ENTSOs’
Working Group Scenario Building

Storyline Release Webinar

Agenda

1. Introduction
2. Scenario Selection
   - Storyline Adjustment
   - NECP Alignment
3. Final Scenario Storylines
   - Carbon Budget
   - Gas supply assumptions and P2G methodology
   - Power Market
   - First insights
4. Next steps

Introduction

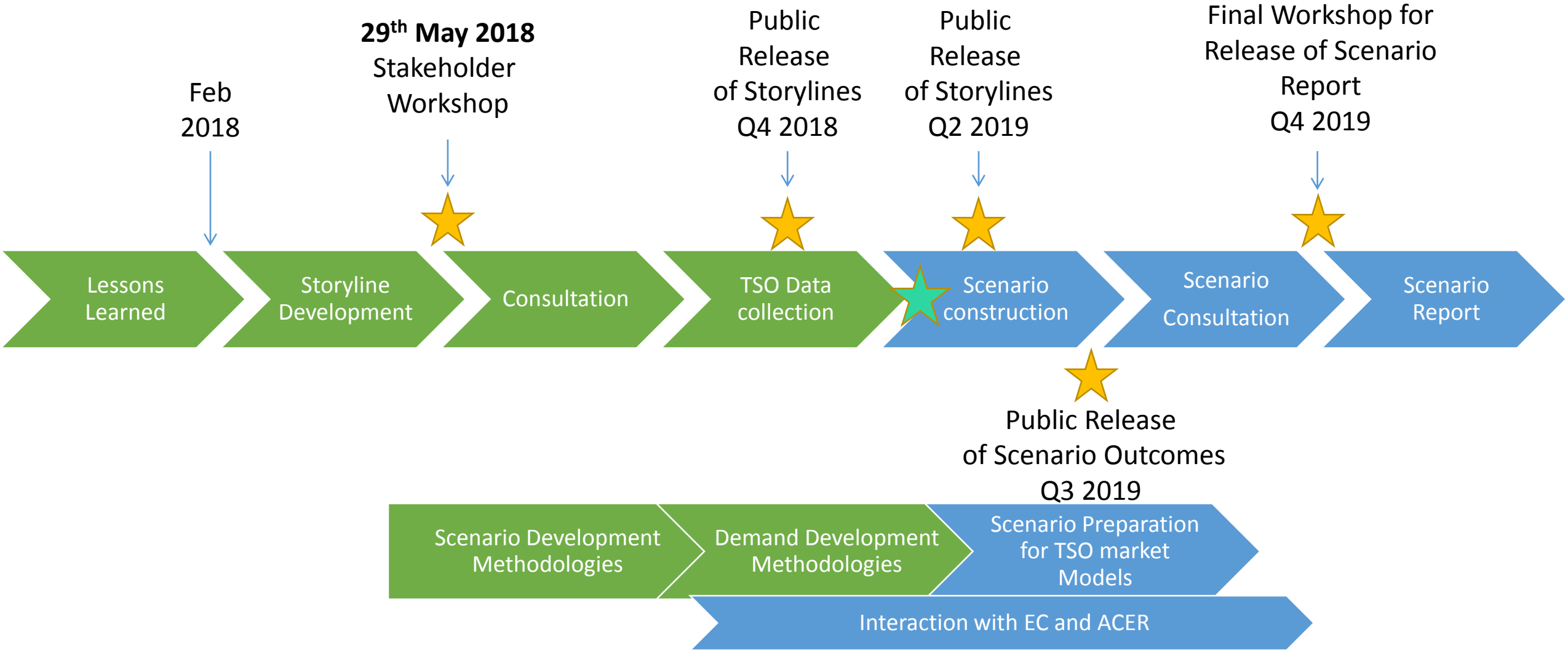
Why do the ENTSOs build scenarios?

- Regulation 714/2009 and 715/2009
- To test and assess the network infrastructure
- To fulfil a core activity to analyse security of supply
- To create technically sound paths toward policy objectives and what this means in terms of infrastructure development

Why do the ENTSOs build scenarios together?

- To combine efforts in developing scenarios, utilising sectoral knowledge and expertise in planning and balancing
- To be a focus point for gathering inputs from a wide range of stakeholders interested in the energy sector
- To reflect that decarbonisation will see increasing synergies between electricity and gas
- This ensures the consistent assessment of the two key energy networks of Europe against the same futures

