> **"Running a society 100% on renewables affordably requires sector coupling, integration of storage solutions and implementation of emerging technologies**
>
> *Berndt Schalin, CEO Flexens*

Flexens

FLEXIBLE ENERGY SOLUTIONS

Demonstrating a society level solution to the renewables integration challenge

Presentation to Aalto University Forum 2021

Berndt Schalin, CEO

Advanced project development rooted in research

With a society scale demonstration as reference

Background in strategic research, Tekes SHOK programs:

2010-2015 Smart Grids and Energy Markets
2010-2014 Future Combustion Engine Power Plants
2012-2016 Efficient Energy Use
2015-2016 Future Flexible Energy Systems

SMART ENERGY ÅLAND

2014
–”Aloitetaan energiakäänne Ahvenanmaalta”

2015- 2018
–FlexE demo and creation of ecosystem

2018
– Flexens founded

2019
– Growth engine finance secured

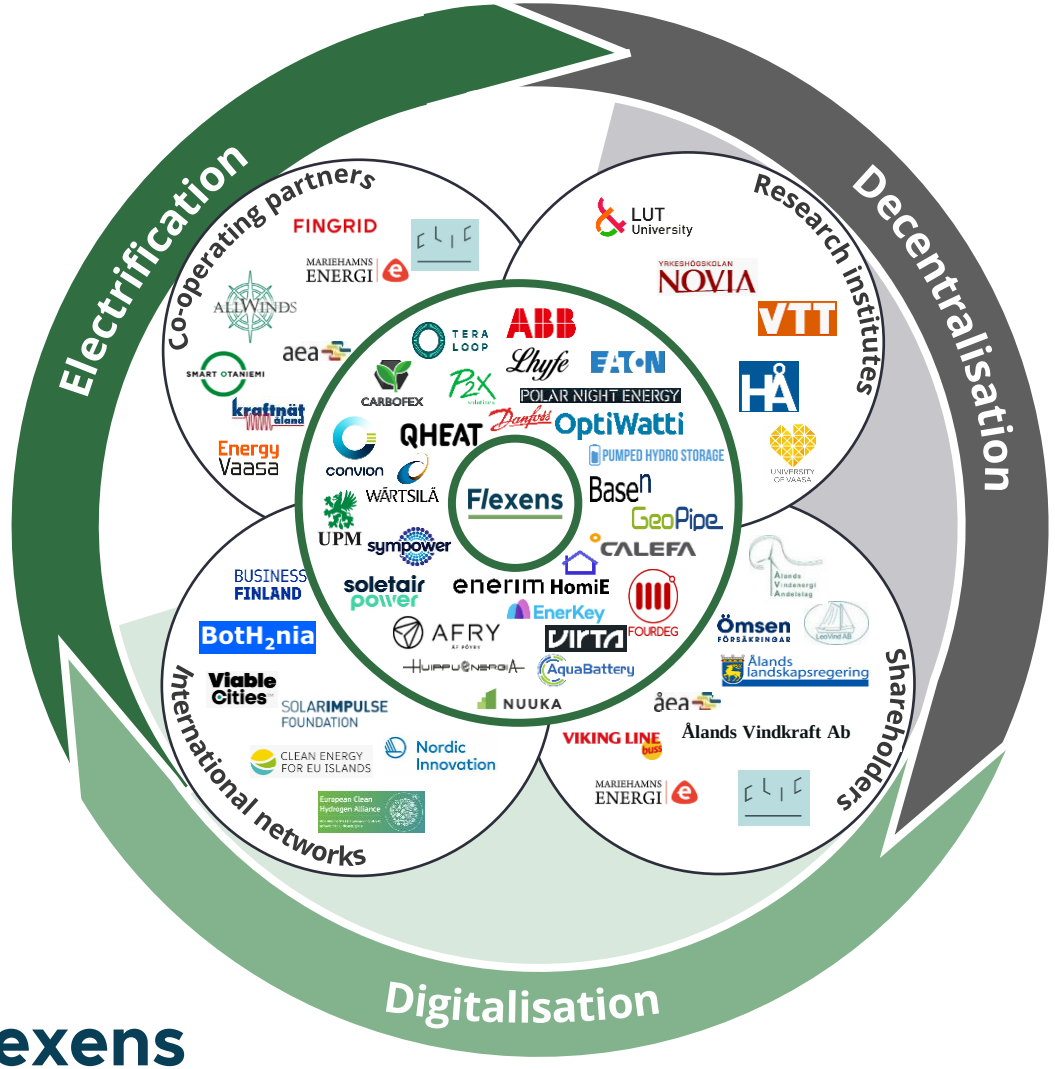
AIMING AT BUSINESS ACTIVITIES AMOUNTING TO BILLIONS OF EUROS

Åland as the test and demo location

- **Åland – the ideal place**
  - Best wind and solar conditions in the region
  - Self-governed (own energy market regulation) and own grid area
  - Ambitious and rewarded sustainability agenda
  - Ideally positioned for Nordic cooperation
- **Full society scale**
  - 30.000 inhabitants, industry & service sector - Results applicable to large markets
  - Operating in a deregulated environment connected to the efficient Nordpool market
- **Adopting future EU regulation**
  - Current and future market models enabling investments in flexibility sources in focus
- **In the tempered climate zone**
  - Heating and cooling central part of the energy mix
- **A platform supporting open innovation**
  - Cooperation with leading R&D&I operator

