Oppeja ja kokemuksia P2X-hankkeista
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Key findings from power-to-X projects

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About us

Established in
1970

In private
Finnish ownership

Number of employees
~1300

Countries with customers
80 +

Countries with offices
~20

Turn over in 2023
123 million €

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Our areas of expertise

Marine

Industry

Pharma

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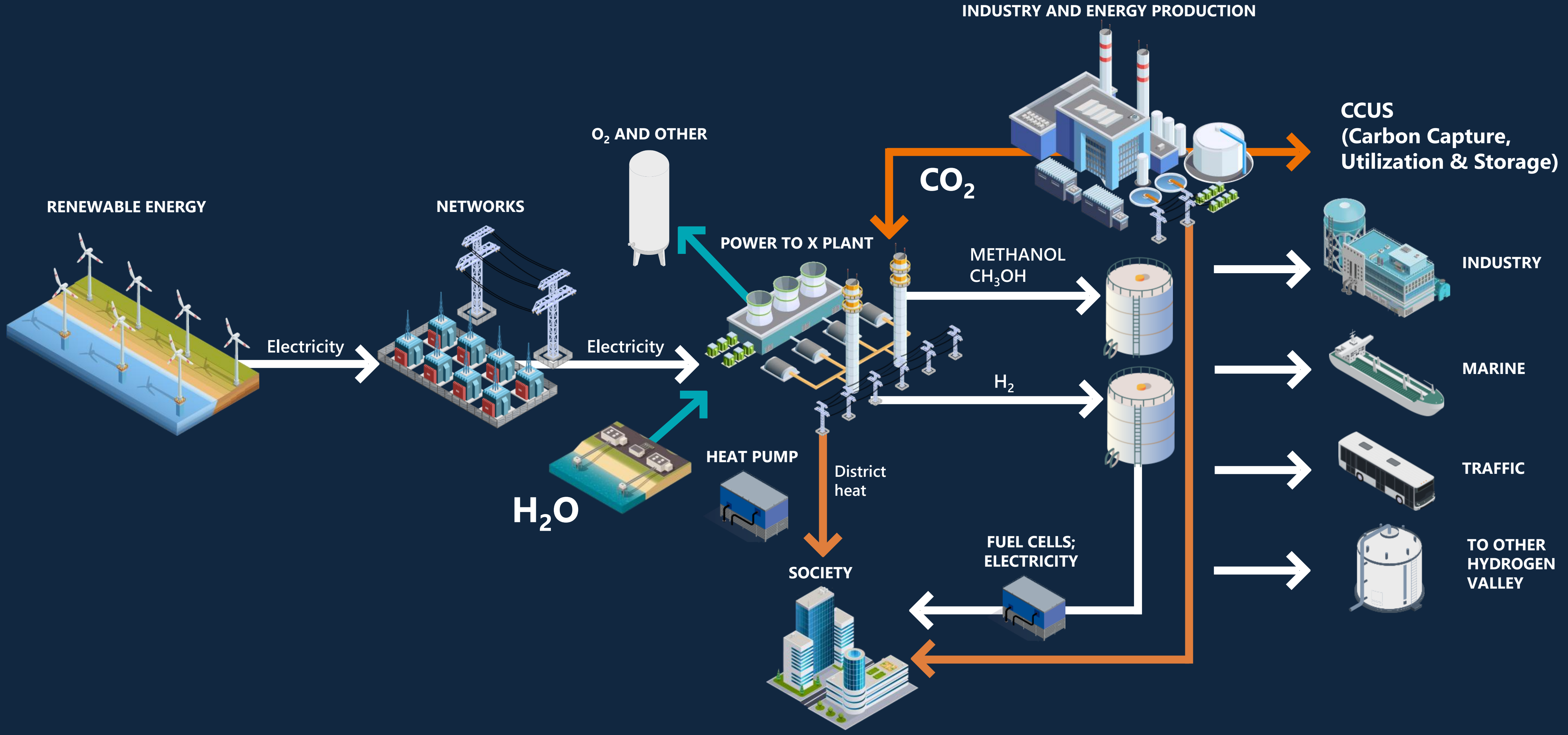
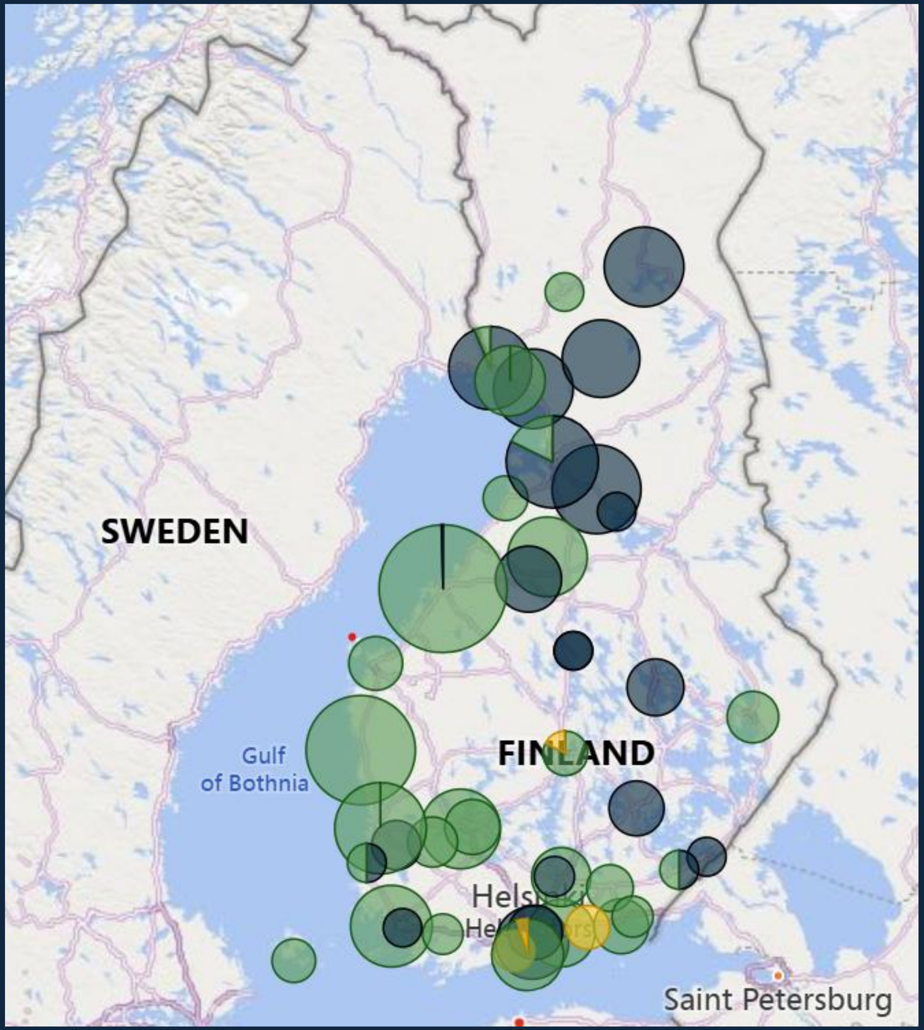
Content