High level Scenario Building Timeline

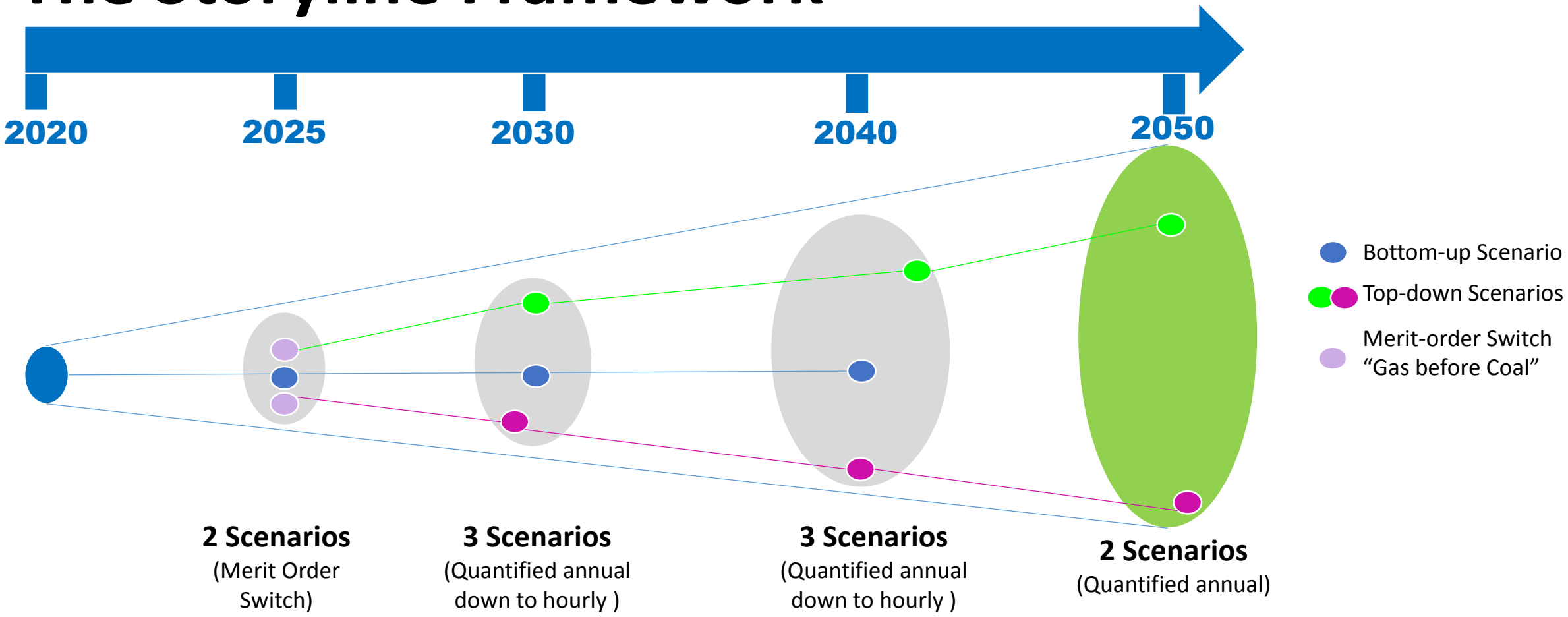


Scenario Building Process

- Storylines & Stakeholder Engagement
- Consultation
- Data Collection & Stakeholder Engagement
- Data Validation (Translation)
- Total Energy Scenarios with Ambition Tool
- Power Market Simulation
- Extra-EU Gas Supply
- Results
- Consultation
- Scenario Analysis, Discussion & Report

Where we are in the process

The Storyline Framework



Scenarios set the range of possible futures needed to test the infrastructure - not forecasts, not visions.

