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Integration of Power-to-Gas Conversion into Dutch Electricity Ancillary Services Markets

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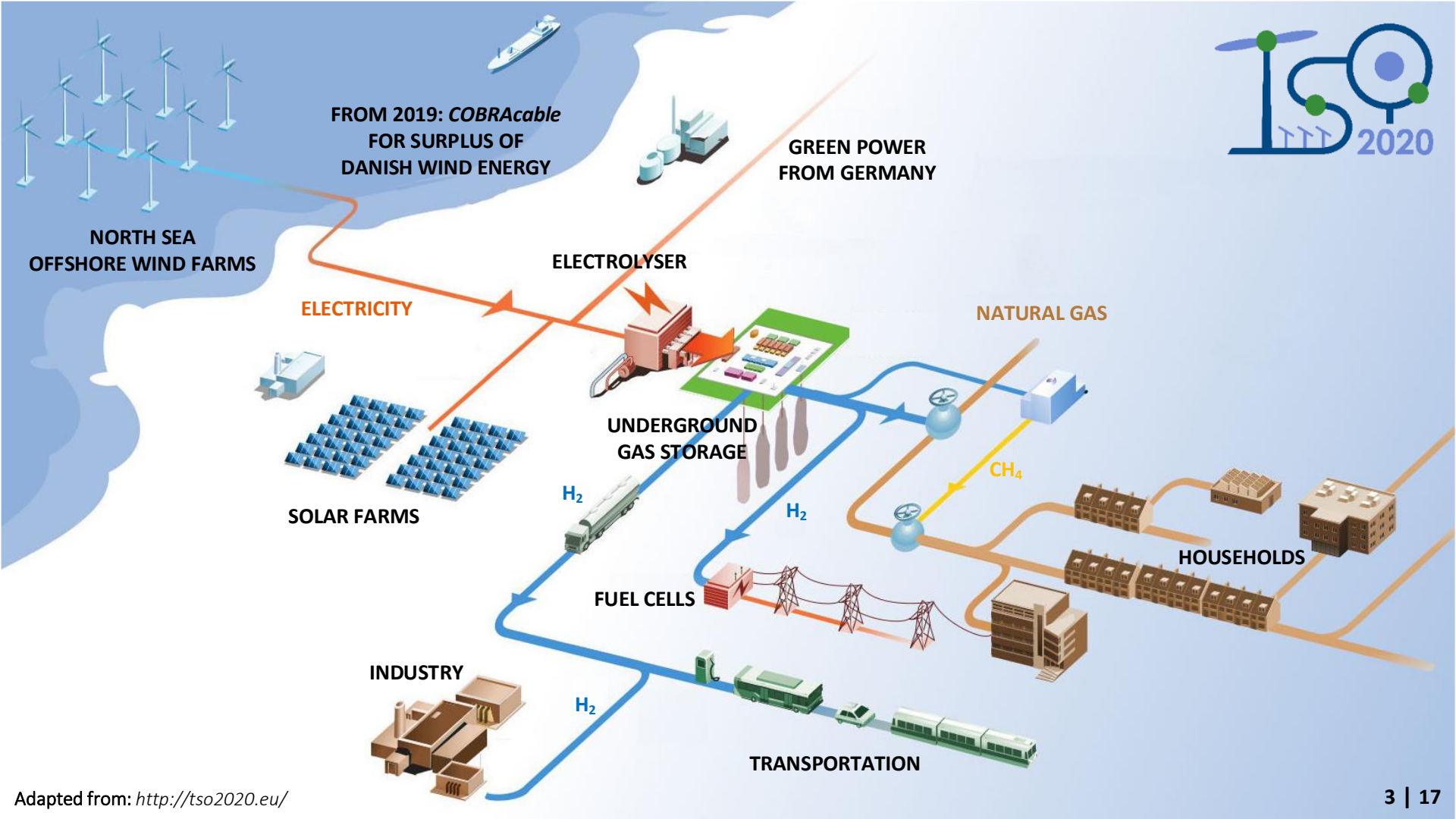
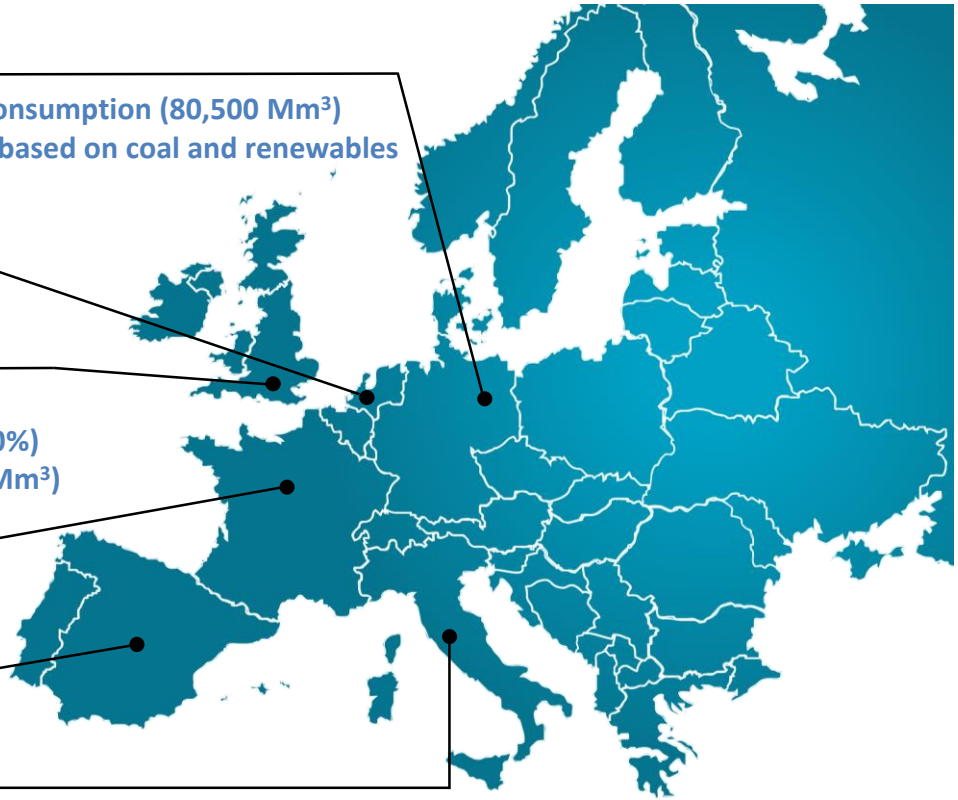
AGENDA

