HUG
HYDROGEN UNDERGROUND

BF CO-RESEARCH PROJECT

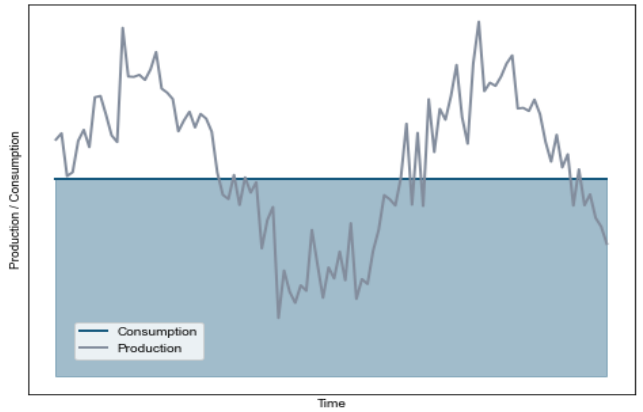
ECONOMIC PROSPECTS OF HYDROGEN STORING

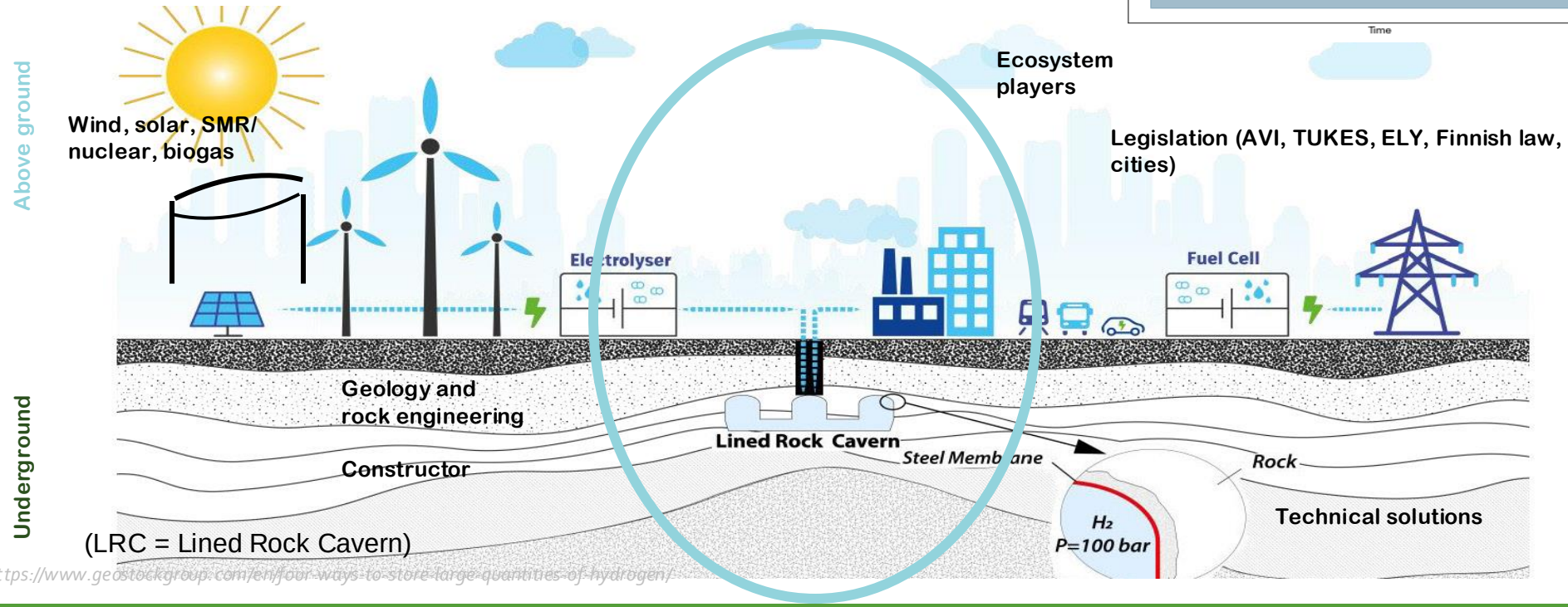
HYGCEL SEMINAR 1.10.2024

PETER YLÉN, VTT

HUG – Hydrogen UnderGround

Large scale Hydrogen underground storage is a key enabler of the hydrogen economy - it allows hydrogen production and consumption to be decoupled from each other, and thus stable H2 distribution to its users.