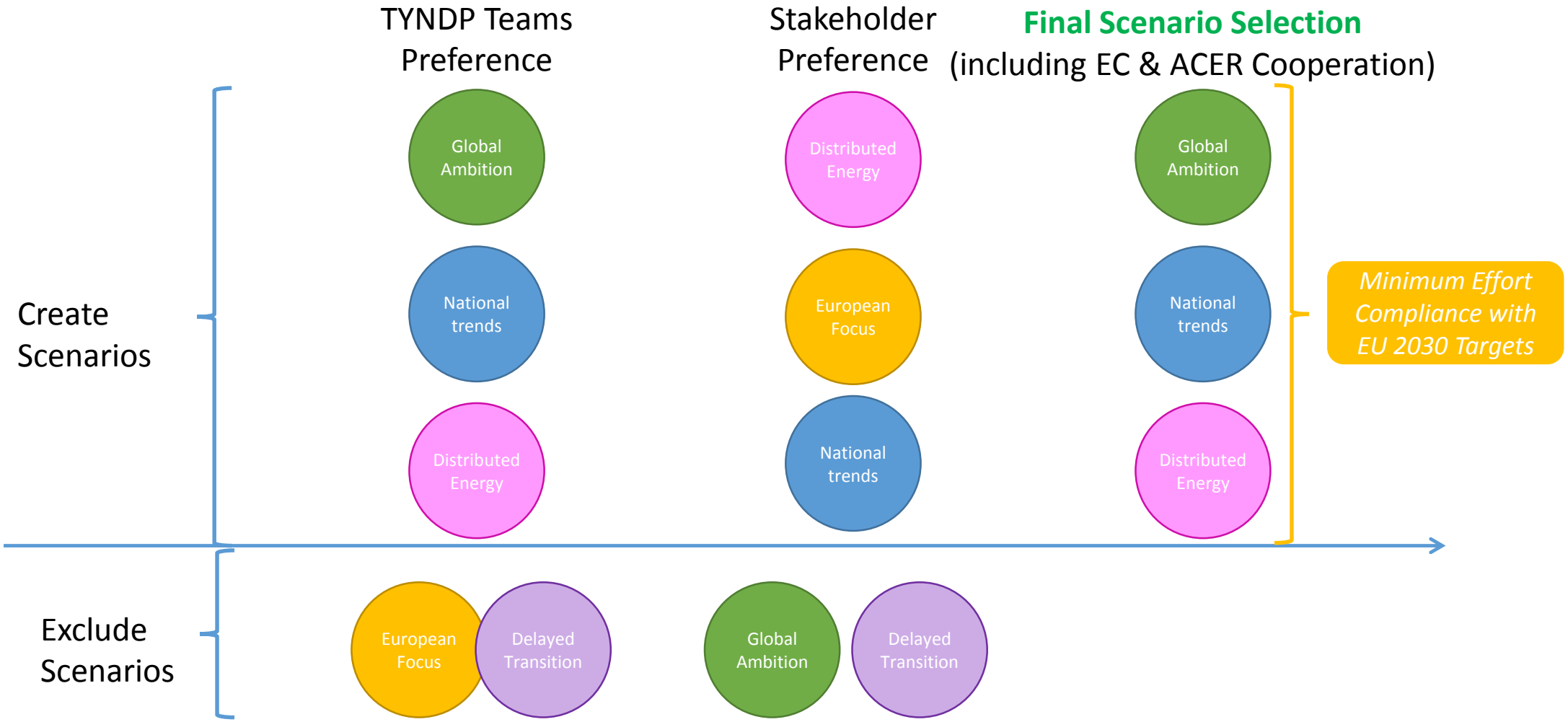
Scenario Selection

Consultation Feedback

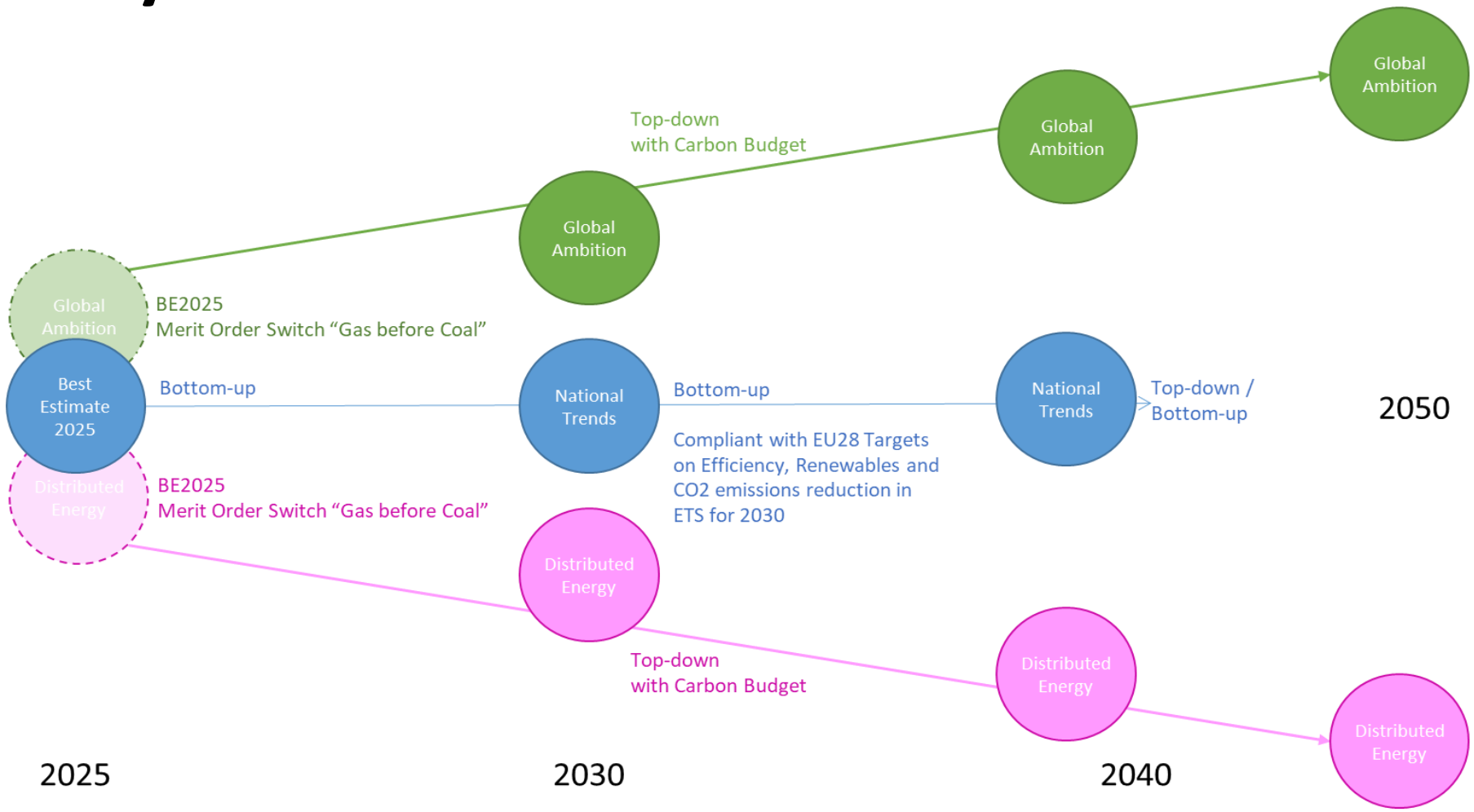
- Feedback received from 35 stakeholders including:
  - Environmental NGOs
  - Government Institutions
  - Energy producers
  - Interest groups and associations for renewables, electricity and gas sectors
- Evaluated and commented on all five storylines and were able to rank the storylines based on their preferences
- Answered a range of questions relevant for the development of storylines including the following topics:
  - Disruptive technologies
  - Future primary energy mix
  - Role of coal in the future energy mix
  - Future energy efficiency gains
  - Role of CCS

TYNDP scenario building is highly inclusive process made with many stakeholders with in-build multiple feedback rounds

Storyline Selection



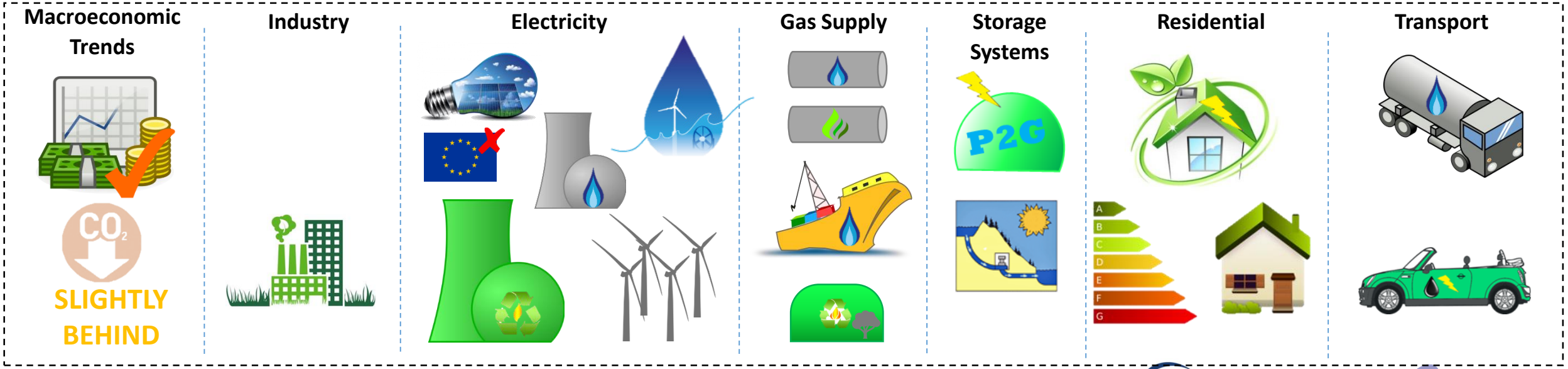
Storyline to Scenarios



National Trends

- National focus on climate change, driven by ETS and national subsidies
- Moderate economic growth
- Growth of RES but dependent on National Policies
- Gas-fired generation provides the necessary flexibility to balance renewables in the power system