- THE POTENTIAL OF POWER-TO-GAS FOR THE NETHERLANDS
- POWER-TO-GAS CONVERSION: PEM ELECTROLYSERS
- DUTCH ANCILLARY SERVICES MARKETS
- CASE STUDY: GRONINGEN-DRENTHE-OVERIJSEEL AREA (2030)



Adapted from: *http://tso2020.eu/*

USAGE OF NATURAL GAS IN EUROPE



- 1st in total gas consumption (80,500 Mm^3)
- Generation mix based on coal and renewables

- 1st in gas installed capacity (54%)
- 1st in electricity produced with gas (45%)
- 1st in gas consumption per capita (1180 m^3)
- World leading chemical industry cluster

- 3rd in gas installed capacity (32%)
- 3rd in electricity produced with gas (40%)
- 2nd in total gas consumption (76,700 Mm^3)

- Generation mix dominated by nuclear power
- Marginal use of gas for electricity production

- Low usage of gas power plants (15%)
- Last overall in total gas consumption

- 2nd in gas installed capacity (35%)
- 2nd in electricity produced with gas (42%)
- 3rd in in total gas consumption (64,500 Mm^3)

- Top-6 EU Countries with Highest GDP in 2017 -

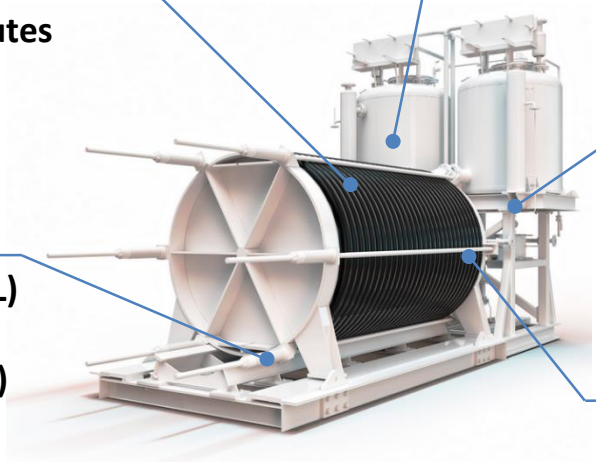
POWER-TO-GAS CONVERSION: PEM ELECTROLYSERS

SPECIFICATIONS

- Size of individual stack ≤ 3 MW
- System efficiency of 75 – 85 %
- Power setpoint change within 1 second
- Startup and shutdown within minutes

CAPITAL COST (CAPEX)

- 1000 €/kW at 1 MW scale in 2018
- 500 €/kW at 10 MW scale by mid 2020s



PEM = Polymer Electrolyte Membrane

LIFETIME

- ≈ 80,000 hours for the stack
- 20 – 30 years for the rest of the plant

ONGOING / PLANNED PROJECTS

- TSO 2020 – 1 MW pilot station (NL)
- Shell / ITM – 10 MW refinery (DE)
- McPhy – 13 MW methanation (AT)
- Gasunie – 20 MW station (NL)

POTENTIAL USES FOR POWER SYSTEMS

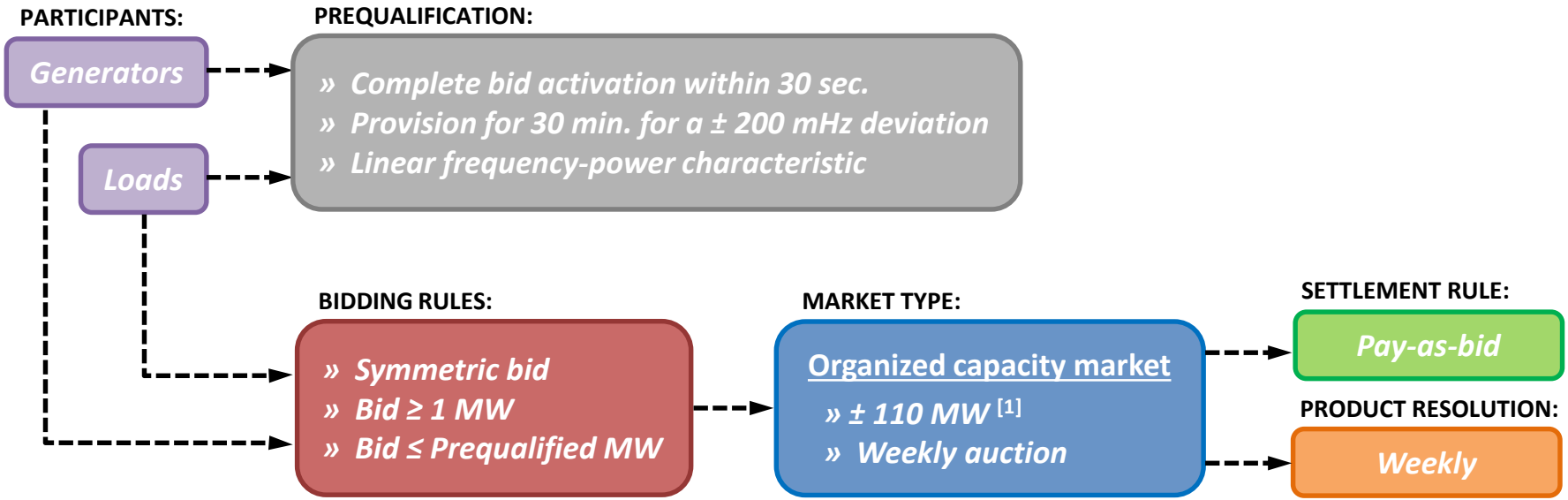
- Frequency regulation
- Renewables curtailment reduction
- Congestion management
- Voltage control

