Analyzing the decarbonization pathways of energy systems for two contrasting EU islands under flexibility issues

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OUTLINE

PROJECT GOALS

The main objective of the GIFT (Geographical Islands FlexibiliTy) project is to **decarbonise the energy mix of islands**.

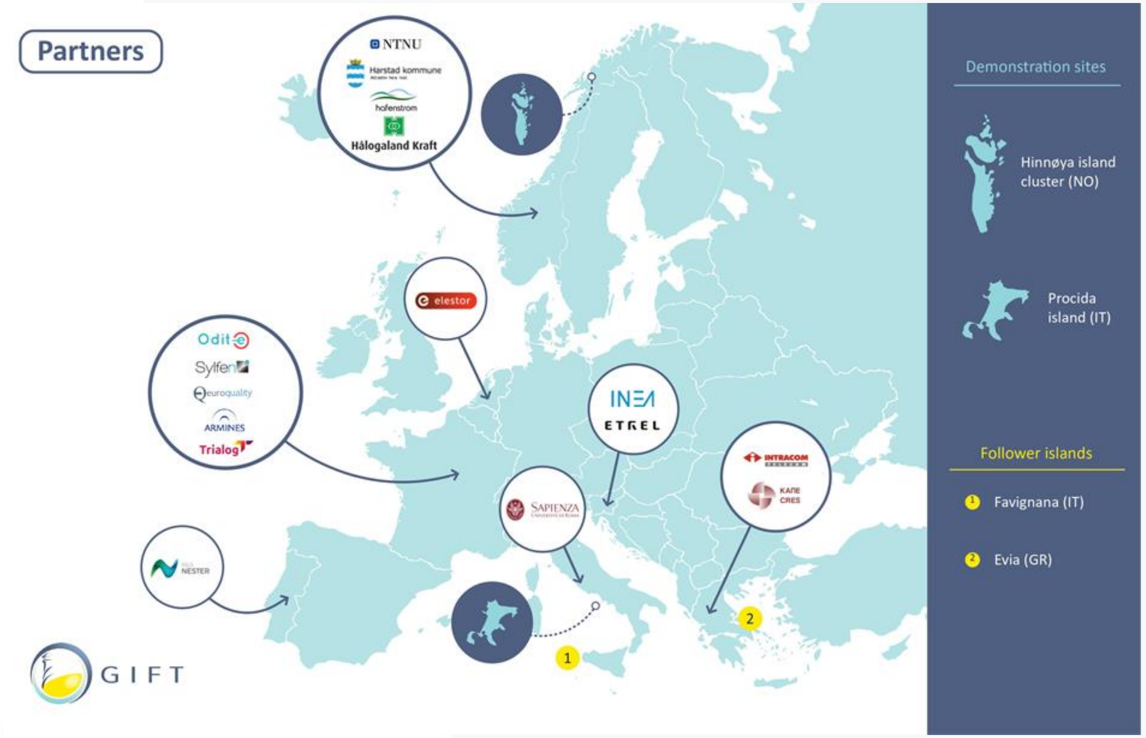
1: Allow a high level of **local renewable energy** sources penetration

2: Provide visibility of the energy grid to better manage its **flexibility and plan its evolutions**

3: Develop **synergies** between the electricity, heating, cooling, water and, transport networks

4: **Reduce** the use of **hydrocarbon-based energies**

5: Ensure the **sustainability** of the solutions and their **replicability** in other islands



The Demonstration Sites

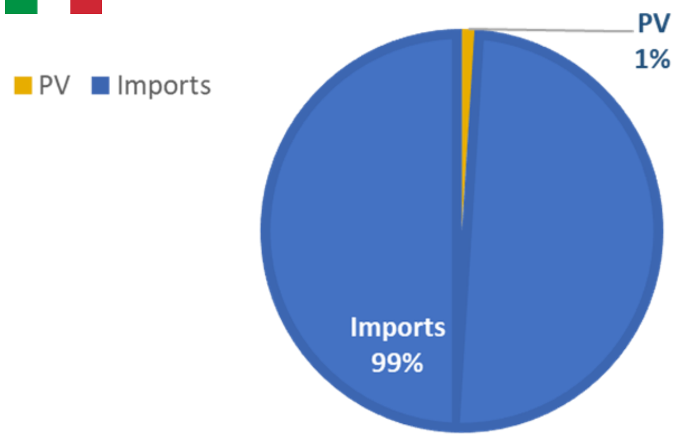
Procida Island (IT)

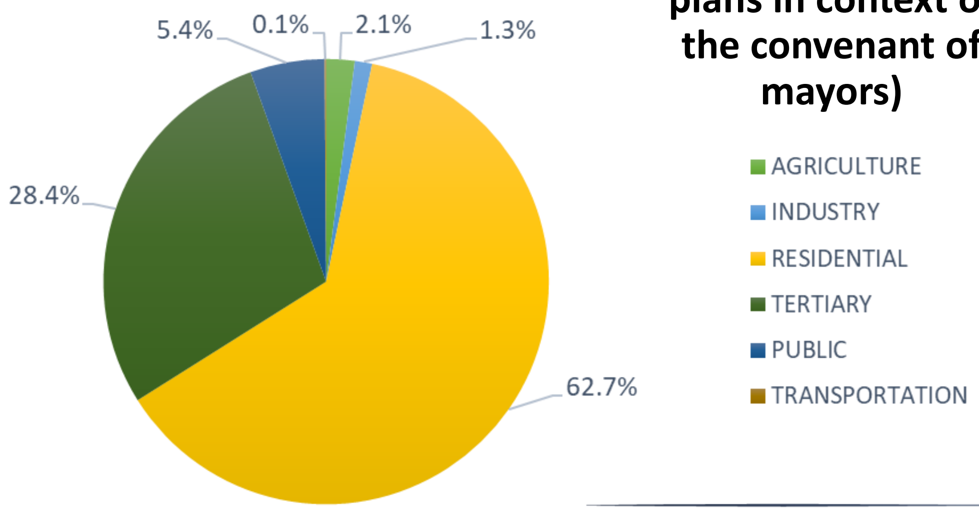
- ✓ Smallest island in the Gulf of Naples, Area = 4.26 km^2
- ✓ Density = 2449 inhabitants/km^2
- ✓ Challenges: Grid congestions, High seasonality of demand (tourism)
- ✓ High reliance on imports 99% of the electricity supply

Hinnøya Island Cluster (NO)

- ✓ Largest coastal island in Norway: cluster of large and small islands, Area = 2240 km^2
- ✓ Density = 14.52 inhabitants/km^2
- ✓ Challenges: Limited possibilities of new grid connections, Fish farms using diesel generators
- ✓ Import/export between the islands, main import from NO4 (Nordpool)