Our cooperation platform

Core strength

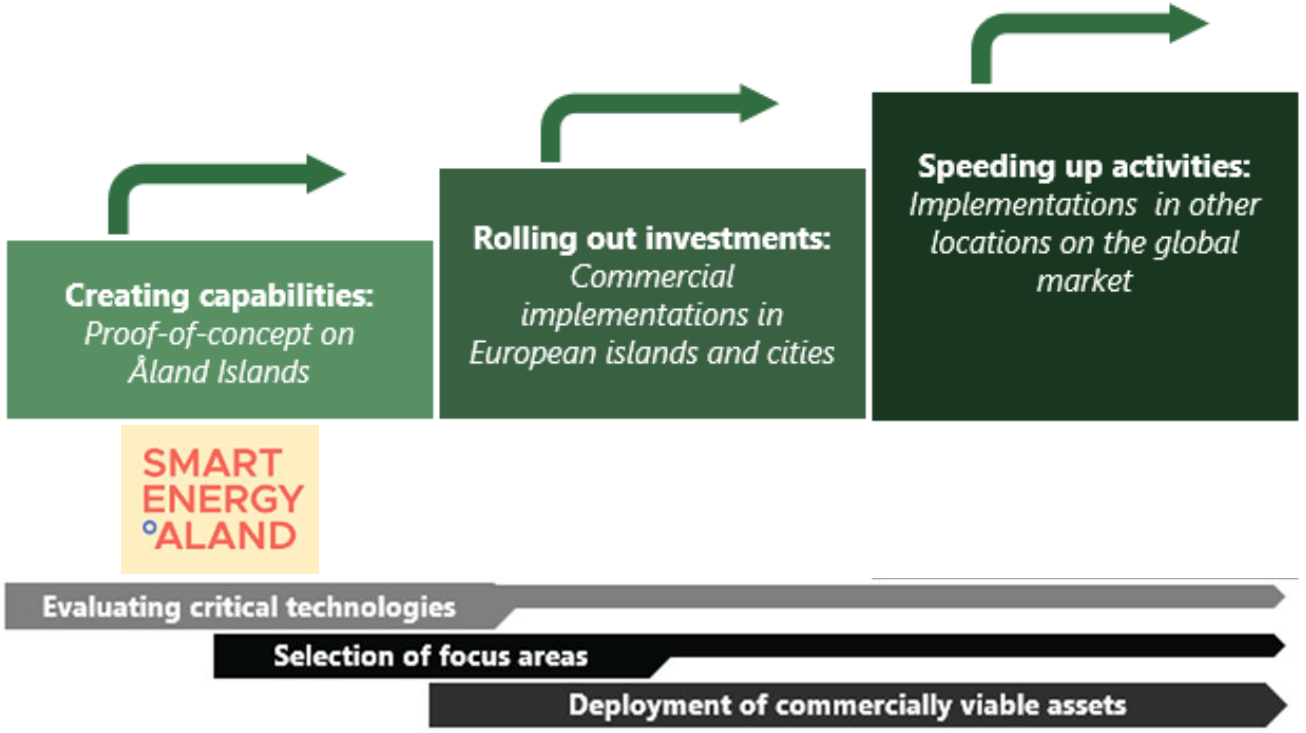


- **Business Ecosystem**: Large multinationals and cutting-edge technology start-ups, providing Flexens with the deep sector and technology insights needed to be at the front of the energy transition. Currently, 28 companies are part of Flexens business ecosystem.
- **Research institutes**: Universities and research agencies with extensive competence within the novel field of flexibility resources and disruptive technologies
- **International networks**: Change agencies with a common interest in facilitating the energy transition gives Flexens a global network of experts
- **Co-operating partners**: Local actors in the Flexens' vicinity who are vital to co-operate with in achieving the Smart Energy Åland targets
- **Shareholders**: Flexens' owners provide both industrial advice and strategic business development support

Business plan overview

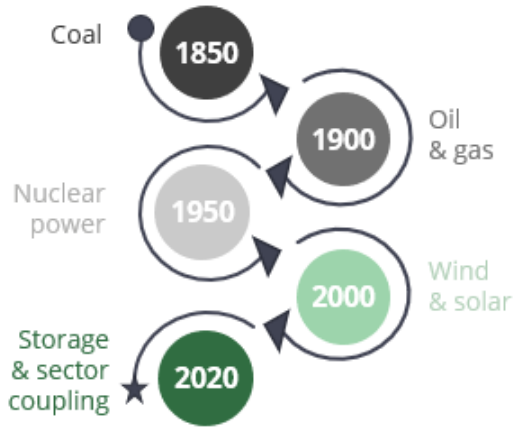
Replicating solutions created in a world leading demonstration

- The company was founded in 2018 to capitalise on the capabilities accumulated in the world leading Smart Energy Åland testbed and demonstration
- With this unique background Flexens plans to become a significant player in the RES project development market globally
- Islands are ideal starting points for the energy transition
- Flexens is already an ideal partner for renewable investors, project developers and communities seeking renewable energy solutions



The roll-out of renewables creates disruption

- In the same way as successful wind- and solar power developers succeeded in the last 10-15 years, the next big wave in the renewable energy market will be the massive deployment of energy storage and other flexibility resources – necessary for the energy transition
- By creating and managing a world leading demonstration of these new technologies Flexens has developed a unique capability to develop this type of critical assets
- Flexens is well placed to take a leading role in this fast growing market, and in this way make a real impact and a significant contribution to the energy transition



There are good examples and role models of success stories in the market for renewable energy project development with their origins in the previous wave:

NEOEN https://www.neoen.com/en/

res https://www.res-group.com/en

OX2 https://www.ox2.com/

A new player with focus on the emerging critical technologies of the next wave can take a significant role in a fast growing market

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Smart Energy Åland

Goals, tasks & responsibilities

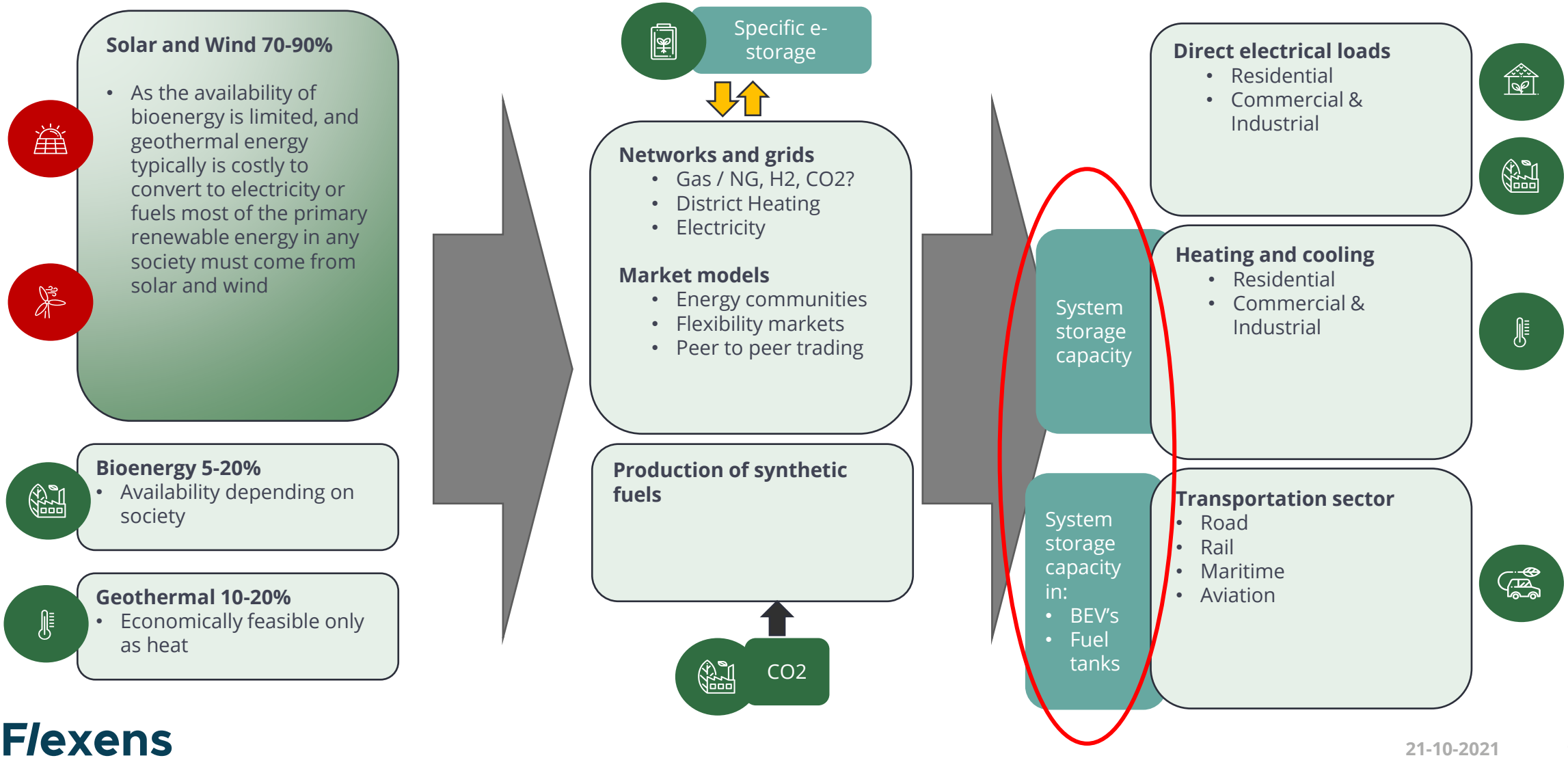
Project goals

- Build a full society scale demonstration of an affordable and self sustained energy system based on 100% renewables
- Provide a unique piloting platform for solutions supporting the implementation of variable renewable energy sources
- Accumulated knowledge that can be utilized in other regions

Flexens tasks & responsibilities

- Lead the energy system development
- Lead multiparty projects to provide holistic solutions
- Engage local citizens and decision-makers
- Raise capital and project financing

