Summary of Equinor's Energy Perspectives 2018 Renewal scenario and its implications for EU

Content

1. The Energy Perspectives scenario set

Energy Perspectives sets out Equinor's long-term perspective on global macroeconomics and energy markets in a 2050 perspective. Energy Perspectives is updated annually with the latest version released in June 2018. The analysis contains three scenarios (*Reform*, *Renewal* and *Rivalry*) that provide a wide outcome space for global energy market developments. There is no probability attached to the scenarios, but each scenario is technically achievable based on a distinct set of assumptions. The main scenario drivers can be summarised as economic development, climate policies, market forces, technology, energy efficiency and geopolitics, with the individual scenarios placing more emphasis on certain drivers. In *Reform*, market forces and technology developments take priority, while in *Renewal*, climate policies are driving the outlook. *Rivalry* is a scenario where geopolitics play centre stage. Energy market developments are kept similar in all three scenarios until 2020, at which point they start to diverge. The size of the global energy system and its inherent inertia entail that it will take some time before new development paths will become clear and visible. Out of the three scenarios, only *Renewal* represents a sustainable future from a climate perspective.

2. Renewal scenario main assumptions and drivers at a global level

- Emissions: The Equinor *Renewal* scenario sets out a 2° consistent pathway and operates with a global carbon budget that brings the cumulative energy-related emissions of CO_2 between 2016 and 2050 to around 816 giga tonnes (Gt). To achieve this, annual emissions would need to fall by around 60% towards 2050 to 12.6 Gt, from 32.1 Gt in 2015. The projections end in 2050, but it is implicitly assumed that energy-related carbon emissions continue to fall further and fit to a carbon budget of around 250 Gt during the second half of the century.
- Economic growth and energy: Global economic growth over the whole projection period 2015-2050 amounts to 2.7% CAGR. Global total primary energy demand (TPED) decreases by 0.2% CAGR.
- Electricity: Global electricity demand increases by 65% to 40100 TWh as all sectors of the economy use more electricity. Electricity demand for transportation is the fastest growing sector, reaching almost 6000 TWh by 2050. The share of electricity in total final consumption (TFC) of energy goes from 18.5% in 2015 to almost 33% in 2050. Solar and wind become the two largest sources of electricity, reaching a share of 49% in 2050, followed by hydro and nuclear. Some gas and coal power generation remain also in 2050, accounting for 10% and 4% of the electricity mix respectively.
- Role of policy: It is assumed that strong policy intervention will force the necessary investments in low carbon technologies. This applies to renewables in the power sector, decarbonisation of the buildings

sector, electrification of transportation, realisation of efficiency gains in industry and CCUS, in power generation and industry. This scenario also assumes a global and collective effort being pursued.

- Fossil fuel and CO_2 prices: Producer prices are assumed subdued, due to lower level of supply. End-user prices must be higher to contain demand, due to higher taxation of the related externalities. All regions of the world implement CO_2 prices or taxes or a combination, and these tend to be at high levels. The phase-out of subsidies, and significantly higher global carbon costs help to fund new capital-intensive low-carbon electricity infrastructure and CCUS.
- Pace of technological development: Rapid digitalisation of the energy industry contributes to efficiency gains in the overall economy. We see broader technological shifts, such as in passenger cars, where ICEVs are almost completely phased out in new car sales, and in power, where coal power generation almost disappears by 2050. Technology developments spread widely and speedily, helped by global arrangements that foster international relationships in areas important for green growth.
- CCUS: This technology figures prominently in most 2° scenarios. The Inter-Governmental Panel on Climate Change (IPCC) have since 2001 stressed that CO_2 removal (CDR) is needed to prevent catastrophic climate change and catastrophic ocean acidification and estimates that reaching the 2° target will be more than twice as expensive without CCUS as with. In *Renewal*, capture increases to approximately 1.5 Gt of CO_2 per year by 2050 which is a bit more than 10% of the gross emissions. This means the completion of almost 1100 projects the size of the US Petra Nova CCUS project, the world's largest post-combustion CO_2 capture system in operation.

