2040 story lines document

The elaboration of the electricity and gas TYNDPs to be released in 2018 have begun. The first task, in the network development exercise, is to define relevant energy scenarios for the European future.

So far, for the 2040 time horizon, five story lines have been derived:

- Vision 1: Global climate action – page 4
- Vision 2: Subsidized Green Europe – page 6
- Vision 3: Sustainable Transition – page 8
- Vision 4: Behind Targets – page 10
- Vision 5: Distributed generation –page 12

The story lines address the overall EU situation for both gas and electricity sectors and have been built taking into account both sectors expertise.

ENTSO-E and ENTSOG aim with this consultation to hear your opinion on the proposed 2040 assumptions. Your feedback will guide both gas and electricity ENTSOs to refine the 2040 visions for the next 2018 TYNDPs. The aim is to have up to three visions for this specific time horizon.

How to read this document

The document starts with an overview of all five proposed 2040 visions (page 3).

Further on (pages 4 to 13) for each of them we have allocated two pages which we recommend to be read together. The first page of each vision describes the overall story line and the second page presents, in a table format, how each of the relevant parameters varies.

Please note that each parameter has a range of values to indicate the uncertainty for the respective topics. In the table the choices for the parameters used in the story line are highlighted in green.

After reading this document you are kindly invited to return to the consultation page and answer the questions related to the 2040 visions.

Overview of the current story lines

Scenario		Global climate action	Subsidized Green Europe	Sustainable Transition	Behind Targets	Distributed Generation
Category	**Criteria**	**Parameter**				
Macroeconomic Trends	**Climate action driven by**	Global ETS	Global ETS & direct RES subsidies	EU ETS & direct RES subsidies	Climate action low	EU ETS
	EU on track to 2050 target?	Yes	Yes	Slightly behind	Behind	Yes
	Economic conditions	High growth	High growth	Moderate growth	Low growth	High growth
Transport	**Electric and hybrid vehicles**	High growth	High growth	Moderate growth	Low growth	Very high growth
	Gas vehicles and shipping	High growth	High growth	Moderate growth	Low growth	Very high growth
Residential / Commercial	**Demand flexibility**	High growth	High growth	Moderate growth	Low growth	Very high growth
	Electric heat pump	Moderate growth	Very high growth	Low growth	Low growth	Moderate growth
	Energy efficiency	Moderate growth	Very high growth	Moderate growth	Low growth	High growth
	Hybrid heat pump	Very high growth	Moderate growth	Moderate growth	Low growth	Very high growth
Industry	**electricity demand**	Stable	Favourable development	Stable	Stable	Favourable development
	gas demand	Stable	Reduction	Stable	Stable	Reduction
	demand flexibility	Moderate growth	Low growth	Low growth	Low growth	Very high growth
Power	**Merit order**	Gas before coal	In par	Gas before coal	Coal before gas	Gas before coal
	Nuclear	Potential for growth	Stable	Minimum new units	Reduction	Reduction
	Storage	Moderate growth	High growth	Low growth	Low growth	Very high growth
	Wind	High growth	Very high growth	Moderate growth	Low growth	High growth
	Solar	High growth	Very high growth	Moderate growth	Low growth	Very high growth
	CCS	Not significant	Not significant	Not significant	Not significant	Not significant
	Adequacy	Some surplus capacity	High surplus capacity	Some surplus capacity	Low surplus capacity	High surplus capacity
Gas Supply	**Power-to-gas**	High growth	High growth	Not significant	Not significant	High growth
	Shale Gas	Not significant	Not significant	High growth	Low growth	Not significant
	Bio Methan	High growth	High growth	High growth	Not significant	High growth

1. Vision 1: Global climate action story line

The "Global climate action" story line considers global climate efforts. Global methods regarding CO2 reductions are in place, and the EU is on track towards its 2050 decarbonisation targets. An efficient ETS trading scheme is a key enabler in the electricity sector's success in contributing to Global/EU decarbonisation policy objectives. In general renewables are located across Europe where the best wind, solar resources are found.