- Low growth of storage, P2G develops after 2030
- Heat pump technology common in new buildings and moderate growth of the gas condensing boiler
- Electrification of heating and the light transport fleet sees stable development
- Gas sees a growth in the heavy goods transport sector depending on the country
- Low surplus capacity in generation portfolio



National Trends – Consultation Feedback

- The rationale~~s~~ of the scenario
  - Development towards EU climate targets driven by national policies
  - Moderate economic growth means that the decarbonisation goals are placed alongside affordability issues by national governments
  - Technological development continues but is not rapid

Feedback received

- Scenario is redundant as all EU-national development plans are based on common European goals
- Policies will not meet targets of Paris Agreement
- Most national development plans currently run until 2030/2035. These should be extended until 2050
- Private (non-state) investment in RES is underestimated

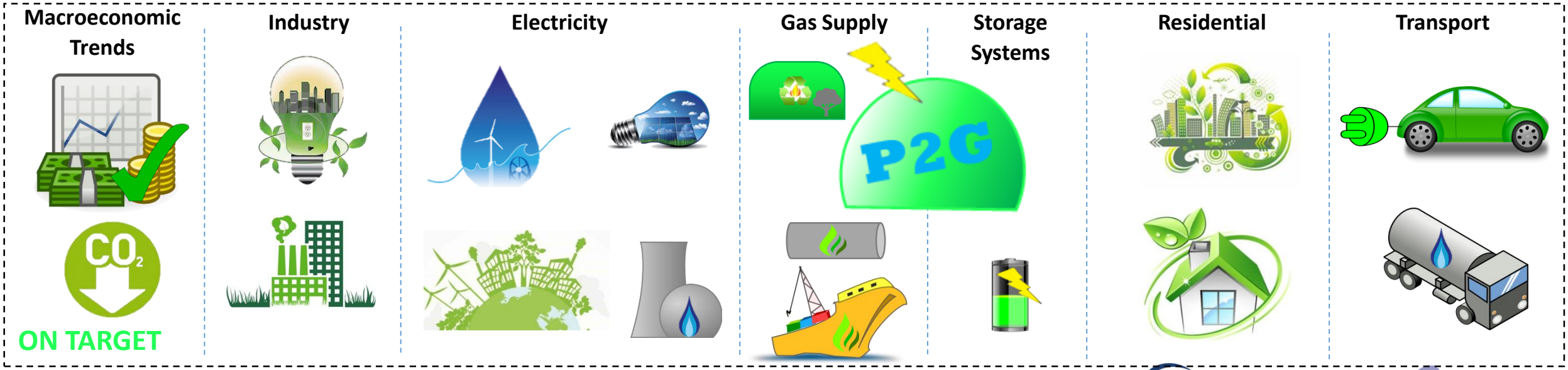
ENTSOs' Reaction

- The scenario depicts the MS divergent policies and recognises that EU targets will be achieved
- EU will unlikely meet the 1,5° C target of the Paris Agreement
- Scenario will take latest info on National Energy and Climate Plans into account (in cooperation with EC)
- Data modelling later in the scenario-building process will consider both public and private RES investment

Global Ambition

- Sustainable growth
- Global emission trading
- Low-carbon technologies competitive without subsidies
- Wind & solar are the leading sources of generation
- Carbon-free gases substitutes natural gas, centralised production from P2G

- P2G and batteries are key storage technologies
- Electricity generation remains mainly centralised
- Fossil fuels replaced with electricity and renewable and decarbonized gases in heating & industrial sectors
- Electric vehicles used in passenger transport while gas used in heavy duty & shipping
- Bio energies sustainably managed



Global Ambition – Consultation Feedback

- The rationales of the scenario
  - Ambitious approach to climate with future technologies contributing, but dependent on global action
  - Fair competition of the industrial sector across the world
  - Positive impact on technological development
  - Possibility to have commodity flows between regions

Feedback received

- The ambition should be carbon neutrality rather 95% GHG reduction
- Global action is unlikely
- Too high reliance on green energy import from unspecified regions
- Too much focus on centralised solutions