- Reference data taken from different manufacturers - Electrolyzer sample image retrieved from Nel Hydrogen -

DUTCH ANCILLARY SERVICES MARKETS

- **PREQUALIFICATION, MARKET MECHANISMS AND FUTURE FRAMEWORK OF:**
  - **BALANCING MARKETS (FCR and aFRR)**
  - **VOLTAGE CONTROL**
  - **CONGESTION MANAGEMENT**
- **ASSESSMENT OF THE TECHNICAL ADEQUACY OF PEM ELECTROLYSERS**
- **BUSINESS MODEL OF ELECTROLYSERS AS ANCILLARY SERVICES PROVIDER**

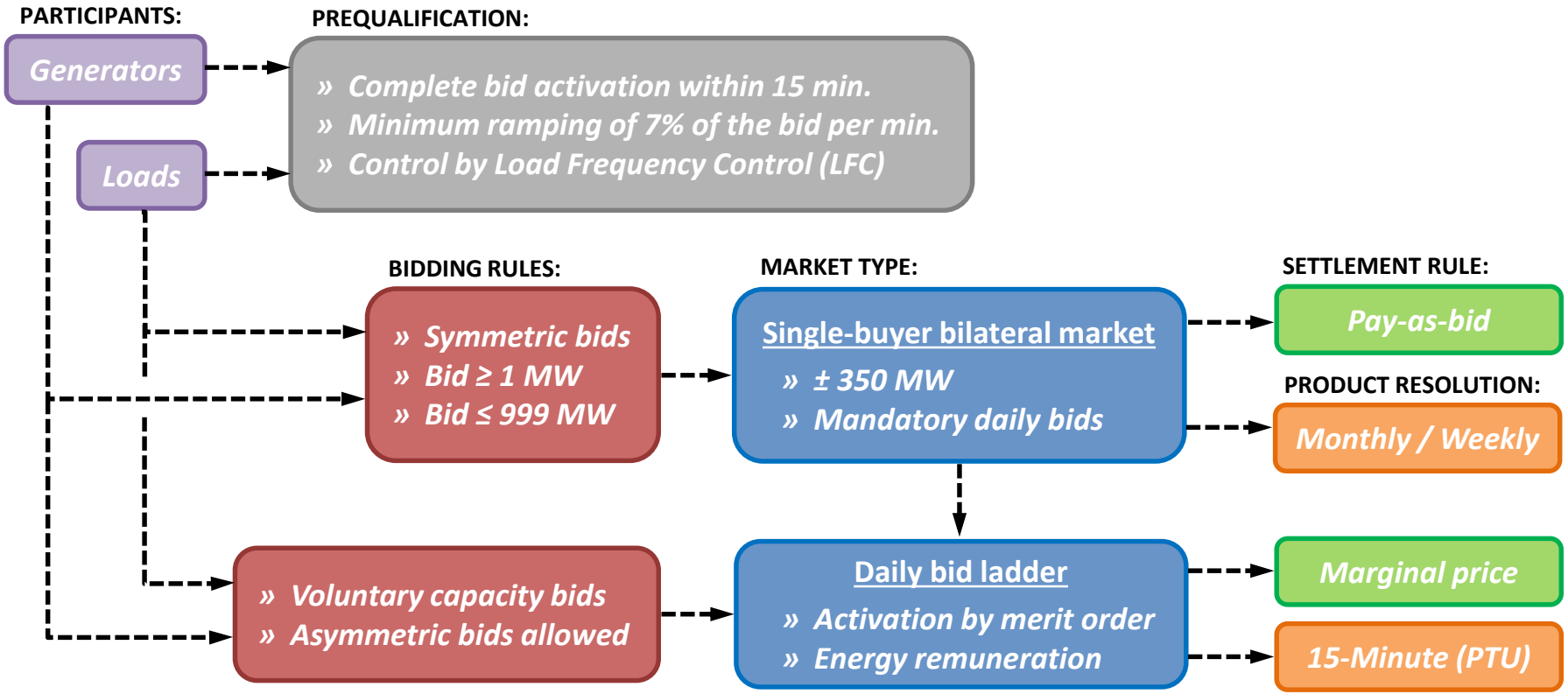
FREQUENCY CONTAINMENT RESERVE (FCR)



