Final ENTSOs' TYNDP 2020 Scenario Storylines

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ENTSOG AISBL: Av. de Cortenbergh 100. 1000-Brussels: Tel: +32 2 894 5100: Fax: +32 2 894 5101: info@entsog.eu www.entsog.eu. VAT No. BE0822
ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel +32 2 741 09 50 • Fax +32 2 741 09 51 • info@entsoe.eu • www.entsoe.eu

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1. Our final Storylines in more detail

1.1 The information we are providing…

The purpose of this document is to update stakeholders on the final storylines choices and to provide further information on the next steps in the scenario building process. It is important to know that this document will not go too deeply into the scenario building processes, the datasets or methodologies. The scenario report due for publication in quarter 4 2019 will provide more detailed information on the quantification processes for the ENTSO scenario development. A further information annex supplements this document, its purpose is to cover the high level introduction of all storylines initially proposed, the storyline consultation feedback and the storyline selection process.

This document only covers the selected storylines that are to be finalised and quantified.

Central Matrix

The Central Matrix is an **EU-wide high level view of 2050**, showing how the primary energy mix and key final energy use sectors are assumed to change from today. It is important to note that country level and/or regional differences will be present, when compared to the EU-28 figures, the differences are driven by factors such as national policy, geographical and/or technical resource constraints.

The scenario building central matrix is a tool used to identify the key elements of the storylines. The central matrix enables creation of scenarios consistent along a pathway; yet differentiated to other storylines. Remember the central matrix represents an overall EU Level view, to understand the matrix notation it is worth understanding the following assumptions:

- The growth or reduction indications are in relation to what is seen today, but also in relation to the rates observed within that category in comparison to other scenarios. For example, compared to today, solar generation is expected to increase significantly in all scenarios from today, but only receives a +++ in **Distributed Energy**.
- Equally, growth and reduction rates across the different categories are not directly comparable. For example, two categories with ++ rating may differ significantly in their actual percentage increase from today, based on the starting point and ultimate potential.

The use of the primary energy mix is an essential new feature of the TYNDP 2020 process, designed to enable the ENTSOs to gauge the overall shift in the energy sector required to ensure the decarbonisation pathways specified by the scenarios are met.

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Final energy use sectors have been grouped into key categories (high/low temperature heat[1], transport, power and lighting), with indicators for the expected development of the total demand of energy use, and then the resulting effect on the electricity and gas demand in these sectors.

Due to this approach, it is important to understand the step between the primary energy mix and final energy usage, and the effect this has on some of the categories.

For example:

- The transport overall energy demand is expected to decrease as traditional internal combustion engines become more efficient, switch fuels or are replaced by electric motors. This can lead to positive indicators for both gas and electricity demand, whilst the total demand decreases, due to the displacement of oil in this sector.
- Biomethane is produced from anaerobic digestion or gasification feedstock which are categorised under biomass.
- Gas produced from Power-to-Gas has it's primary energy source coming from solar and wind, but has a separate row in the Central Matrix.
- Imported energy is represented in the primary energy mix as these are produced from primary energy outside the EU.

GHG Emissions

In general the decarbonisation of Europe is driving the energy transition. ENTSOs' initial storylines were mainly guided by the EU Decarbonisation targets, set by the 2030 climate & energy framework and EU long-term goal of reducing greenhouse gas emissions by 80-95 % (by 2050).

Based on the consultation feedback, ENTSOs changed their approach for the two top-down scenarios **Global Ambition** and **Distributed Energy**, by taking the targets of the Paris Agreement (United Nations Framework Convention on Climate Change, 21st Conference of the Parties) of keeping temperature rise well below 2°C and pursue efforts to keep below 1.5°C, as compared to pre-industrial times, into account. To ensure the correct translation of the global carbon budget (see section 1.3) stated by the IPCC Special Report[2] into an EU share, ENTSOs have been advised by the Renewable Grid Initiative (RGI) and its member Climate Action Network Europe (CAN Europe). Furthermore, ENTSOs used the European Commission's strategic long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050 presented in their study "A Clean Planet for all" as guidance.

[1] High temperature heat: usage for industrial processes (material transformations, chemical reactions, process steam, etc) which can be in excess of 1000°C, with the dominant range in Europe above 500°C.
Low temperature heat: usage for space heating and hot water.

[2] The Intergovernmental Panel on Climate Change, Global warming of 1.5°C, An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, 2018, https://www.ipcc.ch/sr15/

For the bottom-up scenario **National Trends**, the latest available data from the National Energy and Climate Plans (NECPs) will be taken into account. This will ensure that the scenario is compliant with the national and EU targets on GHG emissions reduction.

Depending on the type of technological developments, policies and societal engagement observed, the level, speed and method of transition will differ. How this manifests within the scenarios is shown within the GHG Emission charts (Figure 2 & 3).

The primary drivers for the scenario building process will be based on the EU-28 carbon budget and at a minimum where available; politically agreed targets for each of the time horizons. The central matrix defines the "high level" assumptions for scenario storyline, and how the pathway for each storyline will enable the energy transition. The central matrix ensures that we achieve differentiated data sets that can cover several future outlooks for the energy transition.

Storyline Descriptions

The storyline descriptions are designed to build further on the themes of the scenarios and provide some insight into the technologies used within various sectors and overall trends observed within that energy future.

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1.2 Central Matrix

Factor		2050 Scenario Overview		
Scenario		National Trends	Global Ambition	Distributed Energy
Category	Criteria			
Primary mix	Coal	---	---	---
	Oil	--	---	---
	Nuclear	--	--	---
	Hydro	o	o	o
	Geothermal	o	+	++
	Biomass	+	++	+++
	Imported Renewable and decarbonised Gas	+	+++	+
	Natural gas	-	--	---
	Wind onshore	++	+++	+++
	Wind offshore	++	+++	++
	Solar	++	++	+++
	Wind for P2G	+	+	++
	Solar for P2G	+	+	+++
	Imported Green Liquid Fuel	+	++	+
High temperature Heat	Total demand (all energy)	o	-	-
	Electricity Demand	+	+	++
	Gas Demand	+	++	o
Low temperature Heat	Total demand (all energy)	-	--	--
	Electricity Demand	+	++	+++
	Gas Demand	-	-	--
Transport	Total demand	-	--	--
	Electricity Demand	+	++	+++
	Gas Demand	+	++	+
Power and Lighting	Electricity Demand	o	-	-

Legend

Change from Today	---	--	-	o	+	++	+++
	Not available	Moderate Reduction	Low Reduction	Stable	Low growth	Moderate growth	High growth

Figure 1: Central Matrix

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1.3 GHG Emissions Reduction

As the GHG reduction indicator is one of the most important political drivers for defining future national and/or pan-European climate ambitions this parameter is introduced into the overall scenario building process at an early stage. Clear GHG emissions reduction targets have been set by the European Union for 2020 and 2030 as part of the pathway towards a low carbon society in 2050 by reducing GHG emissions by 80-95 % compared to 1990 levels. The 2020 Climate and Energy Package forms basis for 20 % cut in GHG emissions by 2020 and the 2030 Climate and Energy Framework sets the target for 40 % reduction by 2030.

All storylines will be translated into scenarios that at a minimum; aim to achieve the above mentioned targets. **National Trends** will rely on the latest info available from draft NECPs and National Development Plans (NDPs). This will ensure that the scenario is compliant with national and EU climate targets.

However, ENTSOs acknowledge that target of the Paris Agreement of keeping temperature rise below 1.5°C, as compared to pre-industrial times, will not be met by only intermediate GHG emissions reduction targets for 2030 and 2050. Therefore, **Global Ambition** and **Distributed Energy** will consider a carbon budget including emissions and removals from agriculture and from Land Use, Land Use Change and Forestry (LULUCF).

The IPCC Special Report on warming of 1.5°C (SR1.5 - 2018) shows why 1.5°C is a critical threshold, and assesses 1.5°C compatible carbon budgets.