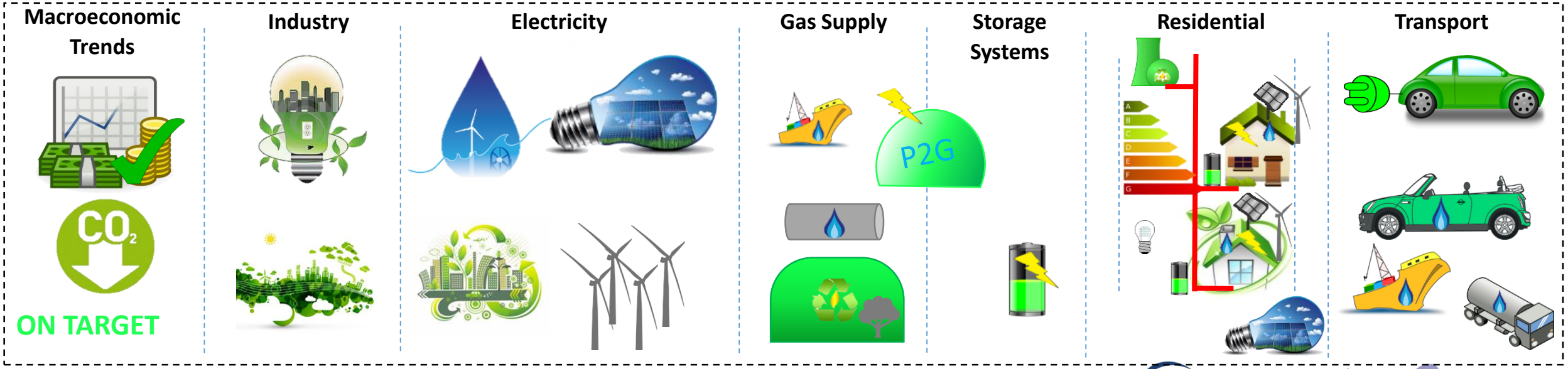
ENTSOs' reaction

- Updated to carbon neutrality in 2050 or EU Carbon budget derived from IPCC report
- Keeping global warming below -1,5° C supposes strong action beyond EU (e.g. emission volumes and carbon leakage)
- Imports will be limited in volumes and to surrounding regions
- Decentralisation is not excluded but not targeted per se

Distributed Energy

- High economic growth with strong climate policy
- Prosumers engaged in decarbonisation but also selecting price competitive solutions
- Decentralised RES growth, driven mainly by small scale PV
- Electrification in combination with renewable gases decarbonises heating residential sector, utilising hybrid solutions

- Significant leaps in innovation of small scale generation and storage technologies
- Smart digital solutions develop at all scales
- Home energy storage systems become more common, with smart technology management
- Rapid increase in electric vehicles with smart charging
- Decarbonised and Renewable gas solutions for heavy transport & shipping



Distributed Energy – Consultation Feedback

- The rationale of the scenario
  - Broad acceptance of GHG targets (supported by regulatory framework and economic growth)
  - Strong development of distributed/de-centralised energy solutions
  - Positive Technology development (especially efficiency and flexibility)

Feedback received

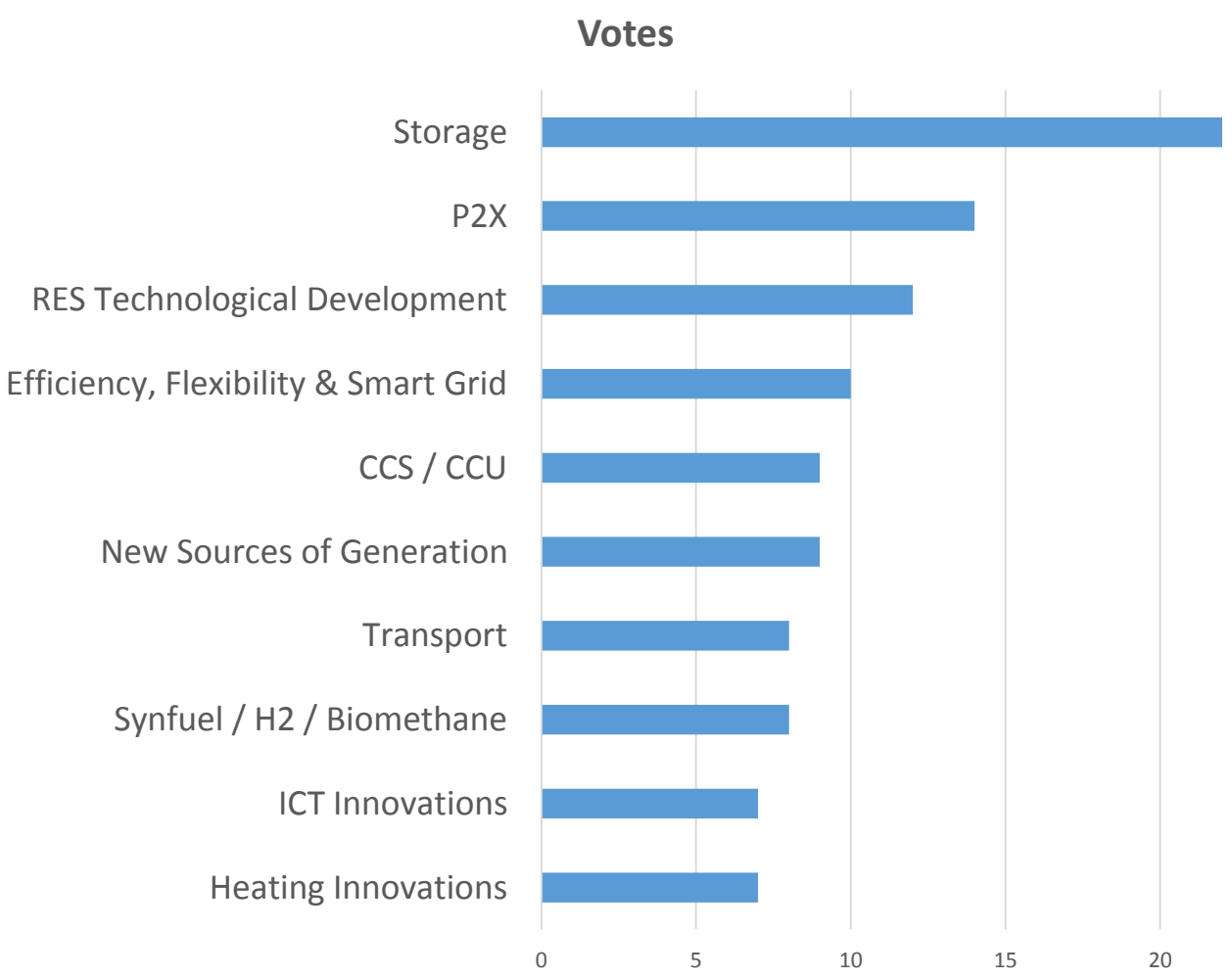
- Distributed Energy should be more ambitious than Global Ambition
- Centralised vs. Distributed is a too simple storyline
- In Distributed Energy the development is carried by people´s motivation – where should this come from?
- Electrification – mainly industry – has limits
- Problem to handle a *Dunkelflaute*

ETNSOs' Reaction

- Storyline consistency and plausibility is seen as quite high
- The ideas/tools behind Distributed Energy are expected to work well to archive GHG-targets
- The scenario will be developed with a strong focus on smaller scale technologies and self sufficiency
- Storyline triggered the creativity of stakeholders – concrete relevant points for the scenario where pointed out (e.g. role of district-heating)

Statistics – Disruptive Technologies

Which disruptive technologies can you see having the biggest impact on our scenarios?