A CO2 market price provides the correct market signals that trigger investments in low-carbon power generation technologies and for flexibility services. A technology-neutral framework is established, which supports both investments in renewables and nuclear power. Power-to-gas becomes a commercially viable technology for use as energy storage. The CO2 price makes natural gas fired CCGTs appear before coal in the merit order. Gas-fired units provide flexibility needed within the power market, helping facilitate intermittent renewable technologies within the market. Carbon capture and storage has not developed to widespread commercial use. System adequacy is driven by price signals, which allows market-based investments in peaking power plants to be made.

The efficient and widespread implementation of global climate schemes prevents carbon leakage between countries, therefore improving the relative competitiveness of energy intensive industries within Europe.

Electricity and natural gas are both key components for the transport sector in reaching emission reduction goals. The impact of electrification is that demand for electricity use in the private and small commercial transportation sector increases. There an increase in the use of LNG for the transportation of heavy goods and also in the shipping sectors.

Electric and hybrid heat pumps are a significant technology in heating sector, helping to offset the use of fossil heating fuels. All electric heat pumps are installed in new high efficiency buildings, while hybrid heat pumps are installed in existing lower efficiency buildings with an existing gas connection.

Demand response in both industrial and residential sectors has increased - increased automation and internet of things gives consumers the option to move their demand to the lower-priced hours. Demand flexibility is also a key factor ensuring system adequacy due to its ability to shift demand peaks.

Yearly electricity demand has increased in various sectors, overall electricity demand growth is limited by increasing energy efficiency. High GDP growth means that people invest in high efficiency produces such as, lighting, computers, and white goods all of which help to reduce the overall residential consumption.

Yearly final gas demand is increasing in the transport sector and whilst decreasing in the residential sector, driven mainly from improvements in technology efficiencies and building insulation measures. Gas is required for peak demand situation, such as, cold weather conditions. Industrial gas demand for heating is stable in this scenario.

Factor		Scenario Overview				
Scenario		**Global climate action**	Subsidized green Europe	Sustainable Transition	Behind Targets	Distributed generation
Category	**Criteria**	**Parameter**				
Macroeconomic Trends	**Climate action driven by**	Climate action low	EU ETS	EU ETS & direct RES subsidies	Global ETS	Global ETS & direct RES subsidies
	EU on track to 2050 target?	Behind	Slightly behind	Yes		
	Economic conditions	Low growth	Moderate growth	High growth		
Transport	**Electric and hybrid vehicles**	Low growth	Moderate growth	High growth	Very high growth	
	Gas vehicles and shipping	Low growth	Moderate growth	High growth	Very high growth	
Residential / Commercial	**Demand flexibility**	Low growth	Moderate growth	High growth	Very high growth	
	Electric heat pump	Low growth	Moderate growth	High growth	Very high growth	
	Energy efficiency	Low growth	Moderate growth	High growth	Very high growth	
	Hybrid heat pump	Low growth	Moderate growth	High growth	Very high growth	
Industry	**electricity demand**	Reduction	Stable	Favourable development		
	gas demand	Reduction	Stable	Favourable development		
	demand flexibility	Low growth	Moderate growth	High growth	Very high growth	
Power	**Merit order**	Coal before gas	In par	Gas before coal		
	Nuclear	Reduction	Stable	Minimum new units	Potential for growth	
	Storage	Low growth	Moderate growth	High growth	Very high growth	
	Wind	Low growth	Moderate growth	High growth	Very high growth	
	Solar	Low growth	Moderate growth	High growth	Very high growth	
	CCS	Not significant	Low growth	Moderate growth	High growth	
	Adequacy	Low surplus capacity	Some surplus capacity	High surplus capacity		
Gas Supply	**Power-to-gas**	Not significant	Low growth	Moderate growth	High growth	
	Shale Gas	Not significant	Low growth	Moderate growth	High growth	
	Bio Methane	Not significant	Low growth	Moderate growth	High growth	

2. Vision 2: Subsidized green Europe story line

In the "Subsidized Green Europe" story line, climate policy consists of subsidy mechanisms that directly support renewables technologies. Subsidy schemes may mean that renewables are located across Europe where the wind, solar resource location may not be optimal.