ENTSOs have sought expert opinion on what the carbon budget means for the “EU-28” with CAN Europe and the Renewable Grid Initiative. To build the Carbon Budget compliant scenario the ENTSOs will use a carbon budget figure of 48,5 $GtCO_2$ based on population.

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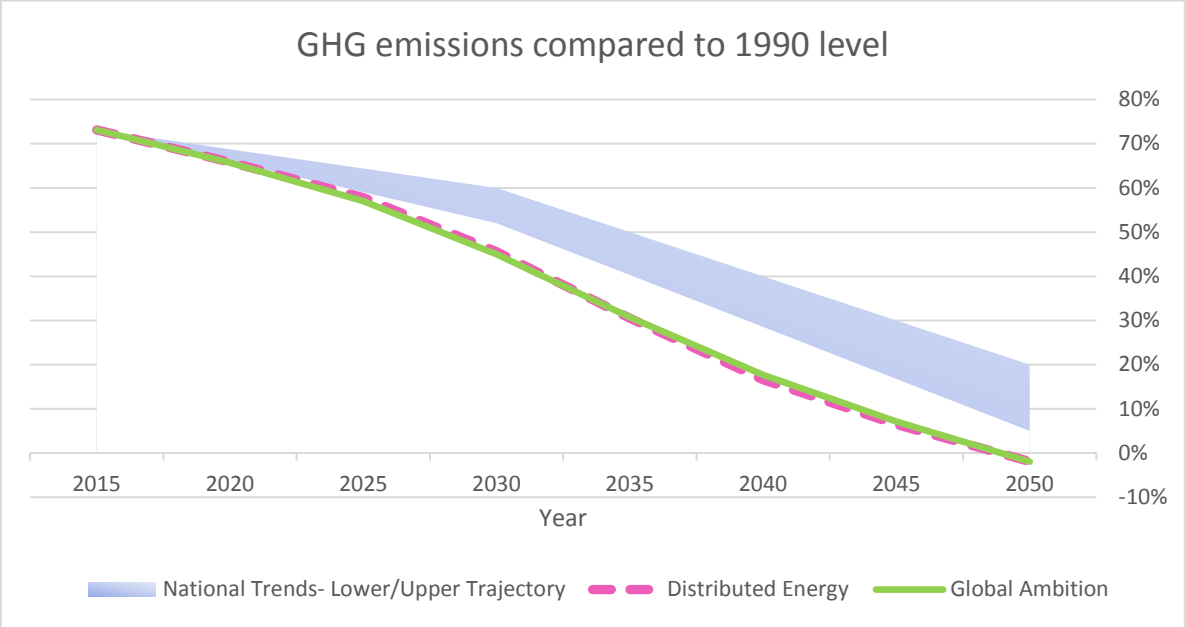

Figure 2: Storyline-specific Decarbonisation Pathways (including LULUCF)

Although all storylines are heading towards a decarbonised future for the EU, they all differ substantially in their energy transition approach. For instance, one emerging theme is that the European energy transition could be driven either by a centralised or decentralised pathway, and this general lever is considered in the graph below.

As an example, **Global Ambition** looks at a future that is led by large development in centralised generation including offshore wind and Power-to-X. In contrast to that, **Distributed Energy** is a storyline that embraces a de-centralised approach to the energy transition, with rooftop solar installations linked with batteries, community or regional uses of biomass and geothermal resources.

It is important to understand that these levers are not absolute, and are intended to give a strong indication of the future development anticipated in the scenarios. For example, decentralised technologies will still exist in a centralised scenario, but to a lesser extent.

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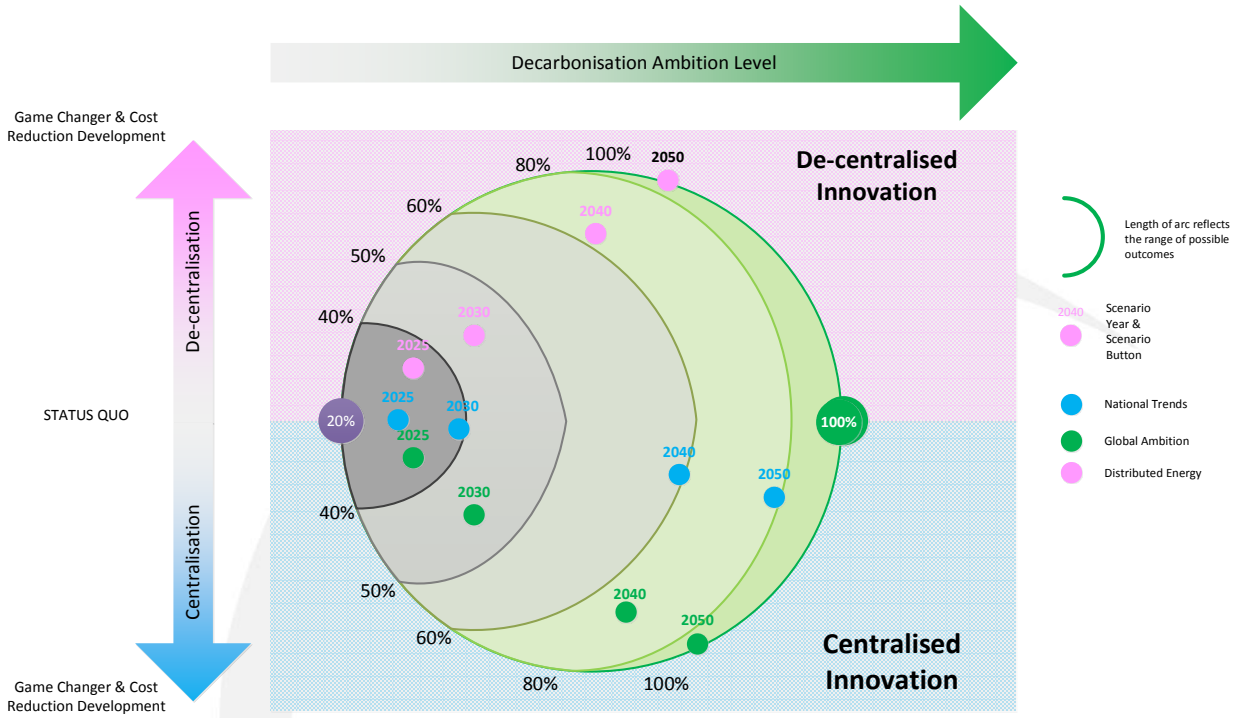

Figure 3: Decarbonisation & (De-)Centralisation

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Side Note: Carbon Budget

Carbon budgets refer to the net total of CO_2 that can be emitted in a given time period taking into account the total CO_2 that is removed in the same period. Hence, carbon budgets include emissions and removals from LULUCF.

The IPCC Special Report on warming of 1.5°C (SR1.5 - 2018) shows why 1.5°C is a critical threshold, and assesses 1.5°C compatible carbon budgets. These carbon budgets in SR1.5 are higher than those in the IPCC's Fifth Assessment Report (AR5 - 2014), mainly because of an effort of rebasing. The "Summary for Policy Makers of SR1.5" provides four 1.5°C compatible carbon budgets (for global CO_2 emissions), with differences due to:

- likelihood of staying within the temperature threshold: 50 % or 66 % (which is an expression of the number of scenarios that allow a certain carbon budget);
- means of temperature measurement: based on computer modelling only (global mean surface air temperature) or computer modelling combined with real-time observations (GMST).

The carbon budgets in the IPCC reports refer to the available budgets for CO_2-emissions, while they take into account a certain limited reduction pathways for non-CO_2 emissions. Assuming stringent emission reductions of non- CO_2 gases, in line with the deep reductions of CO_2 emissions needed for 1.5°C compatible budgets, could help in converting CO_2-budgets into greenhouse gas budgets that would according to SR1.5 Coordinating Lead Author Joeri Rogelj be approximately 25 % higher.

Based on above mentioned parameters and assumptions the global carbon budget is 712 $GtCO_2$ from 2018 onwards till the end of the century. There are multiple ways to divide the global carbon budget across countries. The main approaches take population and/or equity into account.

