The Energy System of the Future

To a carbon neutral energy system in the Netherlands in 2050

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From Dutch Climate Agreement to the Energy System of the Future

2019-2021

- Gasunie, TenneT and DSOs start an

  Integral Infrastructure Exploration for **2030-2050**

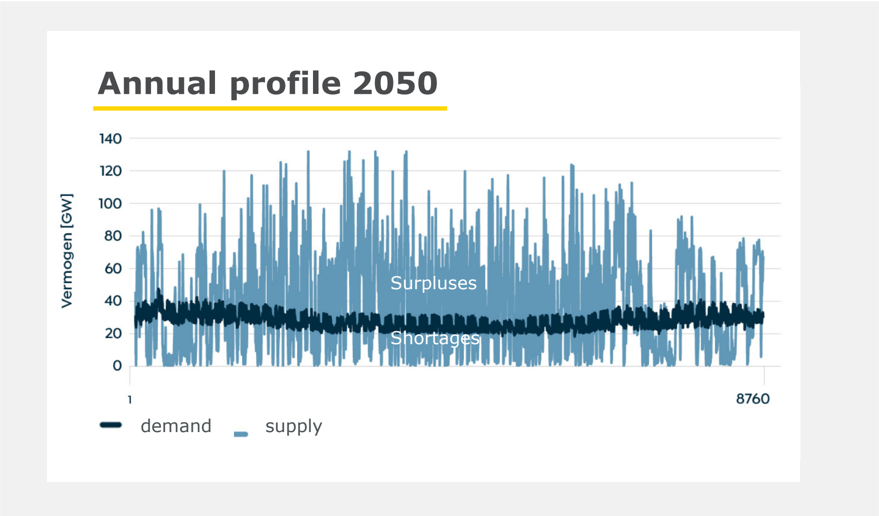
Klimaat-akkoord

- Use insights from **energy sector**
- Include **industrial demand** development and **regional energy strategies**
- Involve relevant stakeholders and market players

How to balance the energy system of 2050?

- Current energy system: conventional production, demand-driven
- Future energy system: variable generation from wind and sun

➢ Continuous difference between supply and demand (hourly and seasonal)



Supply & demand scenarios for 2050

Starting principle: 100% CO2 reduction in 2050

Scenario Regional

- Regional development CO_2 reduction
- **Almost self-sufficient and circular**
- **Local projects** (solar, district heating)
- Reduction of energy-intensive industry

Scenario National

- National development CO_2 reduction
- **Largely self-sufficient**
- **Large scale projects (offshore wind)**
- Stable energy-intensive industry

Scenario European

- EU CO_2 tax with border compensation
- **Import oriented: green gas and biomass**
- Energy-intensive industry growth
- Lowest cost CO_2 reduction incl CCS

Scenario International

- Entire world aiming for CO_2 neutral
- **Import oriented: H_2**
- Free trade of CO_2-free energy
- Energy-intensive industry growth