3. Key EU Energy Characteristics in the Renewal Scenario

- CO_2 emissions: EU energy-related CO_2 emissions peaked in 2006 at 4200 million tonnes (Mt) and declined by almost 20% by 2015. Towards 2030, emissions are seen to fall by another 40% compared to 2015 levels, and 80% by 2050. Compared to 1990, emissions fall by 84% by 2050 to 680 Mt (Figure 1).
- Economic growth and energy: Economic growth in the EU is assumed to be 1.7% per year on average between 2015 and 2050. TPED in the EU peaked in 2006 at 1900 million toe and by 2015 has dropped to below 1700 mtoe. This decline in energy consumption continues and by 2050 EU's TPED drops by 42% and falls below 1000 mtoe (Figure 2). The reduction in the EU energy consumption is seen achieved through a significant improvement in the energy intensity of the economy. Compared to 2015, the energy intensity is improved by 2/3 by 2050 or 3.1% CAGR. Transforming the energy system is by nature labour-intensive, and new renewable energy capacity additions create local jobs.
- Share of fossil fuels in the energy mix: The share of fossil fuels in the energy mix has been declining over the past decades going from a level of 83% in the mix in 1990 to 73% in 2015. The share of oil and gas drops to below 42% by 2050 and new renewables (solar and wind) become the largest component in the mix, growing from a share of 3% in 2015 to 23% in 2050. Coal is nearly completely phased out, declining at a 12% CAGR;
    - Oil and natural gas will be needed in significant volumes also in 2050, but demand will have to fall at respectively around 3 and 2% CAGR. Combined they will still serve 40% of EU TPED in 2050;
    - Other sources than fossil-fuels will represent more than 58% of EU TPED, with hydro, biomass and new renewables growing at between 0.5 and 5% CAGR.
- TFC of energy: TFC drops by 37% by 2050 in the EU. Oil sees the largest drop as it falls by almost 2/3, while gas use is down by around 40% (Figure 3).