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2. Final Storyline Description

National Trends

1) Macro-Economic Trends and Climate Targets

The **National Trends** scenario follows the trends developing in the climate policies on a national level. A centralised and top-down climate policy driven by the European Union is largely eschewed in favour of independent national solutions. The economic climate in storyline **National Trends** is one of moderate growth. As a result, there is stable rather than rapid development in many sectors and societal ambition to contribute to climate action is tempered by affordability. NECPs supported by subsidies and a robust EU ETS scheme push towards the decarbonisation of Europe.

2) Transport

Overall uptake of electric and hybrid vehicles grows moderately, influenced by the economic climate, with consumers still conscious of the cost. Internal combustion engines using gas and oil with high shares of green gases and biofuels see low growth at an EU level, with a focus on heavy good vehicles and shipping. However, total energy demand in the transport sector decreases, mainly caused by the shift towards electrical vehicles and higher efficiencies in internal combustion engines.

3) Residential and Commercial

Driven by the economic climate, energy efficiency improvements in the residential and commercial sectors occur at a moderate rate resulting in overall lower heat demand. This leads to a variety of heating solutions being deployed, based on regional climatic specificities and building stock conditions. Electric heat pumps are common in new efficient buildings, but there is still a high share of gas fuelled appliances, also as part of hybrid solutions such as hybrid heat pumps. Overall the gas demand in the residential sector slightly decreases in the long-term, whereas electricity demand for power and lighting remains stable.

4) Industrial

Total industrial energy demand is relatively stable as energy efficiency measures balance with the moderate economic growth, leading to increased production. Post 2030, both electricity and gas demand in the industrial sector are marginally increased replacing coal and oil. Due to the current political view of CCS/CCU in most of European countries, it does not play a notable role in this scenario.

5) Electricity

The power sector sees high growth of solar and wind generation, however national policies dictate on a country level which technology is favoured. Generation is typically more centralised. Decentralisation is limited to those in society who can afford to invest in self-generation solutions. Electricity storage sees low growth with limited large-scale battery solutions available. Gas fired power generation replaces coal and to a certain level nuclear due to national regulations rather than price in the short-term and provides the necessary flexibility to balance renewables in the long-term.

6) Gas Supply

Natural gas supplies via pipeline and LNG are still dominant sources of supply. Power-to-Gas sees limited development and is used more for energy storage than a key supply of gas. Biomethane growth is reliant on national policy support. Storage capacity remains as a key component of the energy system. The

storyline takes into account imports of green gases using the existing gas infrastructure leading to a decarbonisation of the gas mix in the long run.

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Global Ambition

1) Macroeconomic Trends and Climate Targets

The **Global Ambition** storyline assumes moderate economic growth based on sustainability. The storyline looks at a future that is led by economic development in centralised generation, economies of scale lead to significant cost reductions in emerging technologies. The storyline is driven by the ambition of meeting the climate targets of the Paris Agreement of keeping the temperature increase below 1,5°C. Based on population as a allocation parameter, the carbon budget share of the EU is assumed to be 48,5 $GtCO_2$ from 2018 till the end of the 21st century. The storyline therefore shows a full decarbonisation by 2050 and the potential to stay within the above mentioned carbon budget with net negative emissions after 2050. Global climate efforts and global methods regarding CO_2 reductions such as a global emission trading are in place.

2) Transport

Wide adoption of zero-emission vehicles is a key component of decarbonisation in storyline **Global Ambition**. It sees a high penetration of electric vehicles in passenger transport across whole Europe. Green gas and hydrogen are the main fuels in the heavy good transport and shipping. Both segments utilize some liquid biofuels, especially as means to decarbonize older vehicles. Efficiency gains from fuel switching combined with development of communication technology reduces total energy demand for transport.

3) Residential and Commercial

Energy efficiency improvements occur at a high rate in residential and commercial sectors, driven by global decarbonisation efforts and technology improvements. Fossil fuels are replaced by electricity and green gases. Hybrid heat pumps are the end user heating appliance with the highest penetration due to their ability to use both electricity and gas to provide heat and therefore allow an efficient use of the existing electricity and gas infrastructure. Although the gas mix can be seen as mainly carbon neutral, solely gas fueled end user appliances run low due to their lower efficiency.

4) Industrial

Fossil fuels are replaced by renewable and decarbonised gases and electrification in industrial use. Combined with energy efficiency and high demand flexibility, overall energy demand is reduced. Carbon capture and storage (CCS) technologies are applied especially in processes where fossil fuels cannot be substituted with electricity or gas. Using CCS, the sector contributes with low or even net-negative emissions. Hydrogen becomes a viable option, being produced via P2G indigenously or imported.

5) Electricity

Low carbon technologies are competitive without subsidies. Thus, in storyline **Global Ambition**, wind and solar are the leading sources of power generation, and they can be deployed where the economics are best. Electricity generation remains mainly centralised with a high penetration of wind farms in the Northern Europe and large scale solar power plants in Southern Europe. New nuclear are not built to a large extent due to challenges with cost and acceptability, whereas decommissioning of existing nuclear units follows national policies. Gas fired power generation replaces coal due to an effective global emission trading in the short and mid-term, and provides the necessary flexibility to balance renewables in the long-term. To stay an option in the long-run, gas power plants will be fired with renewable and decarbonised gases and also equipped with CCS to reduce emissions or even reach net negative emissions. In the long-term, Power-to-Gas and batteries are the main technologies balancing renewables. Gas is also used in CHP units in existing district heating networks.

6) Gas Supply

Carbon-neutral gases substitute natural gas as time progresses. Biomethane growth is high using feedstocks produced in Europe. There is some development of synthetic gases as long-term energy storage, as well as a source of carbon neutral gas for the energy system. Following its main characteristic, which is centralisation, **Global Ambition** shows significant shares of imports of carbon-neutral gases, including "blue hydrogen" from steam methane reforming natural gas in combination with CCS/U or methane cracking (pyrolysis). Gas storage capacity remains as a key component of the energy system providing flexibility for both the gas and electricity sector.

ENTSOG AISBL: Av. de Cortenbergh 100. 1000-Brussels: Tel: +32 2 894 5100: Fax: +32 2 894 5101: info@entsog.eu www.entsog.eu. VAT No. BE0822
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Distributed Energy

1) Macro-Economic Trends

The economic climate in **Distributed Energy** is one of high growth, which sees increased penetration of new or further developed technologies in many sectors. The storyline is driven by the ambition of meeting the climate targets of the Paris Agreement of keeping the temperature increase below 1,5°C. Based on population as a allocation parameter, the carbon budget share of the EU is assumed to be 48,5 $GtCO_2$ from 2018 till the end of the 21st century. The storyline therefore shows a full decarbonisation by 2050 and the potential to stay within the above mentioned carbon budget with net negative emissions after 2050.

Communities and Consumers are heading: People are engaged in climate action in general, leading to societal trends of decarbonisation along with strong climate policies. Society is motivated to make environmentally conscious and socially responsible investments. A greater number of prosumers investing in a range of smart or flexible low carbon energy solutions driven by a favourable market design. In this scenario decentralised energy sources are strongly developed. Biomass (as well in from of biomethane) and geothermal sources for the (low temperature) heat demand are utilised extensively.

2) Transport

The overall transport demand (km/a) is slightly decreasing due to a good development of public transport and solutions like car-sharing and flexible working conditions. People try to buy locally, therefore heavy load transport is staying on a comparable level. There is significant progress of the decarbonisation of the transport sector through the application of a variety of different technologies. Very high levels of growth are observed in the electrification of private transport and are combined with smart charging systems plus offer vehicle-to-grid flexibility. Heavy goods vehicles, shipping and aviation see an increase in renewable liquid fuels, gas and hydrogen vehicles.

3) Residential and Commercial

Energy efficiency grows with very high levels of renovation and insulation of residential and commercial buildings. This leads to a strong increase in the electrification of heating through the use of heat pumps driven by the decentralised generation of electricity by photovoltaic. Hybrid solutions are used for older building and cities with limited potential for PV. Smart technology in combination with home battery storage systems provide flexibility.