(LRC = Lined Rock Cavern)

https://www.geostockgroup.com/en/four-ways-to-store-large-quantities-of-hydrogen/

Questions we want to answer to

Ecosystems and business models

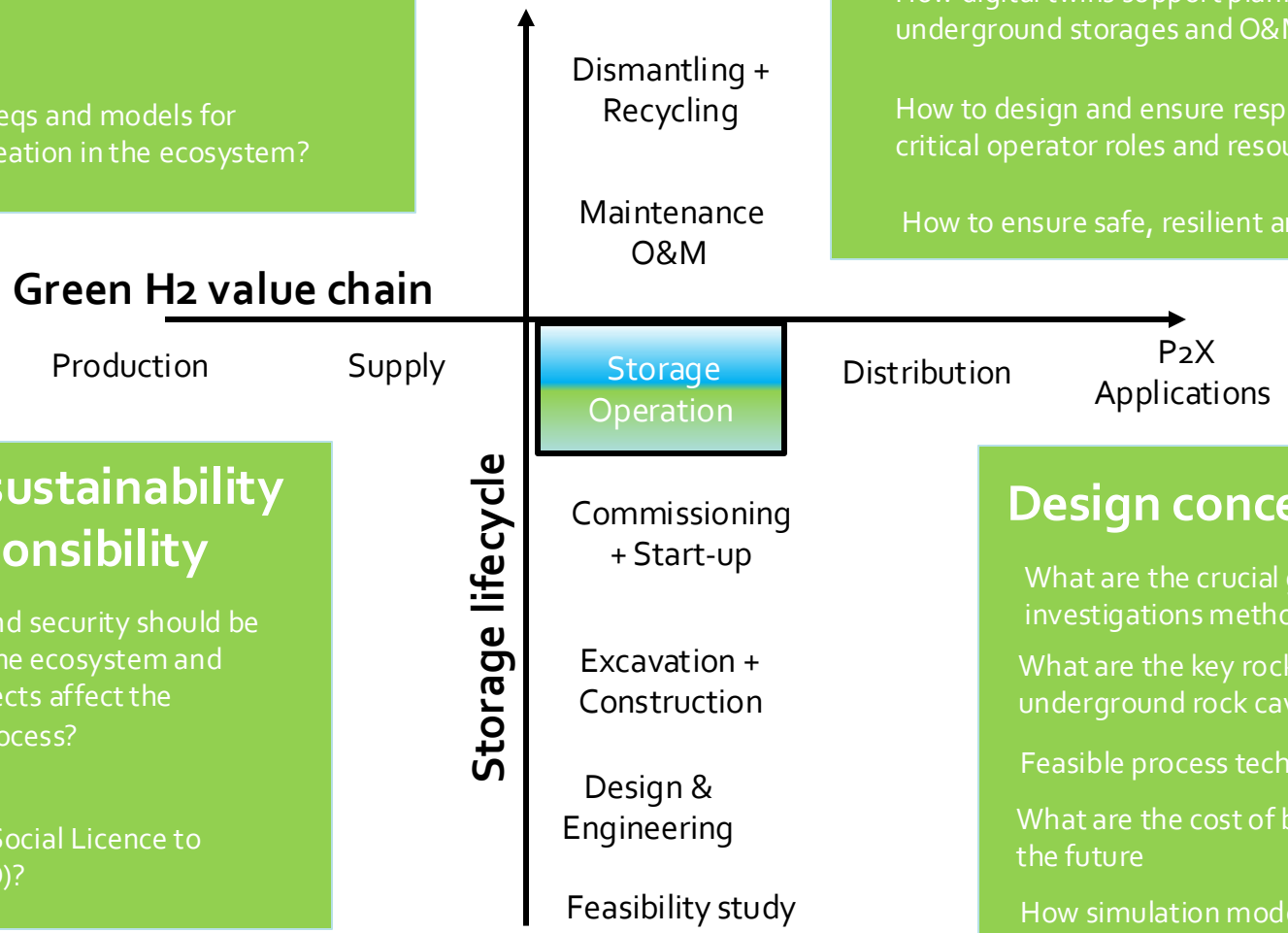
What are the reqs and models for viable value creation in the ecosystem?

