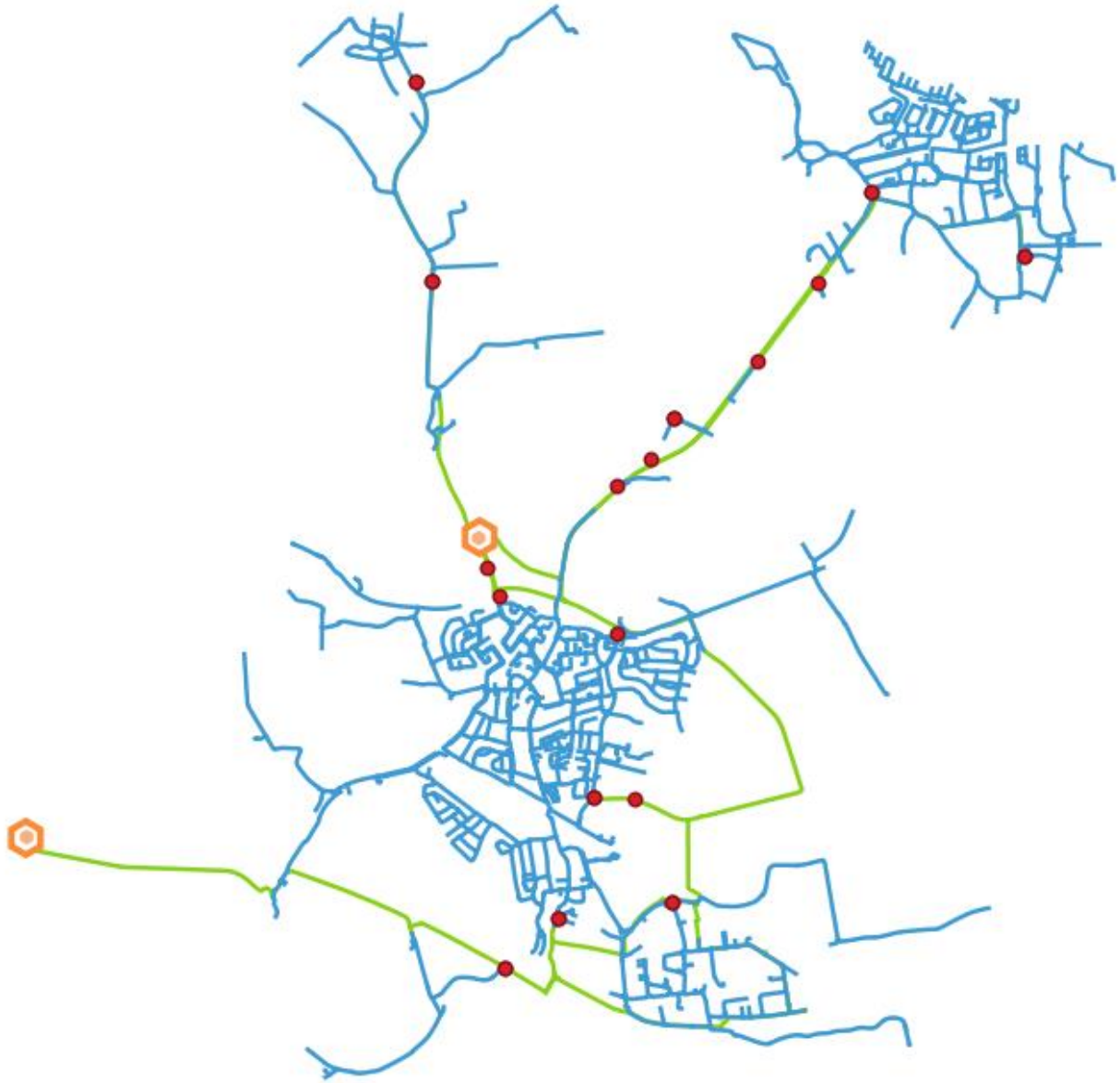
Digitalization of the gas grid

HIPS-NET workshop

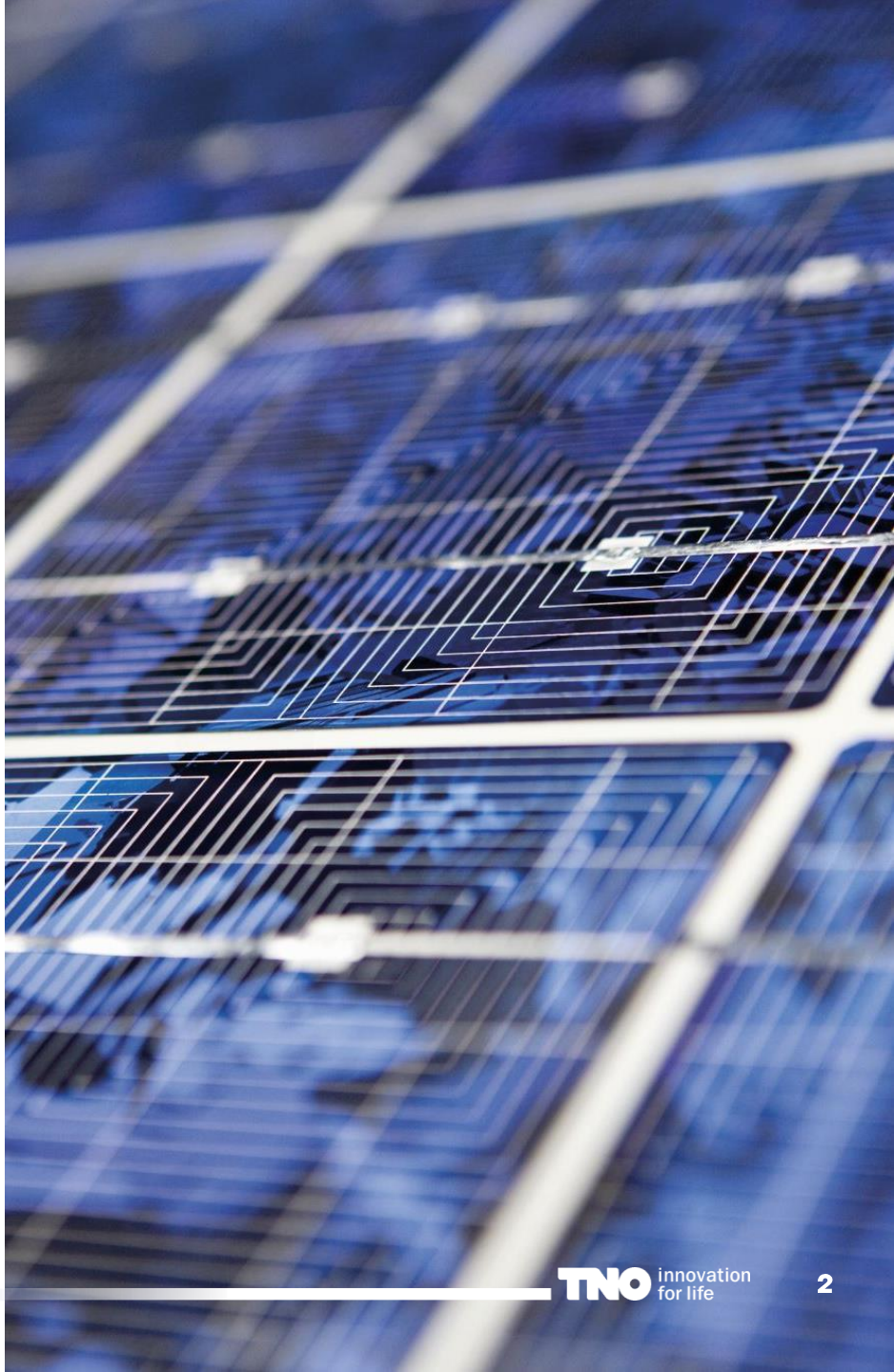
Huib Blokland | TNO

15 June 2023



Content

- Introduction on the HyDelta Program
- Digitalization: scope and definition
- Developing a roadmap on digitalization
- Use case: Kapelle
- Example: smart monitoring
- Conclusions



HyDelta Program

Public-private research program between research institutions and the Dutch **transmission** and **distribution** system operators, with the goal to research the **economic and safety** aspects of **hydrogen transport** via the **existing natural gas infrastructure**.

The HyDelta consortium:

TKI NIEUW GAS Topsector Energie
gasunie
Netbeheer Nederland
New Energy Coalition
TNO innovation for life
DNV
kiwa
Hanzehogeschool Groningen University of Applied Sciences

Two phases, total 2½ year, 4.7 M€

Dit project is medegefinancierd door TKI Nieuw Gas | Topsector Energie uit de PPS-toeslag onder referentienummer TKI2022-HyDelta.

HyDelta-2 topics

1. Economic aspects of the hydrogen system

- Modeling hydrogen market dynamics in an integrated energy system
- Risks, uncertainty, and collaboration in the hydrogen-based value chain
- Hydrogen blending and congestion management

2. Hydrogen safety in the gas grid

- Safe operations of the high-pressure transmission grid
- Safety of hydrogen in the distribution grid and built environment
- Implications of hydrogen in combustion use - NOx effects

3. Hydrogen and transport assets

- Analysis of the conversion of a natural gas distribution network to hydrogen
- **Analyzing digitalization in network management**

4. Social aspects of hydrogen

Dit project is medegefinancierd door TKI Nieuw Gas | Topsector Energie uit de PPS-toeslag onder referentienummer TKI2022-HyDelta.

Link: [HyDelta 2.0 - HyDelta]

Digitalization: definition & scope

Definition: *The transformation of huge amounts of data in useful information about the gas grid. The objective is to create insights in the physical behavior of the gas grid and develop grid modelling tools to be used for (short term) safe and secure operational processes and (long term) grid design processes.*

Three systems:

- Grid Modelling: using model(s) to calculate the capacity of the grid at any time and at any place.
- Grid Monitoring: getting data out the gas grid (flow, pressure, and gas quality), from end-users, suppliers, and external databases.
- Grid Control: control the gas grid balance (by pressure, flow, and gas quality).

Scope:

- Pure hydrogen grids (NB: similarities with grids for green gas and hydrogen blending)
- Distribution grids (Gasunie as benchmark)
- All phases: design, transition, operation
- Grid capacity and hydrogen quality