4) Industrial

Industrial demand is increasingly electrified. The increasing energy efficiency reduces the overall demand slightly and keeps the gas demand stable whilst the economic conditions grow. The sector also offers increasing levels of demand flexibility. Industrial gas use is relatively stable. Fossil gas is replaced by green gas. Carbon capture and storage (CCS) technologies are applied in industry process, which are hard to be decarbonized (e.g. production of cement or high-temperature processes).

5) Electricity

Renewable energy generation growth is strong but more decentralised, with high penetration of small scale PV. The overall demand for renewable energy is very high due to the ambitious CO_2 target. Therefore, there will be as well a high generation from wind. Further innovations in small scale generation and storage technologies are seen. Large scale gas fired power plants play only a small role to provide adequacy but they support the system in early years as coal is phased out and nuclear generation is reduced. To stay an option in the long-run, gas power plants will be fired with renewable and

decarbonised gases and also equipped with CCS to reduce emissions or even reach net negative emissions, but this will mainly evolve in smaller scale power plants or CHP. Energy production is more flexible with intermittent generation and allows for the optimized management of the production and consumption of electricity and heat.

6) Gas Supply

The storyline **Distributed Energy** targets the reduction of imports. It is assumed that the import dependency will decline by half. Biomethane growth is high and widespread utilising a variety of technologies. Furthermore, large scale Power-to-Gas is used to produce hydrogen and synthetic methane, which are fed to the existing gas infrastructure. Still, certain amounts of renewable and decarbonised gases for the energy system will be imported. Storage capacity remains as a key component of the energy system.

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3. Further Information

3.1 Purpose of ENTSO-E & ENTSOG Scenario Storylines

Joint Scenario Development

The ENTSOs consistent and interlinked electricity and gas model in accordance with Article 11(8) of Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013, was submitted in December 2016 and details the foundations of the joint scenario building process.

The scenarios go beyond the EU-28 to the ENTSO-E & ENTSOG perimeters which includes members, observers and associated partners. In total over 80 participants, covering more than 35 countries, are involved in the process.

Gas and Electricity TSOs are in a unique position to provide quantitative European focused scenarios on the impact of the energy transition on the European Electricity and Gas infrastructure needs and challenges for the long-term horizons.

The framework for the joint ENTSOs scenarios was agreed during the development process for TYNDP 2018. The framework enables the ENTSOs to create storylines that are consistent up to the 2040 time horizon and illustrates that uncertainty increases over the 2020-2040 time horizon. Figure 4 graphically represents this framework, using the circles to show that the spread between the scenarios will be greater, but within a plausible range of possibility.

What regulation states…
According to Article 8(3)(b) of Regulation 714/2009 and Article 8(3)(b) of Regulation715/2009, ENTSO-E and ENTSOG have to publish their TYNDPs on a biennial basis. Annex V of Regulation (EU) No 347/2013, covering the methodology for a harmonised energy system-wide cost-benefit analysis for projects of common interest, specifies that: *(1) The methodology shall be based on a common input data set representing the Union's electricity and gas systems in the years n+5, n+10, n+15, and n+20, where n is the year in which the analysis is performed. This data set shall comprise at least:* *(a) in electricity: scenarios for demand, generation capacities by fuel type (biomass, geothermal, hydro, gas, nuclear, oil, solid fuels, wind, solar photovoltaic, concentrated solar, other renewable technologies) and their geographical location, fuel prices (including biomass, coal, gas and oil), carbon dioxide prices, the composition of the transmission and, if relevant, the distribution network, and its evolution, taking into account all new significant generation (including capacity equipped for capturing carbon dioxide), storage and transmission projects for which a final investment decision has been taken and that are due to be commissioned by the end of year n+5;* *(b) in gas: scenarios for demand, imports, fuel prices (including coal, gas and oil), carbon dioxide prices, the composition of the transmission network and its evolution, taking into account all new projects for which a final investment decision has been taken and that are due to be commissioned by the end of year n+5.*

Table 1. Regulatory requirements

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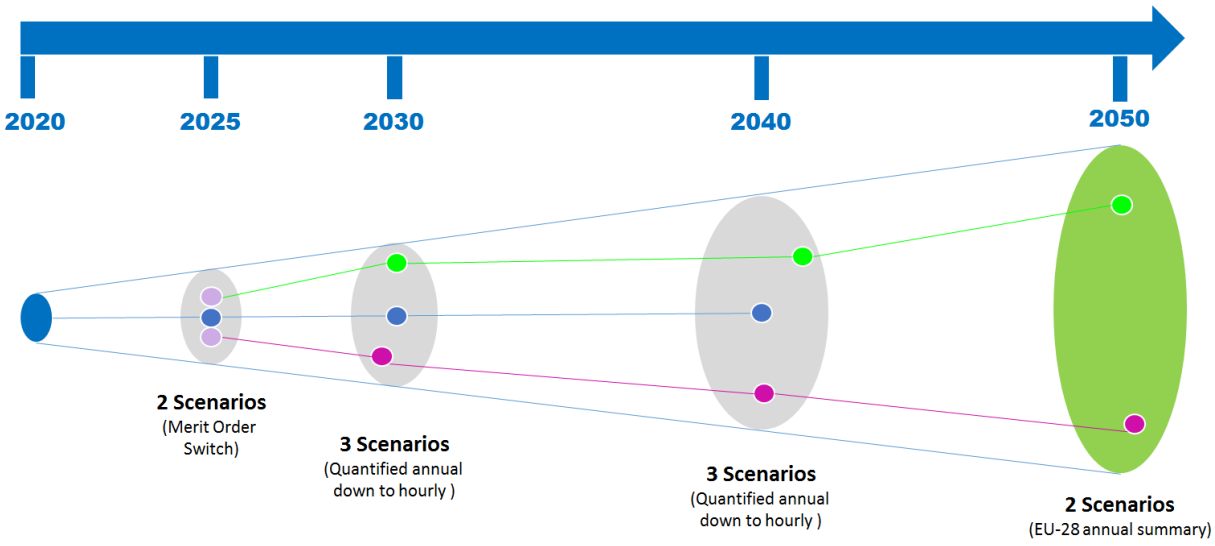

Figure 4. High level framework for Joint ENTSO-E & ENTSOG Storylines

The scenario building process for TYNDP 2020 builds on the work from TYNDP 2018 and seeks to improve the quality of the storylines that are jointly developed.

Figure 5 provides a starting point to assist the discussion on the new storylines for the ENTSOs respective TYNDP 2020 processes. The chart frames the development of the scenario storylines within the context of reaching a low or even zero carbon future in 2050.

The timeline to 2050 is split into three distinct parts; in the short-term we can look at a **Definable Forecast**, in the mid-term a future with **Dynamic Fluctuations**, and finally a common outlook on decarbonisation to a **Definitive Future** in 2050.

The storylines are developed so that they capture multiple trajectories that show the plausible pathways that enable a low or zero carbon, affordable, and secure energy system for Europe.

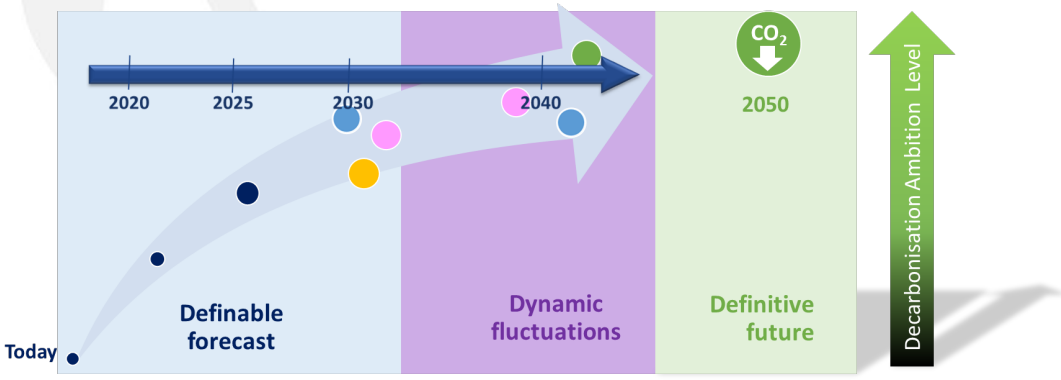

Figure 5. Scenario Building 2020 framework for Joint ENTSO-E & ENTSOG Storylines

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The **Definable Forecast** horizon is a region that captures current trends within the energy sector. A definable forecast typically captures the policies set out by NDPs and NECPs, currently being considered for adoption by Member States in accordance with EU ambitions guided by the Paris COP21 agreement. Recent studies and scenarios indicate that considering the carbon budget for the 21st century stated in the IPCC Special Report, even more ambitious plans for the Definable Forecast period are needed.