LEGEND

- **Storage:** Large scale storage; PV rooftop batteries; …
- **P2X:** P2G; P2H; P2X
- **Synfuel / H2 / biomethane:** Synthetic fuel; Hydrogen technologies; biomethane; methane cracking; …
- **RES technological development:** Wind; Solar; High Efficiency PV panel; …
- **Efficiency, Flexibility & Smart Grid:** Energy Efficiency; Smart metering; Demand Response; Flexibility sources & market; Virtual Power Plant; Smart Grid; Prosumer; V2G; ...
- **CCS/CCU:** Carbon Capture and Storage/Use
- **New sources of generation:** Nuclear fusion; small modular nuclear reactor; fuel cell; …
- **Transport:** Electric Vehicles; H2-Vehicles; Methane Vehicles
- **Heating Innovations:** Heat Pump; CHP; µ-CHP; condensing boiler; …
- **ICT innovations:** Self-driving car, artificial intelligence, robotics; virtual currency; Digitalization; smart control system; Blockchain; ...

Role of CCS

Main comments on CCS:

- To be considered in the most ambitious decarbonised scenarios, being the only way for hard-to-decarbonize industrial sectors and as enabler for negative emissions (Bioenergy CCS = BECCS)
- Greenwashing fossil fuels and CCS and in thermal sector is unlikely, but could be considered for gas fired power plants on an economic base.
- To be used to produce decarbonized gas – e.g. decarbonised hydrogen, preferring pre-combustive instead of post-combustive CCS
- Role of CCS: 27 of 36 respondents provided comment –
  - 44% CLAIM IT HAS NO ROLE;
  - 37% STATE IT COULD PLAY A ROLE IN SOME SCENARIOS, ESPECIALLY THE CENTRALISED ONE.
  - The others say that the CCS role should be limited only on the industrial sector and follow the economic merit order.

<u>ENTSOs' Reaction:</u> The TYNDP Scenarios are very ambitious on emissions reduction and any technologies should be considered to reach the targets. The storylines consider other technologies to reach the decarbonisation target. The need for CCS will also be triggered by the need for net negative emissions, e.g. BECCS.

The Role of Coal

- The majority of stakeholders agree that coal phase-out should be policy driven although some argue that both policy and economy will play important factors
- Some stakeholders were pessimistic that these policies would be realised in the near future

Energy Efficiency

- Stakeholder opinion was generally divided as to whether the efficiency gains would lead to an increase or decrease in energy demand
- Due to the higher efficiency of EVs, the majority of stakeholders expect an overall decrease in energy demand in this sector

Carbon Budget

- A carbon budget allows us to quantify decarbonisation in our scenarios based on the targets of the Paris Climate Agreement.
- To do this we are working together with external advisors – Renewable Grids Initiative (RGI) and Climate Action Network Europe (CAN Europe)
- EU28 GHG budget is **48,5 $GtCO_2$** for 2018 to 2100 (based on calculation of RGI/CAN Europe referring to the IPCC Special Report)

The top-down scenarios - Global Ambition and Distributed Energy - will use this carbon budget to determine their decarbonisation levels and therefore be Paris/COP21 compliant.

National Energy and Climate Plans (NECP)

- Each EU member state is required to develop an integrated National Energy and Climate Plan for the period 2021-2030 based on a common template
- These plans must correspond to the general energy and climate goals set out by the Energy Union
- A draft NECP was submitted by 31 December 2018, this may be amended in consultation with the Commission before submission of the final NECP by 31 December 2019

The NECPs will form the basis for the bottom up elements in our National Trends scenario

National Trends (NT) | Alignment

- EC and ACER are requesting a joint **'policy focused' Scenario**, which can be used for the **PCI process**

► **EU28** situation will be assessed to see, if current **bottom-up** collection of "**National Trends 2030**" meets the **EU 2030 Targets**

- Alignment process
  - If a gap is identified, WGSB sees which countries do not meet EU targets (32 % RES, 48 % CO_2 reduction)
  - WGSB will optimize RES for countries, which don't meet the target to put them in alignment with the targets.
  - Countries which meet or are above targets will not be adjusted.

- Further steps…
  - In Q2/Q3 2019 WGSB will compare "National Trends 2030" with EC recommendations.
  - The methodology for alignment with EC recommendation is TBD.

Final Scenario Storylines

Final Scenario Storylines
Carbon Budget

Background information

- EU approved ratification of the Paris Agreement on 4 Oct 2016
- Strong global and European will to increase existing EU climate targets
  - More ambitious clean energy legislation: 32% RES and 32.5 % efficiency by 2030
- EU's 2050 target: 80 – 95% CO2 reduction, but lack of targets for the time from 2030 to 2050

Conclusion:

- ENTSOs will build total energy scenarios considering a Carbon Budget
  - aiming for compliance with EU climate targets and, moreover,
  - including a CO2 reduction paths

What is a carbon budget?

- The Paris Climate Agreement is based on “carbon budgets”, a concept that first gained traction in 2009
- Budgets have two main variables: temperature and probability
  - Probability: 33%, 50%, and 66%.
  - Temperature: “well below 2.0 degree Celsius” and 1.5 degree Celsius
- IPCC Special Report provides latest numbers for 1.5 degree scenarios with different decarbonisation pathways

ENTSOs were advised by The Renewable Grid Initiative and Climate Action Network Europe and are guided by the EC’s Long-term Strategy Scenarios (“A clean planet for all”).