Current transport and distribution networks

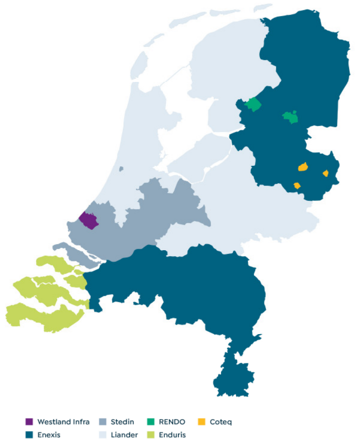
TenneT transport network

Current peak capacity: **20 GW**

Gasunie transport network

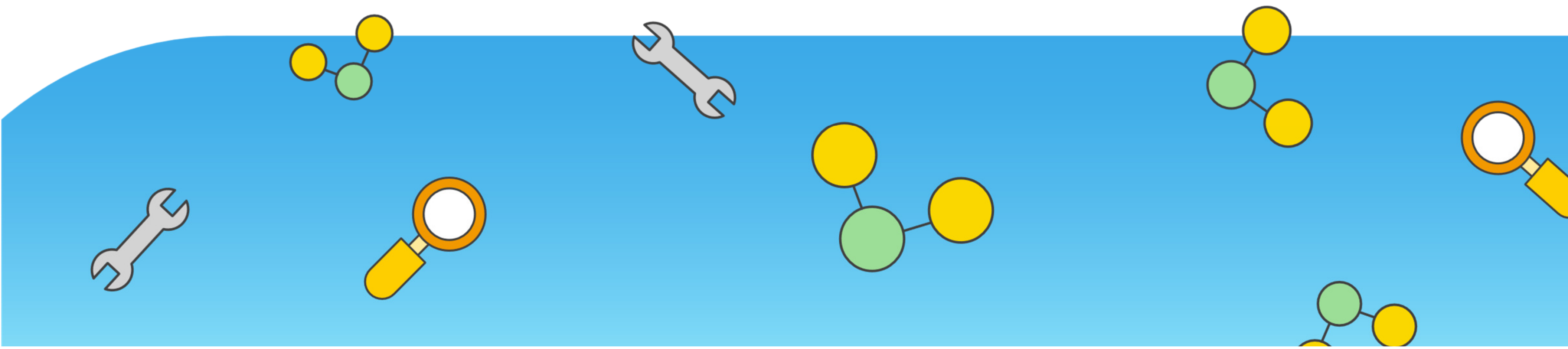
Current peak capacity: **350 GW**

DSOs distribution networks



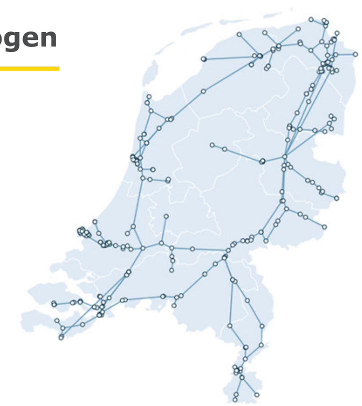
Result 1

Considerable expansion and adaptation of infrastructure



High pressure gas network can be split in H2 and methane networks

Hydrogen

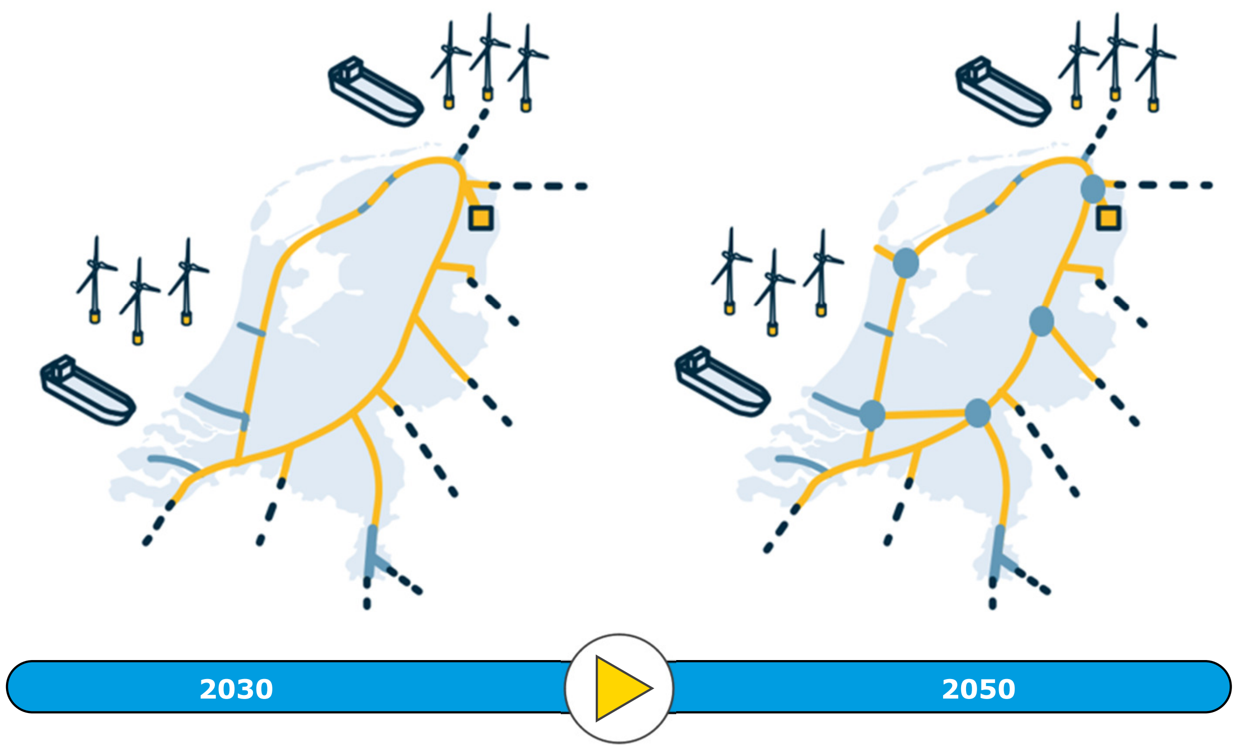


- Starting point: current H-gas routes
- Good connection to industry clusters (feedstock, energy)