- Subsidies within the energy sector mean that renewable technology development has been supported, so that in the longer term they are cost competitive with traditional technologies such as thermal power plants, or oil fire burners for domestic heating
- Within this time horizon, energy policy is agreed in the short-term up to 2020, but the targets for 2030 are being agreed and developed into new NDPs for countries co-operating within the COP21 framework
- The scenarios within this time horizon should provide credible scenarios for meeting EU policy expectations while taking into account technical and realistic build out rates for renewable and conventional technologies
- The definable forecast horizon has the flexibility to test scenario parameters that can have an impact on the gas and electricity systems. Useful scenario checks include merit order switches on grid power flows and gas demand, system adequacy, delayed or accelerated renewable development in the supply & demand sectors

The future time horizon covered by the **Dynamic Fluctuation** is becoming increasingly important.

- This horizon is an important area for future development. For COP21 ambitions that go for the 1,5°C or well belowthe 2°C, new and emerging technologies that can create zero carbon or negative carbon emissions become an important enabler in the ambition to decarbonise the European economy
- The development of large scale infrastructure tends to lag behind the development of renewable technologies, it is critically important for the planning of the European gas and electricity grid that we are prepared for various plausible outcomes
- Within this horizon it is important that a broader range of scenarios is developed to ensure that infrastructure needs are examined across a spectrum of plausible futures. This is to ensure that needs or gaps in system developments are assessed and future project needs promoted

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The **Definitive Future** time horizon looks at the point in time 2050. The range of uncertainty is clearly demonstrated by the broad spectrum of academic and governmental research in the area

- Current obligations mean that the EU target is set to 80-95 % of GHG reduction on 1990 levels by 2050.
- However, the COP21 Paris agreement sets a more aspiring global climate change objective to keep the increase in global average temperature to well below 2°C above pre-industrial levels, aiming to limit the increase to 1.5°C. The recently published IPCC Special Report shows the need for faster decarbonisation of the energy and non-energy sectors than current national and EU policies would allow in order to meet the targets of the Paris agreement. Moreover, it is generally accepted that a full decarbonisation by 2050 is essential to limit the increase in global average temperature to 1,5°C.
- Technologies and policies that are required to achieve the 2050 targets are not fully developed, but given that there are 31 years (16 TYNDP cycles) to deliver the necessary infrastructure, time is short and therefore it is critical that TSOs within the ENTSOs frameworks are prepared to discuss the possible futures out to 2050
- What will be the technology achievers that will enable a competitive European energy sector delivering value, security of supply and clean air to consumers in Europe and in support of our global effort to sustain our planet for future generations?

Where do scenarios fit into the network development exercise?

The scenarios represent the first step in any network development exercise. They offer the frame under which the future is analysed in view of identifying the investment needs and benefits of future electricity and gas projects. They provide a view on many elements e.g. energy demand, prices, technology developments, etc.

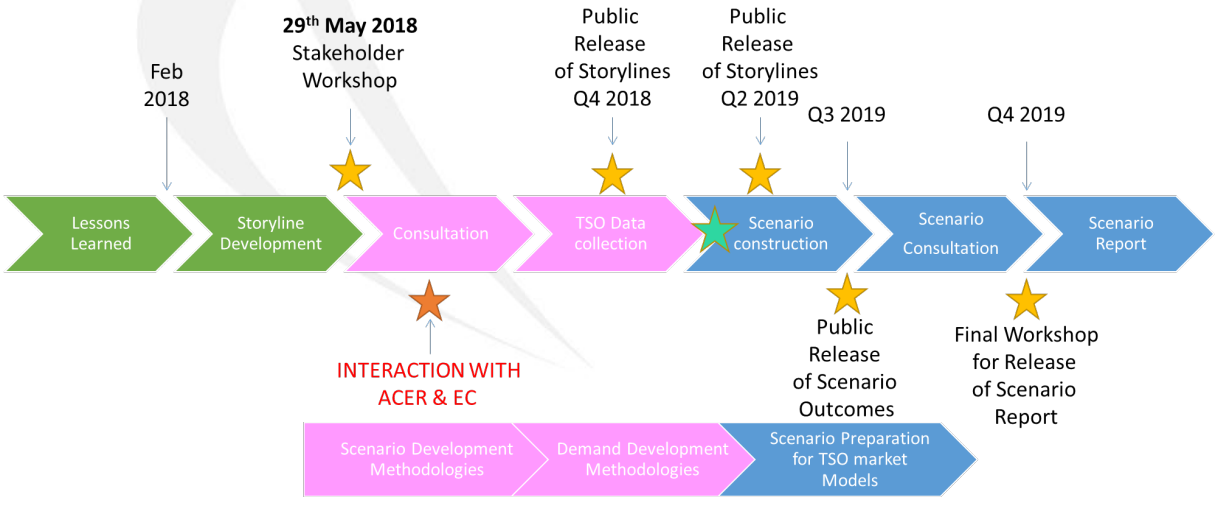

Figure 6. High level steps of gas and electricity TYNDPs 2020 Scenario Building, including more detailed scenario steps

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3.2 What happened so far?

TSOs develop storylines, using as a basis the framework provided by the TYNDP 2018 Scenario Report.

Goals of the storylines – to provide a wide range of plausible scenarios which would have different impacts on the use of electricity and gas infrastructure in the long term

Having included the EUCO 2030 Storyline in the TYNDP 2018 Scenario Report, the team was faced with the challenge of developing new scenarios, which fit the requirements set out by the European Commission and yet also allowed provided the necessary flexibility for modelling and data analysis purposes.

The Draft Storyline Report, published on 2 July 2018 provided an outline for the five initial storylines. At this point the storylines had not been quantified using either bottom-up data from the TSOs or top-down data from official sources (e.g. the Eurostat database). Instead the Storyline Report strived to offer a guideline to the goals and ambitions behind each of the five storylines individually and allow stakeholders to appreciate the differences between different storylines. Even at this stage, the scope of the different storylines was relatively complex and the working group was challenged with simplifying this information so as to provide a clear and transparent overview for stakeholders. To achieve this goal, a brief outline of each study was provided in written form with a breakdown into key energy carriers and sectors. In addition, a "Storyline Matrix" was provided which identified key features of the storyline. This matrix listed key criteria for each storyline (such as energy carriers, technology, sectoral usage and general economic conditions) and described the general growth or decline in these indicators over the course of the storyline. Growth and decline indicators were grouped broadly into four categories ranging from "No Growth/Decline" to "High/Very High Growth". The matrices offered a clear overview of the different storylines, allowing stakeholders to quickly digest the large amount of information and comprehend the context behind each storyline. The matrix-format also allowed stakeholders to quickly and simply comment on the proposed content for each storyline. This allowed the stakeholder workshop on 29th May 2018 and the subsequent consultation process to be conducted in a transparent and interactive manner.

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3.3 Storyline Workshop on 29th May 2018

The Storyline Workshop was the first opportunity for the working group to interact with stakeholders and exchange information and ideas which could support the scenario building process. It offered stakeholders the opportunity to gain insight into the methodologies and timeline for the development of the TYNDP 2020 Scenario Report. It also allowed the working group to introduce the different storylines and explain the context in which they were being developed. In addition to the presentation of the storylines and the scenario building process, a series of stakeholders were also invited to present relevant projects or research which could contribute to the selection of storylines.

