European Association for Storage of Energy

Work Package 3

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Cost-Benefit Analysis Modelling

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TSO2020 Closing Event
online

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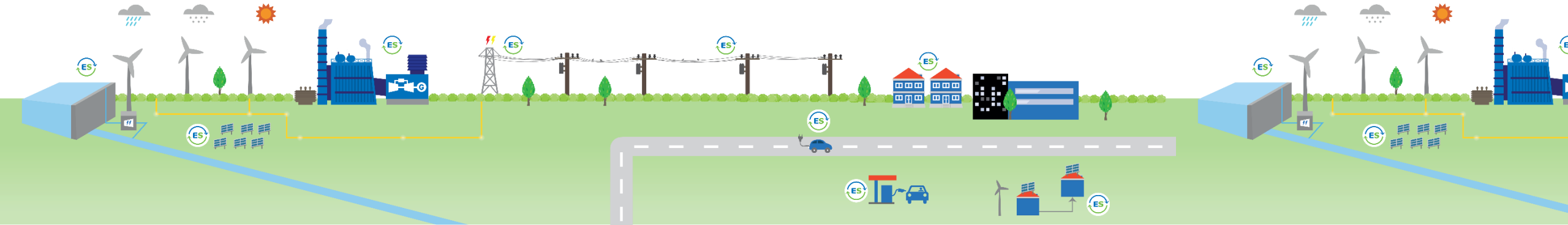


Agenda

Responsible partners

- Task 1: Total value to society
- Task 2: Grid modelling
- Task 3: Business case electrolyser

1. Total Value to Society: Based on multi-criteria analysis

This approach allows to analyse evolution of potential benefits along time horizons and scenarios

Years

- 2030
- 2040

Scenarios

- Conservative
- Reference
- Progressive
- Progressive+

Technologies

- Electrolyser
- Battery

KPIs

- Socio-eco welfare
- CO_2 variations
- Air Quality
- Financial attractiveness

Market model

- RES integration
- Security of supply
- Variation in losses
- Congestion
- Avoided transmission upgrades

Grid model

- Flexibility
- Technical Resilience

1. Total Value to Society: Adapted ENTSO-E Scenarios used as a base

We updated them for foreseen coal phase outs and RES ambition in the core countries

	Conservative	Reference	Progressive	Progressive+
Key assumptions	2030 climate and energy targets (EC Scenario) • Global ETS • Nuclear dependent on national policies	Sustainable Transition • National regulation • EU ETS + Direct RES Subsidies • Reduction of nuclear	Distributed Generation • Increased prosumers & Small-scale generation • High storage growth • Fuel switching	Distributed Generation & National Plans • RES investments ↗↗ • Electrification rate ↗↗
Assumptions	• EUCO ENTSO-E TYNDP 2018	• ST ENTSO-E TYNDP 2018	• DG ENTSO-E TYNDP 2018	• DG ENTSO-E TYNDP 2018 • National plans → Klimaat Akkoord → Bundesnetz agentur → Energynet + New agreem.
	• Coal phase-out 2040	• Coal phase-out 2030	• Coal phase-out 2030 Bundesnetz agentur proposal	• Coal phase-out 2030 Bundesnetz agentur proposal