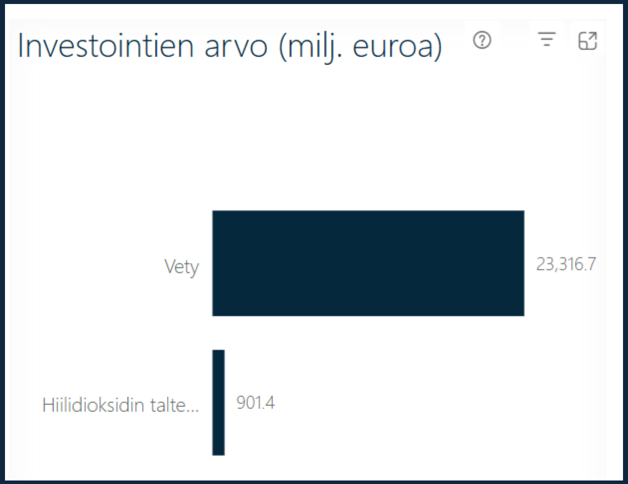
1. Background
2. Key findings
   - Finance is everything
   - Technology still developing
   - Scope management important in procurement phase
   - Focus for safety aspects
3. About Green North Energy projects

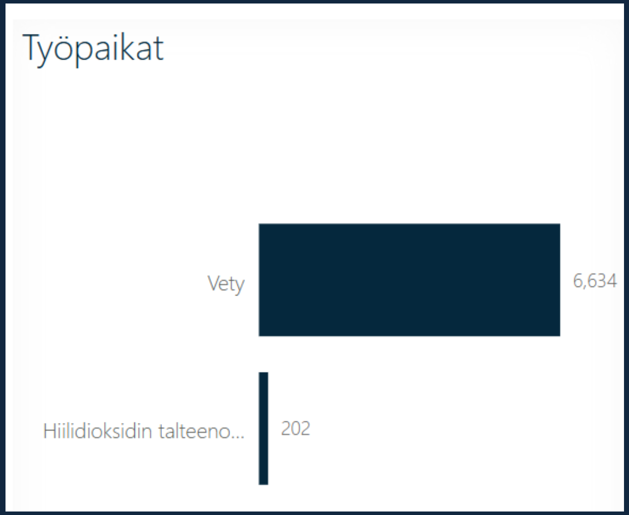
Future ecosystem



Huge potential but…







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Finance is everything

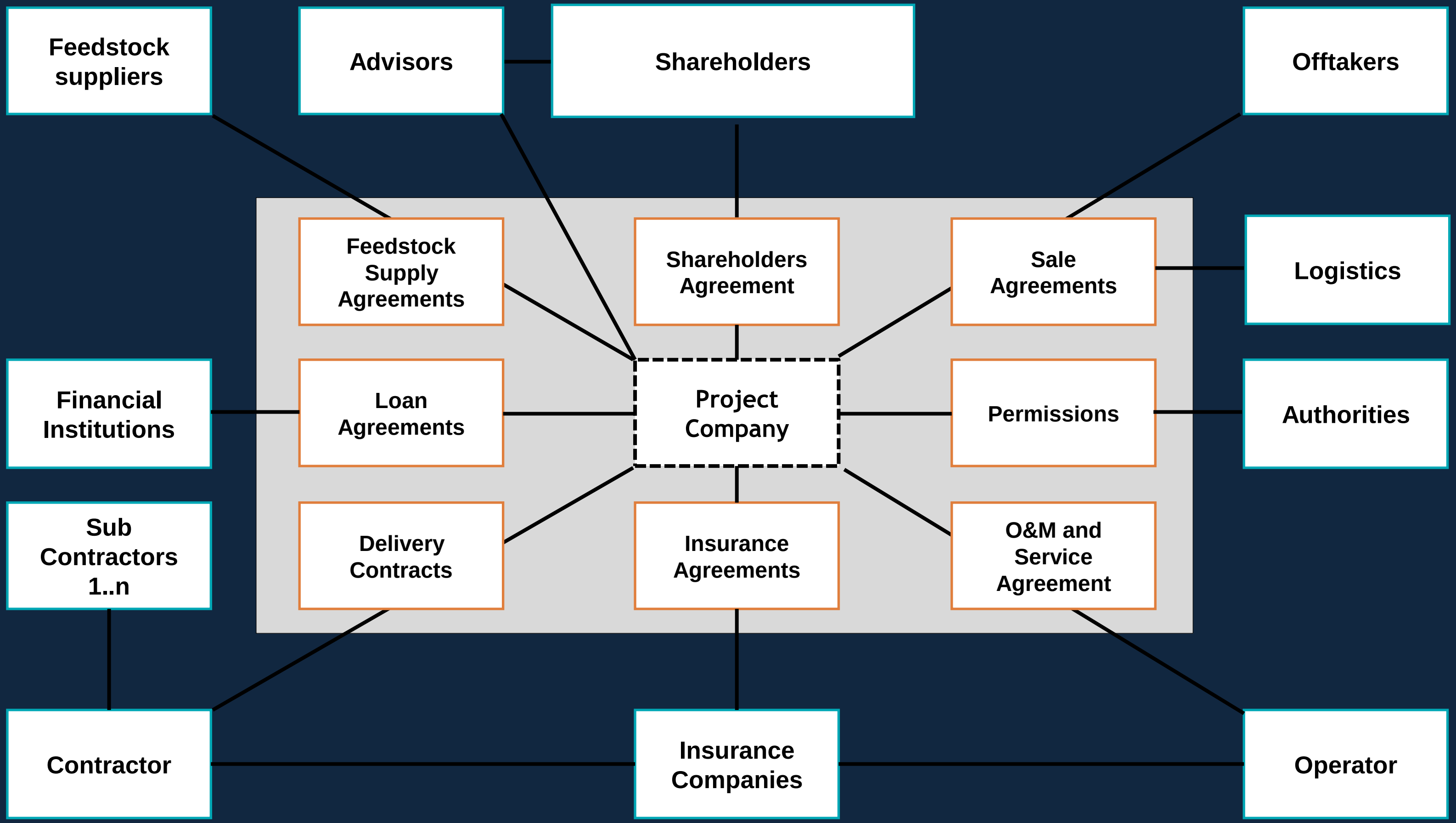
Needed investments are huge

Ren-Gas: The Ministry of Economic Affairs and Employment has granted a €28 million energy investment subsidy to Ren-Gas for its renewable e-methane production facility in Lahti. The total cost of the project exceeds €300 million and is part of Ren-Gas' plan to build a renewable e-methane production network across Finland.