During the event, each storyline was first introduced individually by team members. Stakeholders were then invited to interact with the working group and provide feedback. Stakeholders also took part in a group exercise in the final section of the workshop. Here they were divided into small groups and, working with members of the scenario building working group, developed their own storylines describing alternative scenarios until 2050. The group exercise allowed the working group to compare their own storylines with ideas from other stakeholders and to take new ideas and development paths on board.

From the 2nd July until 9th September 2018 the five storylines were made available for public consultation. The purpose of this consultation period was twofold:

- **To gather feedback from stakeholders on the strengths and weaknesses of the presented storylines.** To this end, stakeholders were provided with a feedback document in which they were ask to comment both generally on the overall credibility and consistency of the individual storylines and also specifically on a range of imported and controversial topics such as the role of coal as an energy carrier and the expected development of disruptive technologies in the future.

- **To elicit preferences for the presented scenarios**. Stakeholders were asked to choose which scenarios they would most like to see developed fully by ranking all five scenarios (favourite to least favourite). This information was then taken into account in the final scenario selection process in winter 2018.

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3.4 Initially Proposed Storylines publication in July 2018

Figure 7. TYNDP 2020 Storyline names

National Trends

The **National Trends** storyline is fairly self-explanatory. The essence of this storyline is that best available information from TSOs is collected, that fits with meeting the agreed national targets for 2020 and meeting the proposed 2030 ambitions currently proposed by the EC on an European wide basis.

TSOs have a wealth of data, information and insight that relates to each TSO's country. The data held by TSOs is based on the current short-term targets to 2020 and in the mid more certainty is coming forward in the context of 2030 with the Clean Energy Package and the negotiation on the NDPs proposed by Member States.

The storyline allows the TSOs to provide information on meeting the targets but also captures technology or market led developments that may be additional to the measures that are applied at a policy level. Beyond 2030, the national trends visible from the data provided will form the basis of the achievement of the long-term energy and decarbonisation goals of the EU.

Global Ambition

The **Global Ambition** storyline is a world where the decarbonisation ambition is embraced by society, global policies and a drive by countries to actively promote worldwide decarbonisation. The storyline looks at a future that is led by economic development in centralised generation, economies of scale lead to significant cost reductions in emerging technologies such as offshore wind and Power-to-X. The flexibility and seasonal storage challenges are solved with the use of hydro resource and Power-to-Gas facilities, which also contributes amongst other solutions to the decarbonisation of the gas mix.

European Focus

The European Focus storyline follows the proposals for the European energy transition. The Storyline provides a central view from the European Commission on technology and policy. In addition, this envisaged pathway achieves the targets and ambitions for the near and mid-term horizons. The long-term strategy is closely linked to the EU roadmap that achieves at least 80 % GHG reduction by 2050.

Distributed Energy

Distributed Energy is a storyline that embraces a de-centralised approach to the energy transition. The theme for the scenario means the energy consumer is actively participating in the energy market and helping to drive the system's decarbonisation. The consumer evolves from not just consuming energy, becoming a more integrated part of the system, which is enabled by small household, community lead and regional energy schemes that deliver value to the end user in terms of security of supply and society's decarbonisation ambition is to achieve 95 % GHG reduction in 2050.

Delayed Transition

The Delayed Transition storyline represents a world where the decarbonisation is a future objective and efforts are being made to reach the European targets, but where the progress of the energy transition is delayed or stagnant. This is caused by a potential combination of factors, such as the failure of policies, resistance to change within the energy sector, limited engagement from society or less progression in the development of decarbonisation technologies that would help enable the transition.

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3.5 Received Consultation Feedback

The scenario storyline consultation received 33 responses. These came from a wide range of national and European organisations including energy companies, environmental organisations, national regulatory authorities and research institutes. Due to the logical conflict of interest that may occur, it is standard policy within both ENTSOs, that member TSOs do not provide comment on ENTSO-publications. In this case one response was provided by a member TSO. This response was not considered within the results of the stakeholder consultation.

Feedback on National Trends

Many of the comments relating to the **National Trends** storyline focused on the credibility of its decarbonisation goals. Many stakeholders pointed out that the CO2 emissions savings were far below the targets set out by the Paris Agreement and therefore that the storyline was not fully aligned with national decarbonisation targets. ENTSOs will therefore align the scenario data with the latest available information on the NECPS. Critics has also been raised with regard to the ten year horizon of NECPs. Therefore, bottom-up data stemming from NDPs and national long-term plans on climate mitigation will also be taking into account. Nevertheless, ENTSOs acknowledge that this scenario will be based on EU and national climate targets of 80-95 % CO2 emissions reduction by 2050.

While above mentioned criticism is understandable it somewhat misses the point of the **National Trends** storyline, which was to underline the difficulty in achieving higher global climate targets without a coordinated international effort. In addition, the storyline hoped to draw attention to the fact that certain European nations appear unlikely to achieve the climate goals of the Paris Agreement of keeping the temperature increase below 1,5 degrees due to economic or social limitations. Several stakeholders also noted that private (non-state) investment in RES was noticeably less than in other storylines. This lack of investment was consciously intended by the working group to depict how a failure to form cohesive cross-border climate policies may result in a slower market development for RES technologies.

Stakeholders have also remarked that the role of some decentralized technologies, such as Combined Heat an Power and district heating, is neglected. Due to the character of the storyline, those technologies based on national policies and targets will be taken into account.

As a general remark, **National Trends** is seen as a ”policy as usual” scenario or to keep it simple as a Central Policy scenario.

Feedback Global Ambition

Many stakeholders felt that the initial outline for the **Global Ambition** storyline was not ambitious enough and argued that this scenario should seek to achieve full carbon neutrality instead of merely 95% CO2 emissions reductions. This sentiment was noted and the storyline was subsequently updated to meet the target of the Paris Agreement of keeping temperature increase below 1,5 degree Celsius by applying a carbon budget. In 2050 the storyline will reach a full decarbonisation. Several stakeholders felt that energy supply under this storyline was too centralised. Furthermore, some stakeholders felt that too much emphasis was placed on the import of renewable fuels from outside the EU. While there are certainly valid arguments, it was also an intention of the **Global Ambition** storyline to portray a particularly centralised energy generation process in comparison to the **Distributed Energy** storyline, which provides a far more decentralised view. Likewise the centralisation of energy generation, as is the case today, is naturally far more dependent on the global energy trade. It seems reasonable to presume that in 2050, even with increasingly localised

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energy production through the growth in RES sources, that a certain portion of European energy demands will be met by suppliers from outside the EU.

Feedback Distributed Energy

As with the **Global Ambition** storyline, several stakeholders were unconvinced by the extremely decentralised nature of energy generation in the **Distributed Energy** storyline and felt it lacked realism. The working group intended for the **Global Ambition** and **Distributed Energy** to effectively depict two extreme variants of a highly decarbonised Europe. The two variants show the challenges which will be faced by infrastructure planners during the Energy Transition, either by heavily centralised or decentralised energy generation. Nevertheless, this will not mean that **Distributed Energy** will not also rely on (large scale) gas power plants as a back-up for the intermittent renewables, on large scale Power-to-Gas facilities to ensure a sufficient sectorial integration and to a certain extent on off-shore wind power generation to meet the increasing electricity demand both for direct and indirect (P2G) electrification. Still, compared to **Global Ambition**, the shares of such above mentioned technologies will be smaller.

Stakeholders also commented on the political framework necessary to effectively develop decentralised generation in this manner. There was uncertainty about the ETS prices necessary to incentivise development of this storyline. It is worth repeating that the ENTSOs explicitly avoid making reference to specific national or European policies which may be necessary to incentivise development. It is assumed that the political and regulatory framework, on a national and European level, is optimal for the development outlined in the storyline.