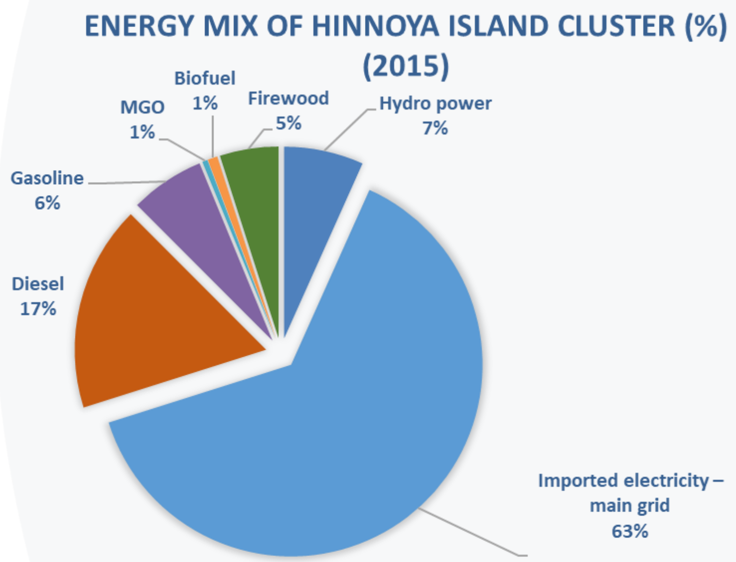
SUPPLY & DEMAND

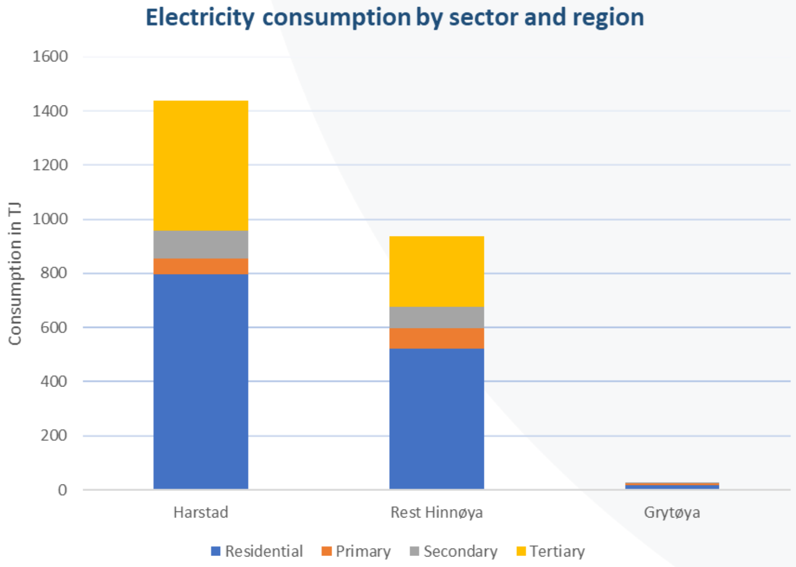




Undiversified electricity mix increases the dependency on the submarine cable.

For the demand side, data was not refined enough, and estimation were made using the PAES of Procida (action plans in context of the convenant of mayors)



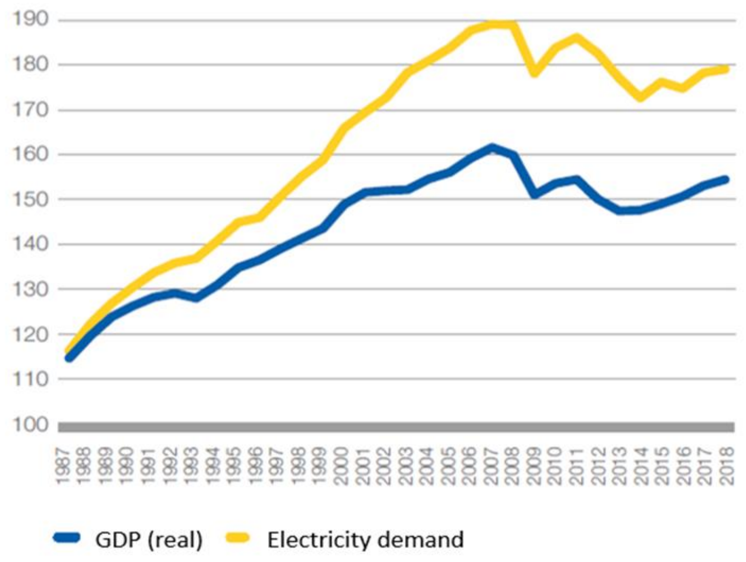


Hydro-based electricity is the main source of supply: end-uses are already decarbonized (except for fish farms)

Economic activities are mostly in Harstad where the transportation sector accounts for 69% of the emissions (in 2018)

Evolution in Time

Italian indexed GDP and electricity consumption trend (source: Terna, 2019 , based on Eurostat)

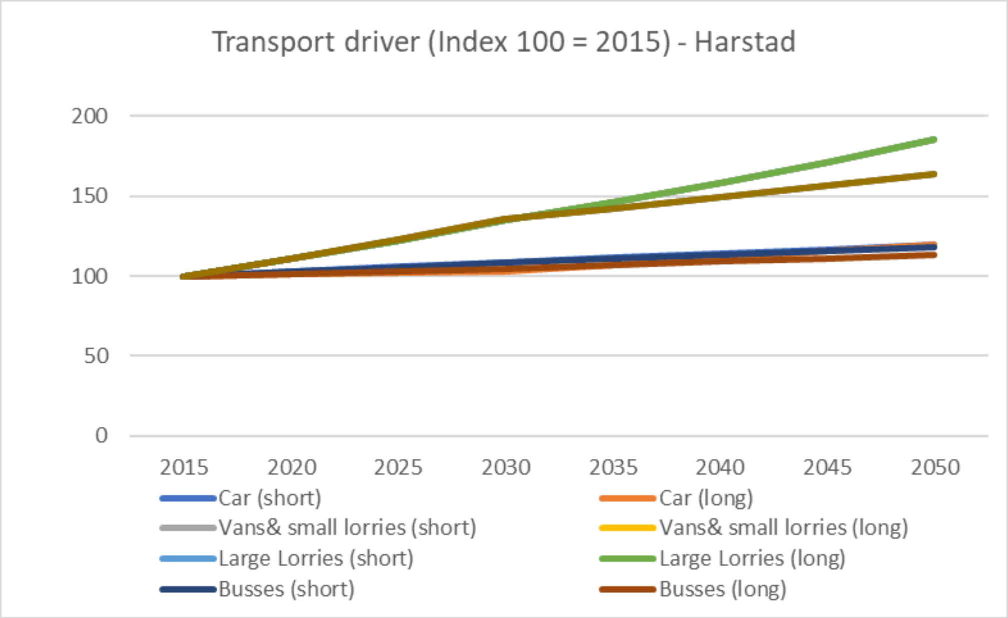


For electric cars, a trend is based on the strategic plan for the energy system (PNIEC), assuming the total number of cars is the same as 2018.