Lifecycles and Operations

How digital twins support planning the use of underground storages and O&M

How to design and ensure responsible operations, critical operator roles and resources

How to ensure safe, resilient and reliable asset lifecycle



Safety, sustainability and responsibility

How safety and security should be managed in the ecosystem and how new aspects affect the permitting process?

How to gain Social Licence to Operate (SLO)?

Design concepts and technology

What are the crucial geological site selection criteria and investigations methods

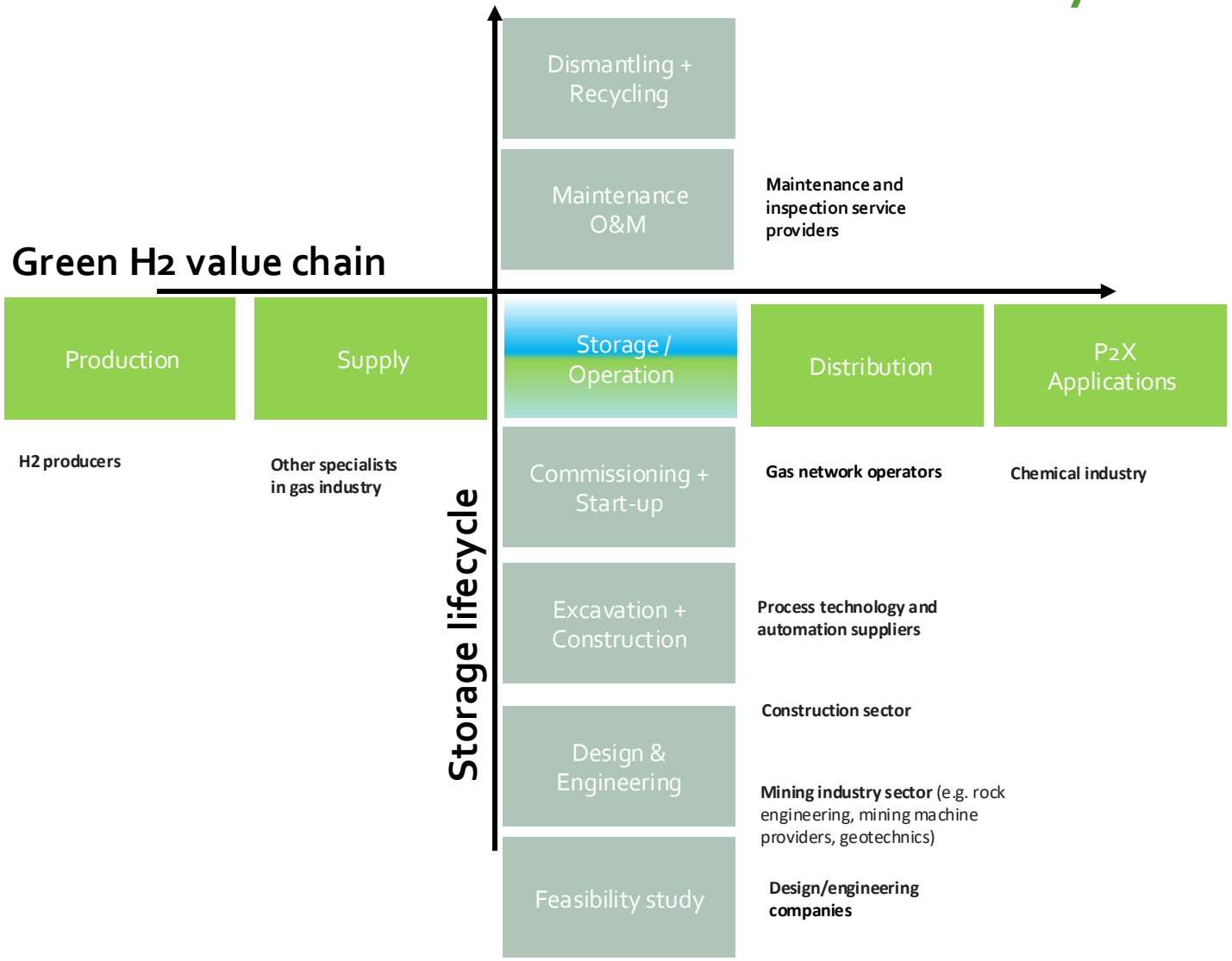
What are the key rock design parameters for pressurized underground rock caverns