Key findings and concept

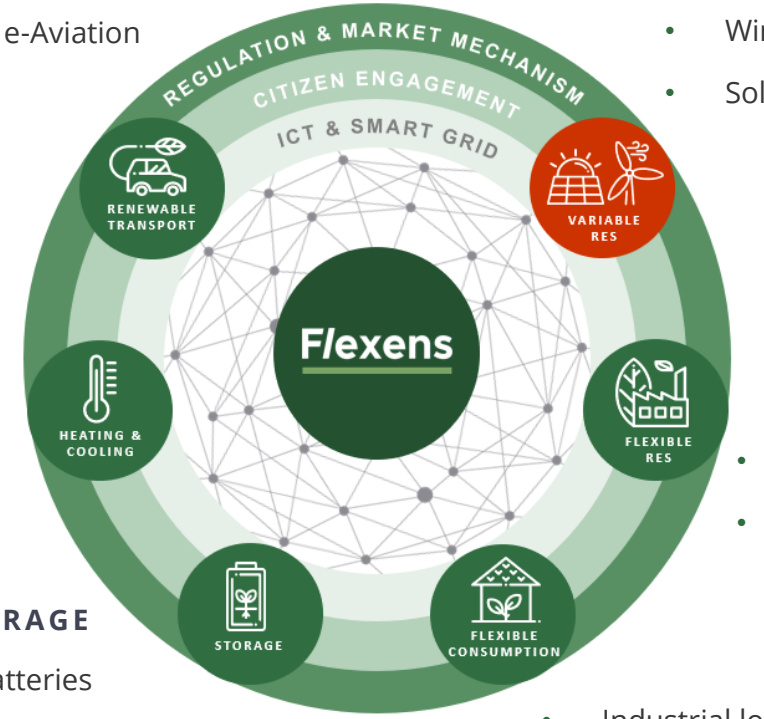


Sector coupling and system integration

Key theme for Flexens capabilities - demonstrations in several areas ongoing

- EV's, e-Buses, Maritime traffic, e-Aviation
- V2G, V2Home, Smart charging
- e-Fuels

- Industrial
- District heating and cooling
- Commercial buildings
- Residential buildings



- Wind
- Solar

- Bioenergy
- Geothermal

HEAT STORAGE

- Residential and commercial building applications
- District heating systems
- Industrial applications

E-STORAGE

- Batteries
- Power to X to power
- Flywheels

- Industrial loads
- Residential loads
- Both electricity and heat

INCREASING FOCUS ON P-2-X as sector coupling and large scale energy storage solution

Hydrogen for maritime transportation as spearhead project

Memberships in

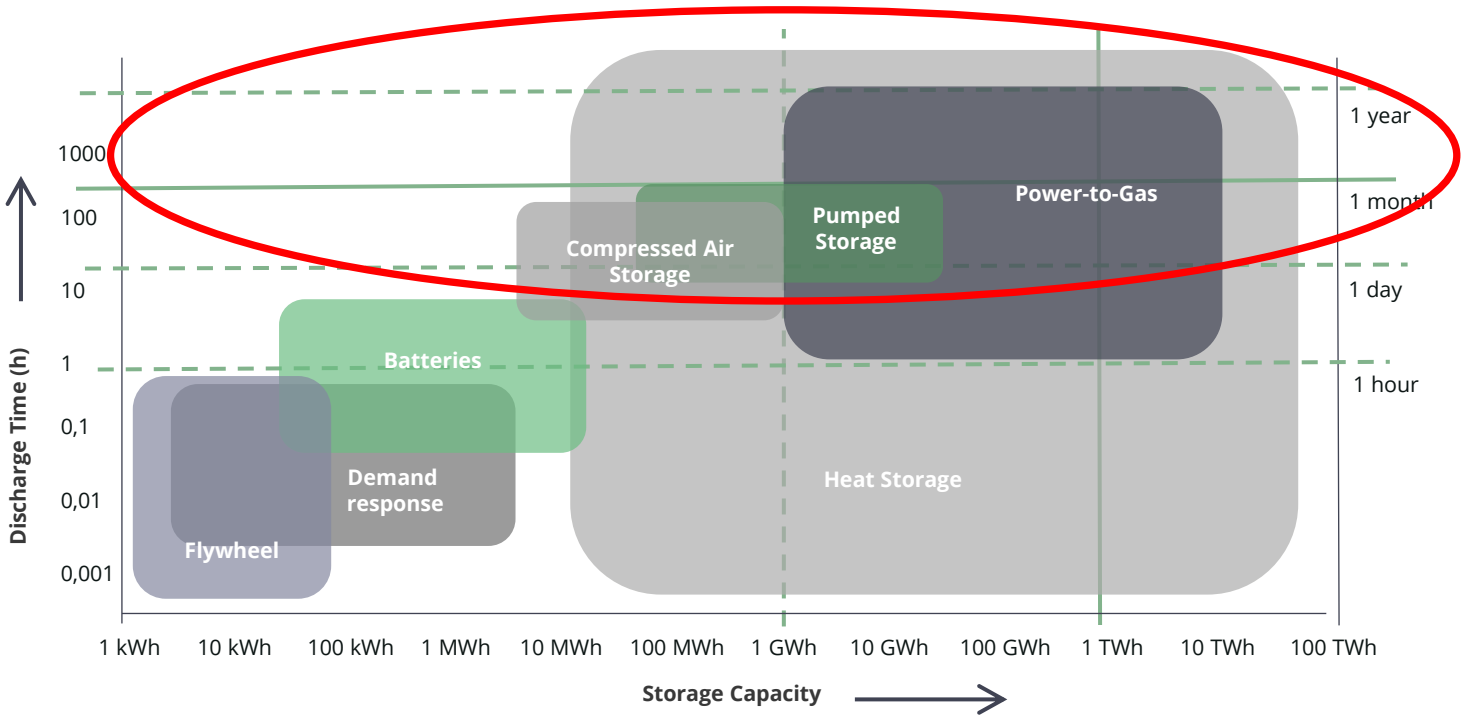
- EU Clean Hydrogen Alliance
  - Seat at CEO Roundtable for mobility
- Finland National Hydrogen Cluster
- GreenE2 Ecosystem