ENTSOs Scenario's Carbon Budget

- Carbon budget for the EU:
  - is 1.5°C compatible;
  - has the highest possible likelihood (66%);
  - and are shared across countries taking into account their current population share
  - to convert the CO2 budgets into greenhouse gas budgets including non-CO2 emissions using a multiplication with 125% (according to SR1.5 Coordinating Lead Author Joeri Rogelj)

For the ENTSOs' Scenarios, a EU28 GHG budget of 48,5 $GtCO2_{eq}$ for the timeframe 2018 to 2100 will be taken into account

Final Scenario Storylines
Gas supply and P2G methodology

Gas Supply | Assumptions

General Assumptions and steps

1. Increasing renewable gas share
   - For the decarbonisation path for gas the top-down scenarios make reference to EC's "Gas Infrastructure 2050" Study
2. For the assessment of biomethane production ENTSOG worked with the consultancy Navigant
3. Decreasing import dependency in Distributed Energy, stable in Global Ambition
4. Output: additional electricity demand for P2G

Gas supply | Import dependency

- Currently, the EU28 has an import dependency of 70 – 80 %
- Indigenous gas production consists of natural gas, biomethane, synthetic gases (P2G)
- Whereas natural gas production is limited and biomethane production is a fixed constraint, P2G is depending on the target import dependency
- External benchmark: EC Long-Term Strategy Scenarios show self-sufficiency for renewable gases

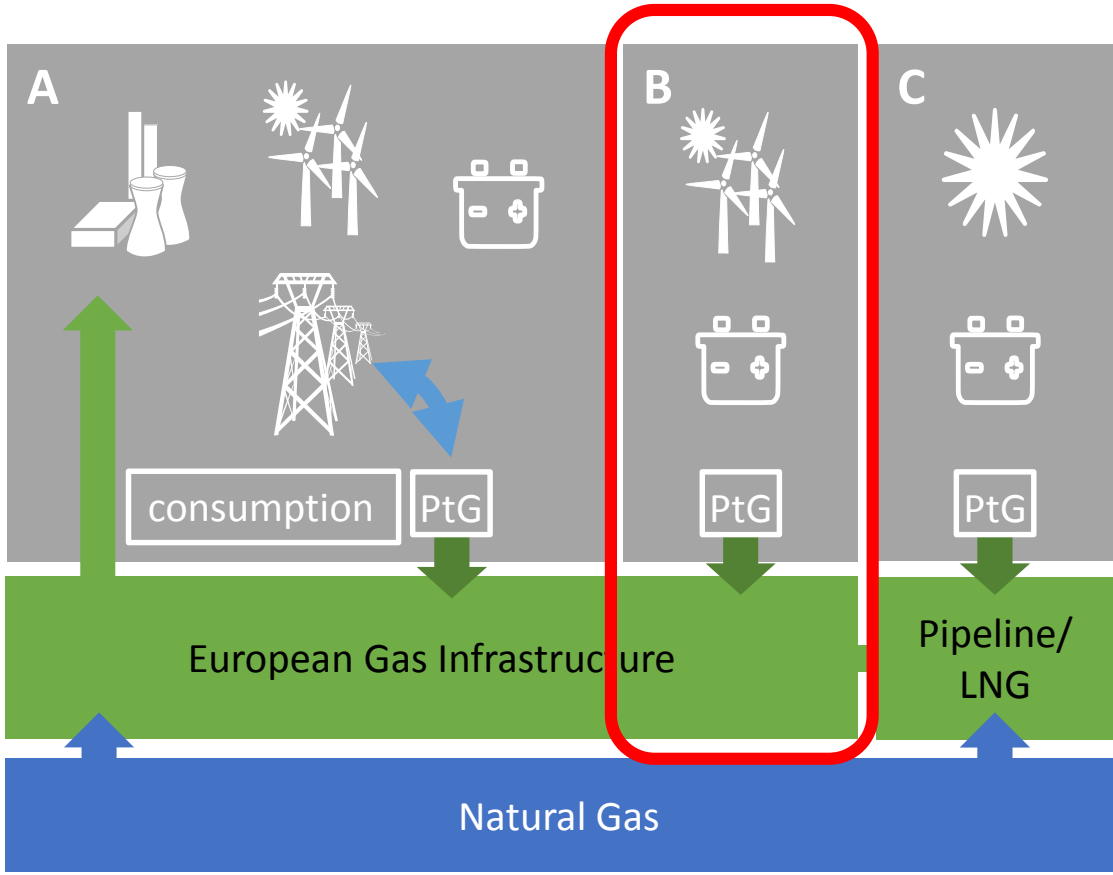
Assumptions:

- **Distribution Energy: halving import dependency (38% in 2050)**
- **Global Ambition: stable dependency compared to 2015**

P2G | Operation

P2G is optimized outside of the market due to:

- New untested process
- Demand for P2G is multidimensional:
  - P2G as key for Sectoral Integration
  - P2G as option for the decarbonisation of gas mix
  - P2G can increase self-sufficiency (decrease import dependency)
- only renewable electricity is used for P2G
- Tools can't consider all distribution keys



ENTSOs' will further improve their methodologies for the next TYNDP Scenario cycle.

