

The multi-facets of increasing the renewable energy integration in power systems

Presented by
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IEW 2022, 26 May 2022 in Freiburg, Germany








THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH & INNOVATION PROGRAM UNDER GRANT AGREEMENT NO 824410

OUTLINE

-  → Introduction
-  → Context and project presentation
-  → Modelling framework: TIMES-Procida
-  → Assumptions
-  → Main findings
-  → Lessons learned & recommendations

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



WHY ARE WE INTERESTED IN INTEGRATING RENEWABLE ENERGY IN ISLANDS' ENERGY SYSTEMS?

Challenges

*Energy supply, Economic,
Vulnerability towards
Climate Change*

Opportunities

*Policy support (EU Clean
energy for EU islands),
Endowment in RE sources,
Cost competitiveness of RE,
International commitments*

→ **Developing island specific energy system models**

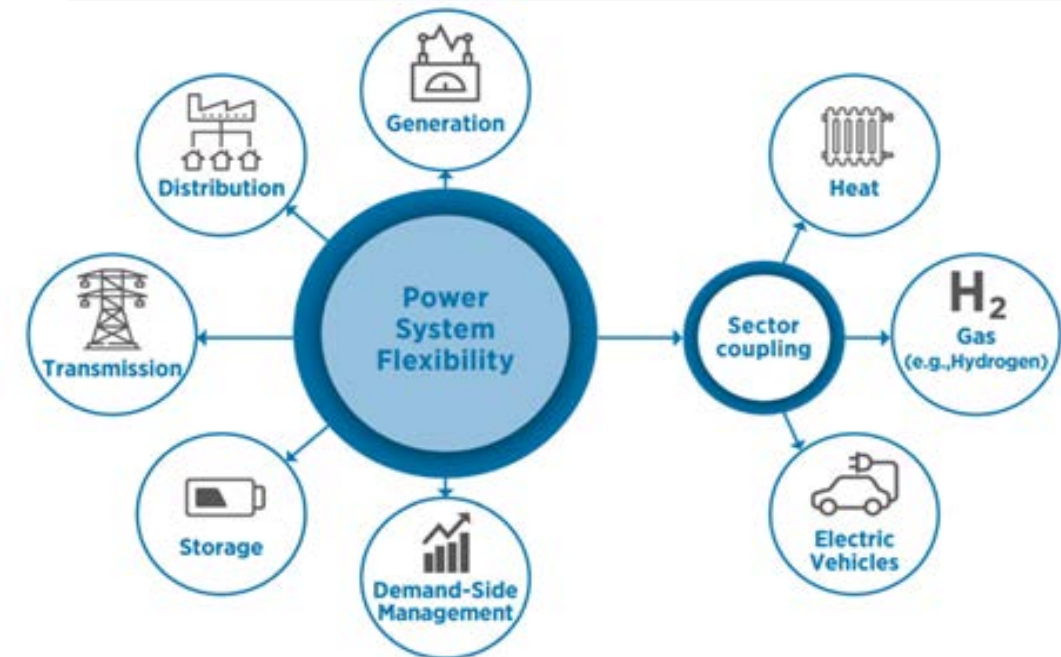
FLEXIBILITY OF THE ENERGY SYSTEM

Grid flexibility

- Operation of the energy system with instantaneous **stability** and long-term **security** of supply
- Reliability and cost-effectiveness
- Management of the **variability and uncertainty of renewable energies**
- Ensure the balance between supply and demand

→ **Develop synergies between the sectors constituting the energy system**

Power system flexibility enablers in the energy sector



IRENA, 2018

LONG-TERM PROSPECTIVE MODELLING



Decarbonization of the islands' energy system
Integration of Renewable energy at high shares

Define an energy plan that ensures a reliable system in the long term

- What type of energy technologies to choose?
- How much capacity should be installed?
- When should new capacities be installed and scrapped?
- Where to install new capacities?

Long-term prospective modeling of island systems by considering different evolution scenarios

Techno-economic optimization of the energy system over time
+
Environmental, social & political constraints