Sector coupling focus

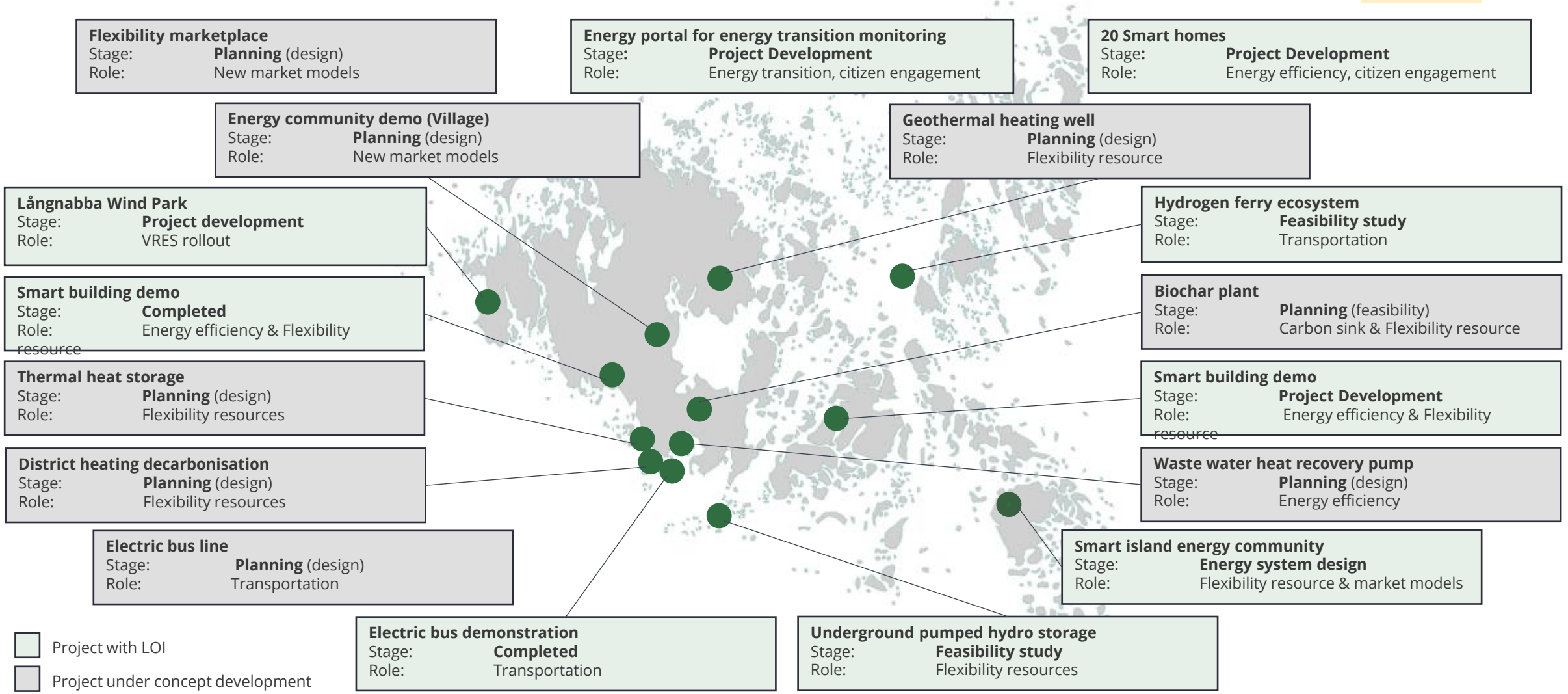
Flexens is having its core competence focus on selecting and implementing mid term and seasonal energy storage solutions ("days-all year")

Initial target markets being island "island like" societies

Discharge time vs. Storage capacity
Illustration of a disruptive technology landscape



Smart Energy Åland subproject overview



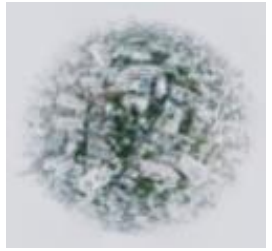
20+ subproject leads in pipeline

Examples of demo projects

Hydrogen ferry running on locally produced green hydrogen

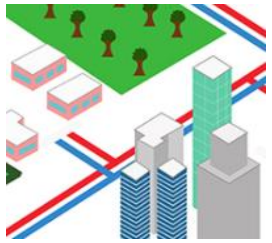
Energy storage integrated in wind farm

Pumped hydro energy storage



Flexibility market

Energy Island community



Energy portal

LocalRES

This project has received funding from the European Union's Horizon 2020 Programme under the Grant Agreement no. 957819

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Case study: Underground pumped hydro storage

Project overview

An underground pumped-hydro storage (UPHS) to be build in an abandoned mine on a small island in direct connection with an existing wind park

- Filling the caves with water running through a turbine at periods of light winds <-> Pumping the water out at periods of strong wind
- The first plant of PHS technology implemented in an old mine

Major benefits from UPHS:

- Absorb excess power in the grid particularly when balancing energy produced by wind & solar plants
- Absorb base load production particularly from nuclear and coal plants

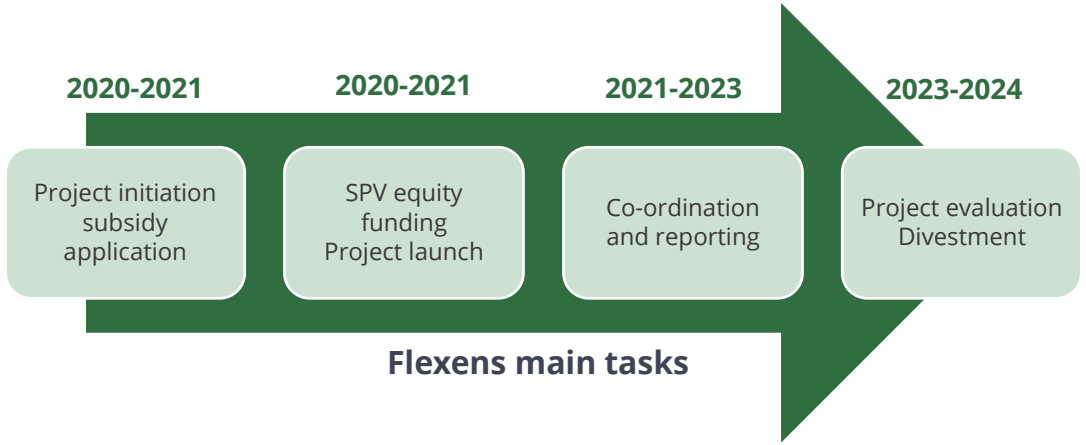
Power capacity:	**2 MW**
Storage capacity	**8 MWh**
Commercially viable by:	**2023**

Funded by the Energimyndigheten

The overall objective of the project is to demonstrate a new, highly innovative method for large scale underground energy storage that enables storage with 70-80% round-trip efficiency.

The project include the following sub-objectives:

1. Verify the innovative concept and full operating conditions
2. Develop and verify a scalable standard design concept
3. Perform a fast replication and commercialization



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Case study: Kökar smart island energy community

Kökar in a nutshell

- Total land area of 64 km2 with 170 inhabitants during winter, and up to 1,000 during summer
- Annual electricity consumption is 2.9 GWh
- The electric cable to mainland 1.5 MW (Min-max load 400-800 kW)
  - *Occasional outages (3-4 interruptions per year)*
- Wind power 500 kW and approx. 75 kW of PV and micro wind
- Ferry transport to and from the island accounts for most of the total energy consumption

Overall goal and ongoing actions

To become a fully renewable energy system

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Modelling the system and creating the decarbonisation plan for Kökar

Thermal heat storage solar PV & battery in progress
Received EU Horizon 2020 funding