Feedback Delayed Transition

The **Delayed Transition** storyline was the least popular storyline amongst stakeholders. Of the five storylines put to the stakeholders in the consultation process, this was considered the least consistent and the least credible. This response was somewhat surprising for the working group. During the 2018 TYNDP scenario building process, there were requests from major stakeholders to also offer a credible alternative scenario in which EU nations fail to meet their own and also ambitious targets of the Paris Agreement due to economic or political issues. As such, **Delayed Transition** intended to show a scenario in which climate targets would not be achieved until sometime after 2050. Several stakeholders felt that the implied link between low economic growth and a slower-than-usual development of RES technologies was inaccurate. They argued that political will, rather than weak economic conditions, was the key factor in the success of the Energy Transition. The working group felt that support for RES development through state-funding or favourable taxation or levy policies was directly responsible for an increase in RES investments. They argued that these favourable conditions were more likely to occur in nations with stronger economies and at time of higher economic growth. They pointed to the strong development of RES technologies in Germany made possible by economic growth, and the lack of RES development in Italy which has been hampered by difficult economic divisions. Nevertheless, ENTSOs acknowledge that again with regard to the German example, high economic growth can also lead to the case that though investments in RES development are high, climate targets can't be met because of increasing energy demand, low energy efficiency measures and not sufficient policies when it comes to fuel switch in the transport and power sector. Therefore, both economic growth and the right policies (on national, EU and global level) will frame the energy transition.

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Feedback European Focus

With regard to the EUCO30 scenario in the 2018 scenario building process, **European Focus** was meant to be a place holder for an external scenario, as requested by the European Commission. It was clear from the stakeholder feedback that the **European Focus** scenario was viewed by many as being quite similar to **National Trends**. In addition to the feedback received within the scope of the consultation process, the working group also held extended bilateral meetings with the two key stakeholders/sponsors: the European Commission and ACER to elicit detailed feedback on the development of the storylines and the scenario building process in general. The ENTSOs, EC and ACER have jointly agreed that the **National Trends** Scenario; provided it meets national and EU targets, will substitute the **European Focus** scenario. For this, the ENTSOs will cooperate with EC to align the **National Trends** data set with the latest available information stemming from the NECPs.

Other Feedback

- **Carbon Capture and Storage/Use:** Stakeholders recommend to consider CCS in the more ambitious scenarios, especially considering a carbon budget and the necessity to not only reach a decarbonisation target in 2050, but also abate CO2 emissions in the short term. They foresee a role for CCS in the industry, the power sector, as well as pre-combustive CCS technology to decarbonise natural gas via Steam Methane Reforming in combination with CCS/U.
- **Energy Efficiency:** Energy Efficiency should play a major role in the energy transition from the external stakeholders' point of view. Key sectors where efficiencies can have a significant impact include building (low temperature heating) and transport where electrification could be a game changer. ENTSOs acknowledge this and will assess the possible penetration of different electrified end-user devices in all sectors.
- **Data Centers :** Data centers are seen as an important factor in future societies increasing the electricity demand especially in decentralized scenarios. ENTSOs will include additional load for data centers based bottom-up data submitted by the TSOs.
- **Carbon Budget/Paris Agreement Compliance:** Many Stakeholders ask for compliance with more ambitious climate targets, especially in the frame of COP21 and the aim of keeping global temperature increase below 1,5 degrees. ENTSOs will include a carbon budget in the two top-down scenarios **Global Ambition** and **Distributed Energy**.
- **Synergies between gas and electric grids/infrastructure:** Stakeholders ask for more analysis of existing and future synergies between gas and electricity infrastructure, demand and supply. Due to the unique character of the joint scenarios profiting by the deep knowledge of both the gas and electricity TSOs, ENTSOs will further improve their scenarios by creating top-down scenarios assessing sectoral interactions (e.g. fuel switch, hybrid demand solutions etc.) and integration (e.g. gas fired power plants, Power-to-Gas etc.).

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3.6 Selection of Storylines to be developed to Scenarios

As for TYNDP 2018, ENTSOs have selected three storylines out of the five presented initially, which will be developed into scenarios to be used as input for the TYNPD 2020.

ENTSOs' Preference
In a first step, the ENTSOs consulted the storylines internally with their members. From a gas and electricity grid operator's point of view differing scenarios are necessary to show their impact on network operation and assess the network needs in an robust assessment. Moreover, it is of high interest for the TSOs to also respect latest national policy decisions into account, since future grid projects have also be seen as energy transition enablers and their lack can be a barrier. Therefore, members of the ENTSOs have stated their strong preference for **National Trends** as the bottom-up scenario, which relies on the latest NDP and NECP. To capture current and future trends such as decarbonisation and de-/centralisation, **Global Ambition** and **Distributed Energy** are the other two preferred scenarios that provide a stress case for more ambitious EU wide energy transition targets.

Stakeholders' Preference
Based on the feedback we have received, Stakeholders prefer following scenarios: **Distributed Energy**, **Global Ambition** and **European Focus**. This can be seen as a strong preference for more ambitious scenarios, since all three scenarios comply with the EU targets for 2030 and 2050. For a better understanding of the final storyline selection, it has to be said, that **European Focus** was a placeholder for scenarios, submitted or requested by the European Commission (EC), as it was the case in the TYNDP 2018 for EUCO30.

European Commission's Preference
During the scenario building process for the TYNDP 2018, EC requested the ENTSOs to include EUCO30 as part of the Scenario Report 2018, replacing Global Climate Action in 2030. As part of the European Commission's (EC) impact assessment work in 2016, EUCO30 was a core policy scenario, created using the PRIMES model and the EU Reference Scenario 2016 as a starting point. The scenario models the achievement of the 2030 climate and energy targets as agreed by the European Council in 2014, but including an energy efficiency target of 30%. As a result, the scenario created using the input data from EUCO30 has replaced Global Climate Action for 2030 within the TYNDP framework.
ENTSOs wanted to be prepared for this discussion this time round, including **European Focus** which could be used as a placeholder for the latest EUCO version (or any other external scenario).
During intensive discussions, both parties, EC and ENTSOs have decided to develop **National Trends** into a national policy scenario taking into account the latest information on the NECP, but also not to include an external scenario as it was done for TYNDP 2018.

Final Scenario Selection
Based on the ENTSOs', EC's and external Stakeholders' preferences **National Trends**, **Global Ambition** and **Distributed Energy** were chosen to be developed to scenarios. Following above mentioned EC preference, **European Focus** can be substituted by **National Trends**, which ensures full alignment between all three Stakeholder groups and makes a "one size fits all" selection possible.

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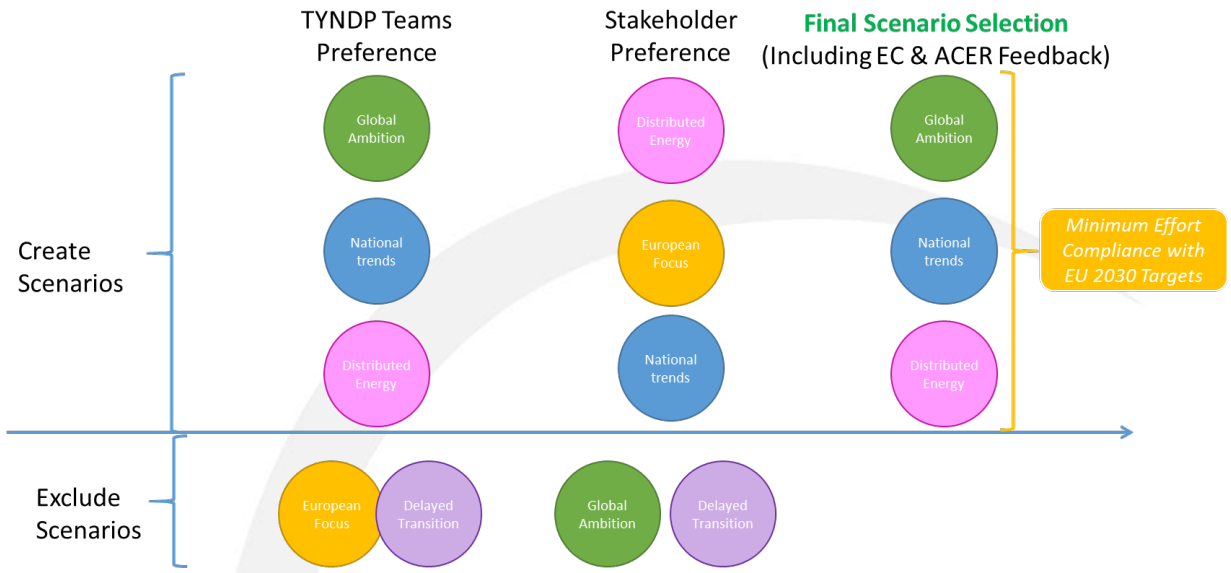

Figure 8: Final Scenario Selection (3 out of 5)

The next steps within the scenario building process is to assign the storylines to the trajectories defined within the scenario framework. The ENTSOs scenario building approach uses two high level principles for scenario construction:

"Bottom-Up" scenario building process.