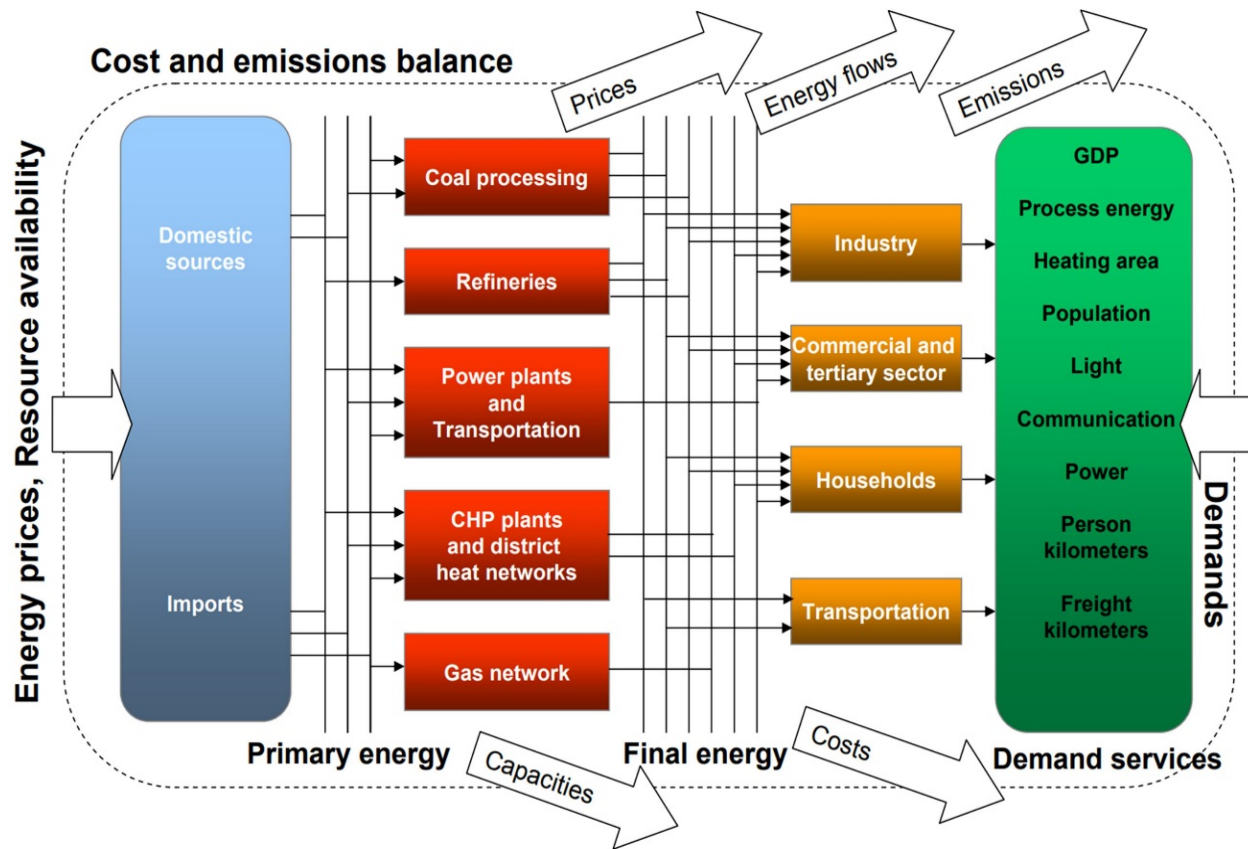


TIMES
The Integrated
MARKAL-EFOM System



Advice policy makers and authorities to make knowledge-based decisions in the implementation of their energy planning

TIMES MODELLING



- Partial equilibrium linear programming, bottom-up, technology rich, and demand driven optimization model
- Minimizes the total discounted system cost
- TIMES allows the user to divide the time horizon into years and subdivided into four sub annual segments: annual, seasonal, weekly, daily
- Exogenous inputs related to the projection of service demands in the different sectors, one can use the GDP and population growth as inputs to predict future demands

$$\min(NPV)$$

$$= \min\left(\sum_{r \in R} \sum_{y \in Y} (1 + d_{r,y})^{T_{0-y}} \cdot ANNCOST(r, y)\right)$$

R. Loulou, G. Goldstein, A. Kanudia, A. Lettila, and U. Remme, 'Documentation for the TIMES Model - Part I'. Jul. 2016

CASE STUDY-PROCIDA

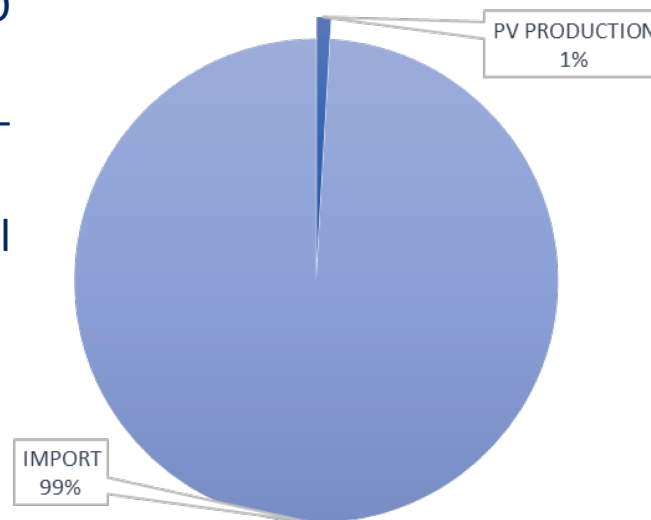


- ✓ Smallest island in the Gulf of Naples, Area = 4.26 km²
- ✓ Density = 2449 inhabitants/km²
- ✓ Challenges: Grid congestions, High seasonality of demand (tourism)
- ✓ High reliance on imports 99%, local electricity production of 1% in 2018