Developing a roadmap on digitalization

Interviews with Dutch DSOs

ENEXIS NETBEHEER
STEDIN
RENDO NETWERKEN
Liander

Literature review

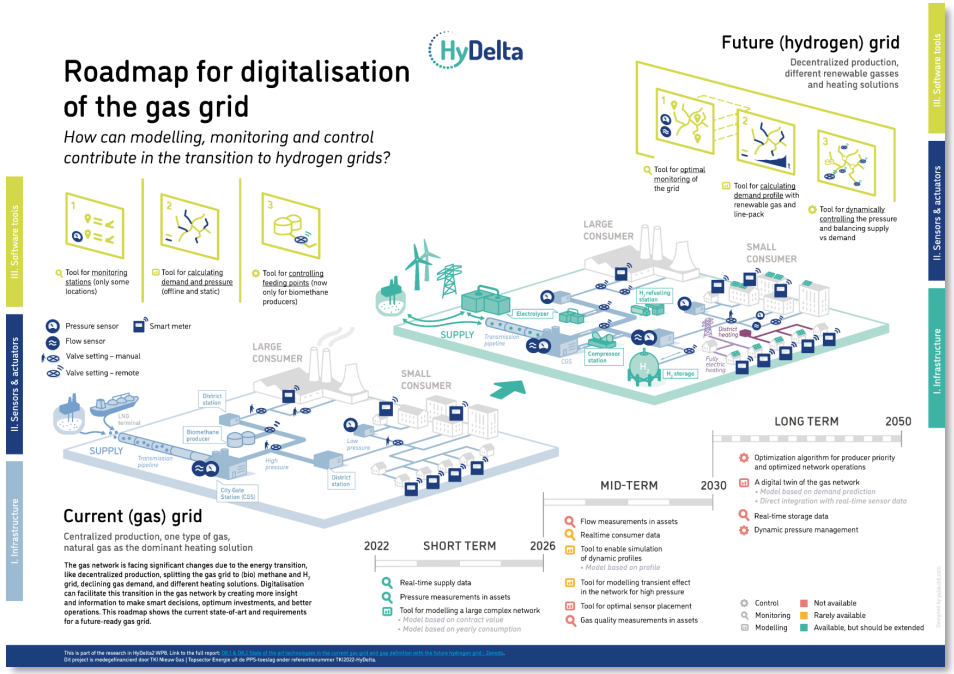
Workshop

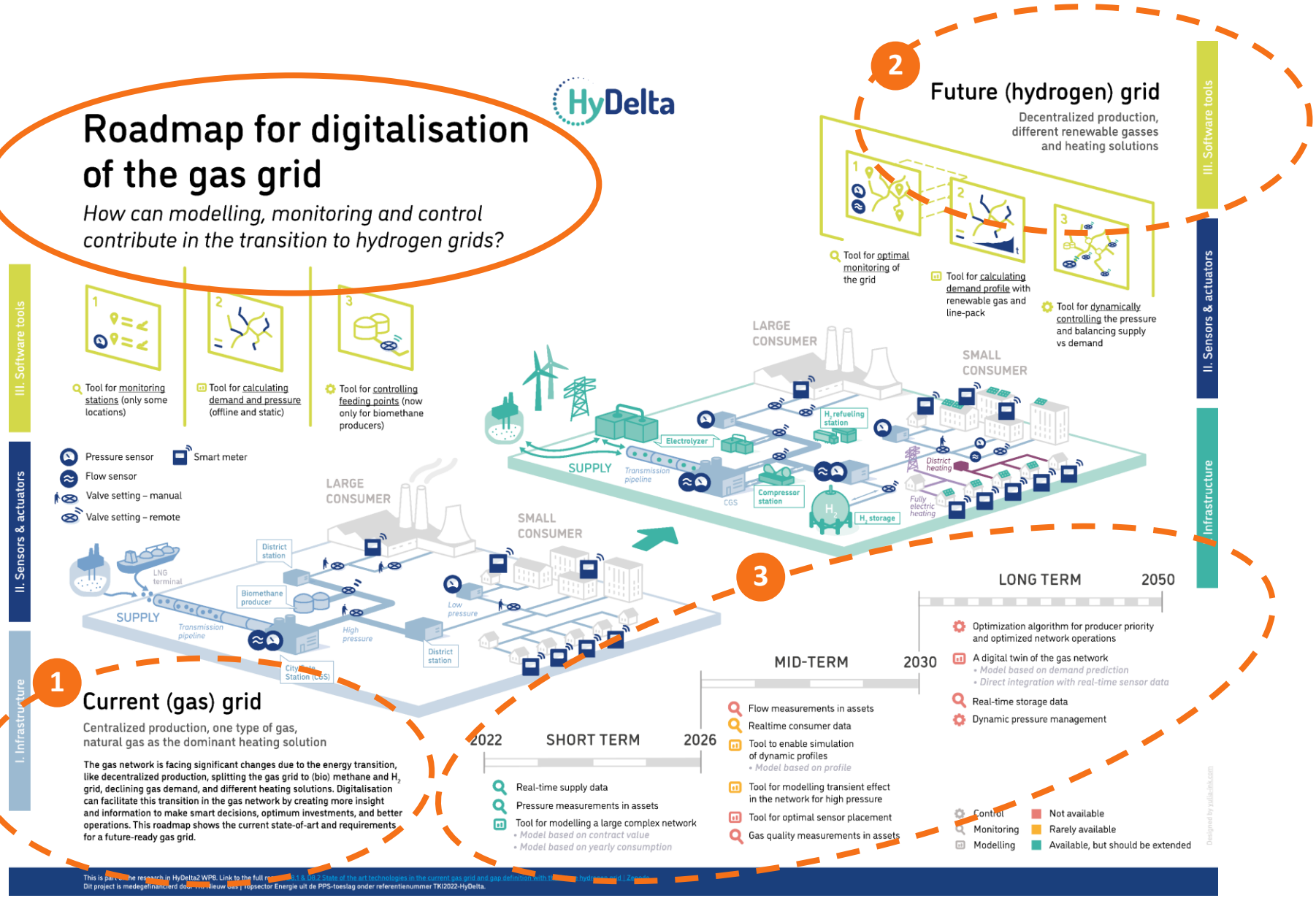
State of the Art

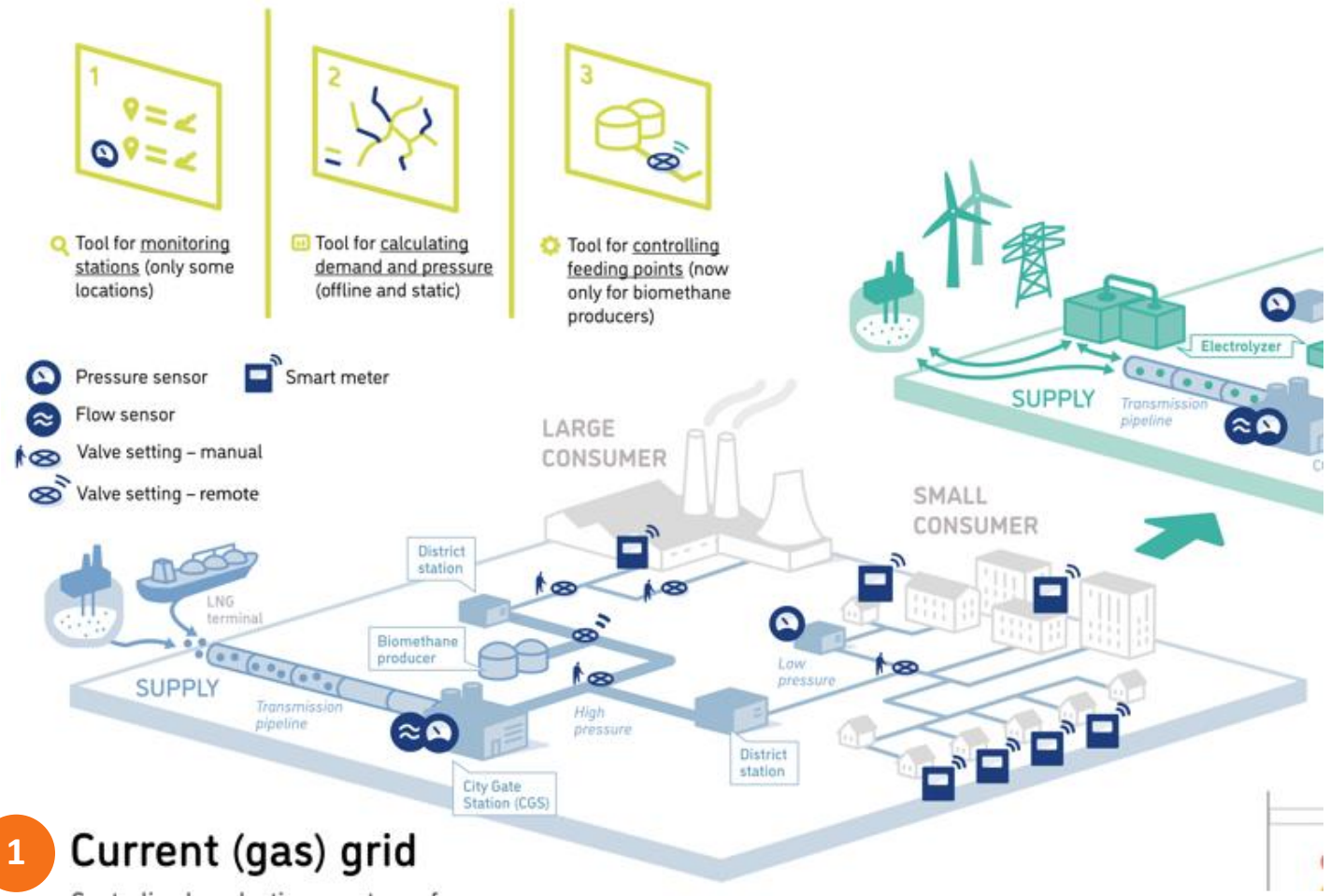
Requirements future hydrogen grid

Gap analysis

Perform use cases




HyDelta
Roadmap for digitalisation of the gas grid
How can modelling, monitoring and control contribute in the transition to hydrogen grids?
III. Software tools
II. Sensors & actuators
I. Infrastructure
Tool for monitoring stations (only some locations)
Tool for calculating demand and pressure (offline and static)
Tool for controlling feeding points (now only for biomethane producers)
Pressure sensor
Smart meter
Flow sensor
Valve setting – manual
Valve setting – remote
LARGE CONSUMER
SMALL CONSUMER
LNG terminal
District station
Biomethane producer
SUPPLY
Transmission pipeline
High pressure
Low pressure
City Gate Station (CGS)
1
Current (gas) grid
Centralized production, one type of gas, natural gas as the dominant heating solution
The gas network is facing significant changes due to the energy transition, like decentralized production, splitting the gas grid to (bio) methane and H_2 grid, declining gas demand, and different heating solutions. Digitalisation can facilitate this transition in the gas network by creating more insight and information to make smart decisions, optimum investments, and better operations. This roadmap shows the current state-of-art and requirements for a future-ready gas grid.
2022
SHORT TERM
2026
Real-time supply data