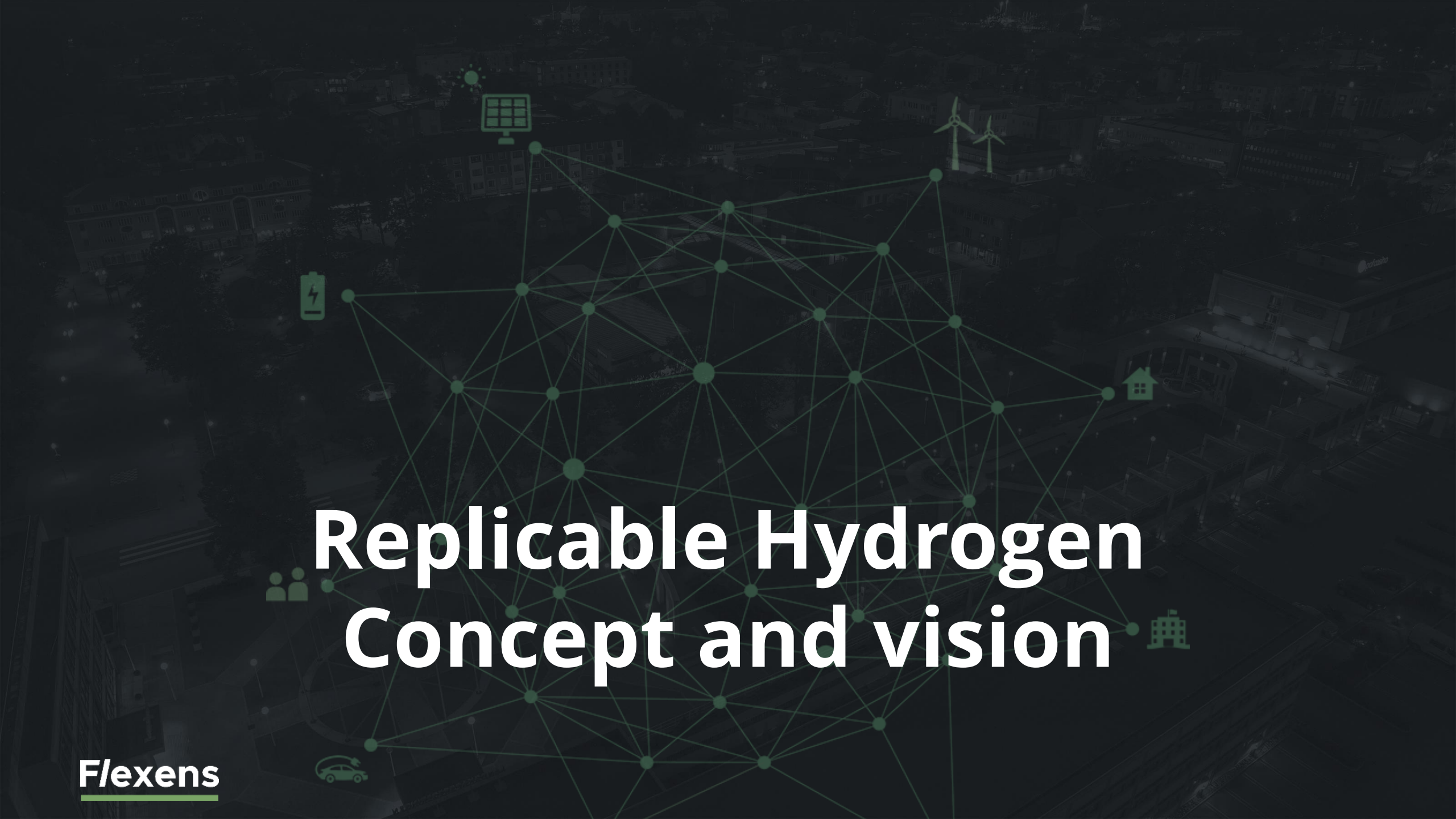
LocalRES

This project has received funding from the European Union's Horizon 2020 Programme under the Grant Agreement no. 957819

Energy Transition Agenda powered by Flexens

2020	2022	2024	2026	2028	2030 –
Installation of heat pumps or wood chip boilers in oil-heated buildings	New energy system for the school and smart heat control	Install 500 kW wind power	Incremental Installation of solar power, reaching 100 kW by 2026	EV carpool at mainland harbor	Electric cars Hydrogen ferries Energy storage systems

Gateway to renewable energy assets



Replicable Hydrogen Concept and vision

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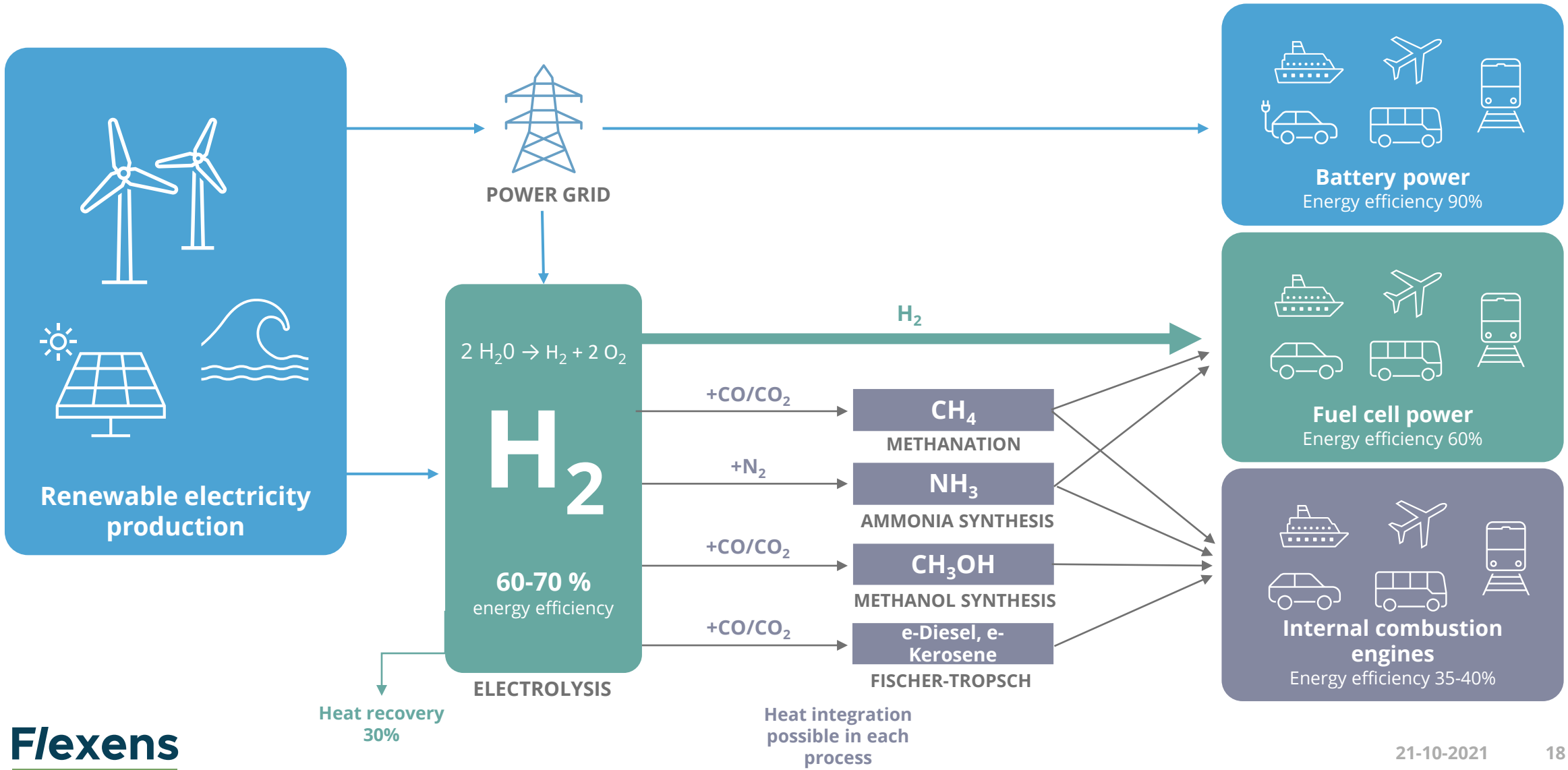
Power sector will run future logistics

Availability of biofuels is limited; E-fuel will be needed.