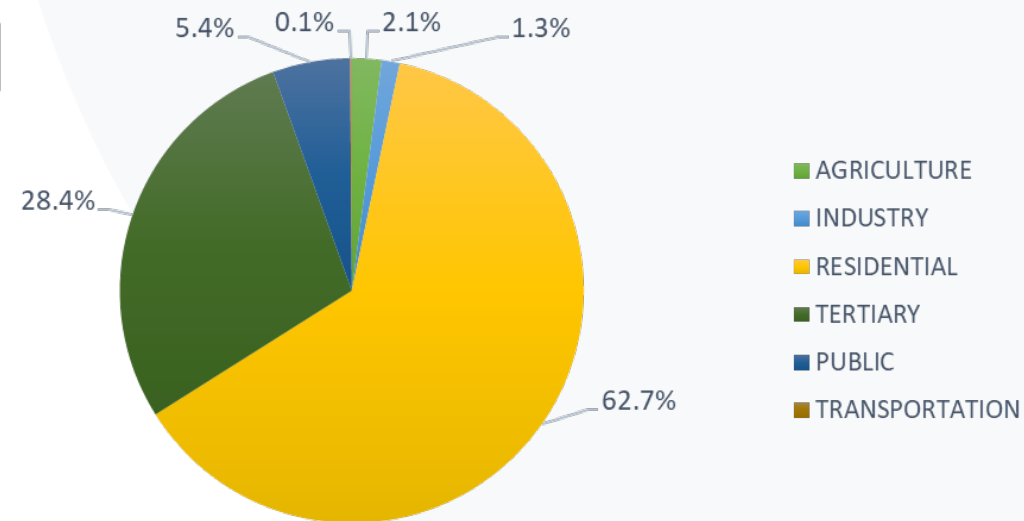
PV production modeling

1. Annual Energy: data by the Italian DSO *E-Distribuzione* for all installation
2. Monthly energy output from a fix-angle PV system (PVGIS)
3. % Energy output on a daytime level using direct irradiance
4. Energy output (daytime and season)
5. Maximum energy output
6. Capacity factor

Electricity supply (2018)

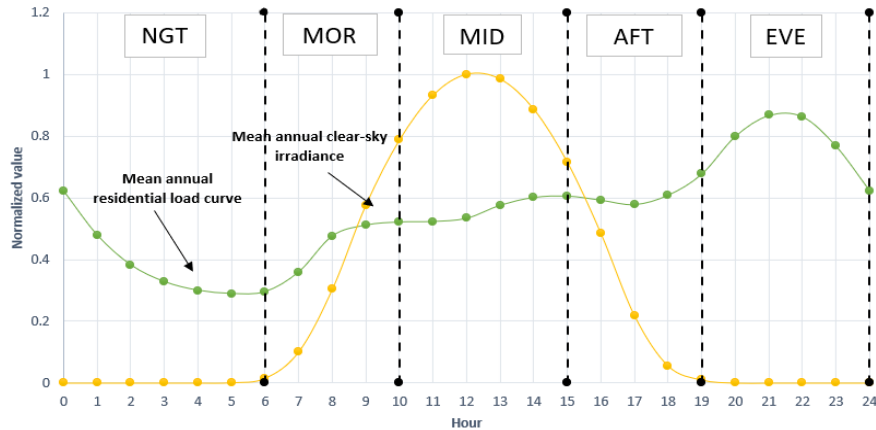


Electricity consumption (2018)