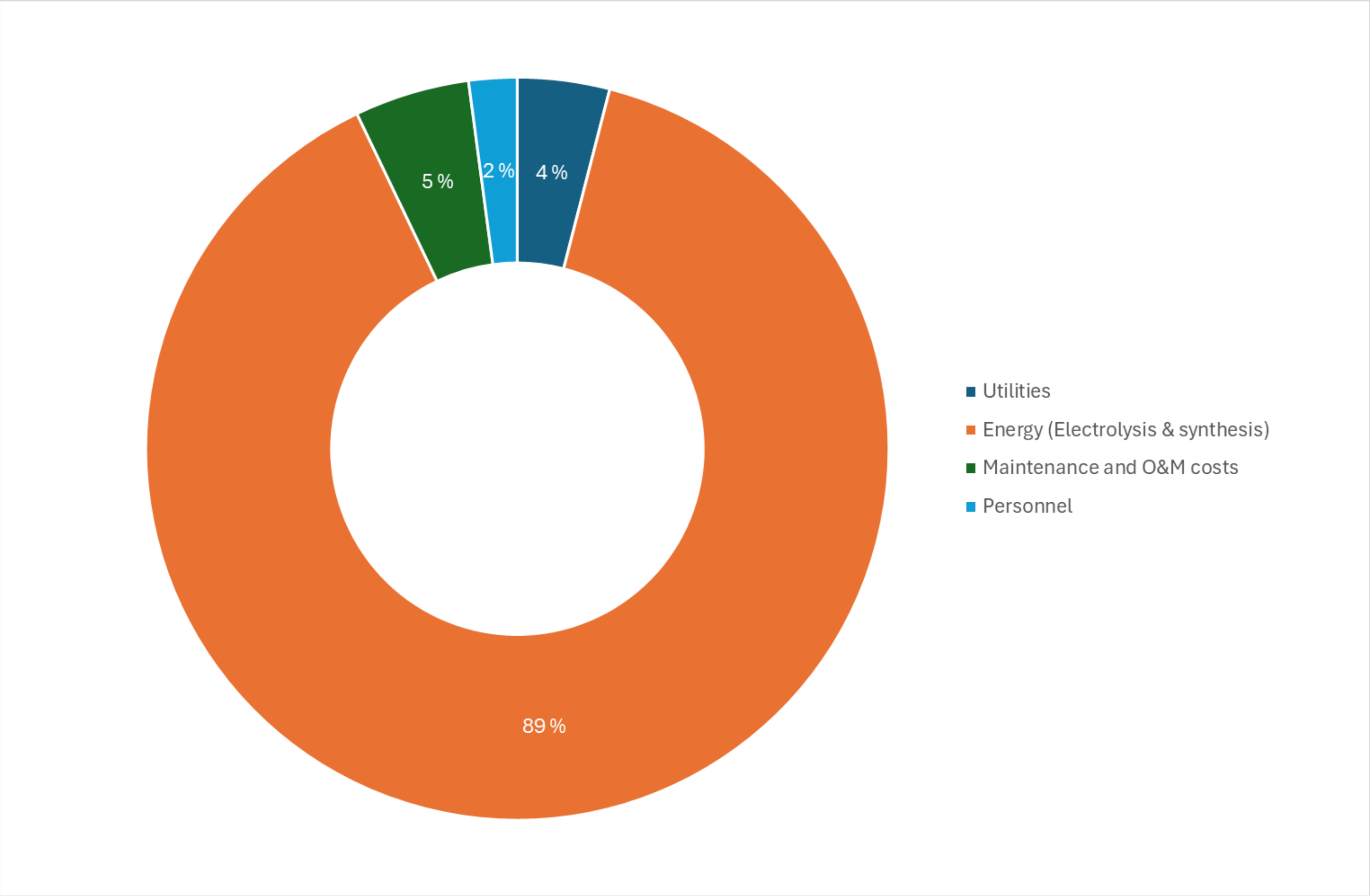
O2X: OX2 has made the investment decision for two onshore wind farms in Finland with a total capacity of 472 MW. The investment amounts to more than 700 MEUR and the wind farms will remain under OX2's ownership once constructed.