Subsidies for renewable electricity generation continue to suppress the wholesale electricity price and in turn the ETS carbon price is relatively low. Weak CO2 price signals mean that investments in capital-intensive unsubsidized base load generation are unattractive. The CO2 price is not a significant component of electricity generation cost, coal and gas are on par in the merit order; however, given that there is growth in renewables, gas-fired generation is preferred due to its flexibility. Power-to-gas in order becomes a commercially viable technology for use as energy storage. In order to avoid price volatility and periods of scarcity, backup and peaking capacity is ensured by subsidizing it separately, thus ensuring system adequacy. Carbon capture and storage has not developed to widespread commercial use.

Electricity and natural gas are both key components for the transport sector in reaching emission reduction goals. The impact of electrification is that demand for electricity use in the private and small commercial transportation sector increases. There an increase in the use of LNG for the transportation of heavy goods and also in the shipping sectors.

Electric and hybrid heat pumps are a significant technology in heating sector, helping to offset the use of fossil heating fuels. Subsidy schemes are available for renovation of existing building stock. With improved building efficiencies into both existing and new buildings all electric heat pumps are the preferred option to hybrid heat pumps. Hybrid heat pumps are installed only in existing low efficiency buildings with an existing gas connection.

Yearly electricity demand has increased in various sectors, overall electricity demand growth is highest due to electrification within the residential heating sector. Subsidies for generation peaking capacity limit business opportunities for market-based demand response.

The yearly final gas demand is increasing in the transport sector. Annual gas demand is decreasing in the residential sector, driven mainly from all electric heating technologies, and building insulation measures. Gas is required for peak demand situation, such as, cold weather conditions. Industrial gas demand is decreasing in this scenario, driven by electrification of industrial process heating. The gas demand for other energy intensive industry processes is stable.

Factor		Scenario Overview				
Scenario		Global climate action	**Subsidized green Europe**	Sustainable Transition	Behind Targets	Distributed generation
Category	**Criteria**	**Parameter**				
Macroeconomic Trends	**Climate action driven by**	Climate action low	EU ETS	EU ETS & direct RES subsidies	Global ETS	Global ETS & direct RES subsidies
	EU on track to 2050 target?	Behind	Slightly behind	Yes		
	Economic conditions	Low growth	Moderate growth	High growth		
Transport	**Electric and hybrid vehicles**	Low growth	Moderate growth	High growth	Very high growth	
	Gas vehicles and shipping	Low growth	Moderate growth	High growth	Very high growth	
Residential / Commercial	**demand flexibility**	Low growth	Moderate growth	High growth	Very high growth	
	Electric heat pump	Low growth	Moderate growth	High growth	Very high growth	
	Energy efficiency	Low growth	Moderate growth	High growth	Very high growth	
	Hybrid heat pump	Low growth	Moderate growth	High growth	Very high growth	
Industry	**electricity demand**	Reduction	Stable	Favourable development		
	gas demand	Reduction	Stable	Favourable development		
	demand flexibility	Low growth	Moderate growth	High growth	Very high growth	
Power	**Merit order**	Coal before gas	In par	Gas before coal		
	Nuclear	Reduction	Stable	Minimum new units	Potential for growth	
	Storage	Low growth	Moderate growth	High growth	Very high growth	
	Wind	Low growth	Moderate growth	High growth	Very high growth	
	Solar	Low growth	Moderate growth	High growth	Very high growth	
	CCS	Not significant	Low growth	Moderate growth	High growth	
	Adequacy	Low surplus capacity	Some surplus capacity	High surplus capacity		
Gas Supply	**Power-to-gas**	Not significant	Low growth	Moderate growth	High growth	
	Shale Gas	Not significant	Low growth	Moderate growth	High growth	
	Bio Methane	Not significant	Low growth	Moderate growth	High growth	

3. Vision 3: Sustainable Transistion story line

In "Sustainable Transition" story line, climate action is achieved with a mixture of national regulation, emission trading schemes and subsidies. National regulation takes the shape of legislation that imposes binding emission target. Overall, the EU is slightly behind the 2050 decarbonisation goals. However targets are still achievable if rapid progress is made in decarbonising the power sector during 2040's.