* All scenarios assume gas before coal in the merit order

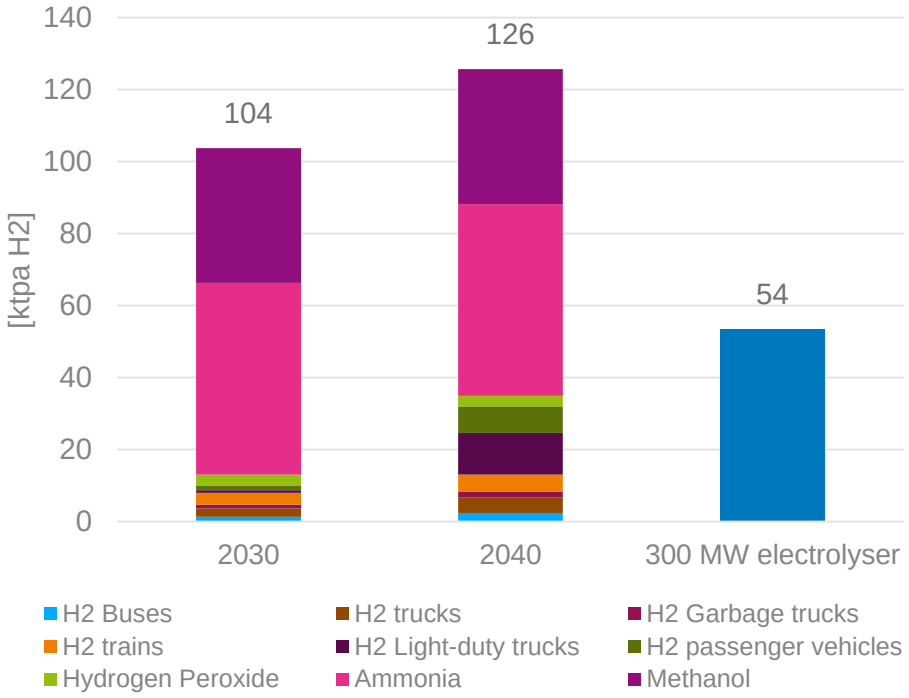
1. Total Value to Society: Highest competitiveness H_2 expected in mobility

But North NL industries could offer larger potential for the electrolyser by 2030

H_2 Market segmentation (North NL)

Mobility: Buses, trucks, trains, light-duty, passenger

Industry: Hydrogen peroxide, Ammonia, Methanol



Green H_2 Competitiveness analysis

Cost end-user will be ready to pay for green H_2 ?