Methane

- Starting point: current G-gas routes
- Good connection to households (via regional network)

Hydrogen development path: adding available pipelines, compression and additional east-west connection

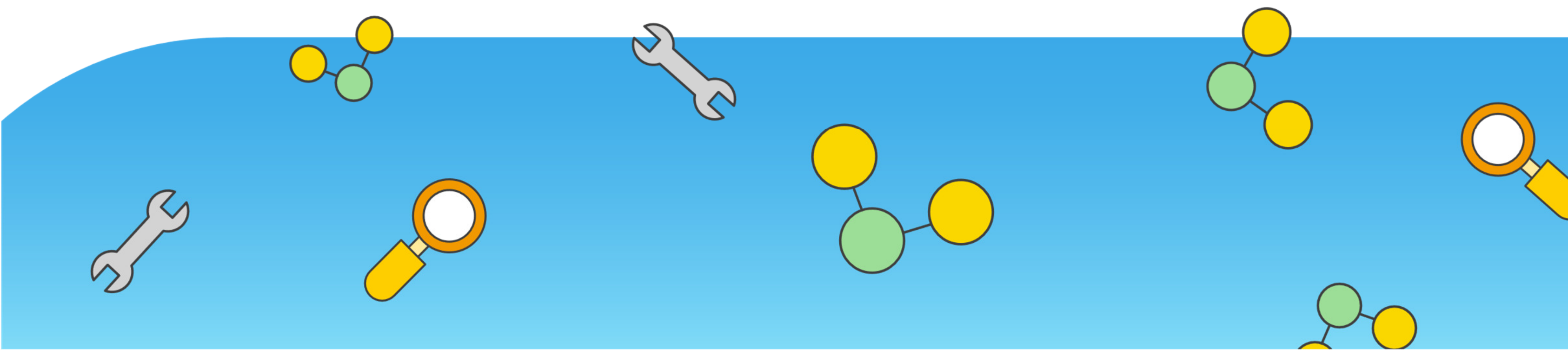


Development 380 kV grid towards 2050

- Most challenging for 380 kV grid:
  - High infeed of wind during periods of high demand
  - Export to Germany
- **Grid expansions** foreseen in certain areas of the country **in all scenarios**.