[1] Online trading platform at regelleistung.net / 30% Dutch exclusive and 70% auctioned together with the following TSOs:

50hertz amprion TenneT TRANSNETBW APG swissgrid elia Rte

AUTOMATIC FREQUENCY RESTORATION RESERVE (aFRR)



BALANCING MARKETS: THE ROAD TO 2025

FCR:

- Daily auction frequency
- Product resolution of 4 hours
- Marginal pricing settlement rule
- Introduction of asymmetric bids

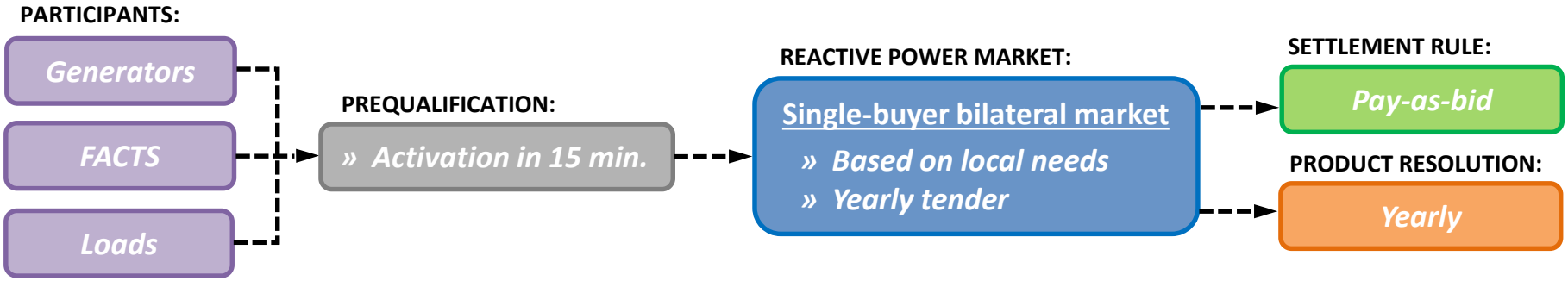
aFRR:

- Full activation time of 5 or 7.5 minutes
- Gate closure times closest to real-time
- Increased imbalance netting through IGCC [1]
- Unified European market model
- Energy activation by a common merit order list
- Cross-border marginal pricing settlement rule

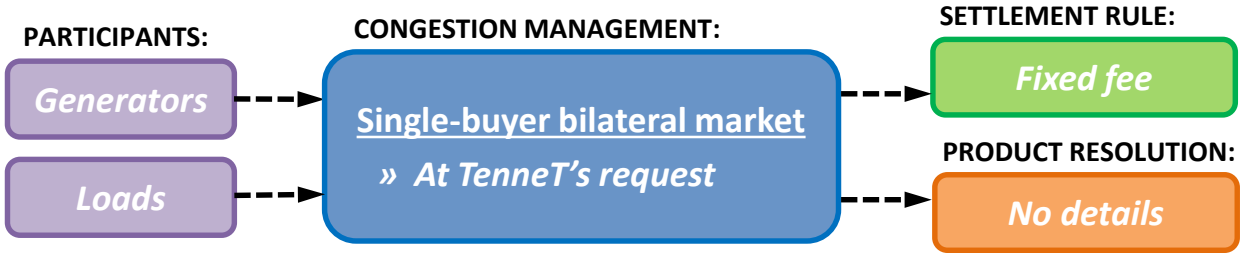
Involved TSOs:

[1] International Grid Control Cooperation

VOLTAGE CONTROL & CONGESTION MANAGEMENT



» Mandatory provision for generators > 5 MW (Contracted service)



» The reinforcement of the grid is the preferred action plan in TenneT to avoid future congestions

TECHNICAL ADEQUACY OF PEM ELECTROLYSERS

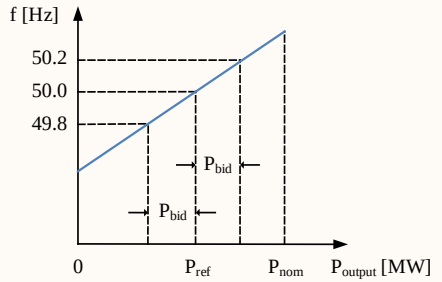
FREQUENCY RESTORATION RESERVE (aFRR)

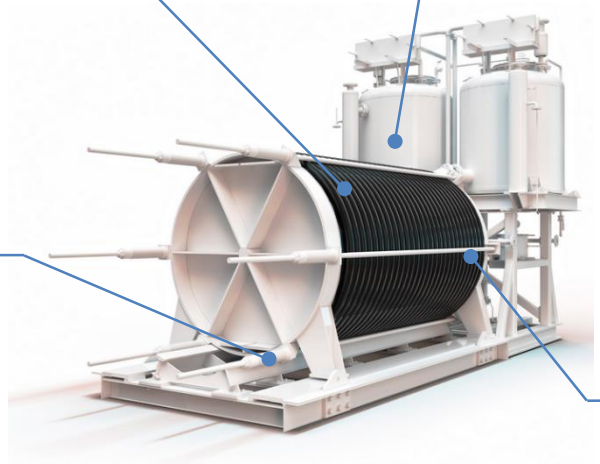
- 1 MW active power steps by LFC
- Power setpoint change within 1 second

FREQUENCY CONTAINMENT RESERVE (FCR)

- Power setpoint change within 1 second

Inverse droop control:





CONGESTION MANAGEMENT

- Curtailable industrial load
- Interruptible load
- Fast ramping in both directions

VOLTAGE CONTROL

- Purely DC load
- Reduction of active power demand
- Use of converter at partial loading

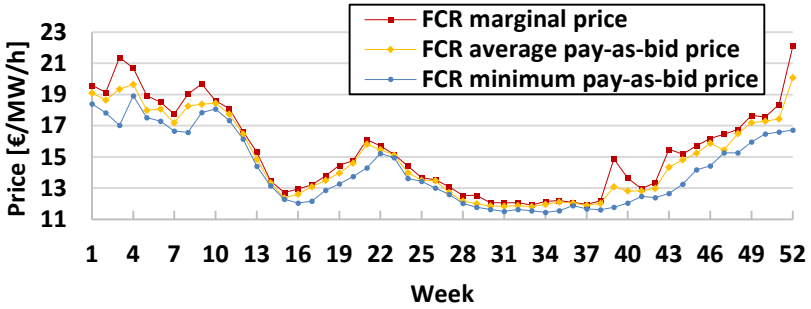
- Electrolyzer sample image retrieved from Nel Hydrogen -

BUSINESS MODEL AS ANCILLARY SERVICES PROVIDER

- The sale of H_2 (production with cheap electricity) and syngas is the main financial revenue source.
- The provision of ancillary services adds extra revenue to the power-to-gas business model.
- Most interest in short product horizons and capacity payments.
- In the new framework, prioritization of FCR and voluntary bidding for upward regulation aFRR.