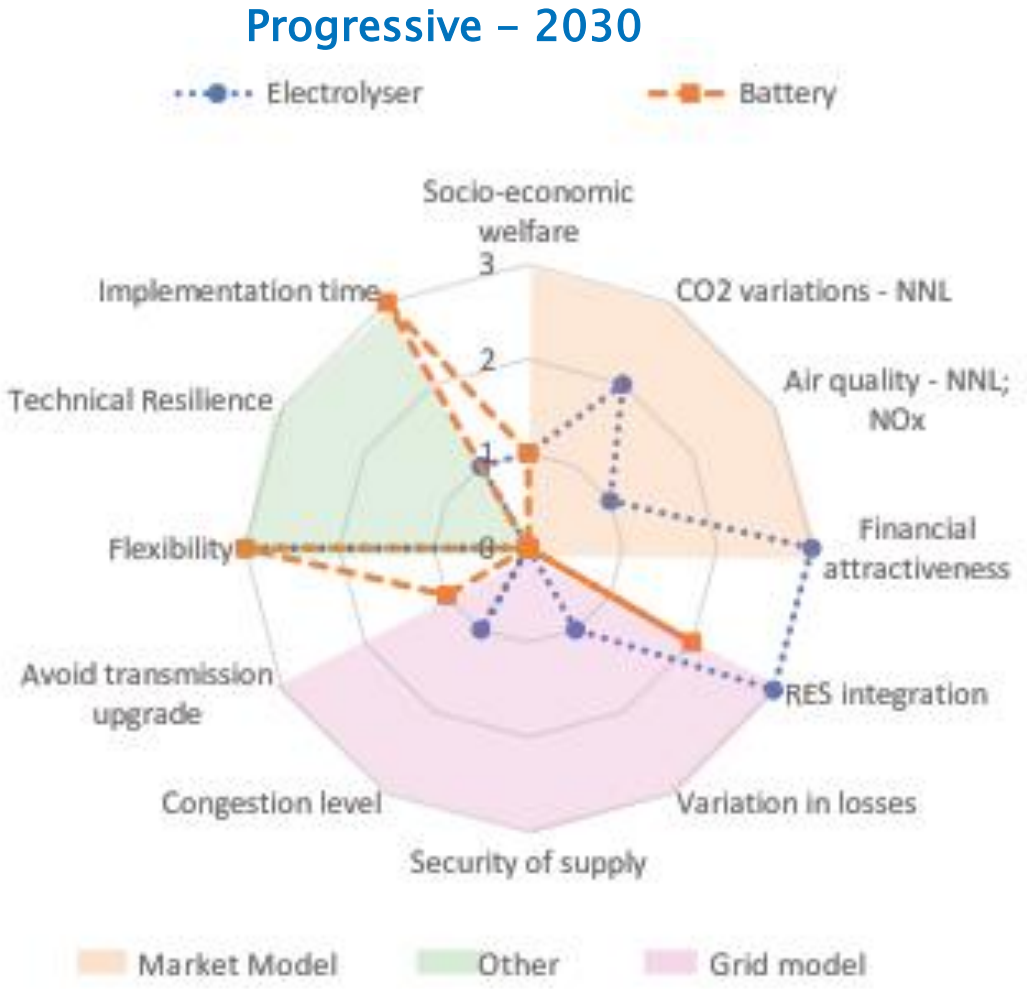
Competitiveness

€/kg H_2*	Conservative		Reference		Progressive (+)	
	2030	2040	2030	2040	2030	2040
Buses/Trucks	3.8	4.3	4.0	3.3	4.0	4.4
Trains	3.8	4.3	4.0	3.3	4.0	4.4
Light-duty	4.6	5.2	4.8	3.9	4.8	5.3
Passenger	4.7	5.3	5.0	4.0	5.0	5.5
H2 Peroxide	1.8	2.1	2.6	1.7	2.3	2.8
Ammonia	1.8	2.1	2.6	1.7	2.3	2.8
Methanol	1.5	1.8	2.4	1.5	2.0	2.5

* Mobility: comparison with diesel*
Industry: comparison with grey H_2 via SMR**
Fuel/CO_2 prices varying with scenarios

1. Total Value to Society: Electrolyser outperforms battery for the considered KPIs

… and this for any given year of any specific scenario



Comparison P2G and Battery

- CO_2 emissions reduction and air quality improvement by 2040 (N-NL) for P2G
  - Transport sector decarbonisation
- Economic viability for P2G
- Higher RES curtailment reduction, lower grid losses and congestion for P2G
  - Higher availability of P2G
- P2G & battery can both participate in FCR and aFRR (i.e., flexibility)
- Lower implementation time for the battery

1. Total Value to Society: Developing the hydrogen will foster economic, environmental and societal benefits for the Northern Netherlands

… focusing first on electricity/mobility markets coupling … but without taking industries out of the picture

- Mobility segment proves to be more promising than industrial segment (i.e., higher willingness to pay)
- Electrolyser operation strategy to be optimized throughout the project time horizon (i.e., context evolution)
- Need for large-scale hydrogen storage
- Cross-sectorial integration (electricity/mobility markets) brings key benefits
  - Revenue increase → economic viability
  - Decarbonisation of transport sector at no extra cost for the society → CO_2, SO_x, NO_x and particles emissions reduction
- Benefits to local economy: demonstration case, modernization of well-established gas industry
- Reduction of RES curtailment, electrical losses and congestion level
- Overall, benefits of the electrolyser increases in more and more progressive scenarios