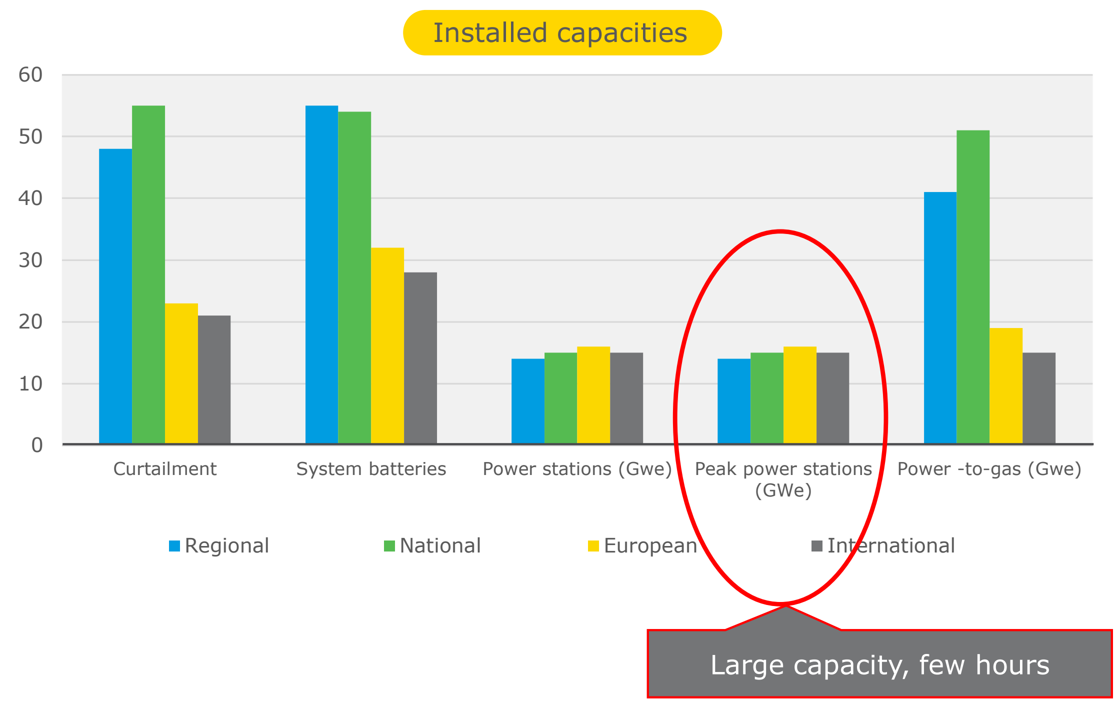
Result 2

Large-scale flexibility resources required



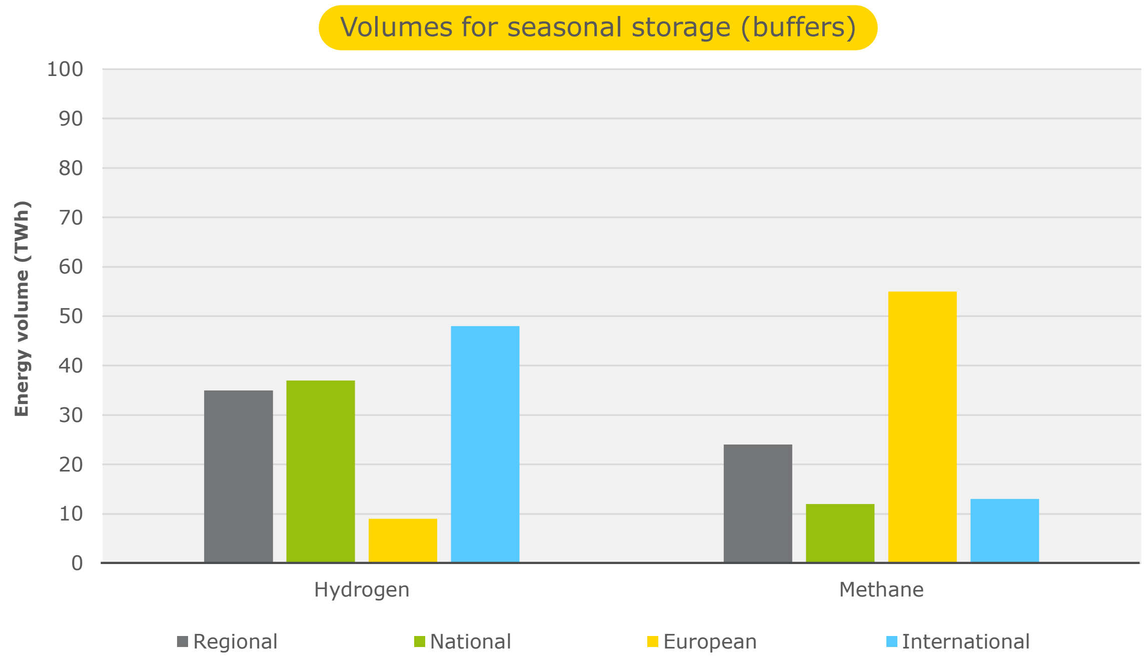
Flexibility:
large capacities needed for power plants and storage

- **Curtailment** powerful instrument at low cost
- **Battery storage** for short periods of imbalances (day/night)
- **Power to Gas** for long periods of imbalances (seasonal storage)
- **Power plants** for security of supply



Flexibility:
extensive seasonal storage of hydrogen and methane needed

- In all scenarios **large volumes of gas storage required** (50 to 60 TWh) to compensate for **seasonal difference** in supply and demand.
- Corresponding to 8 to 10% of final demand.