Gasgrid: The Nordic Hydrogen Route investment is estimated at 3.5B EUR, offering a hydrogen transportation cost of 0.1-0.2 €/kg. The pipeline would enable ten-fold investments around 37B EUR in wind power and electrolysis.

Project development



Typical OPEX of P2X -plant



89 %

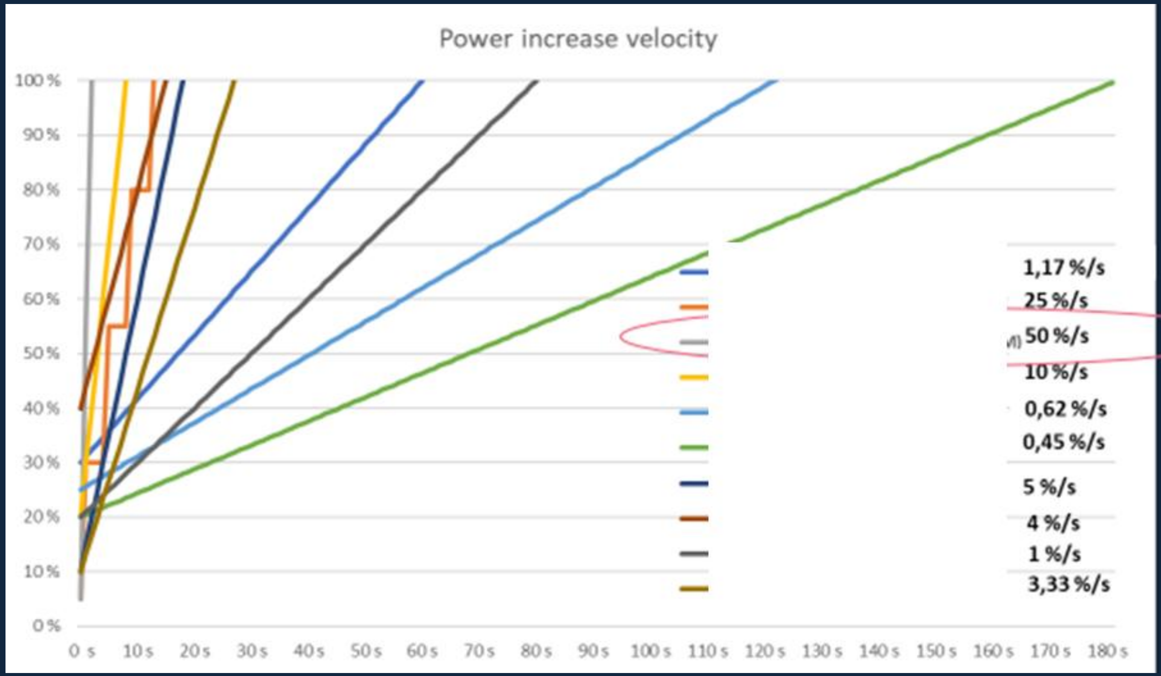
Electricity cost is the most dominating factor