P2G | Optimisation

- An optimization tool is used to convert ENERGY to CAPACITIES of Wind, Solar, Batteries and P2G
- Yearly hourly solar and wind load factors are imported for a specific climate year
- Batteries can be assigned to increase demand FLH of P2G and reduce costs
- Optimisation can be done for FLH maximisation or Cost minimisation
- Distribution: The demand for P2G will be distributed around Europe taking into account distribution keys (gas demand, electricity demand, natural resources like full load hours for renewables and space)

Final Scenario Storylines
Power market

National Trends Scenario

- Scenario will start as a bottom up collection
- Storyline states scenario should meet current EU targets
- Trajectories encapsulating national scenarios have been collected
- If the scenario doesn't meet the EU targets, an optimization will be done with TSO trajectories as boundary conditions

- Another review will be done taking into account the difference between the NECPs and the National Trends scenario in Q3

Top Down Scenario

- Top down scenarios aim to fulfil a storyline
- Scenarios aim at COP21 compliance
- Primes technology prices are adjusted to fulfil the storyline
- More parameters will be optimized as compared to National Trends
- RES Boundaries will be based on historical growth rates and Trajectories.
- Demand side response which can include technologies such as (vehicle to grid, industrial demand and Hybrid Heat Pumps)

Modelling Parameters

Commodities and Natural Resources

- Fuel Cost: TYNDP 2018 – PRIMES
- Technology Prices: Primes + Adjustment for Storylines
- Climate Years: 1982, 1984, 2007

Limiting Factors

- Build Out Rates: Historical data
- RES Limits: Trajectory collection + Build out rates
- Thermal Limits: Trajectories

Top Down Modelling | Investment Candidates

Distributed Energy

Global Ambition

National Trends

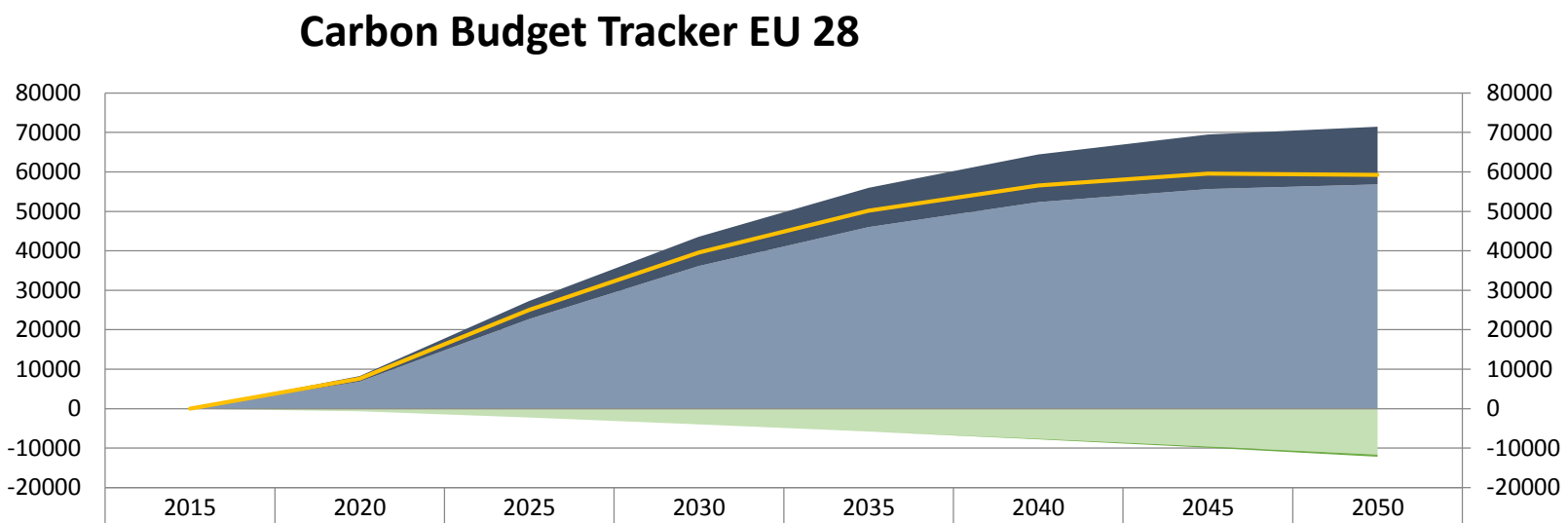
CCGT | Batteries | E - Grid

Wind | Solar PV

First figures..

Distributed Energy: Decarbonisation

Scenarios are compliant with EU targets on RES, Energy Efficiency and CO2 emissions reduction for 2030 and 2050.
Full decarbonisation by 2050.



	2015	2020	2025	2030	2035	2040	2045	2050
Cumulative non-CO2 emissions	0	1410	4609	7446	9923	12037	13790	14577
Cummulative CO2 emissions	0	6853	22719	36111	46054	52339	55670	56826
EU 28 CO2 Budget Tracker BECCS		0	0	0	-39	-146	-313	-524
EU 28 CO2 Budget Tracker LULUCF		-627	-2253	-3963	-5757	-7635	-9598	-11644
Net Cumulative CO2eq emissions	0	7636	25075	39594	50180	56594	59549	59234

Carbon sinks such as LULUCF and BECCS needed to balance out non-CO2 emissions.

Where are we with the Carbon Budget?

	<2050	>2050	until 2100
Energy and Non-Energy* Related CO2 emissions	57 GtCO2	0	
Non-CO2 GHG emissions	14,5 GtCO2	?	
Carbon sinks *(relevant to Energy/non-Energy CO2, non-CO2 GHG emissions)*	-12 GtCO2	LULUCF ? BECCS ? DAC ?	
	59 GtC02	- 11 GtCO2	EU28 share based on population 48.5 GtCO2

*Emissions are taken into account as if the fuel for non-energy demand (e.g. feedstock) was combusted

ENTSOs' scenario building exercise shows that negative emissions after 2050 are needed to stay within the carbon budget to be compliant with the 1,5° C target.

Next Steps

Proposed Top-down Process Steps

Annual Quantification of Demand

EU-28

Balancing Demand & Supply

Power Market
Hourly resolution

Indigenous Gas Supply

Biomethane & P2G Quantification

Extra-EU Supply Potentials

for Natural Gas, Hydrogen and Renewable Gases

Final Scenario Approval

Scenarios will be out for consultation in Q3/Q4

Thank-you for listening

Any questions?