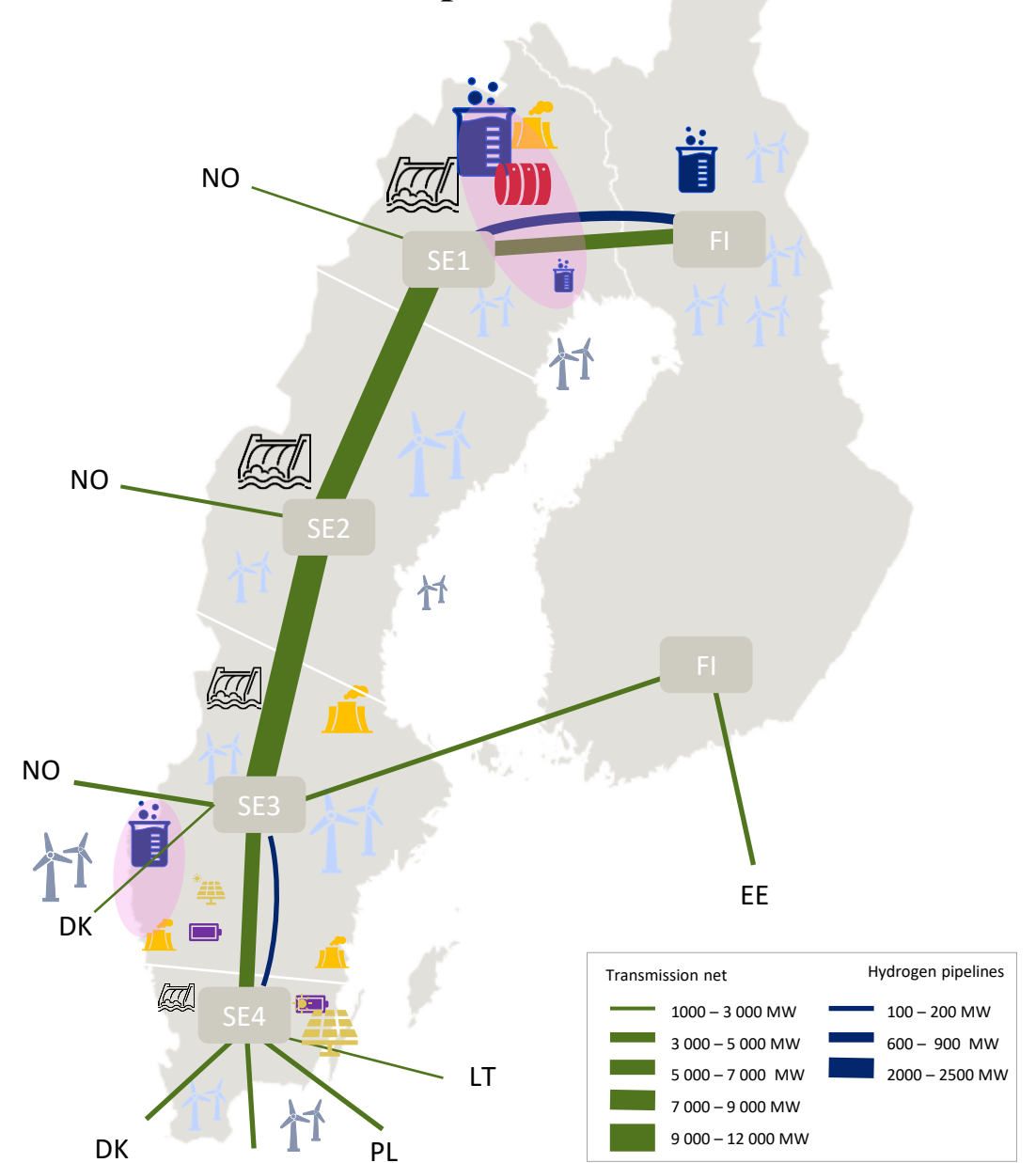
# Electricity use and production



# Hydrogen use and production



# Scenario: Limited expansion of onshore wind in SE1



# Summary

The modelling draws attention to numerous interdependencies, such as energy policy, permitting feasibility, grid connections, timeframes, electrolyzer investment costs, new electricity production, potential investment incentives, price risk mitigation, electricity and hydrogen prices, etc. These factors contribute to considerable uncertainty regarding feasible outcomes or realistic assumptions. While modelling provides valuable insights through sensitivity analyses, the results also come with significant variability and uncertainties

## Given the pre-defined conditions in the modeling

- Most hydrogen production occurs near consumption areas, thereby minimizing energy transfer requirements. However, in the reference case and nearly all sensitivity cases, pipeline capacity is established between SE1-FI and SE3-SE4 only.
- Both hydrogen pipelines and electricity transmission lines are necessary for energy transfer between electricity bidding areas.
- While pipelines are generally cheaper to construct than transmission lines, significantly more investment is allocated to electricity transmission infrastructure

Co-planning of the transmission network and expansion of hydrogen infrastructure is both logical and, by all accounts, economically efficient

# Future studies

- Top-down modeling based on expected future demands from all sectors
- Combine with a comprehensive qualitative analysis including market barriers and impact of various policy frameworks on the infrastructure development

**Thank you!**



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