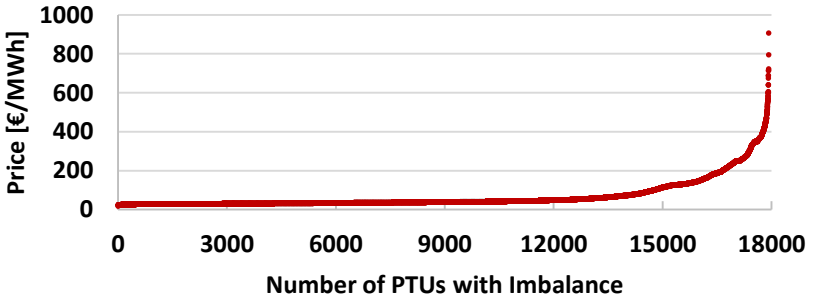
FCR price in the Dutch auction in 2017

Source: *regelleistung.net*



Energy price duration curve for upward regulation aFRR in 2017

Source: TenneT



CASE STUDY: GRONINGEN-DRENTHE-OVERIJSEEL AREA

- GRID TOPOLOGY ACCORDING TO TENNET'S DEVELOPMENT PLAN FOR 2030
- HIGH CROSS-BORDER POWER IMPORT AND LOW CONVENTIONAL GENERATION
- ISSUES TO BE INVESTIGATED:
  - » PRELIMINARY ASSESMENT ON VOLTAGE CONTROL AND LIKELIHOOD OF CONGESTIONS
  - » TECHNICAL IMPACT OF THE PARTICIPATION OF ELECTROLYSERS IN FCR
  - » COMBINED OPERATION OF RENEWABLES AND POWER-TO-GAS