Electricity price: fixed as the average between the mean final electricity price for residential and non-residential users in 2018 (ARERA, 2019).

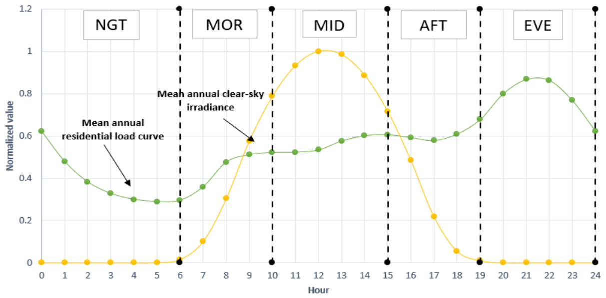
Demand evolution based on the population growth forecast of Statistics Norway (SSB) for the medium growth scenario (SSB, 2018)

Transport evolution: National transport model (NTM) (Madslien et al., 2019)

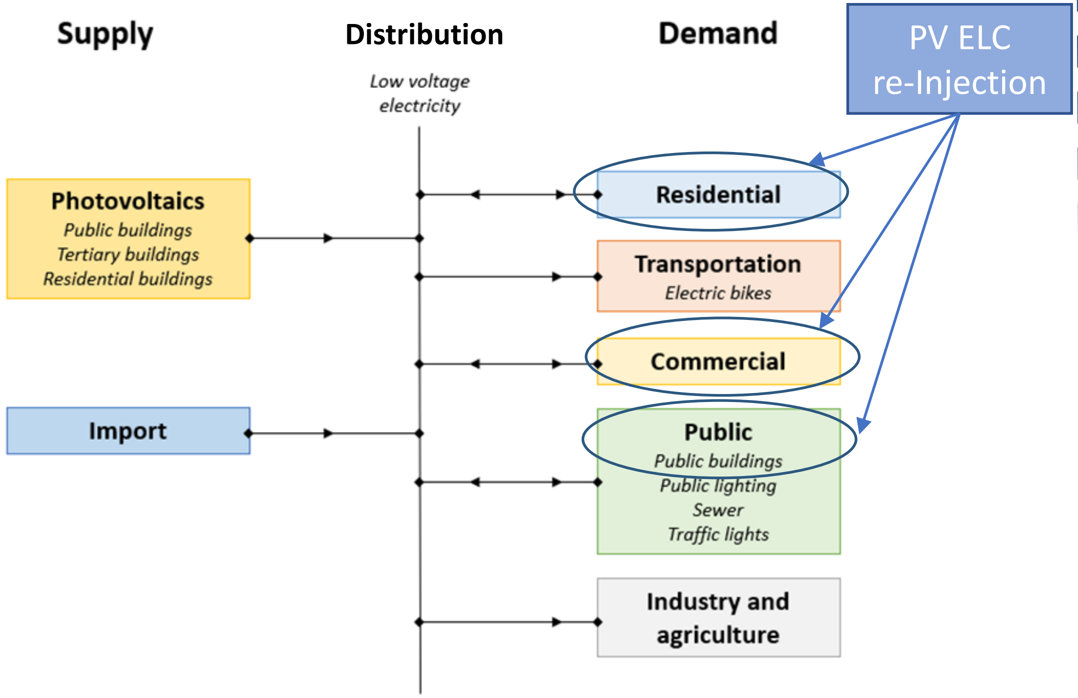


The future electricity prices: variable, NVE forecasts in between 2020 and 2040 (NVE, 2019a)

Modeling Framework

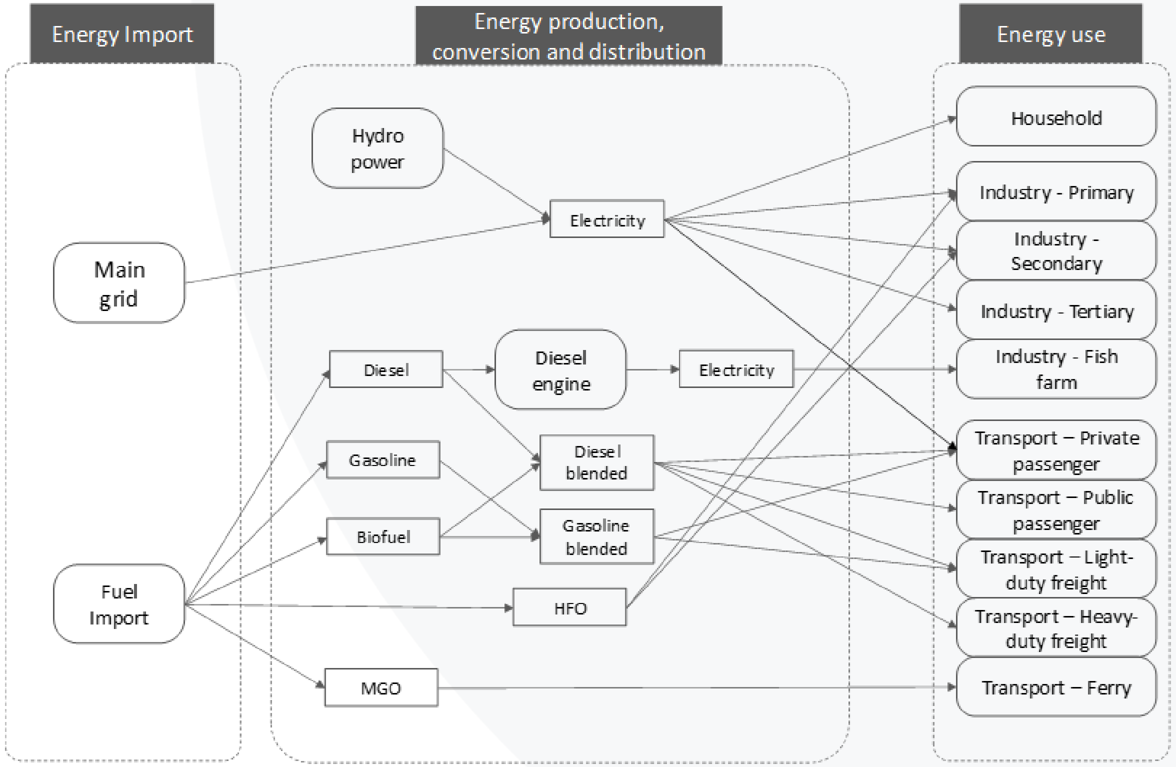


3 seasons: Summer, Winter, Intermediate, 5 daytimes
Horizon: 2018-2050



Reference Energy System (RES) of TIMES-Procida

12 months, Weekday, Week-end day, 24 hours
Horizon: 2015-2050



Reference Energy System (RES) of TIMES-Hinnøya (NTNU), (Zhou et al., 2022)