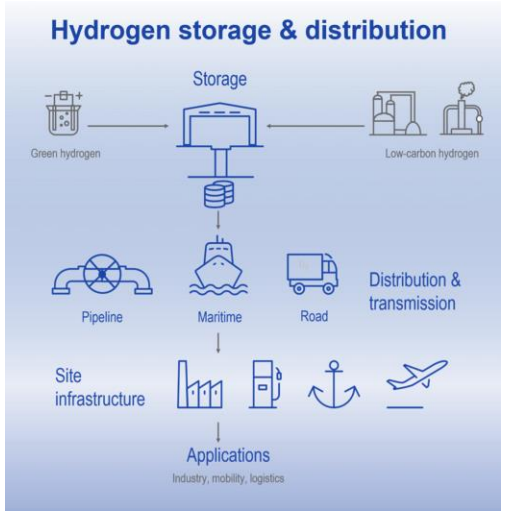
Feasible process technology and automation concepts

What are the cost of building and operations now and in the future

How simulation models support engineering of underground storages

HUG - relevant for the whole ecosystem





https://www.tuvsud.com/en-id/themes/hydrogen/explore-the-hydrogen-value-chain/hydrogen-storage-and-distribution

Regulatory body:

- TUKES

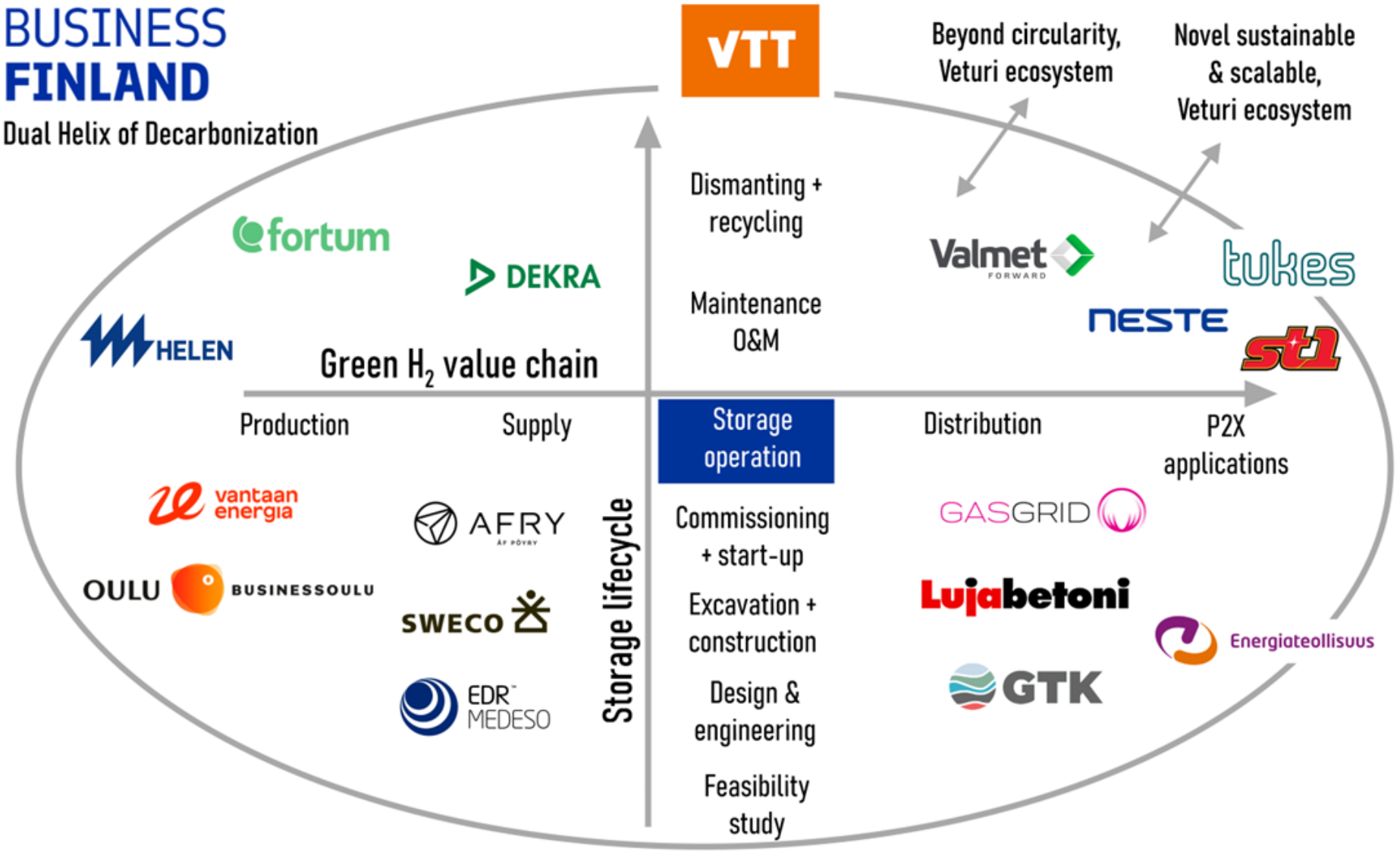
Other relevant external stakeholders:

- Vetyklusteri (audience)
- Huoltovarmuuskeskus

HUG Hydrogen UnderGround

BUSINESS FINLAND

Dual Helix of Decarbonization



Project volume:
2,572 M€

Project duration:
April 2024 – March 2026

Factors affecting storage potential

- Business ecosystem
- Business potential
- Role of government subsidies
- Value network description - companies and roles of each - H2 production + usage volumes (planning/existing/tbd)
- Collaboration model - In construction phase and operation phase
- Local ecosystem
- Landownership
- Investment plans
- Status of investments
- Feasibility study / investment plan / FID / building or operation phase
- Private/public funding

Factors affecting storage potential

- H2 storage capacity/ required mass flow
- Location: Near production - Near use - Integration to main delivery pipeline (Gasgrid)
- Scalability: existing or planned buffer storages - restriction / no restrictions related to scalability at site
- Safety
  - distance to neighbors (residential areas, public facilities e.g hospitals, schools etc.)
  - distance to surrounding nature reserve areas
  - distance to and the type of the surrounding industry (etc. handling of hazardous chemicals)
  - distance to aerial power lines
  - other underground structures nearby (wells, heat wells, tunnels, underground infrastructure)
- Geologic assessment
- And several other key factors recognized so far

Different categories for business models and operation

Steering group decided that the main criterion for selection is that the three use cases should be different from each others.

Three different approaches were identified:

- Ecosystem approach
- Service approach
- Private sector drive

Three use cases will be taken into closer evaluation and later on one selected target site will be drilled, investigated and modelled.

Ecosystem & Business model

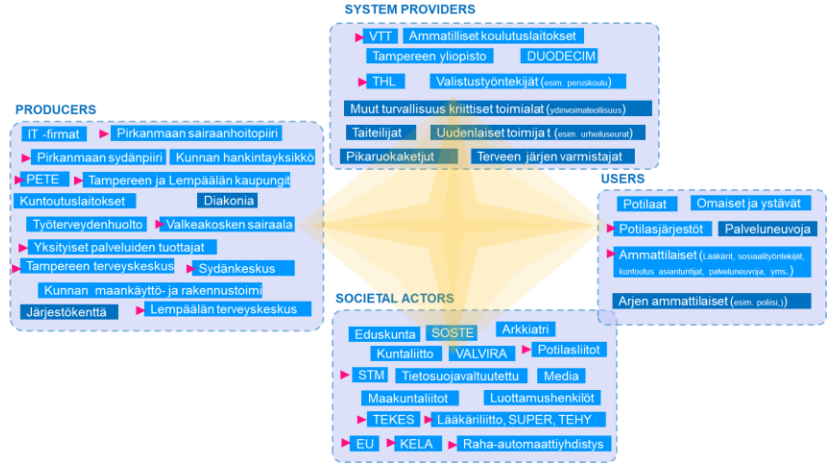
- Objective:
  - To obtain an understanding of potential business models for underground hydrogen storage and the broader ecosystem by
    - identifying critical stakeholders and topic areas to analyse the main bottlenecks of underground hydrogen business ecosystems co-evolution process involving a variety of companies
    - identifying relevant future scenarios under various external factors and uncertainties
    - analysing and defining alternative business models in the underground hydrogen storage ecosystem