Hydrogen Ferry Concept

Integrated solution for Green Hydrogen

Main target area: European islands

- In most Island societies the "getting to and from the Island" represents the biggest CO2 emitter
- In the EU alone there are 2400 inhabited islands, and most of the pilot islands in the Clean Energy for European Islands initiative has identified the opportunity for a hydrogen ferry in their energy transition plan (source: https://euislands.eu/clean-energy-islands)
- Islands typically have good local wind and/or solar conditions but also grid challenges, thus providing ideal conditions for storage and power-to-x solutions

Alternative target area: Other ferry traffic

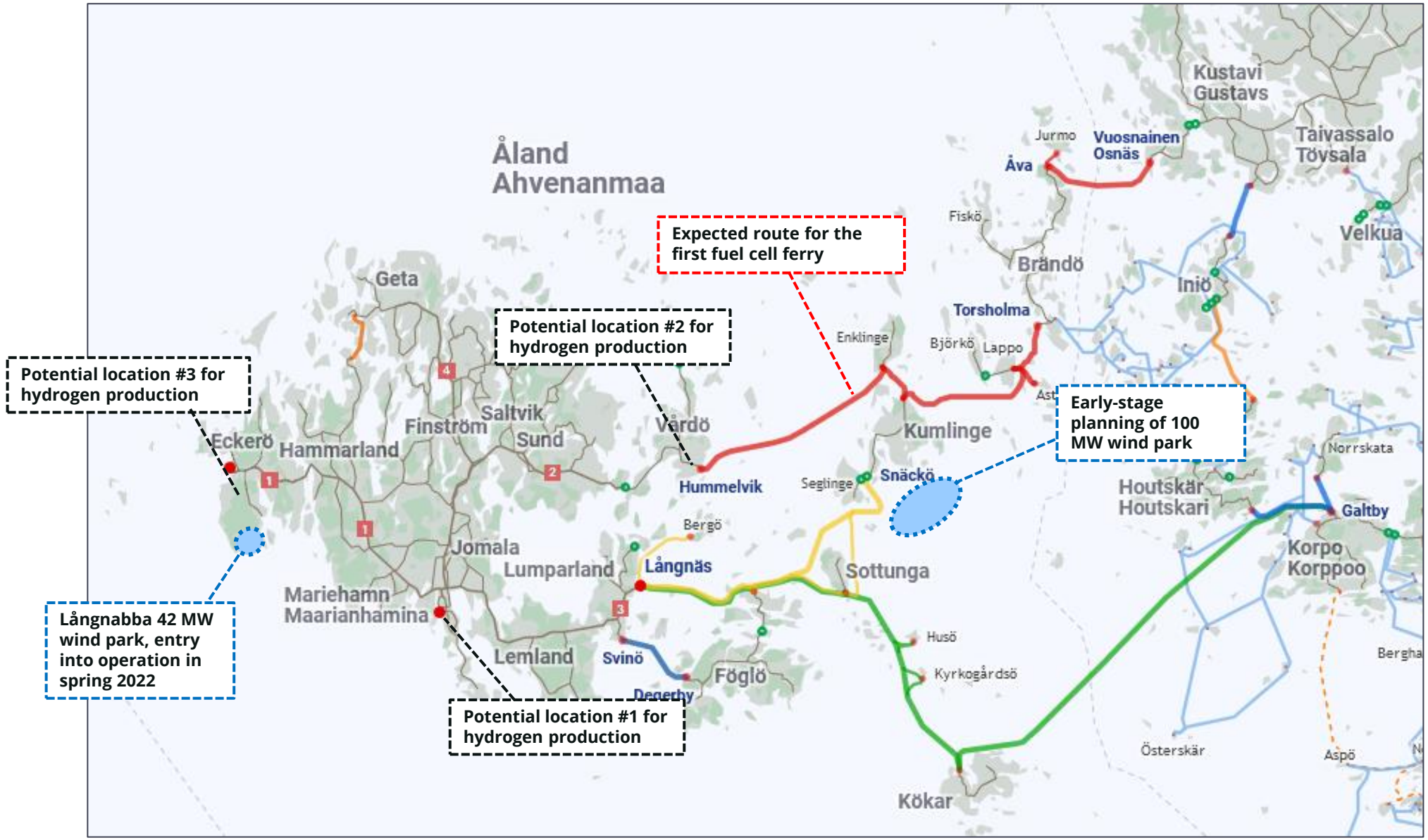
- The concept is also applicable to other ferry routes whenever the local conditions for renewable electricity generation are good

Power2AX PROJECT

LOCAL GREEN HYDROGEN PRODUCTION FOR A FUEL CELL FERRY IN ÅLAND, FINLAND

The feasibility study of Power2AX project was delivered by two engineering offices, Deltamarin and Elomatic in November 2020. In the best-case scenario, if the project would be advanced full-speed, hydrogen ferries could be expected to enter operation in 2024:

(Archipelago ferry routes as coloured lines)



Vision for next steps

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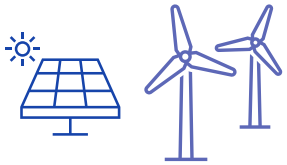
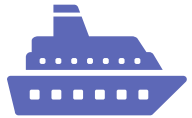
Expanding the Hydrogen ferry concept