CONSTRAINTS & SCENARIOS

Techno-economic parameters provided by partners or publications from EU JRC

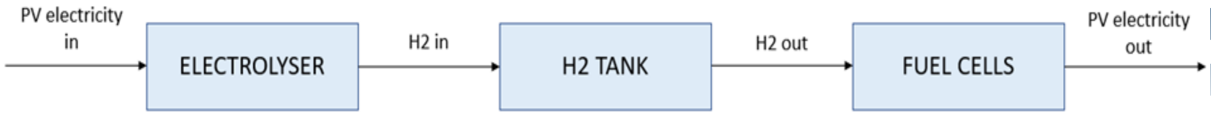
Scenarios: LOW, HIGH, HIGH_STG, HIGH_STG_EFF

Rooftop PV → maximum capacity constraints: geographical + local policies considerations for RNW Energy: PUB, RES, TER

$$C_t \leq C_{max} \qquad \forall t \in T$$

Smart Energy Hub*: reversible solid oxide cell (rSOC) +Li-ion battery

$$C_{SEH,2022} = constant$$



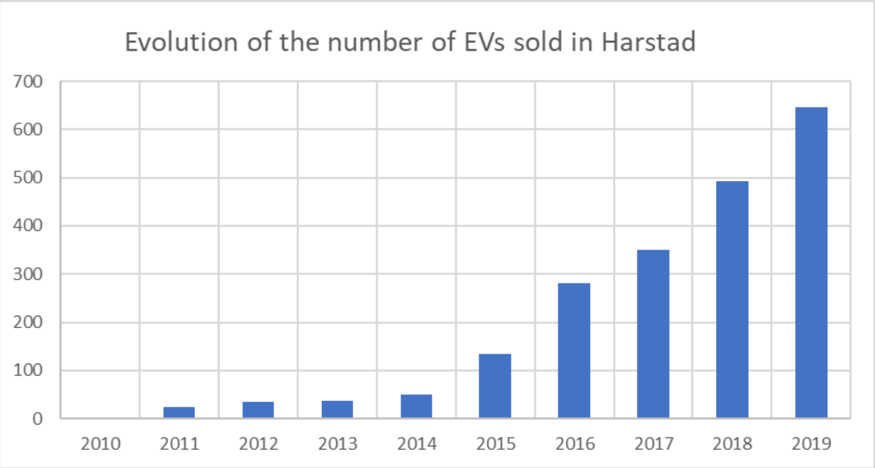
Seasonal storage

Demand for EV (cars & moto)

*The Smart Energy Hub is created by Sylfen (www.sylfen.com) and tested in context of the GIFT project

Scenarios: FLEX and FLEX_ELESTOR, HyWin + FLEX_ELESTOR

EV Chargers



Number of EVs sold in Harstad (based on HLK, from SSB 2020)

ELESTOR*: HBr storage

Harstad; Hinnoya

$$C_{ELESTOR,2025} = constant\ bound$$
$$C_{ELESTOR,2025} = unbounded$$

E-Ferry

$$C_{Ferry100\%ELC,2023} = constant\ bound$$

*ELESTOR (www.elestor.nl)

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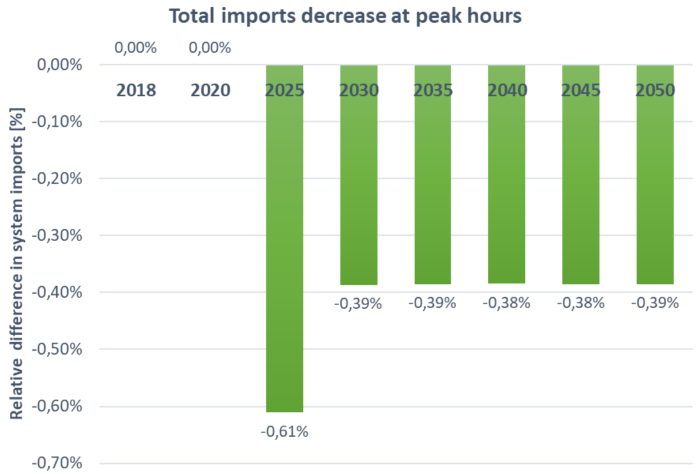
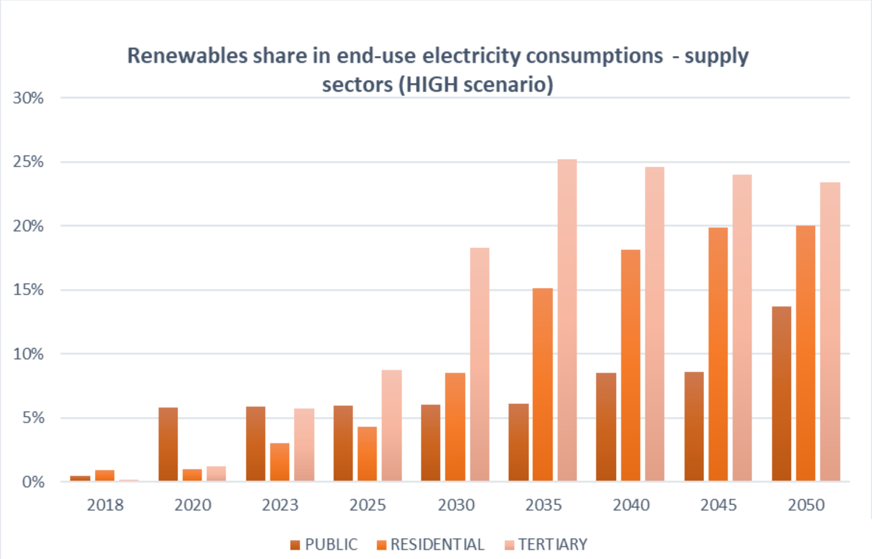
Illustrative Results

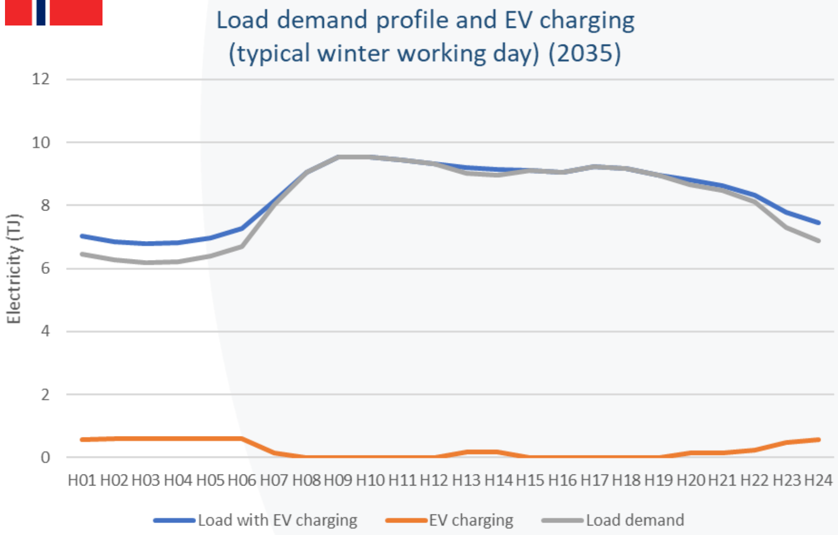
Flexibility solutions include technologies and approaches for the active participation of the demand-side, consumers being "prosumers"