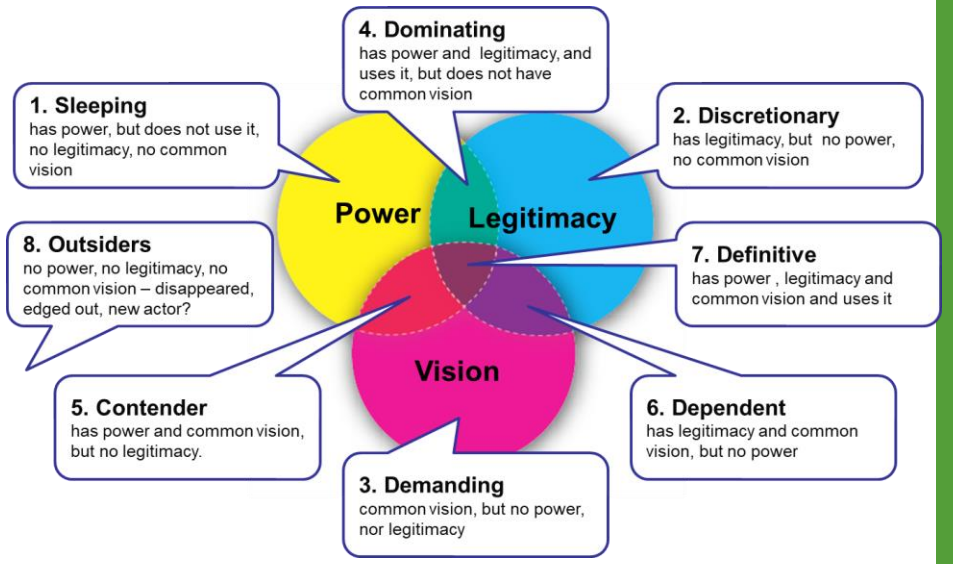
- Outputs:
  - Description of potential business models for underground hydrogen storage
  - Description of the underground hydrogen storage ecosystem

- Structure of the research:
  - First part: analysis is performed on a higher level/lower resolution with respect to the potential sites
  - Second part: A more detailed analysis on the selected site

Identification of critical stakeholders and topic areas of underground hydrogen business ecosystems

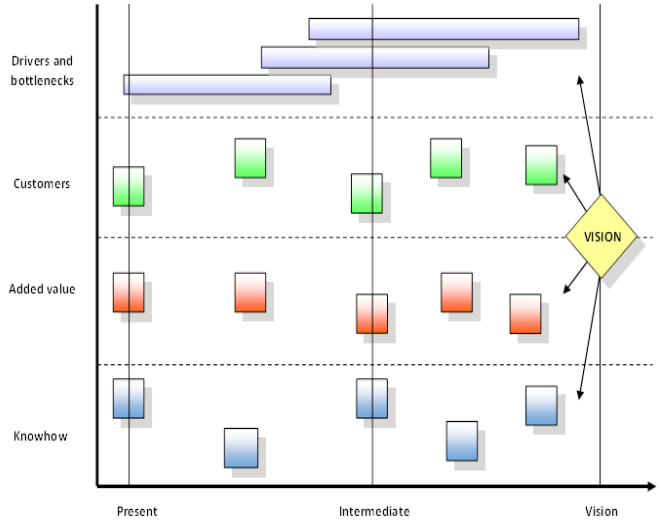
- The aim of the task is to identify the critical stakeholders and find the main bottlenecks of underground hydrogen business ecosystems co-evolution process involving a variety of companies (both established and start-ups, different sizes and roles). The research work is closely linked with the work in other work packages, ensuring the required input from end-users and customers. The end-user involvement is crucial, in order to ensure the future-proofed business opportunities based on multiple business models as a portfolio within firms operating in different platforms and ecosystems. Methods include, e.g., Stakeholder mapping including Starmap role positioning and PLC (Power/Legitimacy/Vision) deconstruction.





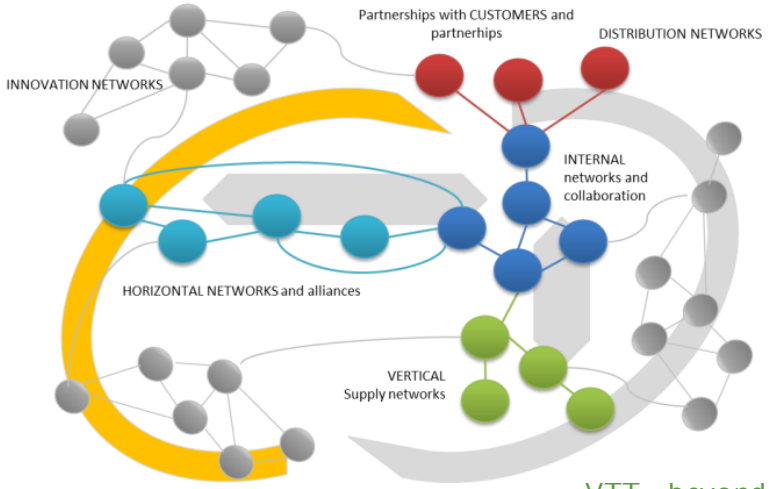
Identification of relevant future scenarios of underground hydrogen business ecosystems