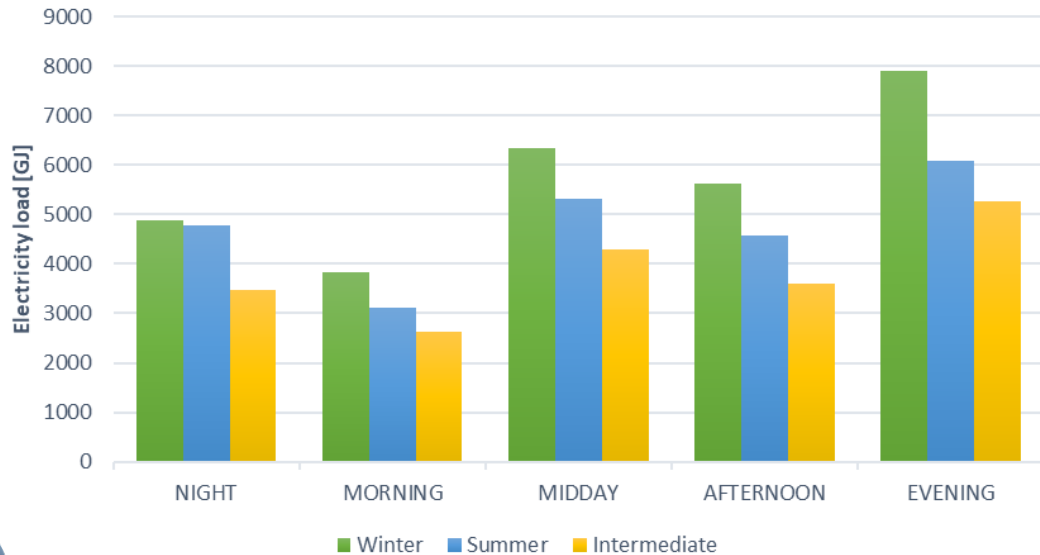


MODELING FRAMEWORK

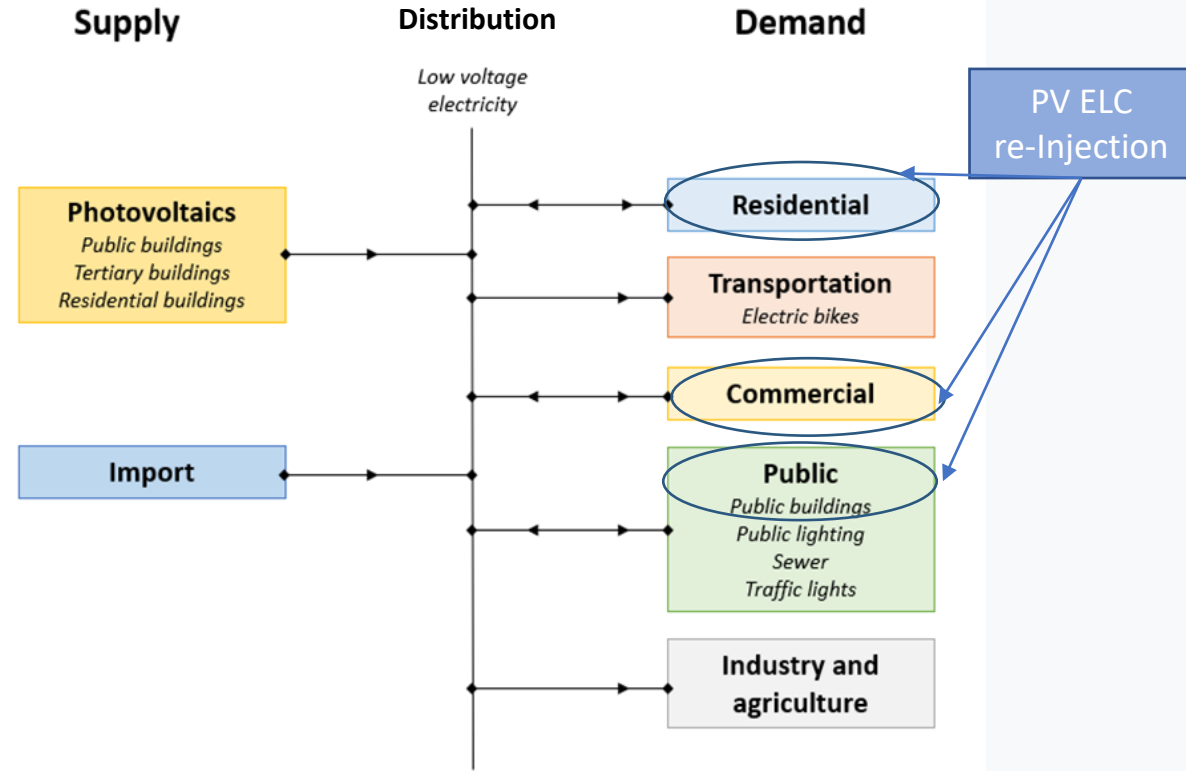
3 seasons: Summer, Winter, Intermediate, 5 daytimes
Horizon: 2018-2050



Electricity load by season and time of the day (2018)



Reference Energy System (RES) of TIMES-Procida



S/MID: Peak of production
W/EVE: Peak of consumption

ASSUMPTIONS

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

1. Renewable Energy production

Rooftop PV → maximum capacity constraints: geographical + local policies considerations for increasing renewable energy on the island

- ✓ New installable PV capacity per year
- ✓ New installable PV capacity per year and per sector



$$\begin{aligned} \sum_i C_{new,i,t} &\leq C_{new,max,t} && \forall t \in T \\ & && i \in (PV_{res}, PV_{ter}, PV_{pub}) \\ C_{new,i,t} &\leq C_{new,max,i,t} && \forall t \in T \\ & && \forall i \in (PV_{res}, PV_{ter}, PV_{pub}) \end{aligned}$$

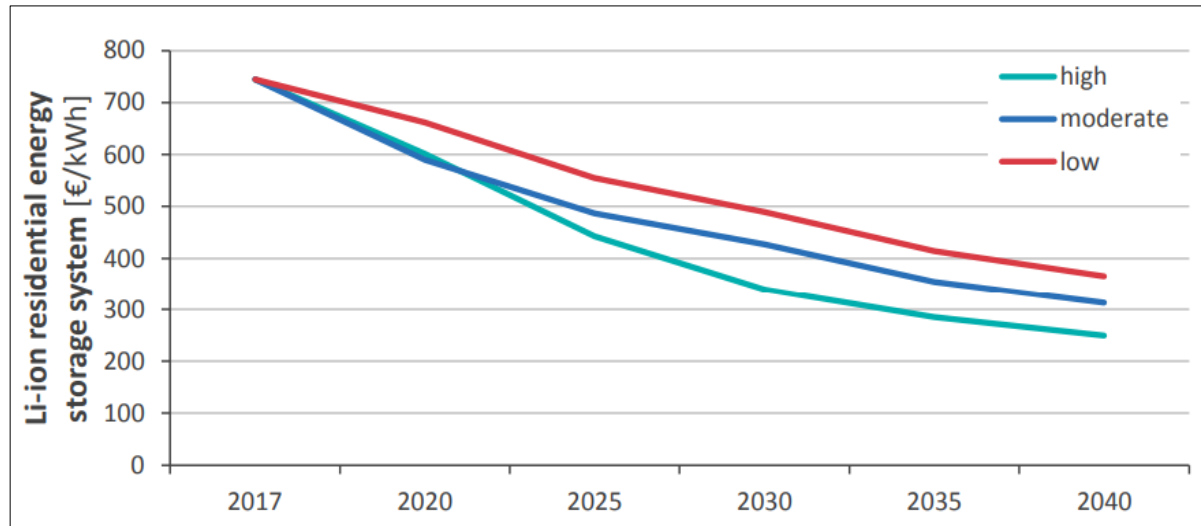
Roof surface estimation and rated power kWp with PVWatts Calculator tool (NREL)

ASSUMPTIONS

2. Energy storage

$$C_{new,i,t} \leq C_{new,max,i,t} \quad \forall t \in T$$

$$\forall i \in (C_{res}, C_{ter}, C_{pub})$$



Cost development of Li-ion residential energy storage (C-rate 0.35) (JRC, 2018)