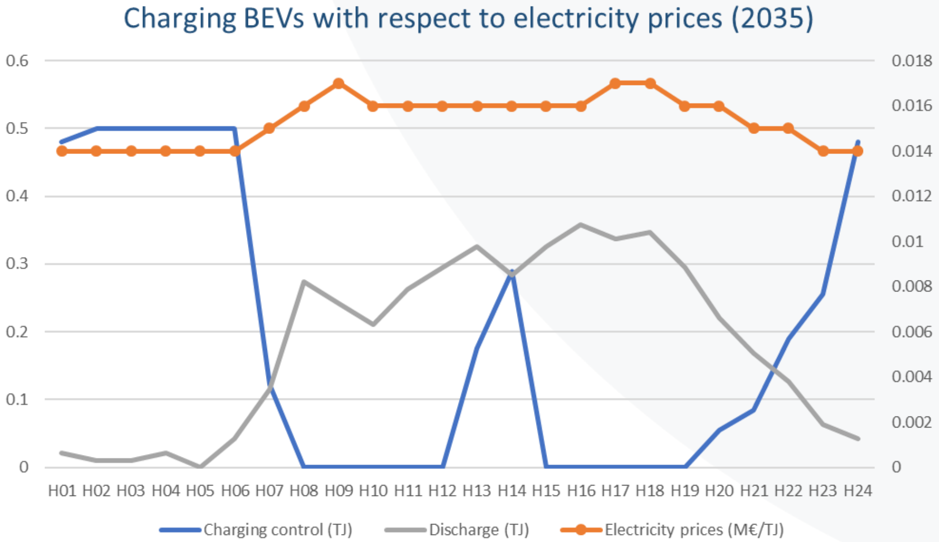


With storage, reduced imports at peak hours



The energy system would benefit from policies aiming for local energy production and from flexibility solutions, i.e Storage.





Shifting the charging time to off-peak hours/low tariffs periods, contributes to the valley filling and smoothing of the load curve.

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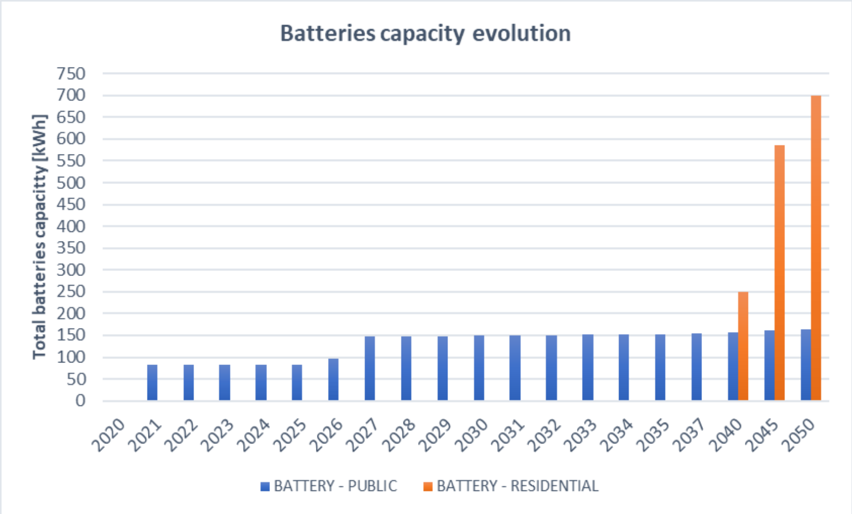
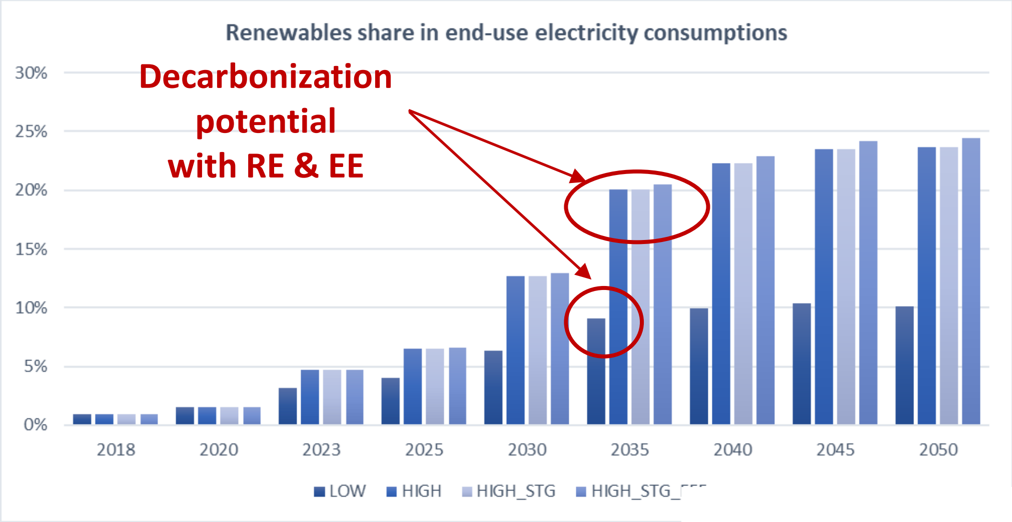
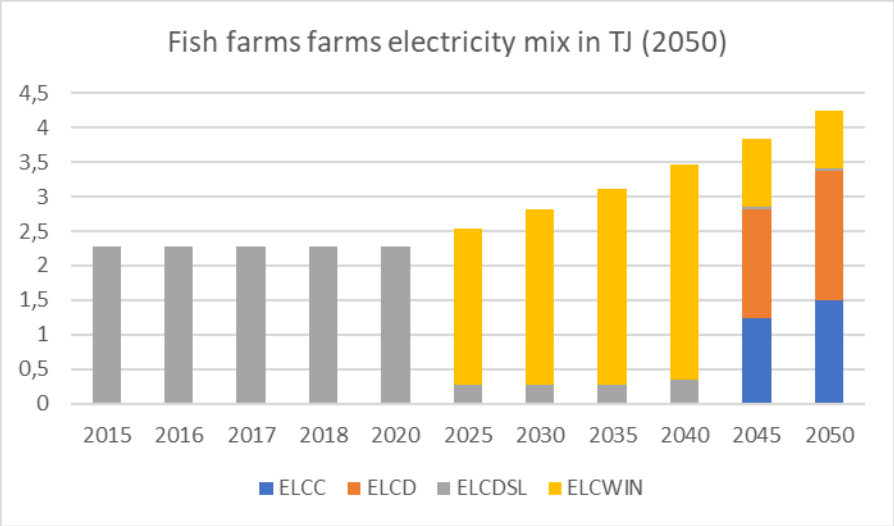
Illustrative Results