Pressure measurements in assets
Tool for modelling a large complex network
• Model based on contract value
• Model based on yearly consumption
MID-TERM
2030
Flow measurements in assets
Realtime consumer data
Tool to enable simulation of dynamic profiles
• Model based on profile
Tool for modelling transient effect in the network for high pressure
Tool for optimal sensor placement
Gas quality measurements in assets
LONG TERM
2050
Optimization algorithm for producer priority and optimized network operations
A digital twin of the gas network
• Model based on demand prediction
• Direct integration with real-time sensor data
Real-time storage data
Dynamic pressure management
Control
Monitoring
Modelling
Not available
Rarely available
Available, but should be extended
2
Future (hydrogen) grid
Decentralized production, different renewable gasses and heating solutions
Tool for optimal monitoring of the grid
Tool for calculating demand profile with renewable gas and line-pack
Tool for dynamically controlling the pressure and balancing supply vs demand
LARGE CONSUMER
SMALL CONSUMER
SUPPLY
Transmission pipeline
Electrolyzer
CGS
Compressor station
H_2 refueling station
H_2 storage
District heating
Fully electric heating
3
III. Software tools
II. Sensors & actuators
Infrastructure
This is part of the research in HyDelta2 WP8. Link to the full report
Dit project is mede gefinancierd door
Nieuw Gas | Topsector Energie uit de PPS-toeslag onder referentienummer TKI2022-HyDelta.



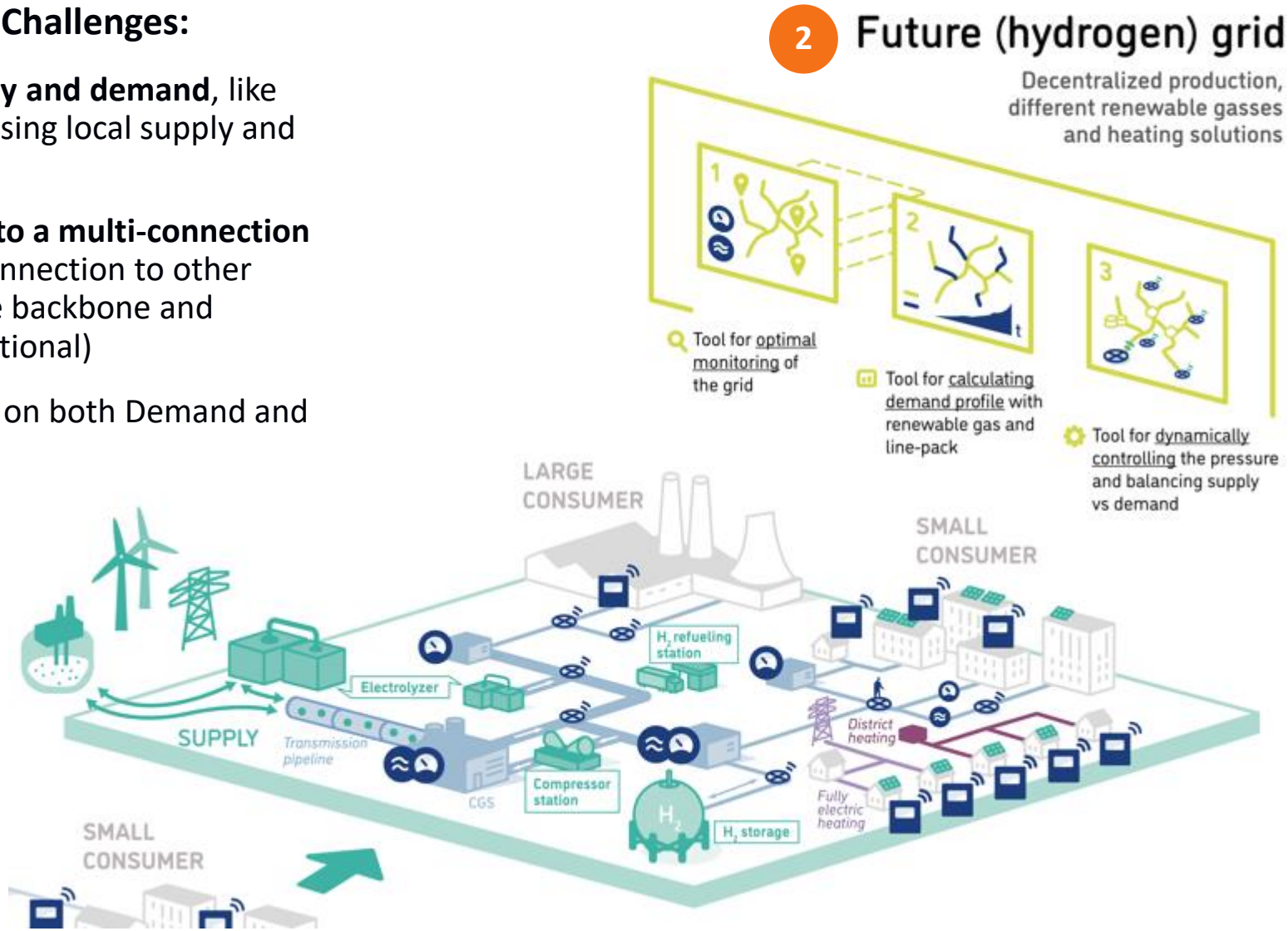
1 Current (gas) grid

Centralized production, one type of gas, natural gas as the dominant heating solution