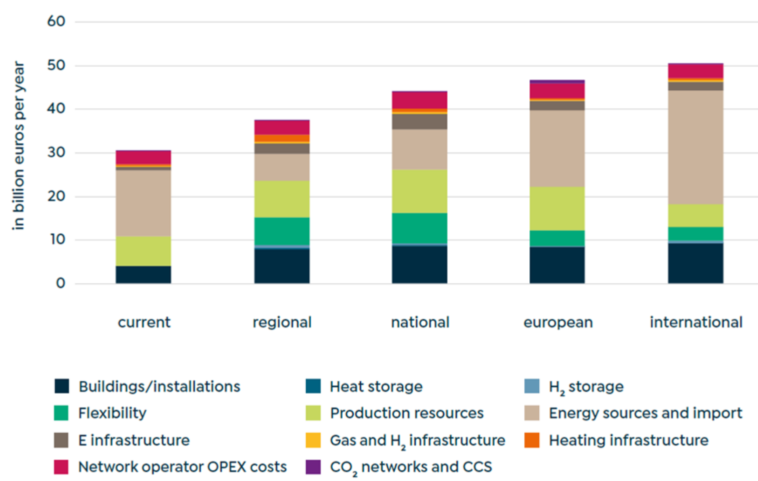
Result 3

Strong increase in costs and space requirements

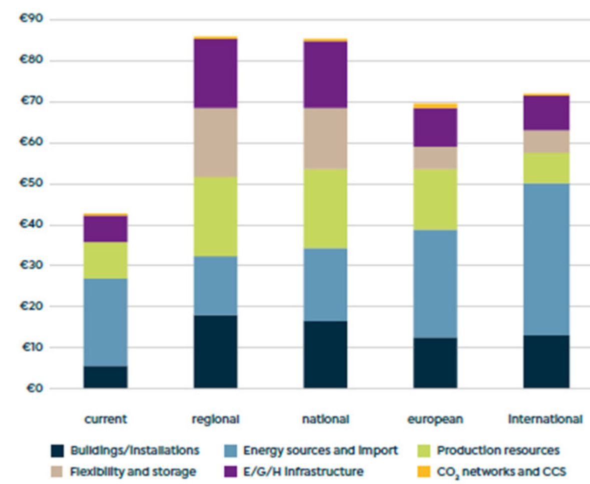
Costs of the energy system will double

- Meeting 100% emission target → doubling of energy prices (all scenarios)
  - Self-sufficient scenarios (REG, NAT): cost dominated by capital costs
  - EUR, INT scenarios: cost dominated by costs for hydrogen or green methane imports

Total costs in billion €*



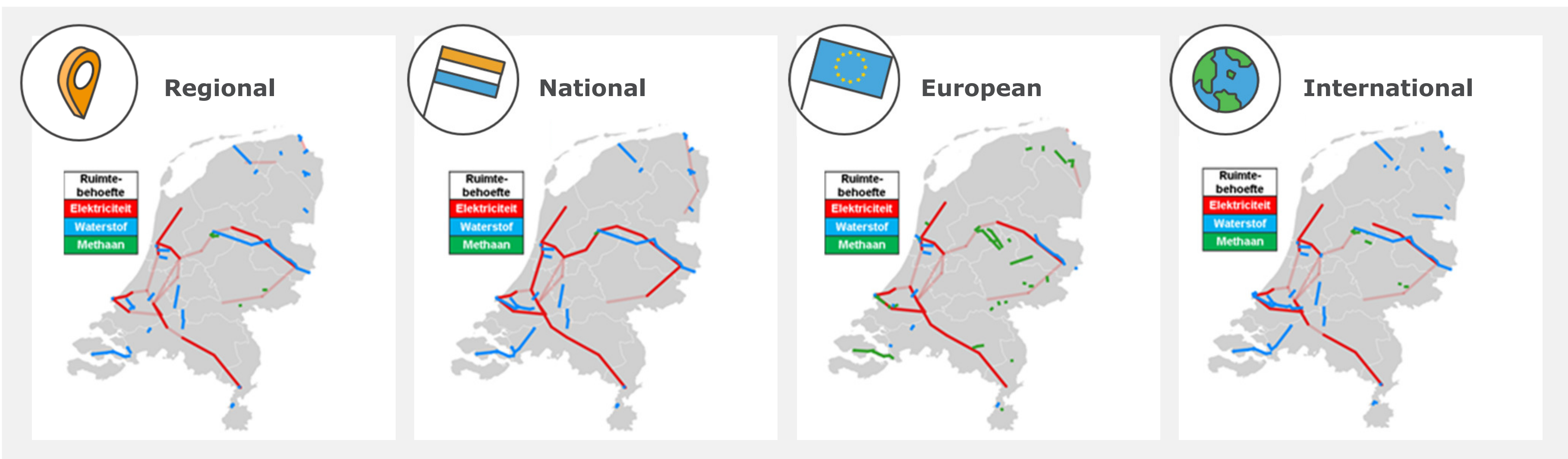
Cost in € per MWh



* On an annual base the cost for grid investments in E&G are inline with the costs presented in Strategy&/PWC study for NBNL of april 2021 https://www.netbeheernederland.nl/_upload/RadFiles/New/Documents/20210407-Finaal%20rapport%20Project%20FIEN.pdf

Feasibility of the construction portfolio is challenging

The II3050 scenarios require a further growth of the 380kV-grid, and new pipelines as well



Conclusions

1. Expand the electricity network and build a nationwide hydrogen transport network

2. Develop large-scale flexibility resources

   - electrolysers, hydrogen storage (caverns, depleted fields), hydrogen fired power plants

3. Expect higher costs and use of extra space

4. Choose the right locations

   - electrolysis near supply of green electricity, power plants near consumption of electricity

5. Speed up the work

   - investment lead times, limited availability of qualified workers

6. Take a long-term perspective

   - to identify and build measures on time

   - to ensure correct choices for an efficient transition to 2050.

Thank you