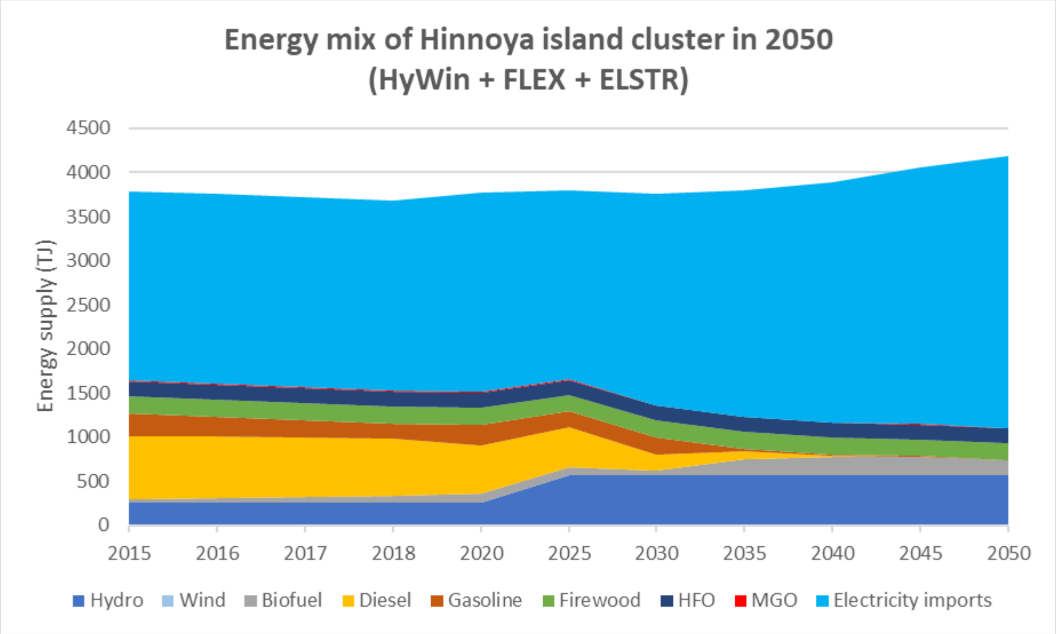
Same battery capacity evolution HIGH_STG and HIGH_STG_EFF scenarios, while the latter scenario increases the share of RE





Decarbonization of fish farms is almost attained whereas flexibility of farmers is not feasible





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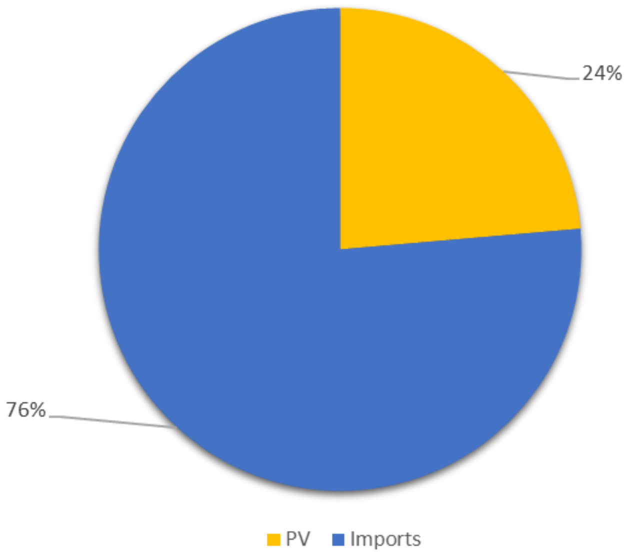
LESSONS LEARNED: SAME OBJECTIVE, DIFFERENT APPROACHES

- Reaching the objectives can be made through:
  1. Producing electricity from local sources
  2. Investing in storage technologies

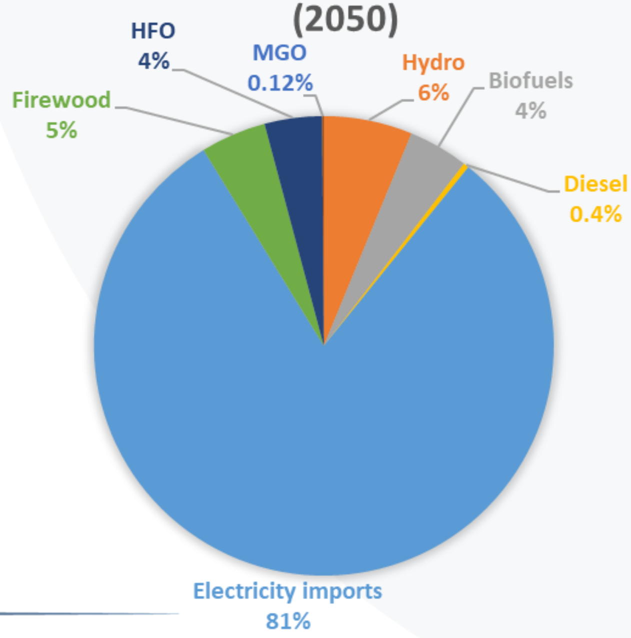
RE integration allows the decarbonization and the energy autonomy of the island

FINAL ENERGY MIX OF PROCIDA (2050)



- Cross-sectoral flexibility solutions: Electrification of the transport sector with policy support
- This increases RE integration and decarbonization *(specific for Norway, while energy autonomy is not an issue)*
- Controlling the load is made possible with storage and energy management systems

FINAL ENERGY MIX OF HINNOYA ISLAND CLUSTER (2050)



Recommendations

- ✓ Integrating RE-based electricity to decarbonize sectors is facilitated by flexibility solutions (manage the additional load and avoid creating peaks with the electrification of emissive sectors)
- ✓ Enhancing the flexibility is linked to investment costs and maturity of solutions, hence the role of supporting research and innovation to achieve it
- ✓ Participation of the demand-side is a source of flexibility in addition to increasing RE shares
- ✓ Studying these two islands allows us to reflect also on the interconnected systems that will see further integration of RE in the future
- ✓ Permissible regulatory frameworks and States' policies play an eminent role for both the success of implementing flexibility options and their sustainability, and decarbonization of energy systems
- ✓ Data availability remains crucial to have a clear representation of the variability of demand and thus study flexibility
- ✓ Engagement of the local authorities fosters the provision of energy-related data and tangible information regarding the issues of the energy system and the collaboration between different entities builds up their capacities.

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Thank you !