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

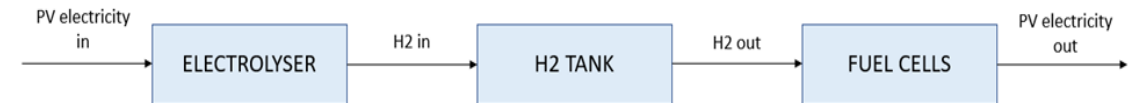


Smart Energy Hub*: reversible solid oxide cell (rSOC) + Li-ion battery

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



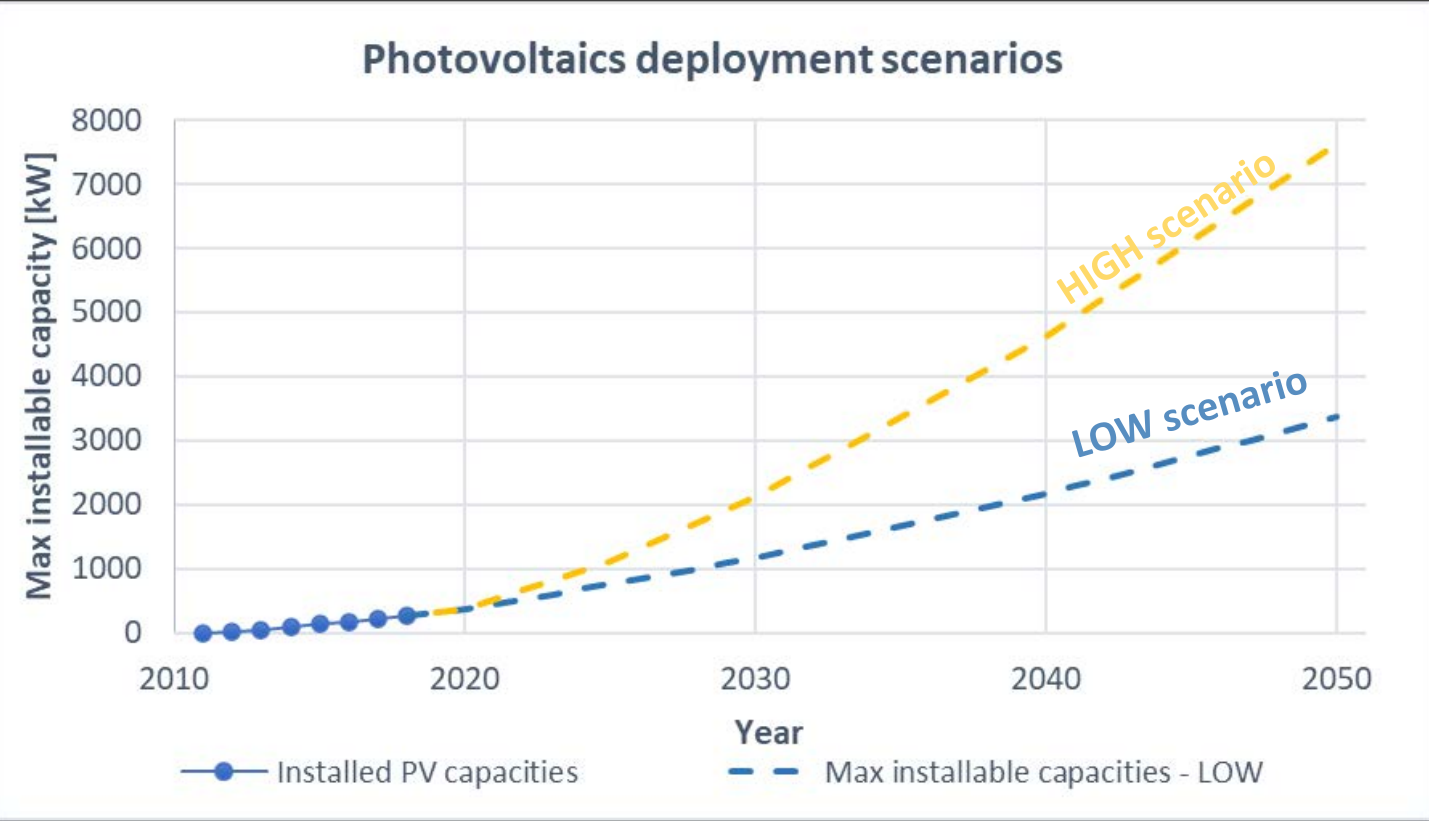
Seasonal storage



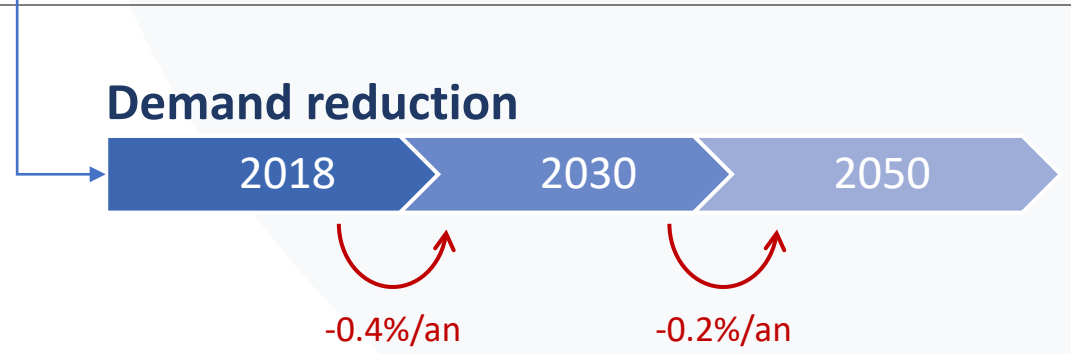
*The Smart Energy Hub is created by Sylfen (www.sylfen.com) and tested in context of the GIFT project

SCENARIOS

Least-cost optimization choice depends on geographical, technical & policy constraints