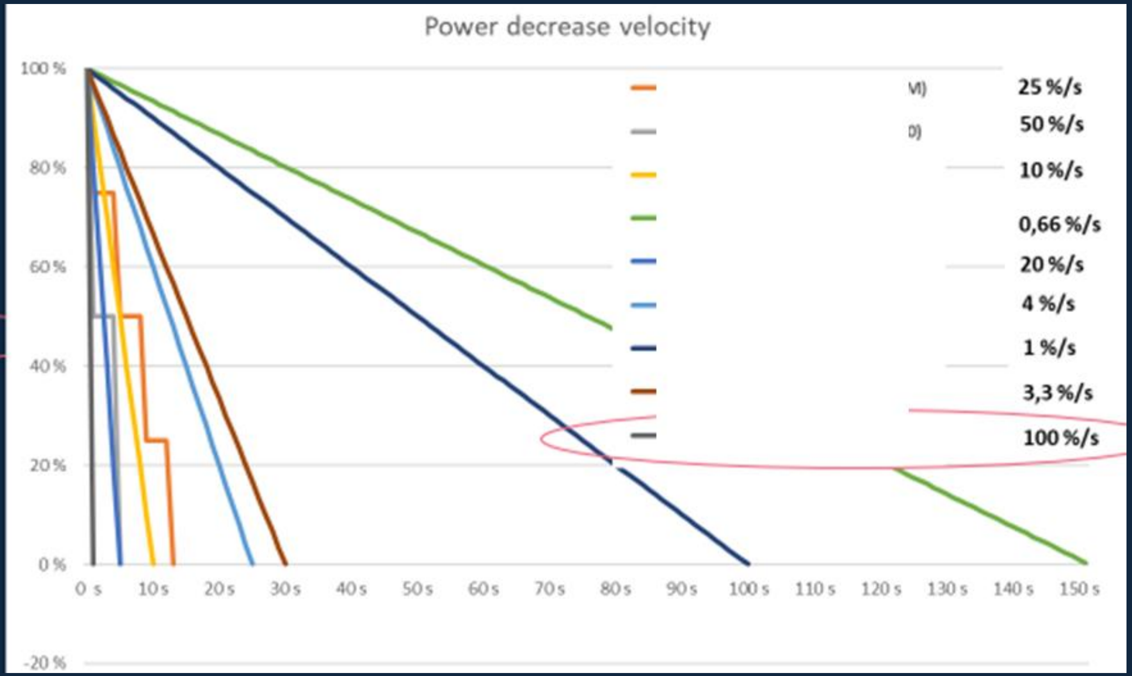
Technology still developing

Comparinson of technology capabilities

	Alkaline electrolysis (AEL)	Proton exchange mebrane (PEM)	Solid oxide electrolyzer cell (SOEC)
+	- Tested and mature technology - Demonstrations in MW range - Competitive efficiency - Does not require critical raw materials - Low price - Low degradation rate	- Fastest load response times - Simple plant configuration - Only contaminant in end-product is water or O2 - Smallest plant footprint	- Highest efficiency - Cheaper materials from more sustainable sources.
-	- Longer cold start than PEM - Plant configuration more complex (including lye recirculation) - Not many western equipment manufacturers	- Electrodes made of precious metals - No several MW range plants currently in operation - Higher investment costs - Load variation affects the degredation rate - No data on long term use in MW range	- Highest cold start time - Currently in development - Biggest plant footprint - Higher investment costs - Higher O&M costs - Slowest ramp-up rate - Highest degradation rate

Technology dynamism at the center





Sustainability more and more important

Alkaline Technology: Metals with no foreseeable supply threats. Nickel price to be monitored due to medium volatility. Recent estimates indicate more than 300 million tons of nickel contained in world wide deposits. Nickel is recyclable material, future utilization depends also on improvement of recycling methods.

PEM Technology: Platinum group minerals have supply, economic and socio-environmental vulnerabilities. Thus alternatives to these materials should be sought after in technology R&D.

SOEC Technology: Yttrium is a rare-earth mineral. Despite name, impure yttrium is common in the earths crust. However the mining and extraction of the metal from the ore is costly. Therefor material prices have a high volatility and are expected to increase. Improved methods to recycle Yttrium impact the availability of material.

Link to source material

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Ranking of suitable technology

Supplier	Technology	Power increase/ decrease speed	Production turndown ratio	Specific power consumption	Lifetime	Modularity / layout requirements	Start-up time to operation	Scope of supply	Maturity of technology / References	CAPEX	Ease of communication / Quotation quality	RANKING
	PEM	3	7	7	4	1	9	6	5	8	7	159
	PEM	3	4	9	8	8	8	5	6	6	6	166
	PEM	8	6	5	8	5	7	4	7	3	5	145
	PEM	10	10	10	8	9	6	7	7	1	10	187
	PEM	5	8	2	8	6	5	6	6	2	4	117
	AEC	2	6	8	8	4	1	10	8	10	8	182
	AEC	5	2	4	8	1	1	8	9	9	3	149
	AEC	2	2	6	10	7	1	7	6	7	9	145
	AEC	6	8	1	4	1	5	6	3	5	1	105
	AEC	8	2	3	8	5	1	9	4	4	2	118
Factor	1-5	3	2	5	2	1	2	2	3	5	1	

Scope management important in procurement phase

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Example of different procurement strategies

EXAMPLES OF DECISION CRITERIA

- *Risk allocation*
- *Schedule*
- *Project finance/bankability*
- *Project developer's own organization*

Direct costs

Option 1: "Full EPC"

Balance of Plant

Electrolyzer module(s)