- Oil: In 2015, transportation demand accounted for over 60% of the EU's total oil demand of 13 mb/d. As transportation is electrified, oil consumption for transport falls below 2 mb/d in 2050. Oil consumption in all other sectors apart from non-energy declines towards 2030/2050. Non-energy demand, i.e. use of oil as feedstock in for instance the petrochemical industry, increases from 1.8 mb/d in 2015 to 2.1 mb/d in 2050, and its share of oil demand goes from 14% to almost half (Figure 5). Overall oil demand falls to 4.5 mb/d by 2050.
- Natural gas: EU gas demand falls from about 430 bcm in 2015[1] to 230 bcm in 2050. Total gas demand remains relatively stable towards 2030 as increases in consumption for power sector and gas use for non-energy purposes partially compensate for declining demand from buildings and industry. After 2030, however, gas use in power drops quickly as gas power generation is squeezed out by renewable power. Gas use in transportation grows throughout the whole outlook period, but from a low level (Figure 4). Domestic gas supply in Denmark, the Netherlands and the UK continues to drop and European indigenous gas supply projections show significant reduction from 2025-30. Dropping demand however means that there should be ample supplies available for import from Russia and via LNG in addition Caspian supplies start arriving around 2020. It will however be difficult to attract gas from regions such as the Middle East (Iraq) or from the Mediterranean region (Cyprus, Israel) due to the significant supply chain costs.
- Electricity: Electricity becomes an increasingly important part of TFC, as the share rises from 20% in 2015 to 34% in 2050. EU electricity consumption increases slightly compared to 2015 levels to 3300 TWh. Industrial and commercial electricity use decreases slightly as energy efficiency measures dominate any new use of electricity, while in the residential sector electricity consumption increases with the replacement of boilers, with heat pumps being an important demand driver.
    - The transportation sector becomes an important source of electricity demand, rising from 60 TWh in 2015 to over 500 TWh in 2050, and its share in electricity demand increasing from below 2% to almost 16% (Figure 6).
    - In 2015, nuclear was the largest source of electricity generation in the EU, accounting for 27%, followed by coal at 26%. Solar and wind stood at around 13%. Towards 2030, solar and wind grow rapidly and become the largest source of electricity, accounting for 35% of generation, while nuclear's share goes down to 21%. Coal power generation drops rapidly and is completely phased out before 2040. Gas power generation grows towards the mid-2020s before it goes in to gradual decline. Gas power generation still plays an important role in the early 2040s, but by 2050 it is marginalized. By 2050, solar and wind are by far the largest sources of electricity generation at almost 60%. Combined, all renewable electricity accounts for 84% of the power mix (Figure 7).
    - Wind generation is the fastest growing source of EU electricity generation, leaping from 300 TWh in 2015 to over 1400 TWh in 2050. Energy Perspectives is not explicit on the split between onshore and offshore wind, but assumes faster offshore wind growth rates, knowing that offshore wind enjoys more stable wind conditions allowing for higher capacity factors, and represents an answer to the growing "Not in My Backyard" reservations against onshore wind.
- Hydrogen: In *Renewal*, the future role of hydrogen is not detailed, and the scenario delivers a 2° consistent pathway without an explicit contribution from hydrogen. An undershooting in other regions or late market reaction however could well call for hydrogen solutions. Hydrogen value chains could come in various shapes and forms, some involve the direct use of hydrogen (power-to-gas), while others build on the conversion of hydrogen in fuel cells (power-to-power). Another variant is turning hydrogen into ammonia, a well-known compound for fertiliser production transportable as liquid in large volumes over long distances. Hydrogen could potentially play a key role in decarbonizing sectors

[1] In 2017 demand stood at 471 bcm.

that are difficult to electrify such as heavy-duty transportation, aviation, shipping and various industrial processes. Hydrogen could also play a role in the heating market and in electricity generation to provide flexibility and storage to meet seasonal fluctuations in demand. Hydrogen will continue to rely on strong policy support and incentives and costs will have to come down significantly before clean hydrogen becomes an affordable, large-scale solution in the EU and globally.

- CCUS: The implementation of CCUS in the EU is assumed to be around 70 Mt or slightly less than 10% of gross emissions by 2050.