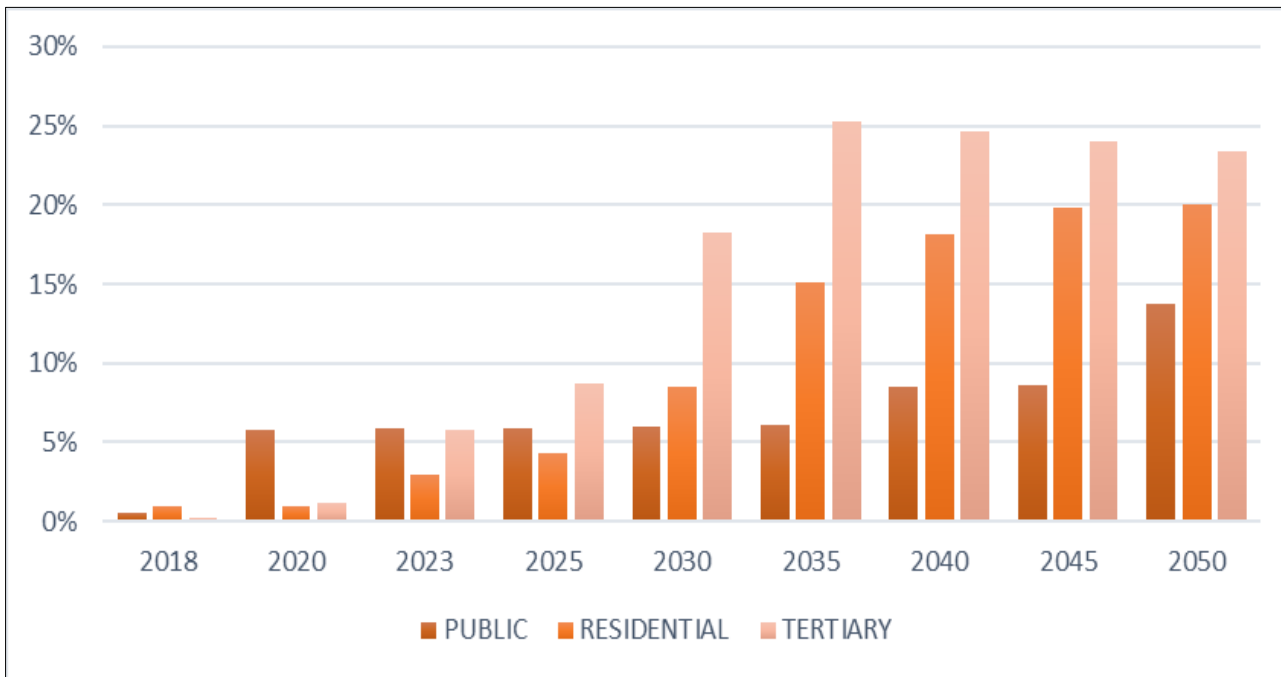


SCENARIO	PV Integration	Storage	Energy Efficiency
LOW	↗	✗	✗
HIGH	↗ ↗	✗	✗
HIGH_STG	↗ ↗	✓	✗
HIGH_STG_EFF	↗ ↗	✓	✓

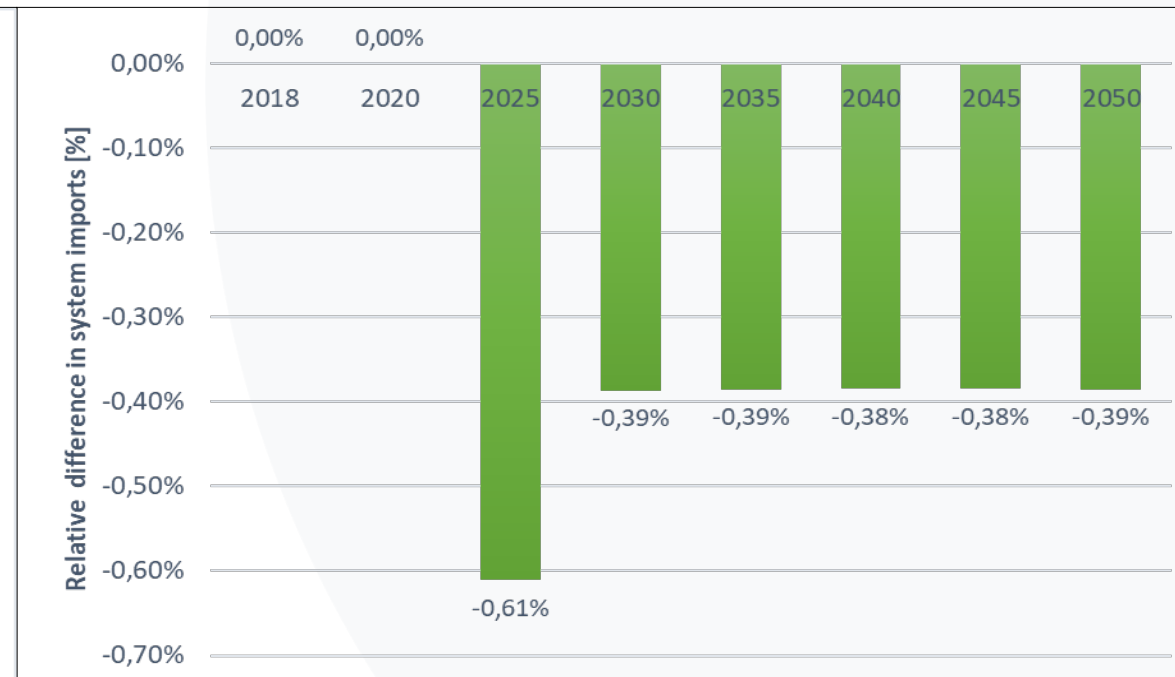


DECARBONIZATION & ENERGY AUTONOMY

Renewables share in end-use electricity consumptions - supply sectors (HIGH scenario)



