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Parallel session on Storage Technologies and Sector Interfaces

Large-Scale Energy Storage in Salt Caverns and Depleted Fields

Short presentation of the project

Project Name: **Large-Scale Energy Storage in Salt Caverns and Depleted Fields**

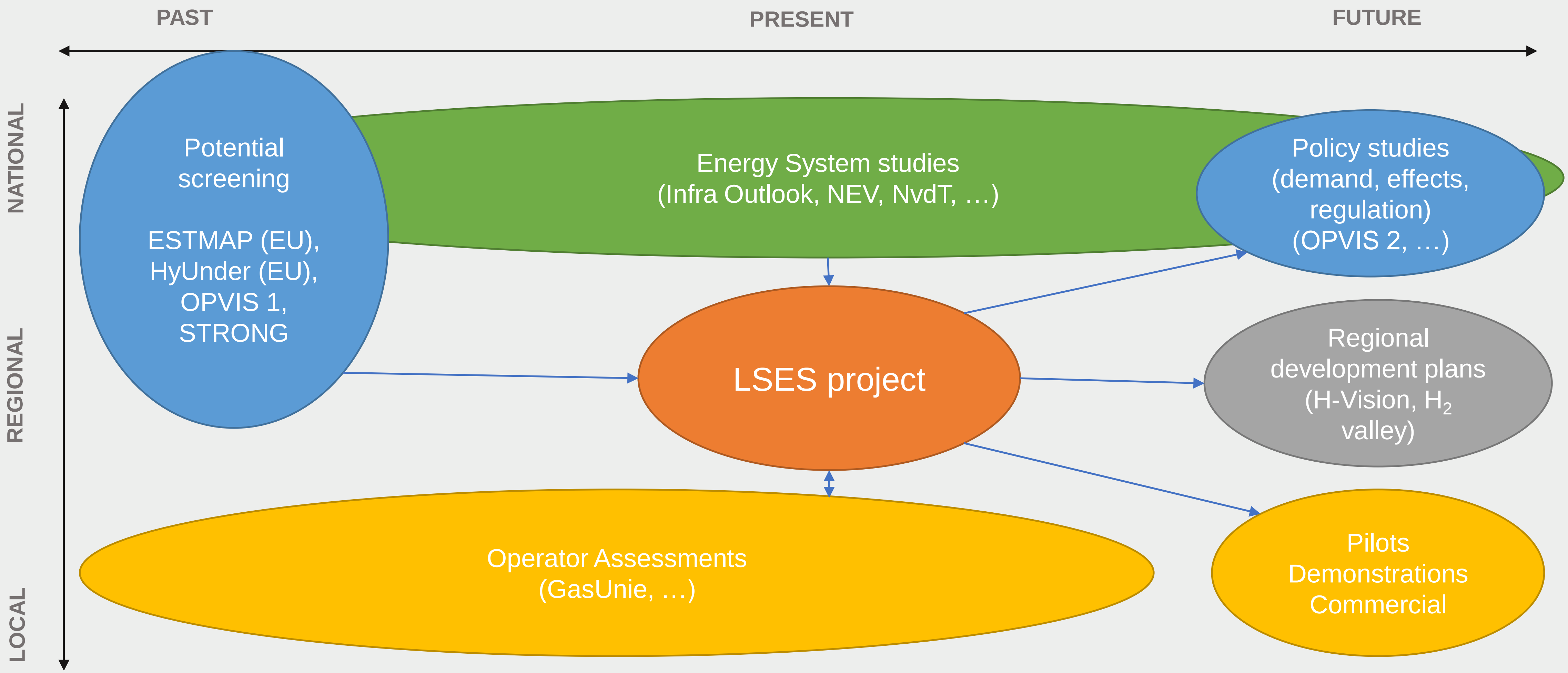
Consortium: **TNO (lead), EBN, NAM, Gasunie, GasTerra, Nouryon**

Budget: **400kEUR**

Overarching objectives:

- **Understand the drivers** for large-scale storage demand in the future Dutch energy system
- **Quantify when** in time it will be required, **where on a regional level**, and **how much**
- Assess to which extent the **technologies** under investigation can deliver this (**readiness**)
- **Identify risks** (technical, environmental, safety) and highlight **barriers** to deployment
- Identify **knowledge gaps** to be systematically addressed in a follow-up RD&I programme

Position in RD&I landscape



Key exploitable results addressing energy system integration

1. Large-scale storage will play a **key role in securing supply over periods of days up to seasons** in a future Dutch energy system that relies on variable renewable production.
2. Power-to-H_2 + storage enables **widespread integration of renewables** by offering a means to shift the use of (converted) clean electricity in time and to other sectors.
3. CAES: its ability to deliver CO_2-neutral energy (GWh-scale) and power (100s of MW-scale) with fast response on a daily basis makes it an **attractive option for managing daily variations in renewable generation** (capacity, and ramp-up/ramp-down).
4. Hydrogen: a cavern offers 50-100 million m^3 capacity; to fulfill estimated storage demand in 2050 (up to 5 bcm) with caverns will meet with **technical, economic, and spatial planning constraints**. Depleted field storage (billion m^3-scale) will then be required.
5. Hydrogen: achievable single-well rates of injection/production are roughly comparable to natural gas in m^3, but **4 x lower in MWh**, which affects their ability to balance short-term variations in renewable production.

Lessons learned and barriers to innovation deployment

Lessons learned:

- A **lowest marginal-cost approach** to **dispatching** favors low cost generation over reliability, and **undervalues** technologies that provide **flexibility** to balance supply and demand, such as **storage**.
- While salt cavern storage (CAES, H_2) can be considered (almost) mature technology, **H_2 storage in depleted fields requires more R&D** before (innovation) deployment.
- **Specific risks** (techno-economic, environment, safety) associated with fast-cycle storage of (in particular) H_2 **must be addressed before commercial deployment** can occur.

Barriers to deployment:

- **Public acceptance** of subsurface activities
- **Regulatory framework** (double taxes, grid fees, ownership, stacking of services)
- **Lack of consistent energy policy** and **incentives** to innovation deployment

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Deployment prospects of the most promising solutions

- **CAES (diabatic** – with co-firing of natural gas, and up to 20% hydrogen):
  - **Mature technology**, several development **projects** have obtained **PCI** status, deployment will probably happen in next 5 years.
  - Stimulated by **increased e-price volatility**, larger **need** for **regulation** and **reserve power**, and possibly the **emergence of a capacity market**.

- **Hydrogen storage in caverns**:
  - **Ready for deployment at pilot-scale** to address remaining risks and build experience and confidence, likely to happen in next 2-3 years.
  - Further upscaling to demonstration-scale and beyond will **depend on scale-up of renewable / low-carbon hydrogen production**, development of a transport infrastructure, market uptake, and the emergence of GoO scheme.

- **Depleted field storage:**
  - **Not mature**, requiring R&D, work towards a pilot in 2025, further upscaling > 2030

Needs for future R&I activities coming out of the project (if any !)

- Adiabatic CAES at demonstration-scale – **efficient storage and re-use of high T heat** (500 °C) to improve round-trip efficiency towards 70% (up from ≈60% for diabatic CAES)

- Diabatic CAES - **turbine fired with 100% (renewable) H_2** (instead of natural gas) to decrease carbon footprint of electricity (re-)generated.

- **H2 caverns:** assess **effects of fast-cycle storage on integrity of storage wells and caverns** (materials, connections, interfaces) **in contact with H2** – requires testing under storage conditions.

- **H2 fields: RD&I to advance towards pilot readiness >**
  - Interaction of H2 with rocks and fluids in reservoir: risks and impact on volume/quality.
  - Flow behavior of H2 in well and reservoir and impact on rates of send-in/send-out.
  - Subsurface potential assessment to find best candidate fields.