Civil works

Utilities

- One contract partner
- EPC guarantees for performance including LD:s
- Limited changes during project, or at high extra cost
- Likely EPC premium costs
- Today limited amount of potential suppliers

Option 2: "Separated EPC lots"

Balance of Plant

Electrolyzer module(s)

Civil works

Utilities

- Two or more contract partners
- Delivery limits between suppliers increase with demand for well defined performance, typically introduces risks
- Performance LD:s are limited to lots

Option 3: EPCM

Compressors

Electrolyzer module(s)

Water treatment

Interconnections

Transformers and rectifiers

Civil works

Utilities

- Multiple contract partners and interfaces
- Project developer carries the technology risk
- Extensive engineering/project management required from project developer
- Lowest direct cost (potentially)

Time to implementation and risks (indirect costs)

Typical exclusions in electrolyzer OEM scope

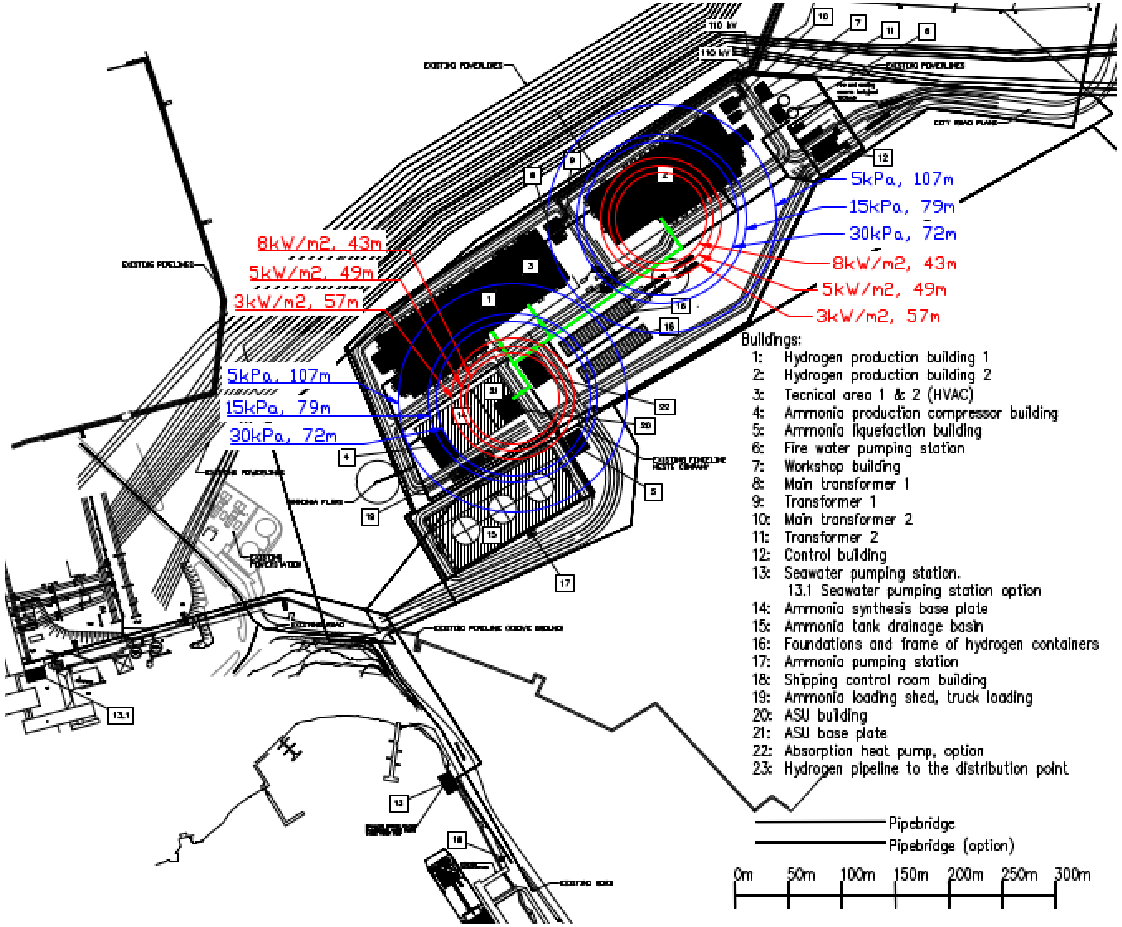
- Demineralized water production
- Cooling water production
- Demineralized water polishing depending on supplier
- Hydrogen purification
- Hydrogen compression
- Hydrogen storage
- General utilities
- Installations
- Piping inside and outside plant
- Civil works
- Fire extinguishing system