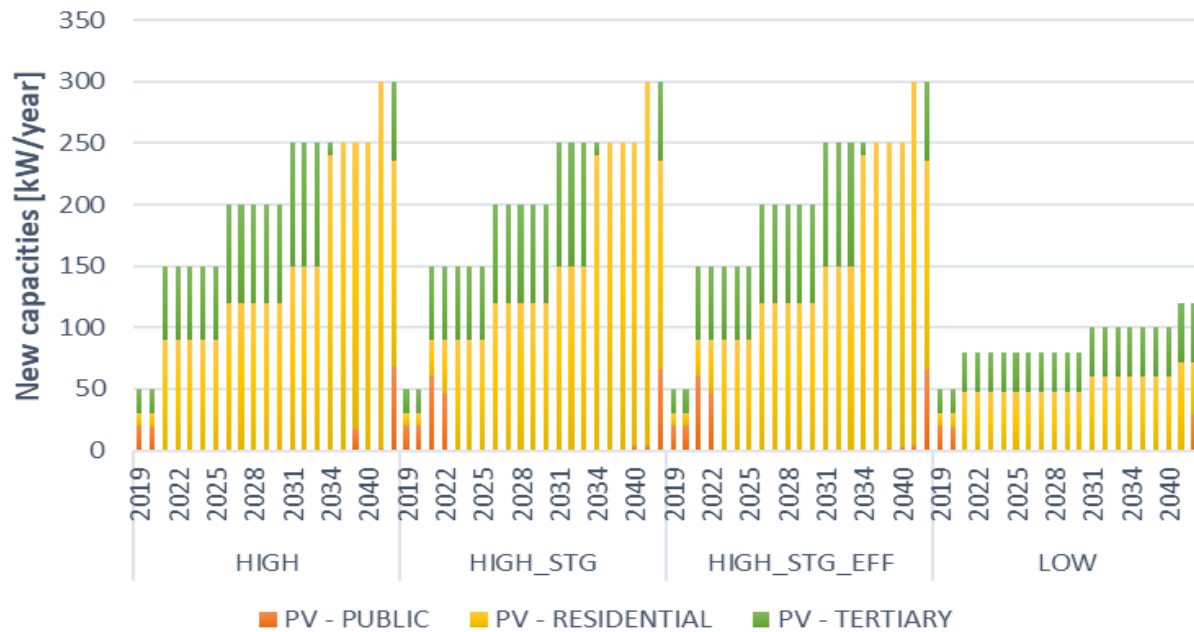
Total imports decrease at peak hours (HIGH_STG scenario)



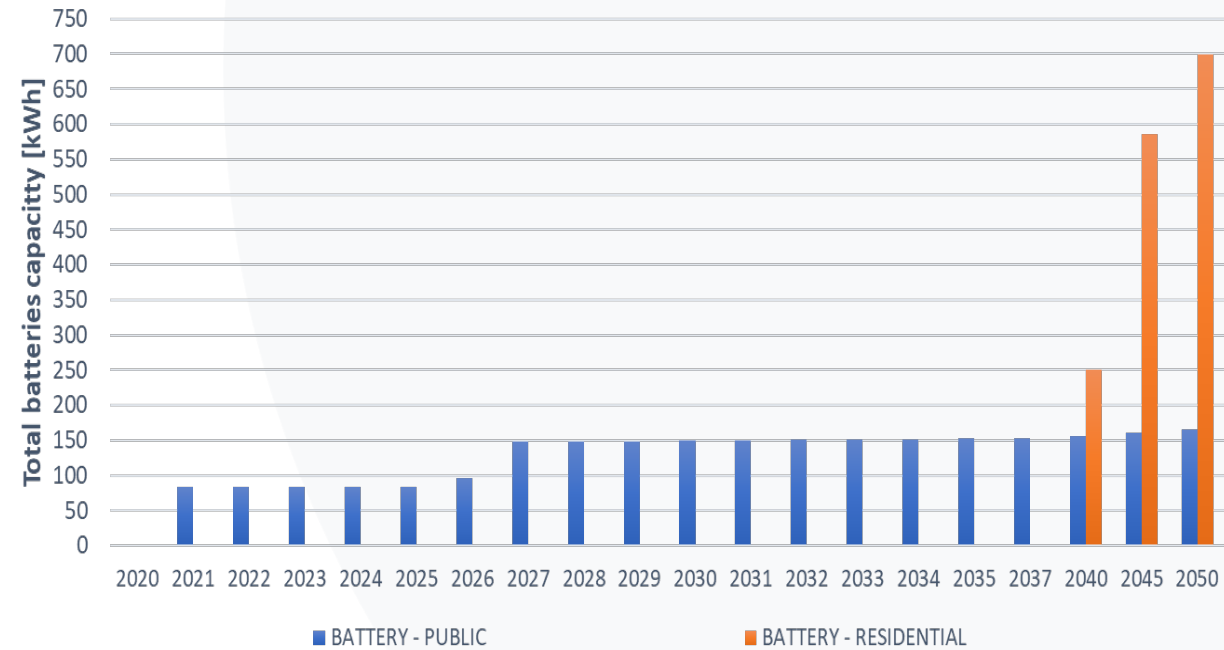
The energy system would benefit from policies aiming for local energy production (decarbonization of the end-use sectors) and from flexibility solutions, (with storage, reduced imports at peak hours)