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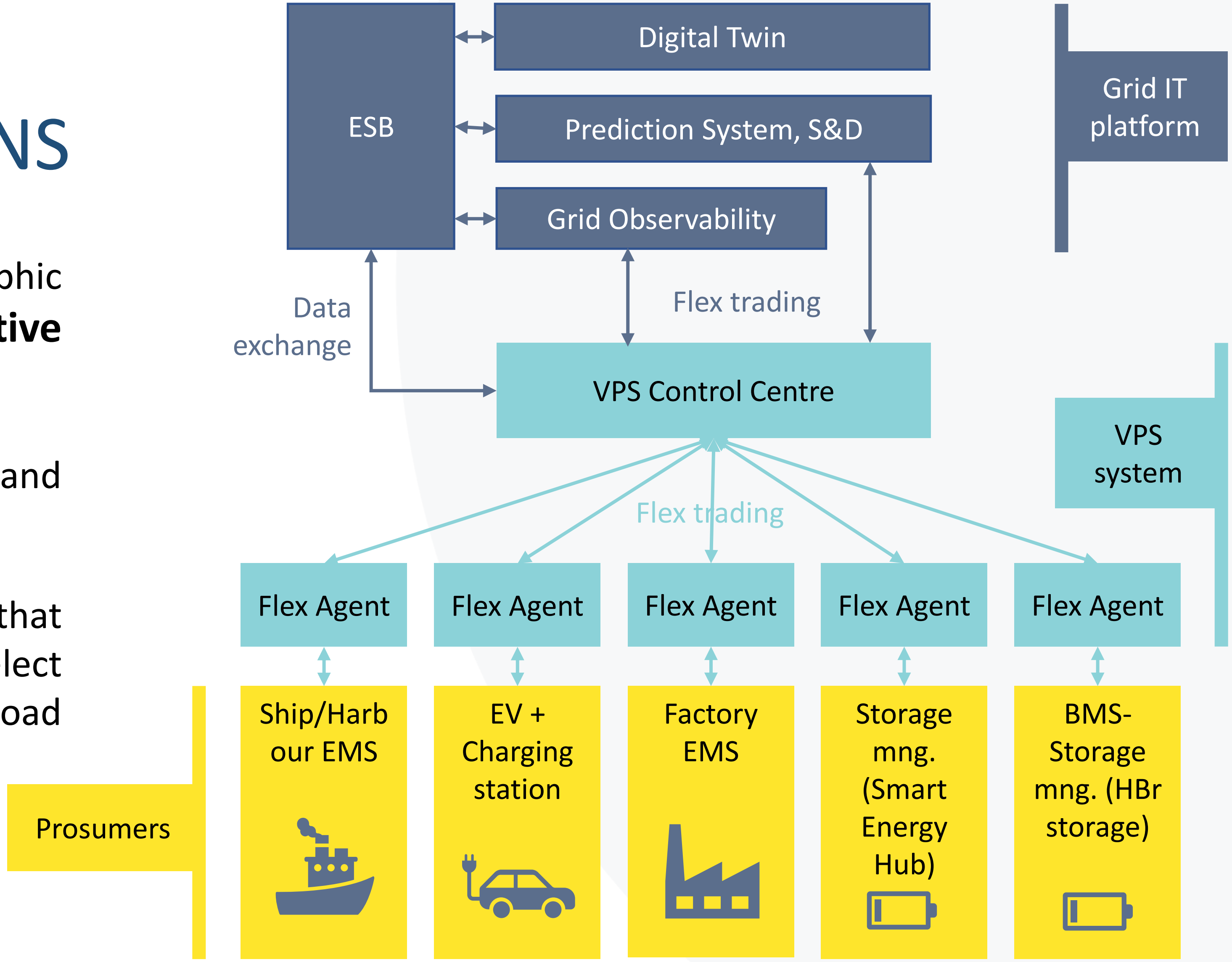
THE PROJECT'S SOLUTIONS

- Grid IT platform for KPI visualisation, geographic visualisation, grid observability, **prospective modelling and long-term assessment.**
- VPS system, a decentralised automatic demand response trading platform
- Prosumers or smart energy consumers that postpone energy demanding tasks or select alternate sources for energy to reduce the load on the power grid, thus providing flexibility.