Focus for safety aspects

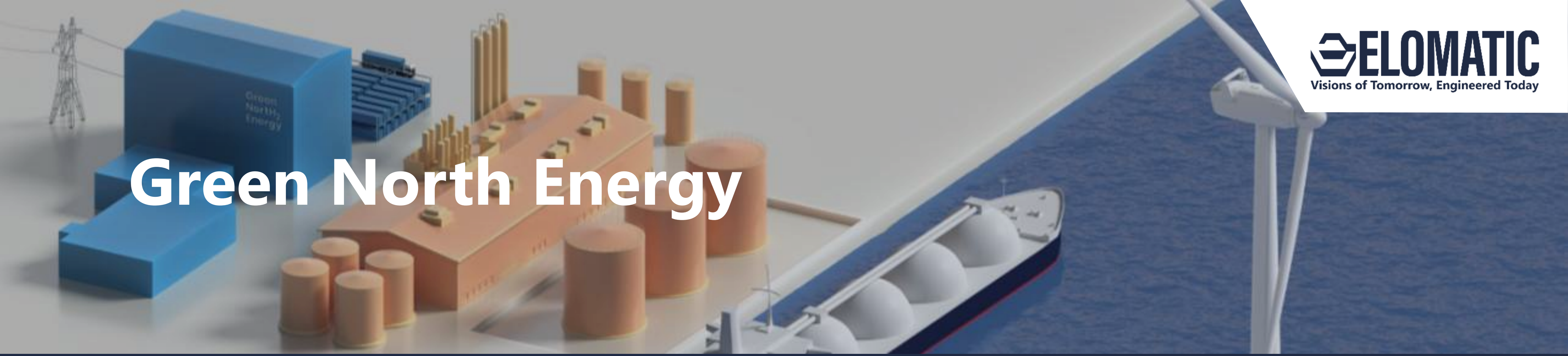
Safety, consequence analysis

Safety distances for explosion pressures		
H2	3 m/s	5 m/s
5 kPa	99 m	107 m
10 kPa	77 m	86 m
15 kPa	70 m	79 m
30 kPa	62 m	72 m

Scenario: Hydrogen, Leakage hole size 10 % of pipe cross-sectional area, pipe DN 150, 30 bar



About Green North Energy projects



Green North Energy

Elomatic has implemented the concept design for Green North Energy's Naantali project with

- Project management services
- Technical concept design for all design disciplines
- Preliminary risk assessments and safety reviews
- Project cost estimate (Capex)

In addition, Elomatic has been investigating and applying for support opportunities for the project from various sources.

As Green North Energy’s partner, we have continued to the basic planning phase, where the materials of the concept planning phase are refined, based on which it is possible to make an investment decision about the project. As part of this work, we have also been creating an EIA program for the project.

Elomatic provides OE services for the Naantali green ammonia project from 2024.

2021		2022		2023		2024		2025		2026
	Feasibility phase		Concept design		Basic design		OE services			

Green North Energy

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Green North Energy (GNE) is planning to implement three integrated green ammonia production plants in Finland. The plants will be located in Naantali, Pori and Kemi. The project in Naantali is in Basic Design phase, while in Pori and Kemi Feasibility Studies are under implementation.

By developing ammonia plants based on green hydrogen, GNE is on a mission to accelerate the green transition. GNE's planned production volumes would be enough to make Finland self-sufficient in ammonia production.

Elomatic's role

Naantali

- Main role in developing the project from the initial project idea to the ongoing basic design including e.g.
    - General concept development, site alternative and capacity assessments
    - Market studies and electricity availability definition including negotiations with power grid companies
    - Comparison of main technologies (AEL, PEM) and main equipment suppliers, requests for budgetary proposals and evaluation of the proposals
    - Preliminary, concept and basic design
    - CAPEX, OPEX, financial calculations
    - Continuous discussion with all relevant stakeholders

Pori and Kemi

- Pre-feasibility studies to define the most feasible options
    - Market studies (ammonia, hydrogen, electricity, side streams)
    - Assessment of site alternatives
    - Electrolysis technology comparison (AEL, PEM, SOEC, AEM)
    - Preliminary design
    - CAPEX, OPEX, financial calculations
- Concept design for the selected options

[What Can Developers of the Hydrogen Economy Learn from Industrial History? - Elomatic]

When it’s time to face the future, face it with Elomatic.

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