Matching optimal hydrogen production costs with high value transport use

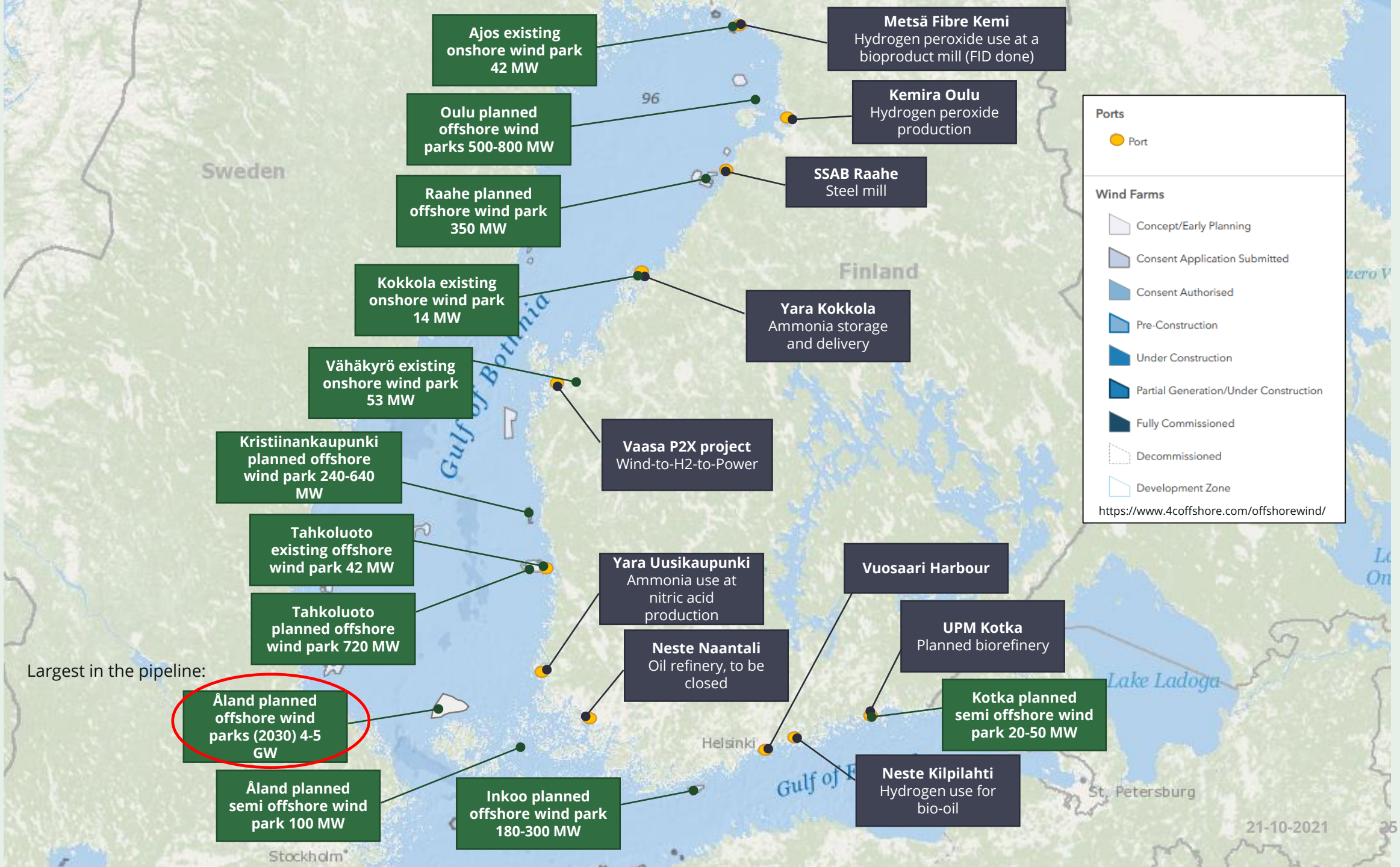




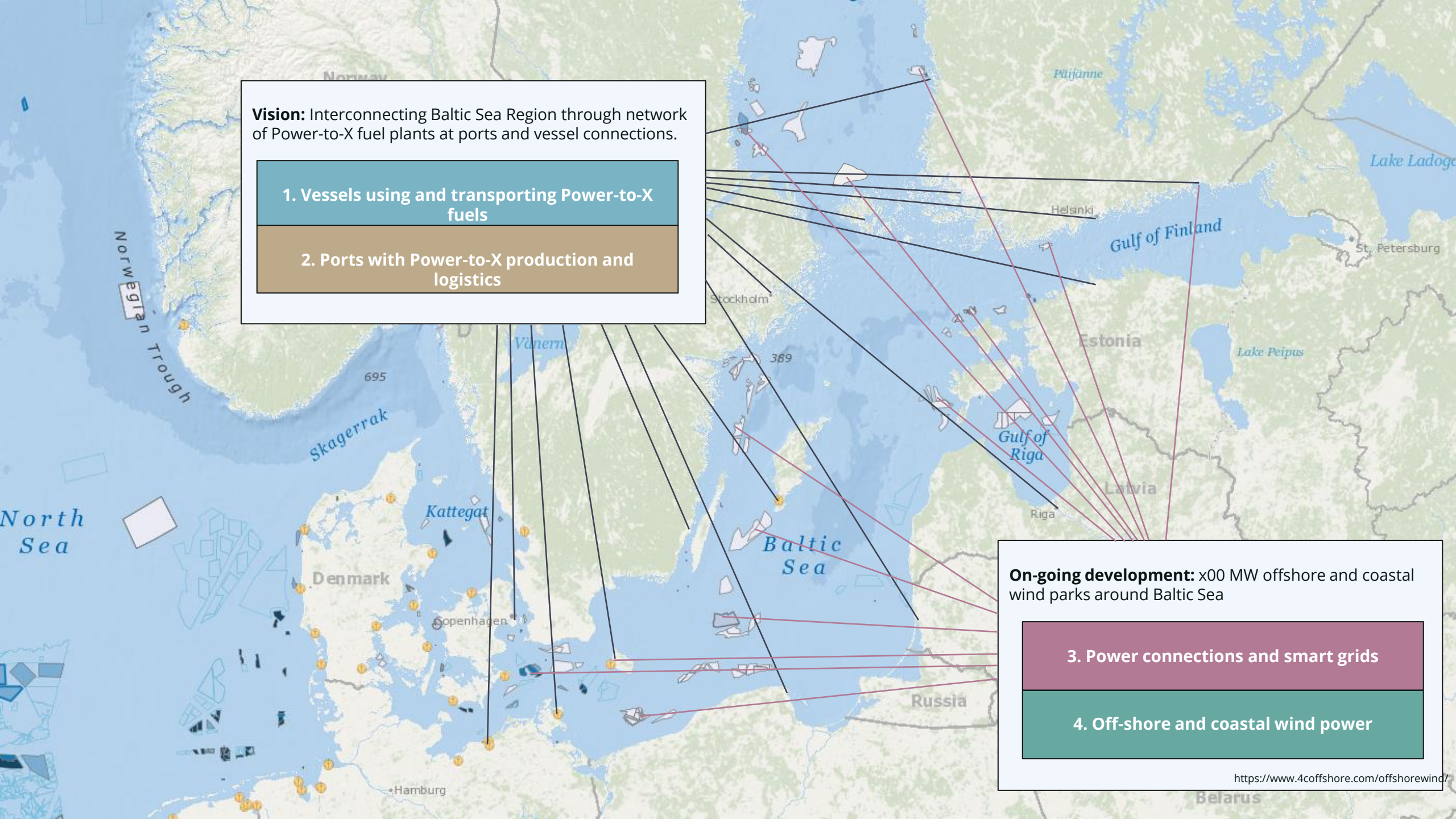
Wind power Solar power	Hydrogen production in electrolyser	(optional: processing further to other P2X fuels or chemicals)	Logistics (Ports!)	Maritime use and delivery
Production cost of solar power and wind power is expected to keep decreasing in 2020-2030, especially in off-shore wind parks. New off-shore wind parks are planned around Baltic Sea.	Hydrogen production cost is in majority dependent on the cost of used electricity. Hydrogen production cost should be minimised by, 1. avoiding power transmission fees by direct integration with electricity production 2. recovering heat produced in the electrolyser 3. using electrolyser for balancing power and frequency control	Hydrogen can be used as a raw material for chemicals or further P2X fuels: • e-methane CH4 • e-ammonia NH3 • e-methanol CH3OH	Logistics of hydrogen (or other P2X fuels) can be minimised when electrolyser is located close to end-users, e.g. at **ports**. Sea connections enable efficient tanker/bunker logistics.	Renewable power sources for maritime applications are limited. Short distance ferries can operate with batteries but fuels are needed for sail times longer than one hour. Availability of biofuels is limited which sets high hopes on e-fuels.

Matching Baltic Sea with Power-to-X

Key conditions	Unique potential to build the value chain
Great wind power potential at coastal areas…	→ Coastal hydrogen production with wind power
Scattered population and industry…	→ Batchwise hydrogen and e-fuel delivery
Strong maritime industries…	→ Development of zero carbon shipping industry



Largest in the pipeline:



Vision: Interconnecting Baltic Sea Region through network of Power-to-X fuel plants at ports and vessel connections.