2. Grid modelling

Network benefits of electrolyser for the four scenarios and for five KPIs

Years

2030

2040

Scenarios

Conservative

Reference

Progressive

Progressive+

Technologies

Electrolyser

Battery

KPIs

Socio-eco welfare

CO_2 variations

Air Quality

Financial attractiveness

Market model

RES integration

Security of supply

Variation in losses

Congestion

Avoided transmission upgrades

Grid model

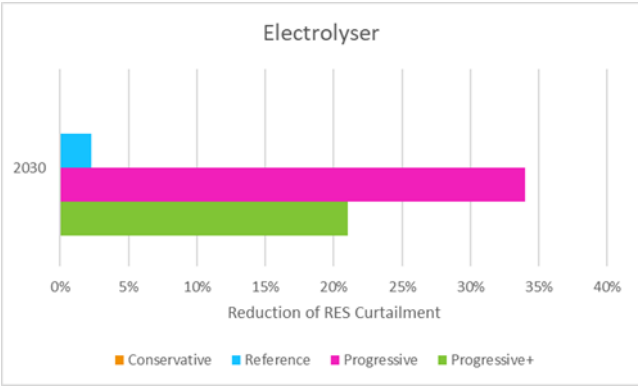
Flexibility

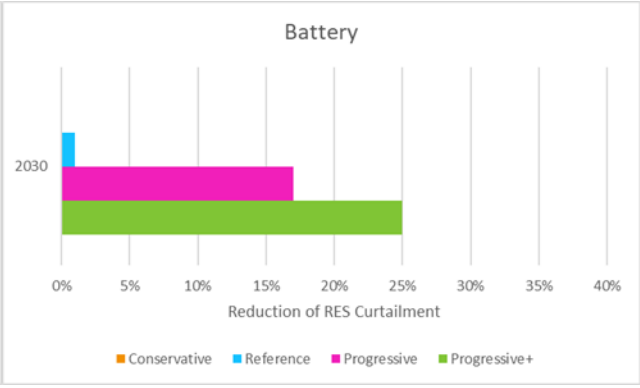
Technical Resilience

2. Grid modelling

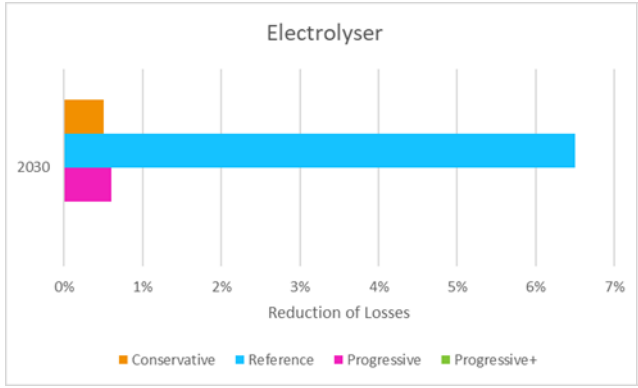
Network benefits of electrolyser for the four scenarios and for five KPIs