The economic climate in the Sustainable Transition scenario is moderate growth, regulation and subsides are achievable since there is the capital available by national governments to fund RES projects (both intermittent and non-intermittent). There is a societal ambition to support and participate in climate action.

Gas-fired power generation flourishes due to relatively cheap global gas prices, and strong growth of bio methane and shale gas. A regulatory framework in place decreases the use of coal-fired power stations. Gas-fired generation provides the necessary flexibility to balance renewables in the power system. There is a decrease in CO2 emissions since much coal fired base load power generation retires or is out of merit due to a reasonably high ETS Carbon prices and governmental policies. Nuclear power can be competitive as an option for base load depending on national policies. Carbon capture and storage has not developed to widespread commercial use. Efficient electricity market and strong price signals ensure necessary investment to peaking power generation, with gas being the preferred fuel

There are no significant changes in the heat generation; in most countries, gas will remain the most prominent source, however the use will decrease due to increasing energy efficiency. Hybrid heat pumps are considered an option in new buildings. Industrial gas and electricity demand is relatively stable. Development of energy efficiency is moderate. Electricity use for residential transport is growing moderately, as is the gas use for heavy-duty vehicles and ships.

Overall electricity demand stagnates or grows moderately. Gas use increases for transport and power generation, but slightly decreases for heating.

Factor		Scenario Overview				
Scenario		Global climate action	Subsidized green Europe	**Sustainable Transition**	Behind Targets	Distributed generation
Category	**Criteria**	**Parameter**				
Macroeconomic Trends	**Climate action driven by**	Climate action low	EU ETS	EU ETS & direct RES subsidies	Global ETS	Global ETS & direct RES subsidies
	EU on track to 2050 target?	Behind	Slightly behind	Yes		
	Economic conditions	Low growth	Moderate growth	High growth		
Transport	**Electric and hybrid vehicles**	Low growth	Moderate growth	High growth	Very high growth	
	Gas vehicles and shipping	Low growth	Moderate growth	High growth	Very high growth	
Residential / Commercial	**demand flexibility**	Low growth	Moderate growth	High growth	Very high growth	
	Electric heat pump	Low growth	Moderate growth	High growth	Very high growth	
	Energy efficiency	Low growth	Moderate growth	High growth	Very high growth	
	Hybrid heat pump	Low growth	Moderate growth	High growth	Very high growth	
Industry	**electricity demand**	Reduction	Stable	Favourable development		
	gas demand	Reduction	Stable	Favourable development		
	demand flexibility	Low growth	Moderate growth	High growth	Very high growth	
Power	**Merit order**	Coal before gas	In par	Gas before coal		
	Nuclear	Reduction	Stable	Minimum new units	Potential for growth	
	Storage	Low growth	Moderate growth	High growth	Very high growth	
	Wind	Low growth	Moderate growth	High growth	Very high growth	
	Solar	Low growth	Moderate growth	High growth	Very high growth	
	CCS	Not significant	Low growth	Moderate growth	High growth	
	Adequacy	Low surplus capacity	Some surplus capacity	High surplus capacity		
Gas Supply	**Power-to-gas**	Not significant	Low growth	Moderate growth	High growth	
	Shale Gas	Not significant	Low growth	Moderate growth	High growth	
	Bio Methane	Not significant	Low growth	Moderate growth	High growth	

4. Vision 4: Behind Targets story line

The "Behind Targets" story line considers a future with low economic growth, which restricts societal ambition to meet the climate targets, due to the perceived high costs associated with RES solutions. The EU is significantly behind its interim goals on a path towards the 2050 targets. The ETS CO2 price is stuck at low level, and this in turn results in low RES-Electricity growth potential. National renewable subsidies are not a viable alternative due to financial pressures. There is scarcity of global financing for new RES-Electricity projects since there is not a strong ETS price or subsidies available to support RES-Electricity business cases. The Global framework on climate action is weak, and there is little willingness for unilateral action on EU side.