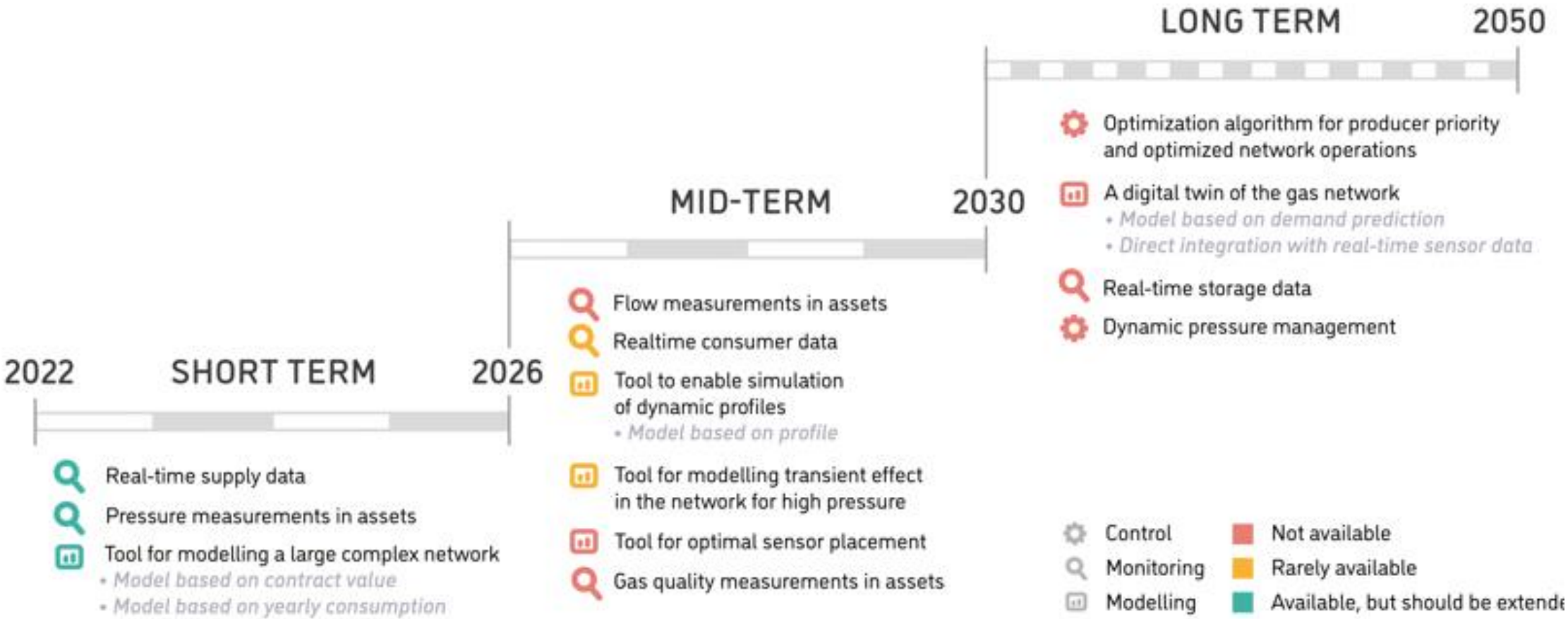
The gas network is facing significant changes due to the energy transition, like decentralized production, splitting the gas grid to (bio) methane and H_2 grid, declining gas demand, and different heating solutions. Digitalisation can facilitate this transition in the gas network by creating more insight and information to make smart decisions, optimum investments, and better operations. This roadmap shows the current state-of-art and requirements for a future-ready gas grid.

Balancing the hydrogen grid. Challenges:

1. **Increasing dynamics in supply and demand**, like changing user profiles, increasing local supply and local storage and line-pack
2. **From a stand-alone gas grid to a multi-connection grid**. Observed trends are: connection to other DSO's, connection to Gasunie backbone and connection to E-grid (bi-directional)
3. **Get access to real time data**, on both Demand and Supply.