1. Vessels using and transporting Power-to-X fuels

2. Ports with Power-to-X production and logistics

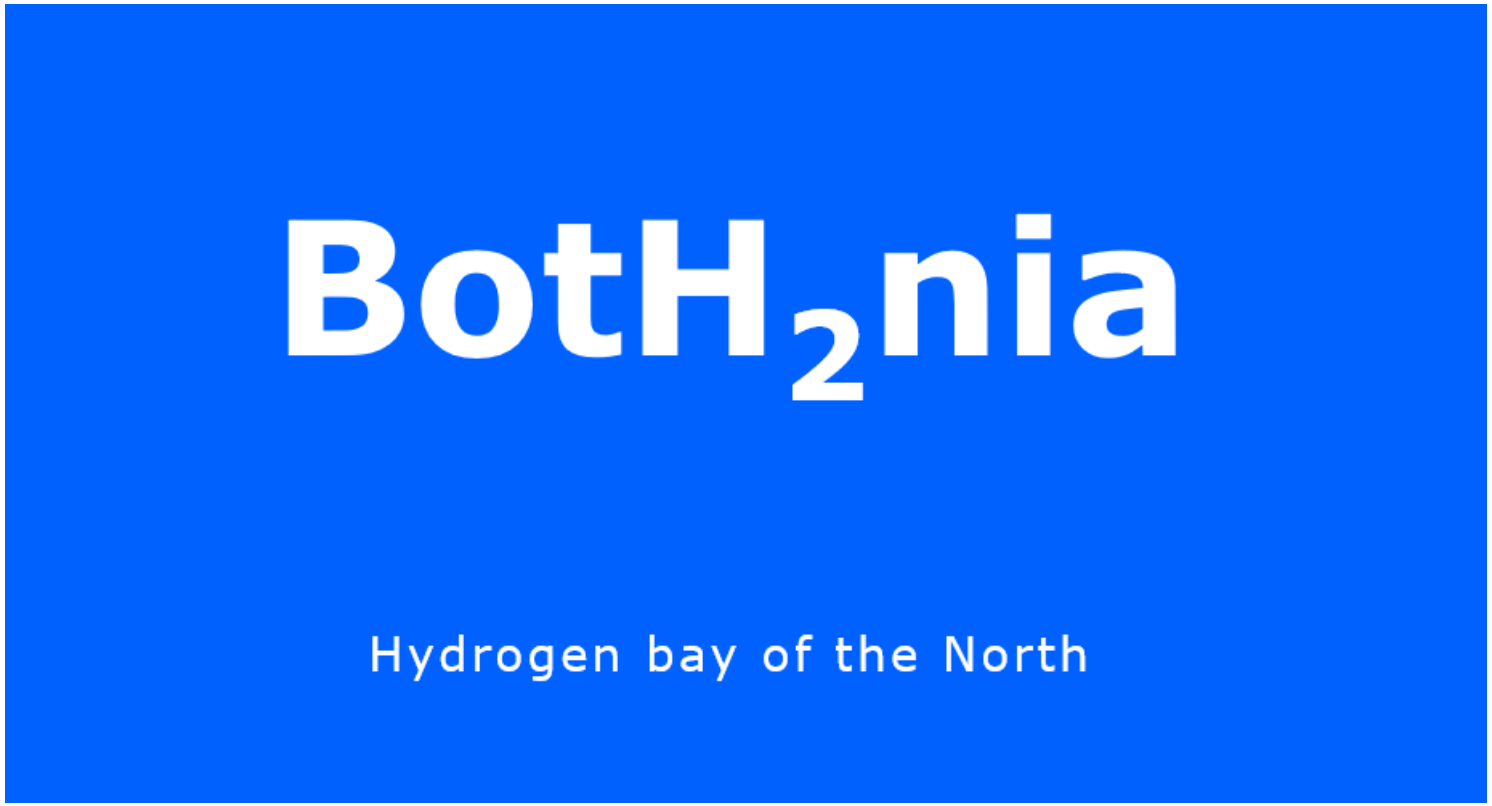
On-going development: x00 MW offshore and coastal wind parks around Baltic Sea

3. Power connections and smart grids

4. Off-shore and coastal wind power

https://www.4coffshore.com/offshorewind/

Membership in Finnish national hydrogen cluster and BotH2nia initiative



Gulf of BothH_2nia – the hydrogen bay of the North

Large industrial H_2 users

- SSAB, LKAB, Kemira, Kokkola Industrial Park ...

Multiple bio-product plants

- GHG-neutral CO_2

Renewable energy available

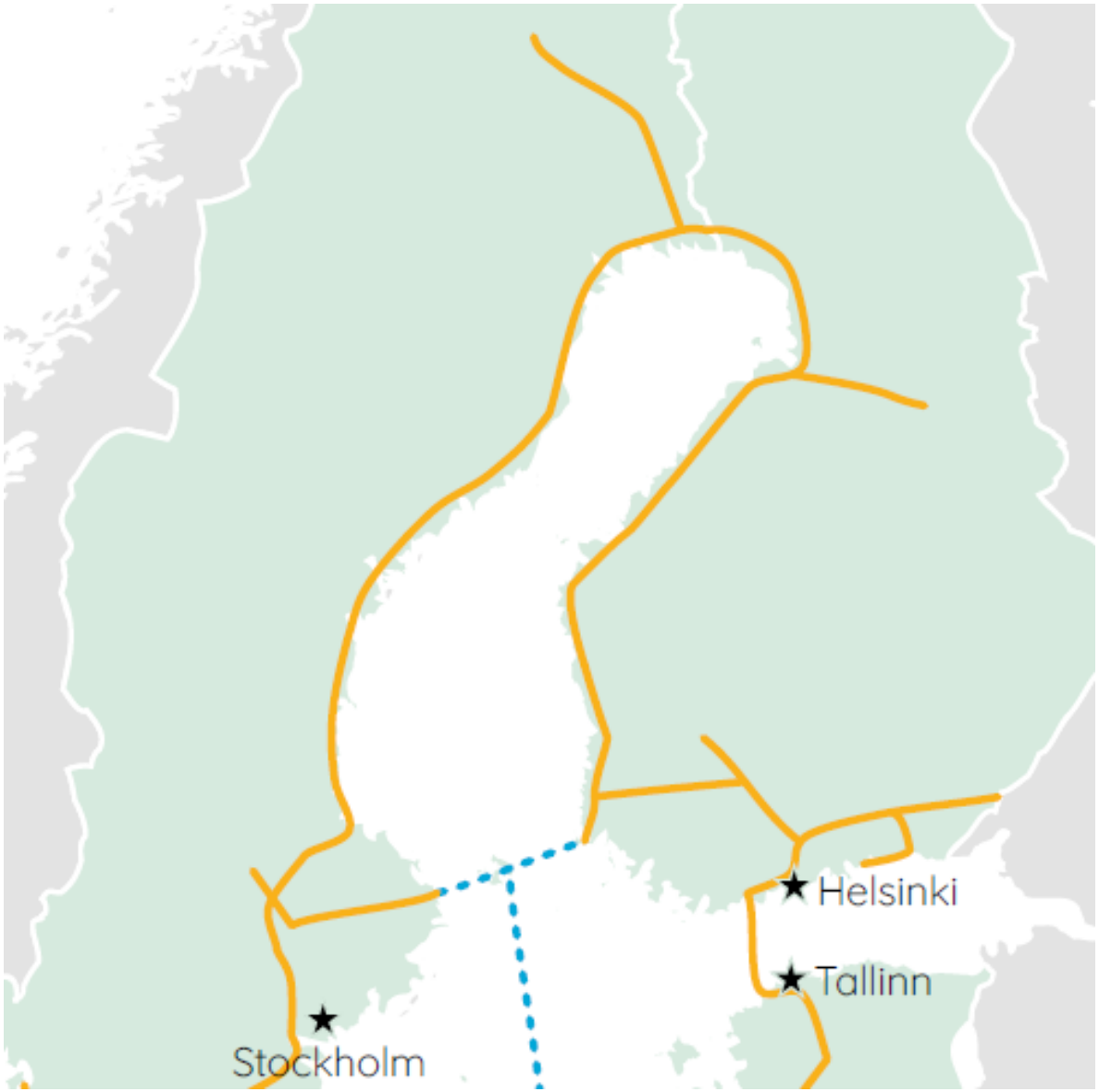
- > 20 GW of new wind power capacity planned
- Lots of hydropower and biomass

New nuclear power plants

- OL3, Pyhäjoki, total 2.8 GW

Developed infrastructure

- Stable power grid, joint market
- >15 industrial harbours
- H_2 grid proposed (see line)



European Hydrogen Backbone; vision 2035

Public-Private -cooperation

- Very close cooperation compared to most other areas
- Good examples of successful cross-border projects

Active projects on-going

- Nordic Arc & Hydrogen Bay

National H_2 clusters

- Swedish H_2 Development Center
- Finnish H_2 Cluster

Cooperation within EU

- ECH2A
- Hydrogen Europe

EU financing possibilities

- EIC / EASME
- IPCEI
- EIB / EIF / RRF ...

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Thank you