Coal and lignite are widely used in power generation, with coal running before gas in the merit order. New gas power plant investments are challenged by low profitability, investment occurs in prolonging the lifetime in the existing power plant portfolio. Renewables are developing only modestly. Carbon capture and storage has not developed to widespread commercial use. Power adequacy is achieved through national security of supply contracts by keeping existing units online in the extent necessary. Poor market conditions do not provide the required price signals to incentivize investment in new Gas power generation.

Electricity and gas as alternative fuels have not been widely adopted in the transportation sector. Innovation in the transportation sector remains with hybrid and biofuel technologies as the preferred method of decarbonization. Heating solutions focus on conventional solutions such as gas boilers and CHP, with a low emphasis on heat pumps and biofuels. Energy-intensive industry stagnates due to low economic growth, however risk of carbon leakage is also reduced. Energy efficiency measures are limited since the economic climate prevents investment in higher efficiency devices. The cost of highly efficient consumer devices remains high, therefore residential and commercial electricity demand tends to increase. There is little innovation in the demand response sector, since costs are high and investment capital availability is low.

Factor		Scenario Overview				
Scenario		Global climate action	Subsidized green Europe	Sustainable Transition	**Behind Targets**	Distributed generation
Category	**Criteria**	**Parameter**				
Macroeconomic Trends	**Climate action driven by**	Climate action low	EU ETS	EU ETS & direct RES subsidies	Global ETS	Global ETS & direct RES subsidies
	EU on track to 2050 target?	Behind	Slightly behind	Yes		
	Economic conditions	Low growth	Moderate growth	High growth		
Transport	**Electric and hybrid vehicles**	Low growth	Moderate growth	High growth	Very high growth	
	Gas vehicles and shipping	Low growth	Moderate growth	High growth	Very high growth	
Residential / Commercial	**demand flexibility**	Low growth	Moderate growth	High growth	Very high growth	
	Electric heat pump	Low growth	Moderate growth	High growth	Very high growth	
	Energy efficiency	Low growth	Moderate growth	High growth	Very high growth	
	Hybrid heat pump	Low growth	Moderate growth	High growth	Very high growth	
Industry	**electricity demand**	Reduction	Stable	Favourable development		
	gas demand	Reduction	Stable	Favourable development		
	demand flexibility	Low growth	Moderate growth	High growth	Very high growth	
Power	**Merit order**	Coal before gas	In par	Gas before coal		
	Nuclear	Reduction	Stable	Minimum new units	Potential for growth	
	Storage	Low growth	Moderate growth	High growth	Very high growth	
	Wind	Low growth	Moderate growth	High growth	Very high growth	
	Solar	Low growth	Moderate growth	High growth	Very high growth	
	CCS	Not significant	Low growth	Moderate growth	High growth	
	Adequacy	Low surplus capacity	Some surplus capacity	High surplus capacity		
Gas Supply	**Power-to-gas**	Not significant	Low growth	Moderate growth	High growth	
	Shale Gas	Not significant	Low growth	Moderate growth	High growth	
	Bio Methane	Not significant	Low growth	Moderate growth	High growth	

5. Vision 5: Distributed generation story line

In the "Distributed generation" story line, significant leaps in innovation of small-scale generation and residential /commercial storage technologies are a key driver in climate action. An increase in small-scale generation keeps EU on track to 2050 targets. A “prosumer” rich society has bought into the energy markets, so society is engaged and empowered to help achieve a decarbonized place to live.

Small-scale generation technologies costs have been rapidly declining. Technologies such as solar offer a non-subsidised option for “prosumers” in most parts of Europe. Major advances in batteries enable "prosumers" to balance their own electricity consumption within a day. Power-to-gas becomes a commercially viable technology for use as energy storage. Technological leaps in small-scale generation challenge large-scale power generation, pressurizing the profitability of traditional power plants. System adequacy is maintained through a centralised mechanism that retains enough peaking capacity, district heating CHP are suitable for both heating and electricity adequacy. The scenario has a strong ETS scheme which favours gas before coal in the power market.