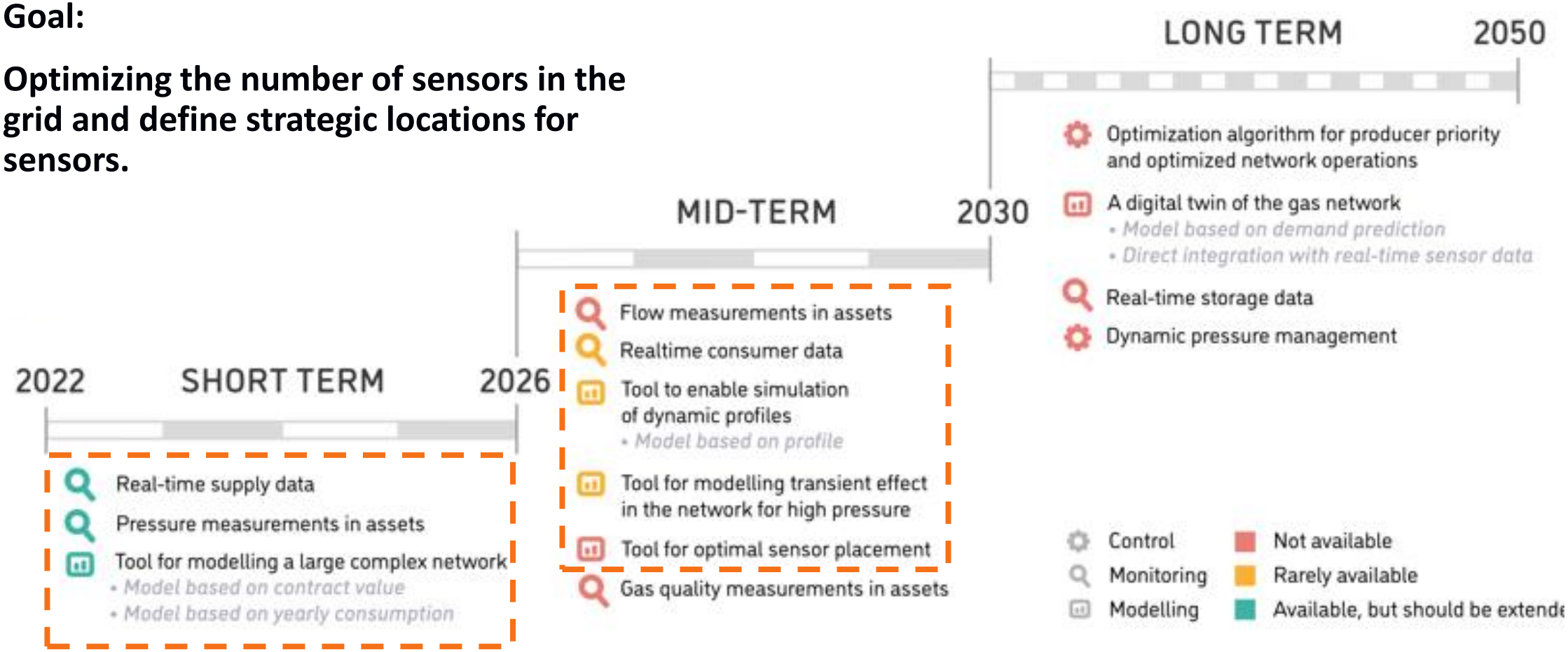
3 Timeline


2022
SHORT TERM
2026
MID-TERM
2030
LONG TERM
2050
Real-time supply data
Pressure measurements in assets
Tool for modelling a large complex network
• Model based on contract value
• Model based on yearly consumption
Flow measurements in assets
Realtime consumer data
Tool to enable simulation of dynamic profiles
• Model based on profile
Tool for modelling transient effect in the network for high pressure
Tool for optimal sensor placement
Gas quality measurements in assets
Optimization algorithm for producer priority and optimized network operations
A digital twin of the gas network
• Model based on demand prediction
• Direct integration with real-time sensor data
Real-time storage data
Dynamic pressure management
Control
Monitoring
Modelling
Not available
Rarely available
Available, but should be extende

Example of digitalization: smart monitoring

Goal:

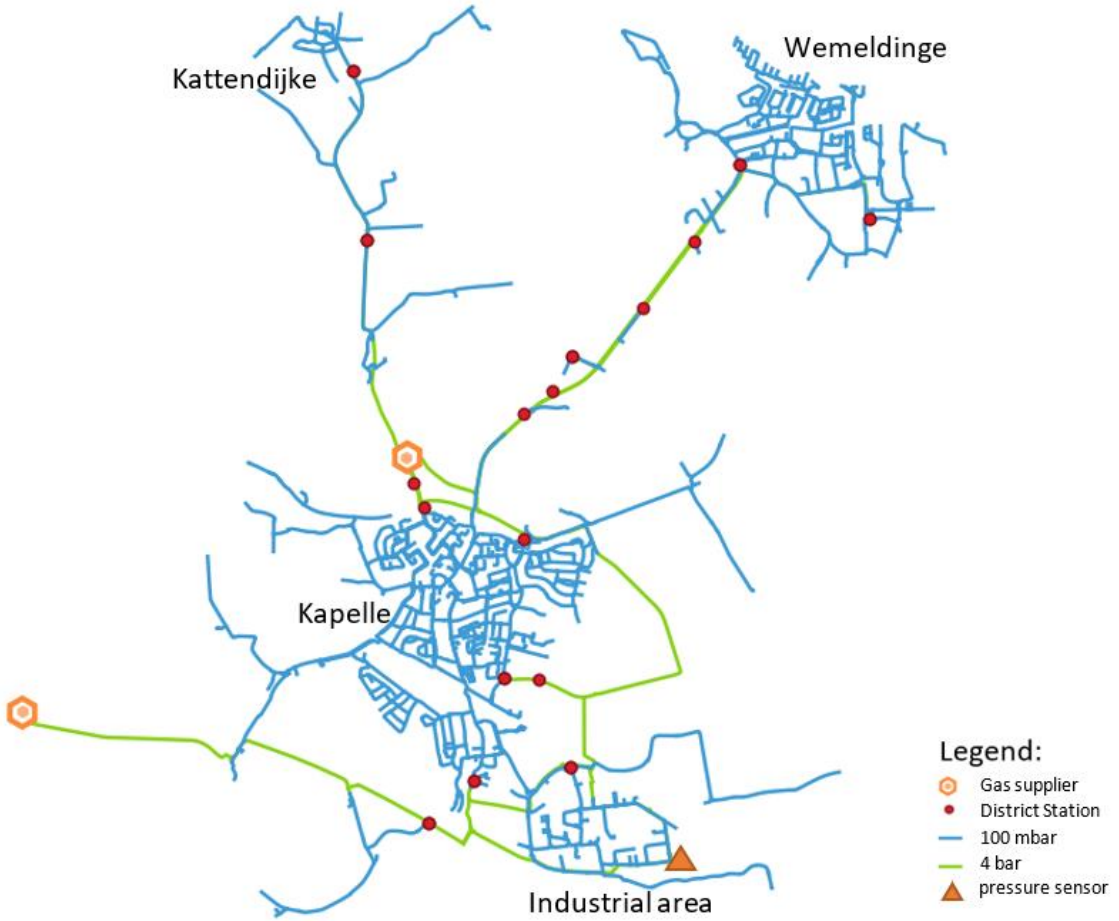
Optimizing the number of sensors in the grid and define strategic locations for sensors.



Use case: Kapelle

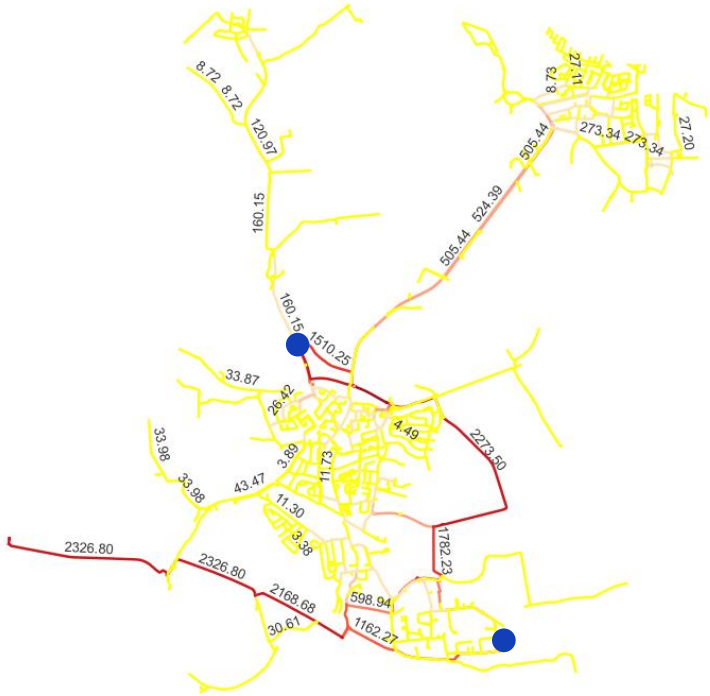
Key figures natural gas grid:

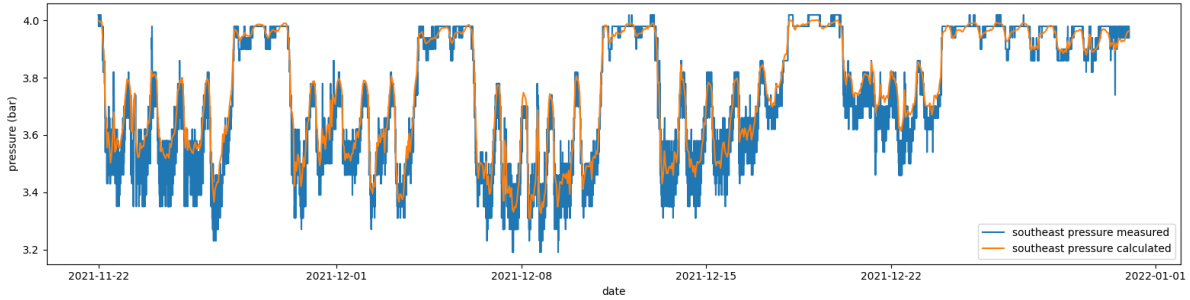
- 5800 small consumers
- 17 industrial users
- Pressure levels: 4 bar and 100 mbar
- Two supply locations
- Peak demand ~5000 Nm^3/h



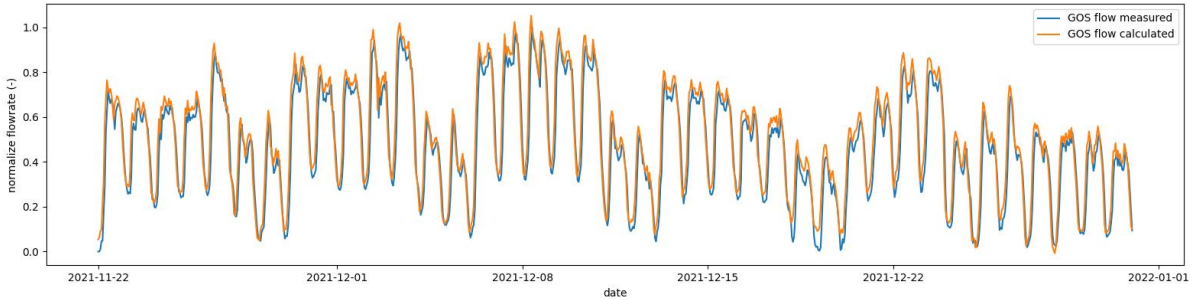
Use case validation

- Using TNO dynamic gas grid simulator Aurora
- Available data (natural gas grid):
  - One pressure monitoring in industrial area
  - Pressure and flow at supply1
  - Large consumers: hourly consumption
  - Small consumers: annual consumption, user profile and meteo data





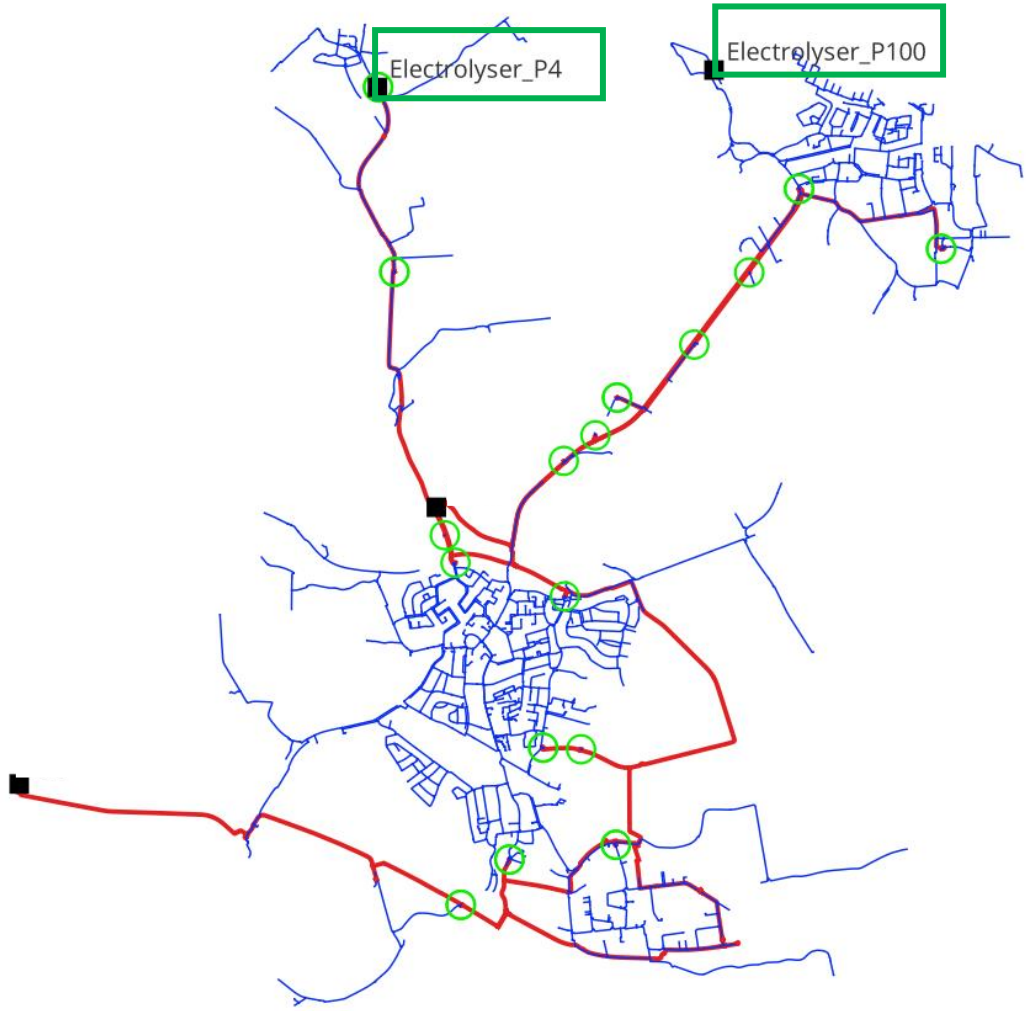
Pressure validation (industrial area)