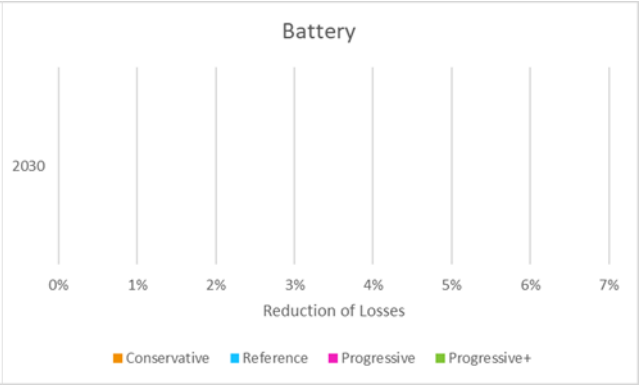
RES Curtailment



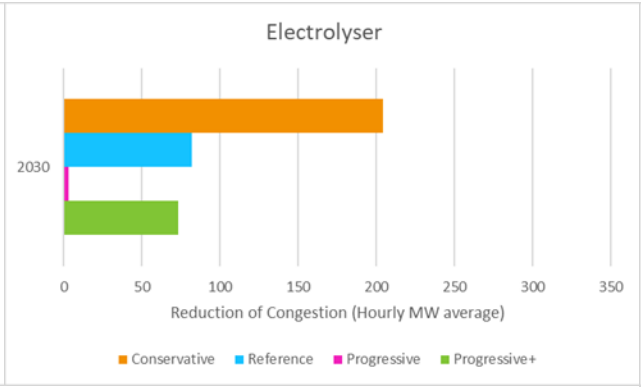


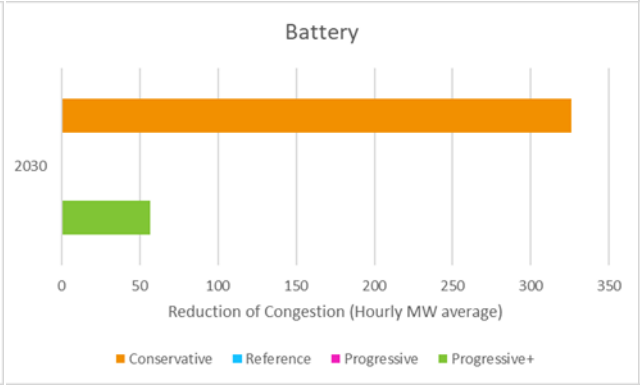
Variation of Losses



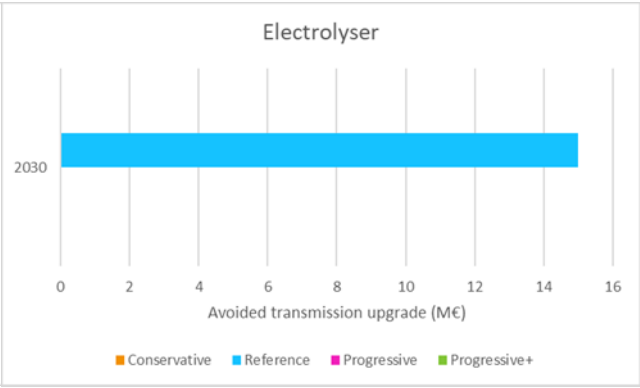


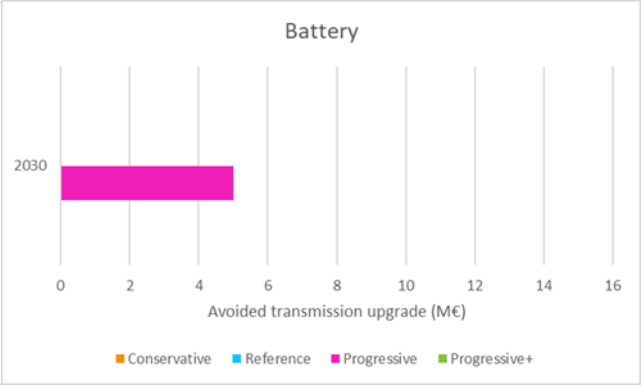
Congestion reduction





Avoided transmission upgrade





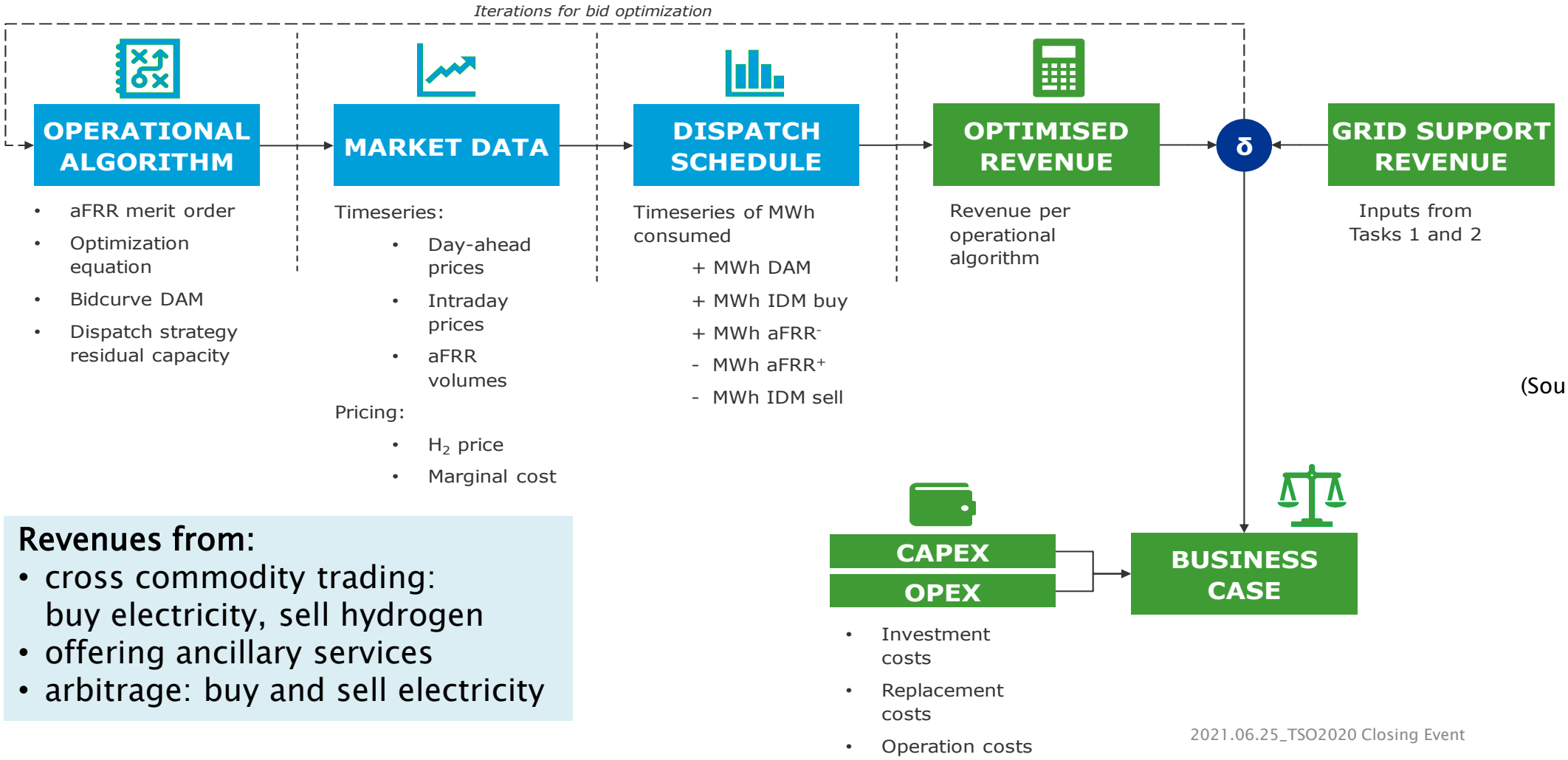
2. Grid modelling

Conclusions

- **Security of supply** is met in all the scenarios, both for the electrolyser and the battery case.
- The electrolyser contributes to a stronger reduction of **RES curtailment** than the battery.
  - Benefits of the electrolyser (and battery) are greater in more progressive scenarios (higher RES penetration)