There is a strong EU climate policy in place, the decreasing cost of small-scale generation technologies drives down the cost of climate action. As solar yields are higher in Southern Europe, investments are likely to be higher in these regions, in comparison to Northern Europe.

Electricity demand flexibility has substantially increased, both in residential and industrial solutions, helping electric power adequacy. However, wintertime with high heating needs and low solar availability remains a challenge, since batteries cannot be used for seasonal storage.

Electricity and natural gas are both key components for the transport sector in reaching emission reduction goals. Lower battery costs have significantly increased demand for electricity in transportation sector. Electrification and gasification compete on a par for the private and small commercial transportation sector. There an increase in the use of LNG for the transportation of heavy goods and also in the shipping sectors.

Electric and hybrid heat pumps are a significant technology in heating sector, helping to offset the use of fossil heating fuels. With improved building efficiencies into both existing and new buildings hybrid heat pumps are the preferred option by the ‘prosumer’s’. Hybrid heat pumps allow the ‘prosumer’ to choose which source of energy to meet their heating needs.

Yearly electricity demand has increased in the heating and transport sectors, overall electricity demand growth reduced in the residential sector due to ‘prosumer’ behaviour, high efficiency goods and building efficiency measures. Demand responds well to market prices, the daily electricity demand profile is smoothened, the effect is that peak electricity demand is reduced in this scenario.

The yearly final gas demand is increasing in the transport sector. Annual gas demand is decreasing in the residential sector, driven mainly from all electric heating technologies, and building insulation measures. Gas is required for peak demand situation, such as, cold weather conditions. Industrial gas demand is decreasing in this scenario driven by electrification of industrial process heating, however gas is still required to cover peak demands. The gas demand for other energy intensive industry processes is stable.

Factor		Scenario Overview				
Scenario		Global climate action	Subsidized green Europe	Sustainable Transition	Behind Targets	**Distributed generation**
Category	**Criteria**	**Parameter**				
Macroeconomic Trends	**Climate action driven by**	Climate action low	EU ETS	EU ETS & direct RES subsidies	Global ETS	Global ETS & direct RES subsidies
	EU on track to 2050 target?	Behind	Slightly behind	Yes		
	Economic conditions	Low growth	Moderate growth	High growth		
Transport	**Electric and hybrid vehicles**	Low growth	Moderate growth	High growth	Very high growth	
	Gas vehicles and shipping	Low growth	Moderate growth	High growth	Very high growth	
Residential / Commercial	**demand flexibility**	Low growth	Moderate growth	High growth	Very high growth	
	Electric heat pump	Low growth	Moderate growth	High growth	Very high growth	
	Energy efficiency	Low growth	Moderate growth	High growth	Very high growth	
	Hybrid heat pump	Low growth	Moderate growth	High growth	Very high growth	
Industry	**electricity demand**	Reduction	Stable	Favourable development		
	gas demand	Reduction	Stable	Favourable development		
	demand flexibility	Low growth	Moderate growth	High growth	Very high growth	
Power	**Merit order**	Coal before gas	In par	Gas before coal		
	Nuclear	Reduction	Stable	Minimum new units	Potential for growth	
	Storage	Low growth	Moderate growth	High growth	Very high growth	
	Wind	Low growth	Moderate growth	High growth	Very high growth	
	Solar	Low growth	Moderate growth	High growth	Very high growth	
	CCS	Not significant	Low growth	Moderate growth	High growth	
	Adequacy	Low surplus capacity	Some surplus capacity	High surplus capacity		
Gas Supply	**Power-to-gas**	Not significant	Low growth	Moderate growth	High growth	
	Shale Gas	Not significant	Low growth	Moderate growth	High growth	
	Bio Methane	Not significant	Low growth	Moderate growth	High growth	