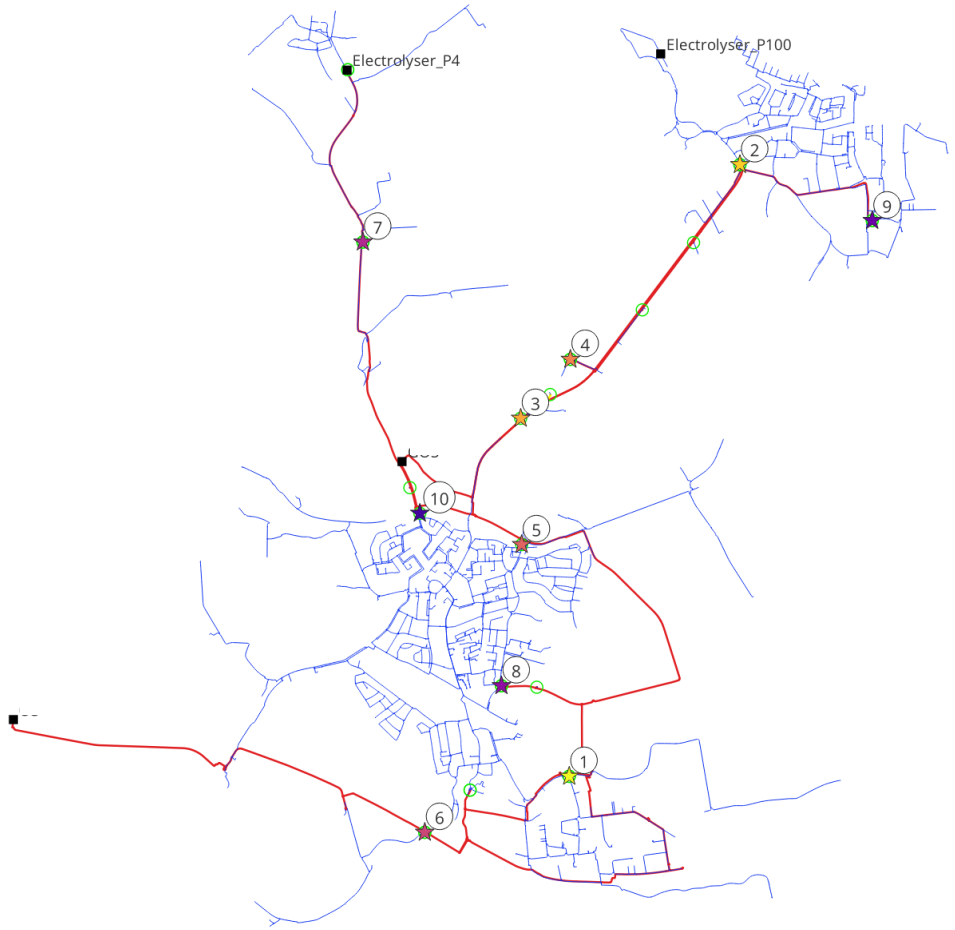
Flow validation (supply1)

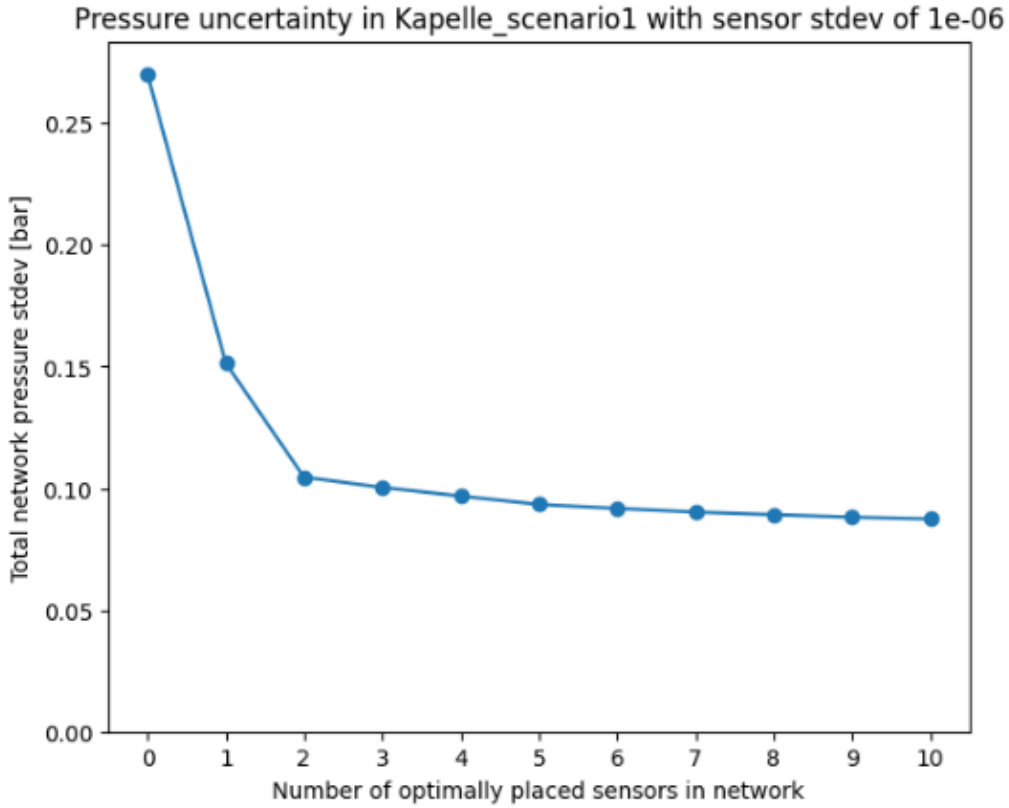
Use case: smart monitoring

- Challenges in balancing the (future) grid: dynamic supply and demand, coupled grids, need for real-time data.
- Trade-off between accuracy of the model and number of sensors
- Example: uncertainty of +/- 20% in all small consumer demand data.
- Scenario: natural gas replaced by hydrogen & extra suppliers (electrolyzers)
- **Where to place my pressure sensors for maximum reduction of the pressure uncertainty in the grid?**



Use case: smart monitoring





Adding two pressure sensors reduces the uncertainty from 0.3 to 0.1 bar.

Adding more sensors has hardly any added value.

Conclusions on digitalization of the gas grid

- A **roadmap for digitalization of the gas grid** has been developed: monitoring, modelling and control of the future gas grid.
- Focus on **hydrogen grids**, similarities with grids for green gas and hydrogen blending.
- Current grids: limited monitoring, statical modelling and manual control.
- Future grids: dynamic supply and demand, storage, connection to other grids, real time data.
- **Challenge in balancing the grid** leads to need of extensive monitoring, dynamic modelling and control.
- Example: **trade-off** between number of (pressure) sensors and accuracy of the grid simulator.
- **Smart monitoring algorithm** has been developed and applied. Results have been shown for **pressure** sensors; algorithm can also be used for **flow** and **quality** sensors.

Further info: huib.blokland@tno.nl | +31 6 513 502 84

Acknowledgements: Ryvo Octaviano, Demetris Palochis, Jonah Poort (TNO) | Iman Pishbin (Stedin)