- Using electrolyser leads to a **reduction on losses** on the electricity network, outperforming the battery.
- The electrolyser contributes to a higher **reduction of the congestion level** compared to the battery, except for the conservative scenario.
  - For the majority of the scenarios, the impact of the electrolyser/battery in the reduction of the congestion decreases when they have more RES installed capacity replacing generation with higher marginal cost.
- For all scenarios, the **avoided costs of the transmission grid reinforcements** are below the 'Grid reinforcement threshold'.

3. Business case

Overview approach – find maximum revenue from different markets (DA, ID, aFRR)



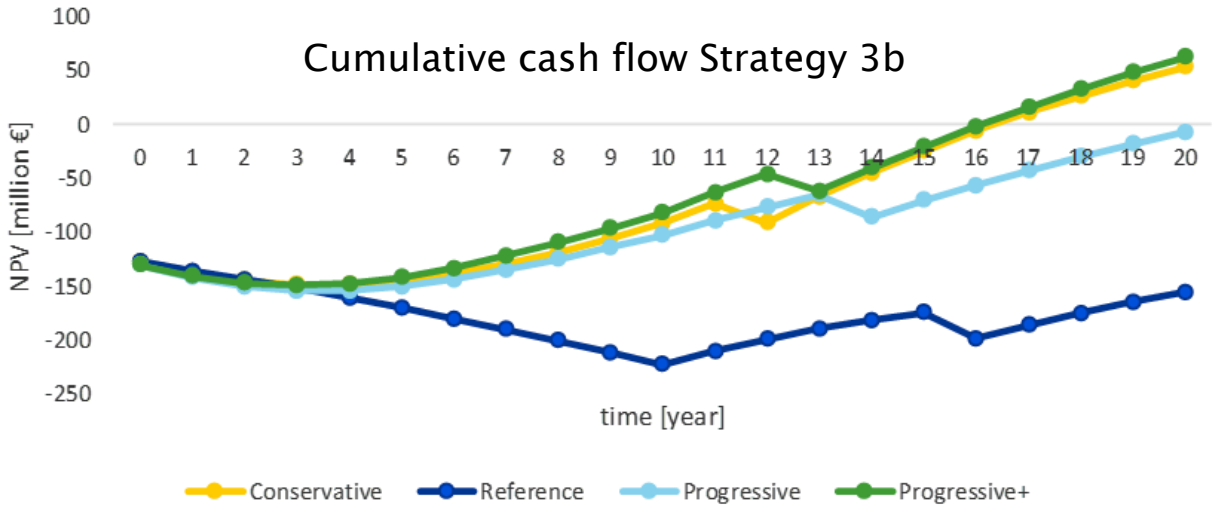
(Source Figure: DNV)