NorNed

COBRAcable

EEMSHAVEN

WEIWERD

VIERVERLATEN

MEEDEN

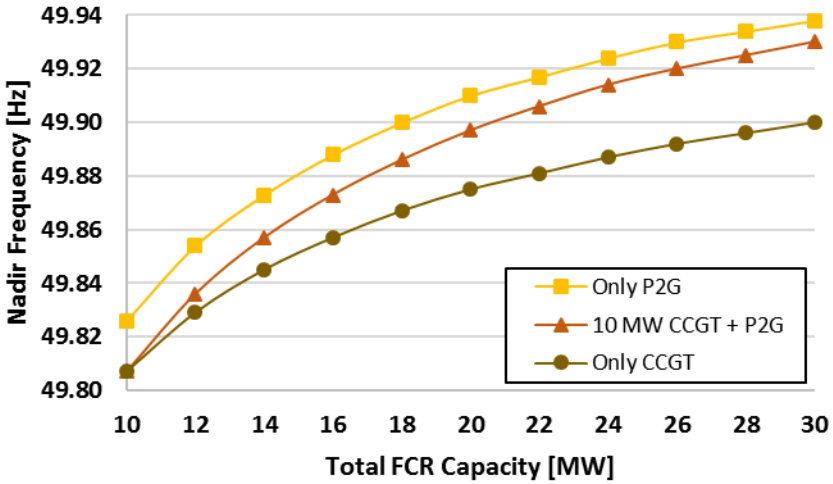
to GERMANY

to ZWOLLE

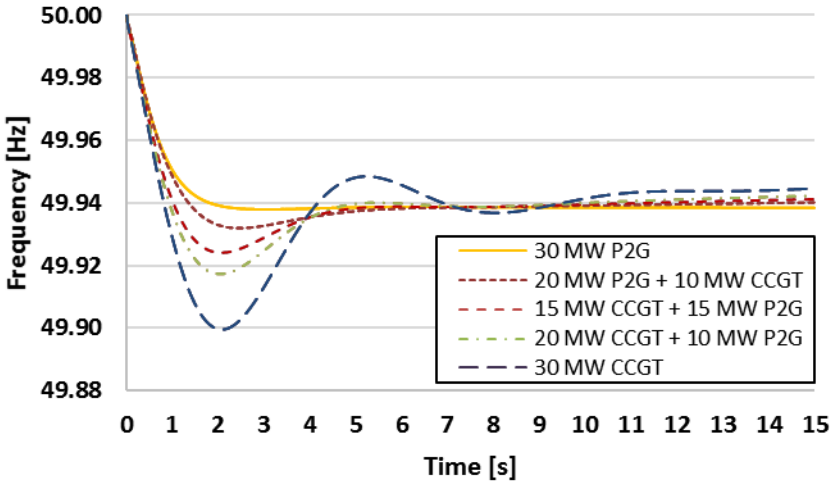
380 kV 220 kV 110 kV

FCR PROVISION: EFFECTS ON FREQUENCY RESPONSE

Frequency nadir for different allocations of FCR capacity



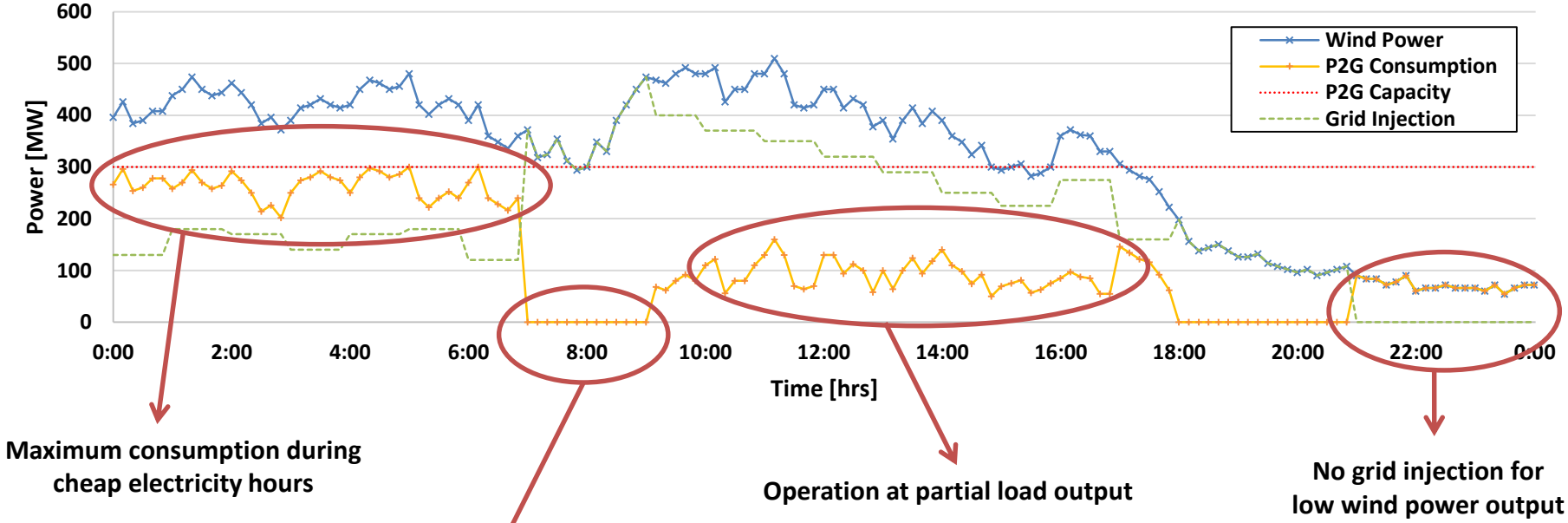
Frequency response for different allocations of FCR capacity



EVENT: Loss of generation due to disconnection of wind turbines or sudden decrease of COBRAcable power import

INTERACTION WITH WIND ENERGY GENERATION

Example of the coordinated operation between the wind park and the large-scale power-to-gas facility



CONCLUSIONS

- TECHNICALLY, ELECTROLYSERS COULD PARTICIPATE IN FREQUENCY BALANCING MARKETS, VOLTAGE CONTROL AND CONGESTION MANAGEMENT
- ECONOMICALLY, FCR IS THE MOST ATTRACTIVE SERVICE DUE TO THE CAPACITY PAYMENTS AND SHORT PRODUCT RESOLUTION (FROM 2021)
- THE FAST DYNAMICS OF ELECTROLYSERS IMPROVE THE FREQUENCY RESPONSE OF THE POWER SYSTEM
- LARGE-SCALE POWER-TO-GAS CAN BECOME ONE OF THE POTENTIAL SOLUTIONS TO MITIGATE RENEWABLE ENERGY VARIABILITY

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