INVESTMENTS IN NEW TECHNOLOGIES

PV installed capacities per year evolution
(4 scenarios)



Total Battery capacity evolution (HIGH_STG scenario)



(%) max.
allowed
capacities

Sectors	Photovoltaic	Li-Ion Storage
Residential	100	1
Public		16
Residential		0



Long-term storage
not chosen,
limited local
electricity
production

CONCLUSION

OBJECTIVE : Decarbonization of EU islands with the integration of high shares of RE

PV integration:



- End-use decarbonization
- Important improvements in terms of costs
- Energy autonomy of the users (and thus of the island itself)

Storage:



- Flexibility of the energy system,
- Reduction of imports during the peak hours,
- promotes self-consumption

Also, in the project

Part II- Second Demo Site: **Hinnøya island cluster** in Norway

- Long-term prospective modeling and discussion
- Flexibility solutions: Electric vehicles charging, flow battery and electric ferry
- Recommendations



Part III- Replicability

RECOMMENDATIONS

Key takeaways:

- Assessing the context of the territory as well as the energy system of the island helps in understanding the flexibility needs and identify the suitable solutions
- Flexibility is linked to investment costs and maturity of solutions
- Long term planning supports decision making in new investments in flexibility solutions, but is limited from a grid operation point of view
- Necessity of involvement of the consumers that become “prosumers” thus participating in the energy transition
- 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 framework and the use of properly designed systems for information and communication, monitoring and measurement are needed for the sustainability of the solutions

Thank you !

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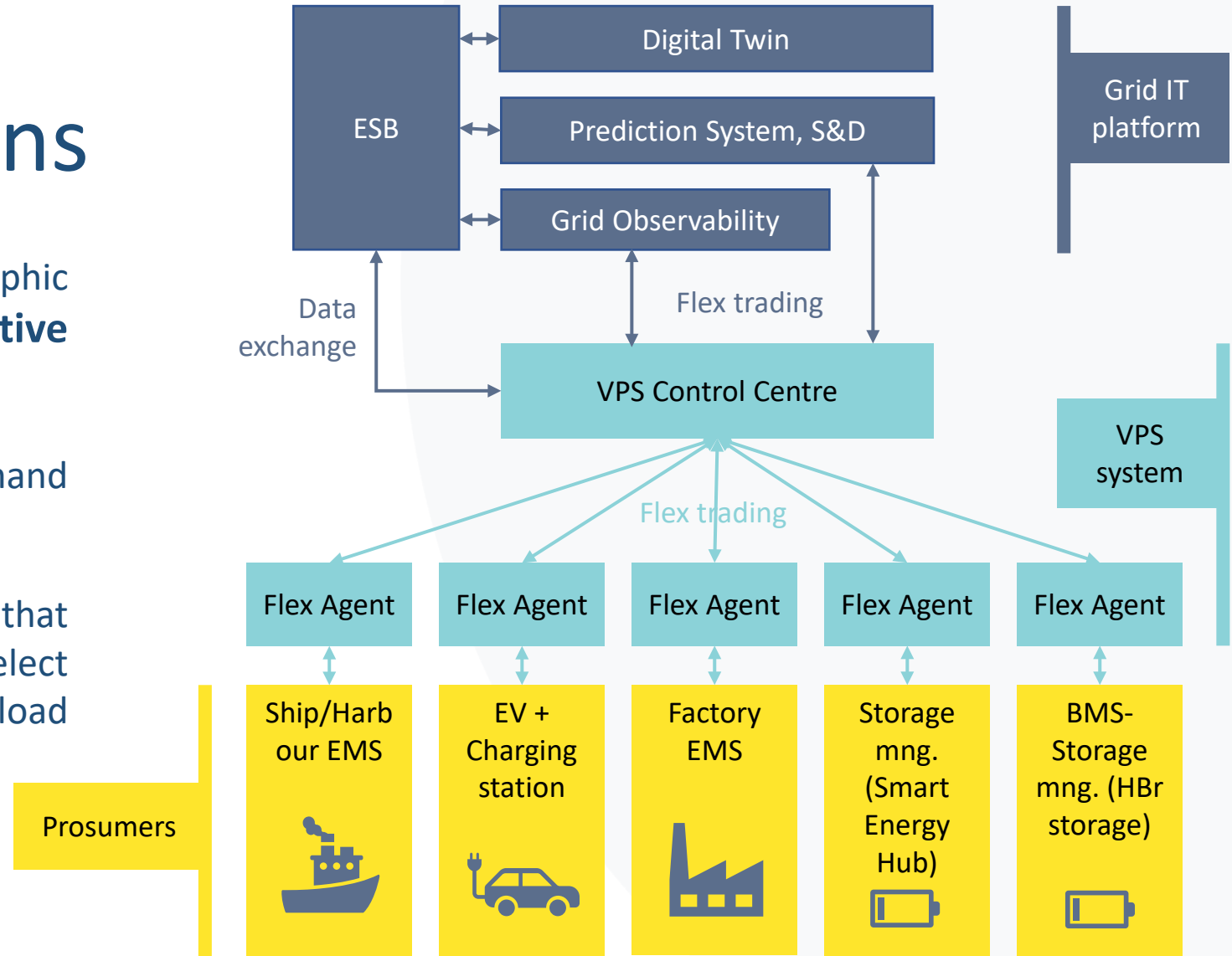


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The project's solutions

- 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.



Annex I: Imports evolution