- The aim of the task is to identify the relevant future scenarios by taking into consideration various external factors (technological innovations, geopolitics, regulation, ecosystem stakeholders …) and uncertainties (economy, demand and supply, safety margins, industry renewal, …) including the critical mechanisms in realization of various futures. Methods may include (depending on findings of) Foresight with Scenario analysis, Future Radar, Morphological analysis, Conjoint priorization of scenarios, etc…



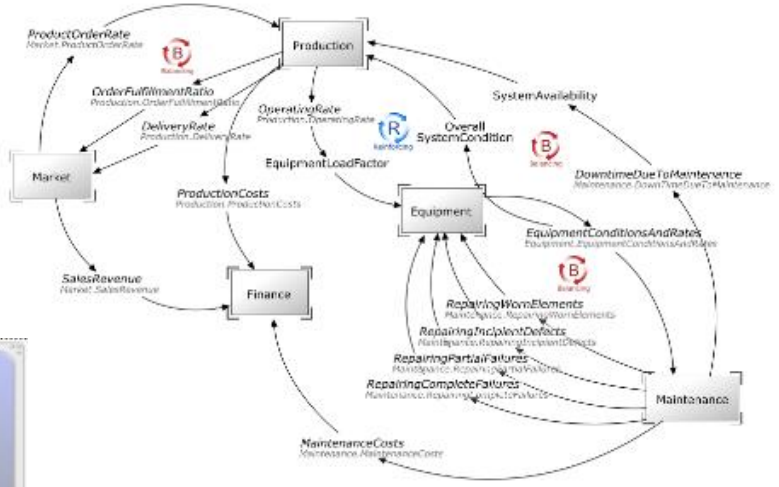
Defining alternative business models of underground hydrogen business ecosystems

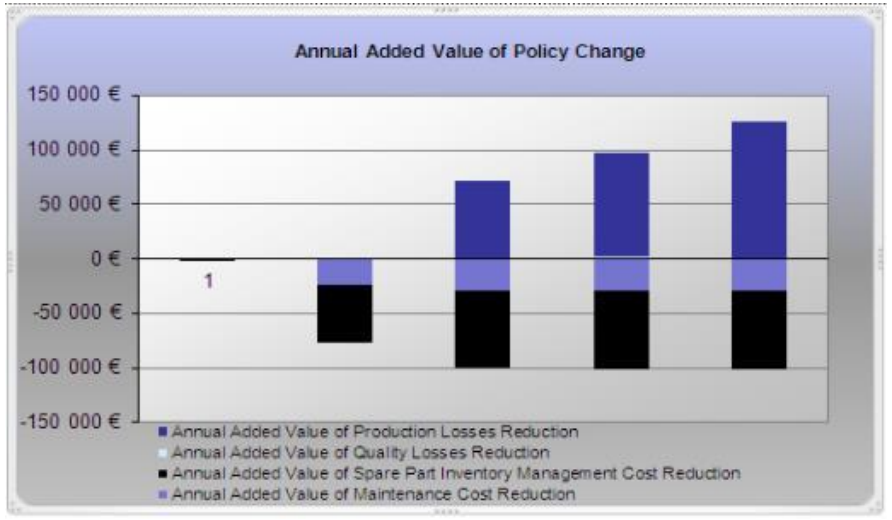
- The aim of the task is to analyse and define alternative business models in the underground hydrogen storage ecosystem by using the input from previous tasks. The methodology may include, Business ecosystem canvas, Earning logic and value distribution decomposition, Resilience analysis against external disturbances and uncertainties



Determination of the leverage factors that can create viable business ecosystems underground hydrogen storage business

- The aim of the task is to map dynamic causalities in different ecosystem scenarios and an action plan (for the ecosystem roadmap). Long and short time horizon impact assessment is performed and leverage factors are determined with sensitivity analysis, The methodology includes System dynamics, Impact assessment, Simulations and sensitivity analysis.





Thank you for interest

Peter Ylen
Peter.ylen@vtt.fi
+358 40 507 7474