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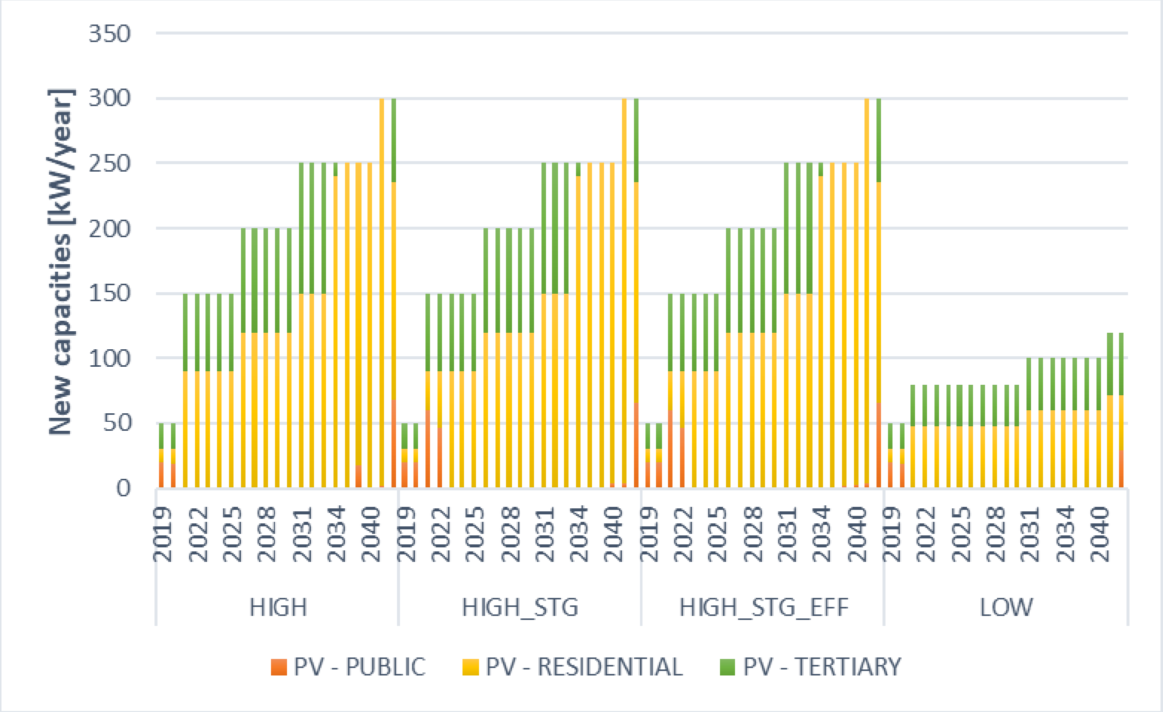
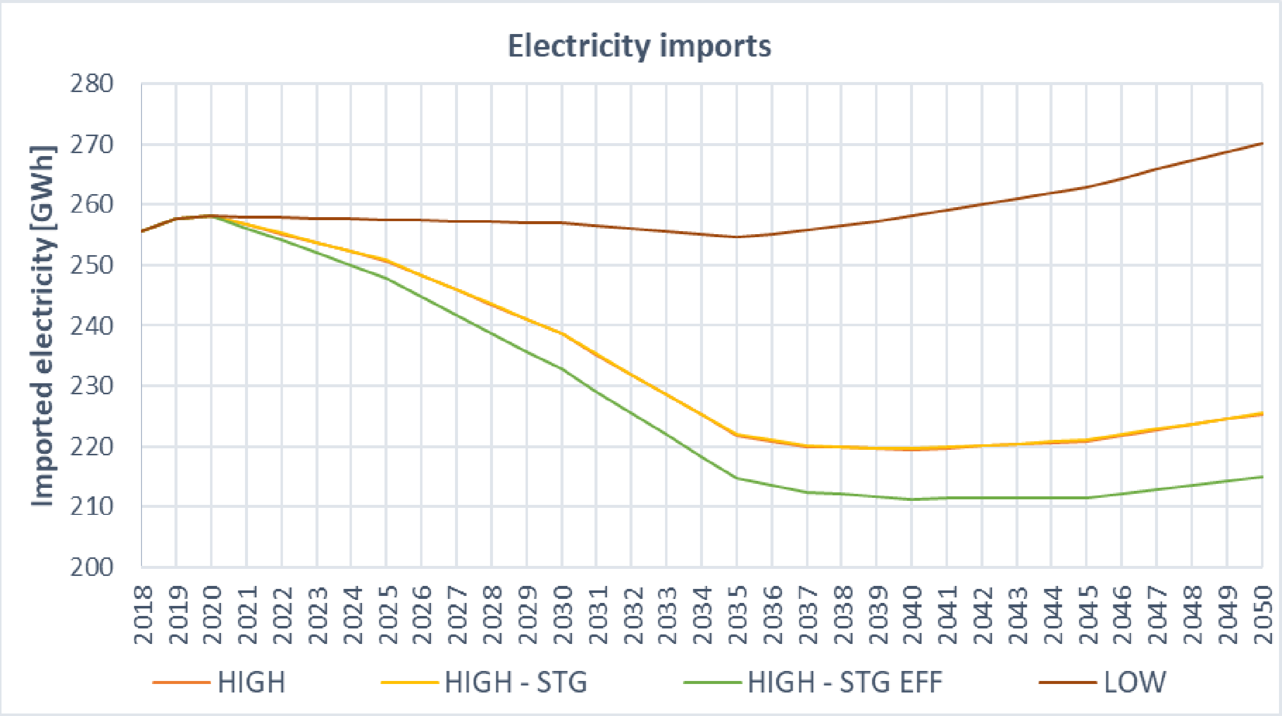
Annex 1: Optimal investments on supply technologies and the evolution of imports in the four investigated scenarios





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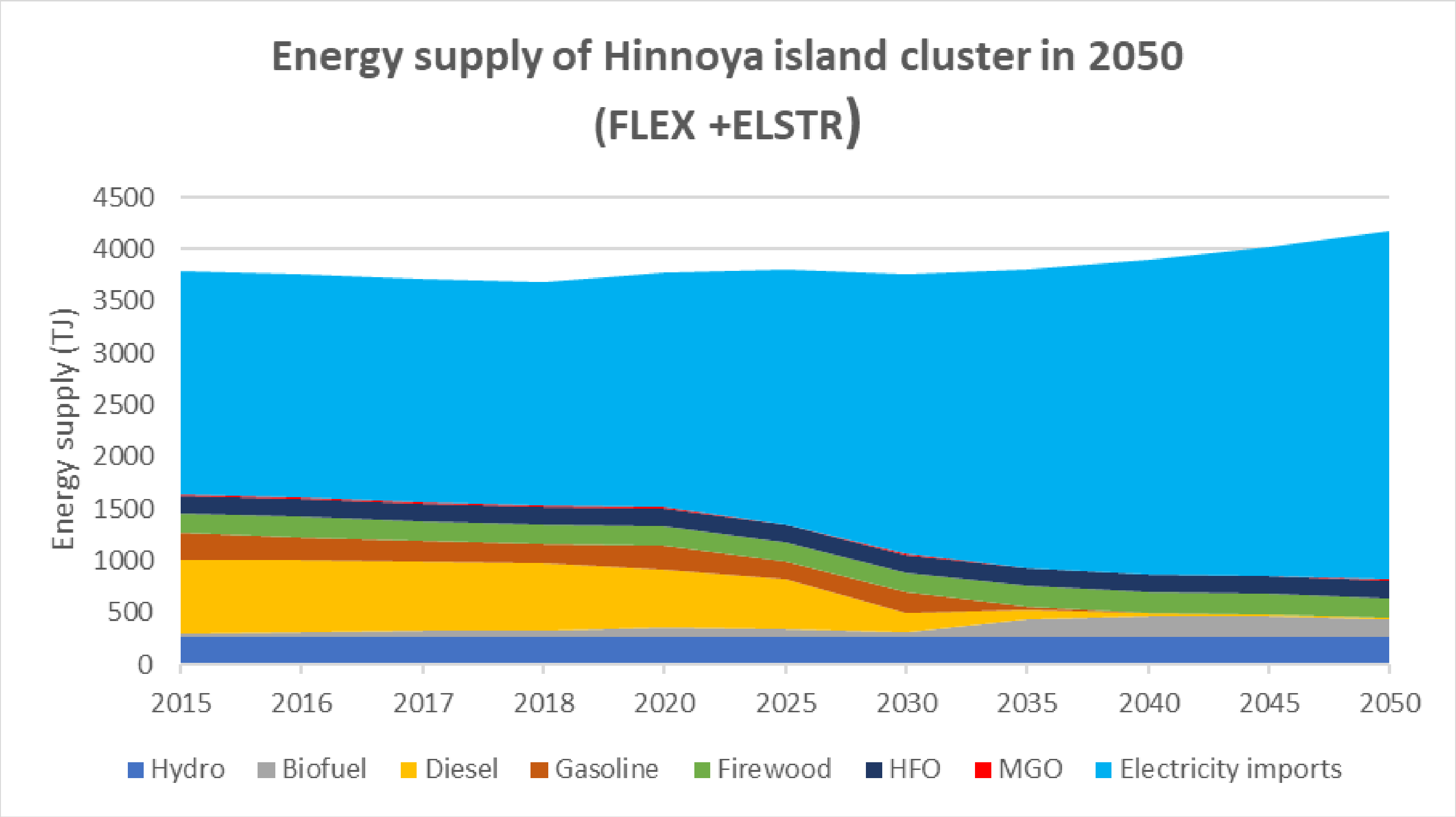
Annex 2: Energy supply evolution for Hinnøya with no new RE investments



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