- This approach collects supply and demand data from Gas and Electricity TSOs
- The TSOs are provided with a data collection guideline that is used to ensure that scenario data is compatible with the appropriate storyline.

"Top-Down Carbon Budget" scenario suilding process.

- This approach uses the "bottom-up" model information gathered from the Gas and Electricity TSOs
- The methodologies are developed in line with the Carbon Budget approach
- The "Carbon Budget" scenarios are built within boundaries, they are built to ensure that supply and demand are balanced, EU-28 targets are an important consideration in the "optimization" phase of the process.
- The "Carbon Budget" methodologies seek to ensure that efficient outcomes are achieved complimentary to what commitments currently agreed and under consideration.

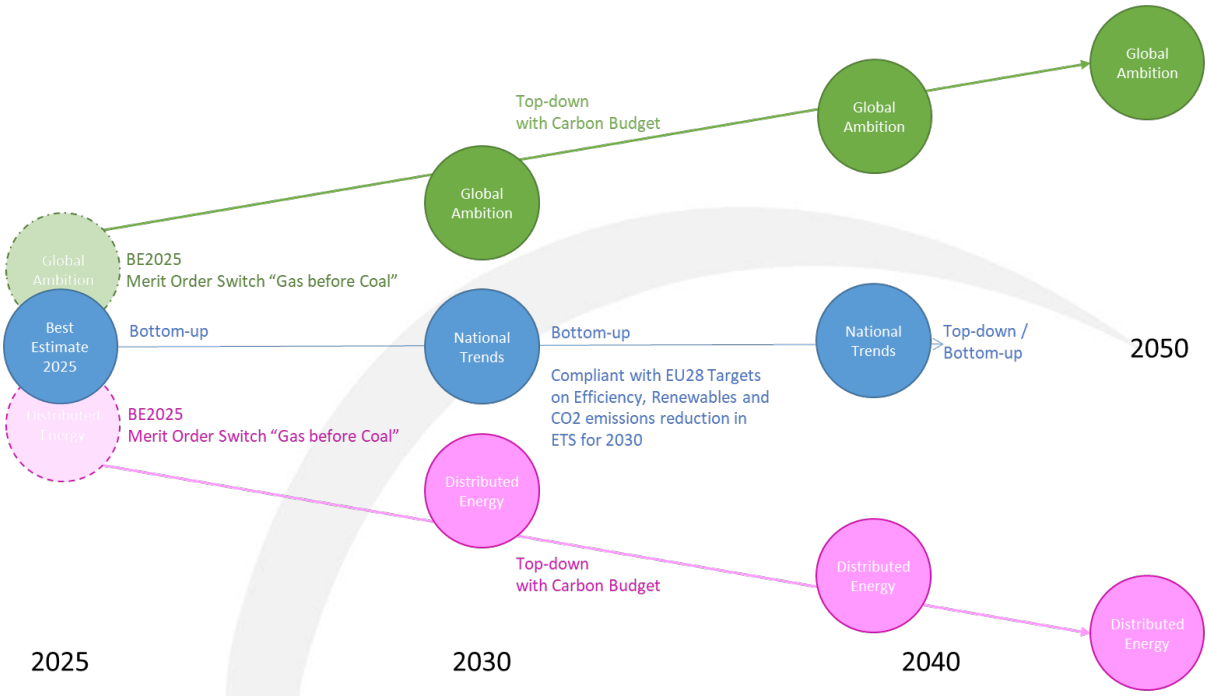

Figure 9: Final Scenario applied to the TYNDP 2020 Scenario Framework

The final scenarios for **National Trends**, **Global Ambition** and **Distributed Energy** can be represented in terms of decarbonisation ambition as illustrated in Figure 2 and Figure 3. Figure 3 represents a number of key elements for the overall storyline. The "Carbon Budget" scenarios **Distributed Energy** and **Global Ambition** are two transition pathways ("What if scenarios?") that aim for carbon neutrality in the energy sector by 2050. The "Carbon Budget" scenarios require a high degree of innovation and cost reductions in technologies to achieve the required decarbonisation levels. The **National Trends** pathway represents a pathway that tracks the market trends, EU and national policies within the European energy sector. **National Trends** has more limited aspirational ambition for decarbonication since it currently focuses on the minimum effort required for 2050. The value of **National Trends** scenario is that it is flexible, especially as governments, EC policy and the markets respond to the call for climate action.

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3.7 Next Steps?

Once the storylines are selected and the EU-28 annual supply and demand figures are created, the detailed input data for the gas and electricity can be created.

The joint Scenario Building Working Group are reponsible for developing:

- Demand Profiles for gas and electricity models
  - What is the impact of energy efficiency?
  - What is the share of transport demand covered by gas and electricty?
  - What is the share of heating demand covered by gas and electricty?
  - Are there new demands that enter the European market?
- On the supply side?
  - What RES sources are increasing share depending on the scenarios?
  - What can be done to decarbonised the gas mix?
  - P2X seasonal storage?

The following flow chart shows the high level scenario building process:

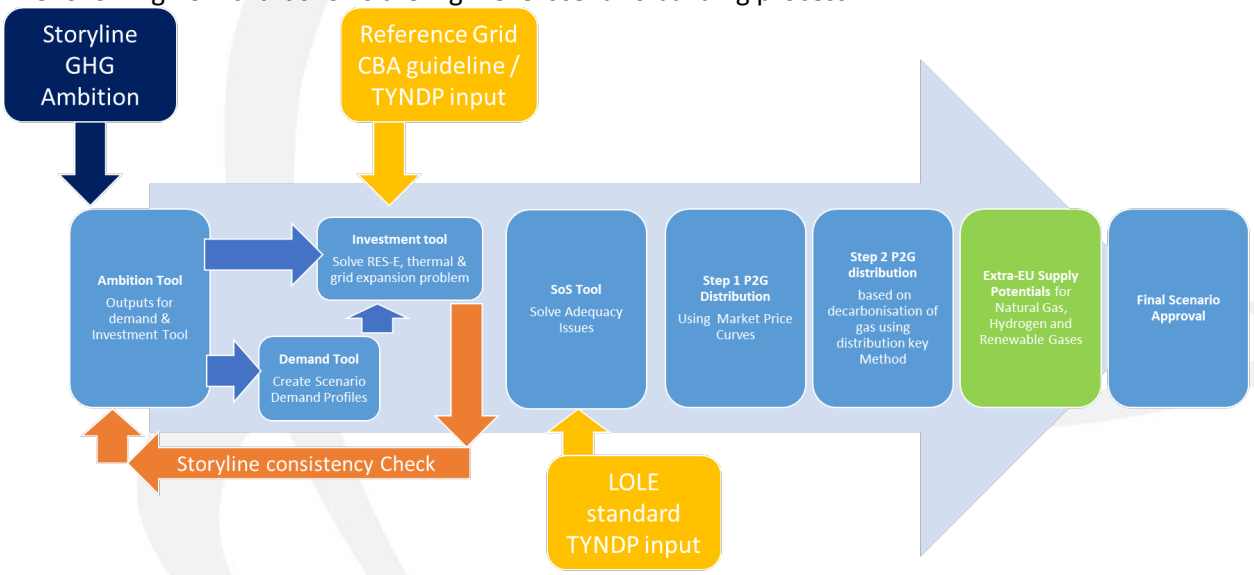

Figure 10: Scenario Building Steps

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