Revenues from:
- cross commodity trading: buy electricity, sell hydrogen
- offering ancillary services
- arbitrage: buy and sell electricity

3. Business case for six different bid strategies for trading residual DAM volume

Results base analysis and NPV for best strategy for analysed market scenarios

Bid strategy \ Scenario	Conservative	Reference	Progressive	Progressive+
1 Maximise DAM	-14.9	-224.9	-72.7	6.0
2a Residual for ID	30.7	-187.2	-32.2	42.4
2b Residual for aFRR	-62.5	-247.2	-113.6	-40.4
3a Residual for ID&FRR 50%-50%	26.4	-177.0	-26.9	41.9
3b Residual for ID&FRR 75%-25%	53.1	-155.5	-6.9	62.7
3c Residual for ID&FRR 25%-75%	1.0	-200.5	-50.6	17.0



(Source Figures: DNV)

Observations

- The best results are obtained for Conservative and Progressive+ scenario regardless of bid strategy due to their relatively low day-ahead prices and the hydrogen market size.
- Operational strategy 3b with residual volume for ID&aFRR 75%-25% shows best results regardless of scenario.

Sensitivity double markets:

- Positive NPV is reached after 20 years for all strategies and scenarios except for the Reference scenario.
- Results are most sensitive for H_2 volume
- Industrial parties often go for much shorter payback times depending on their intentions.

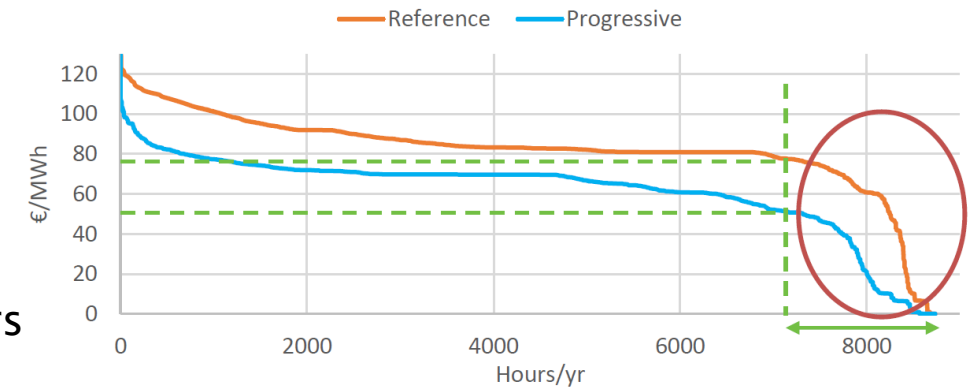
Sensitivity market prices:

- Results are most sensitive for H_2 price

CBA modelling

Major results, opportunities and challenges

- Key message
  - Developing H_2 in the Northern Netherlands will foster economic, environmental and societal benefits
  - Cross-sectorial integration (electricity/mobility markets) brings key benefits to the region
  - Electrolyser is beneficial to better exploit RES sources thus reducing the curtailment of them and has a positive impact on congestion reduction. Electrolyser outperforms battery in most of analysed scenarios.
  - Higher RES penetration drives lower green H_2production costs
  - Positive business case in 2 of 4 scenarios (not per se progressive ones)
  - Optimisation of bidding strategy improves business case
- Opportunities
  - Other ways P2G can help energy transition
  - What does this mean for the larger market than N-NL?
- Challenges
  - Bridge the gap between SCBA and business case results
  - Reduction of cost and increasing performance of electrolysers
  - Further optimise bidding strategy



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Thank you for participating!

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