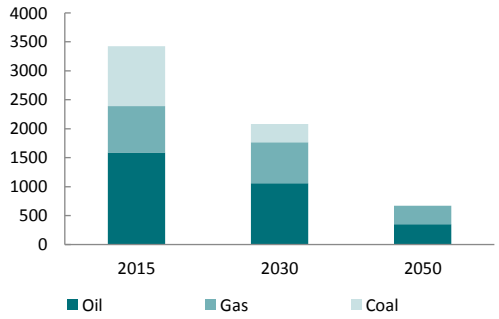

Figure 1: EU Energy-Related CO_2 emissions, mt

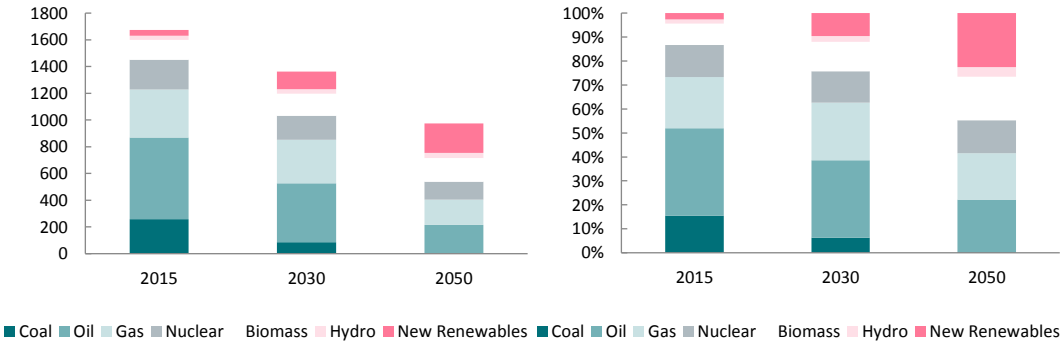

Figure 2: Total Primary Energy Demand (TPED, mtoe) and Energy Mix in the EU

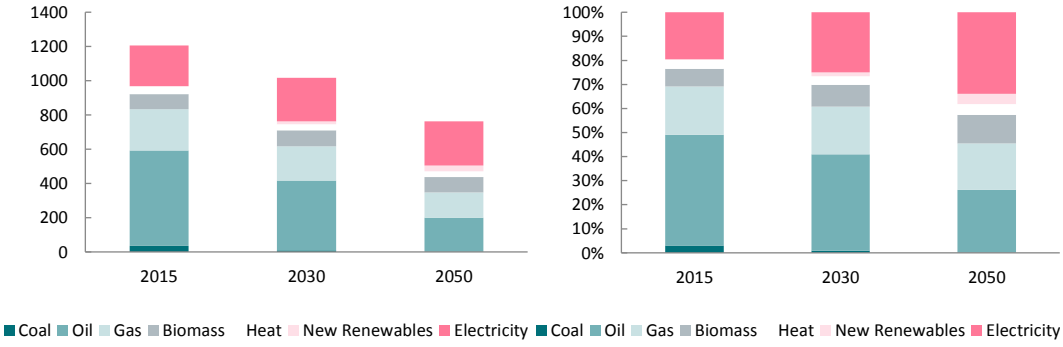

Figure 3: Total Final Energy Consumption (TFC, mtoe) and Energy Mix in the EU

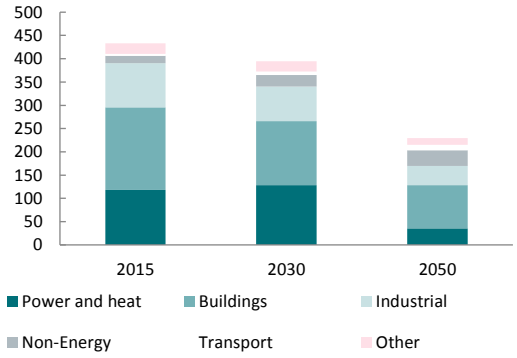

Figure 4: EU Gas Demand by Sector, bcm

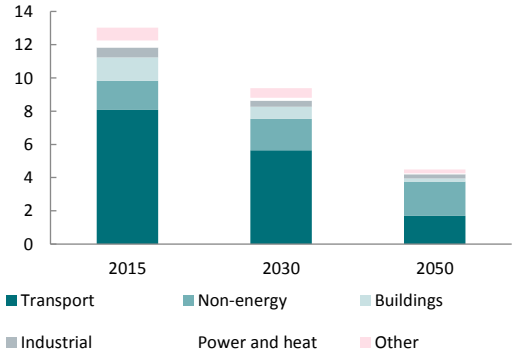

Figure 5: EU Oil Demand by Sector, mbd

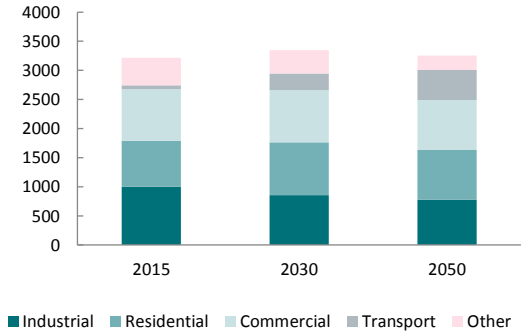

Figure 6: EU Electricity Demand by Sector, TWh

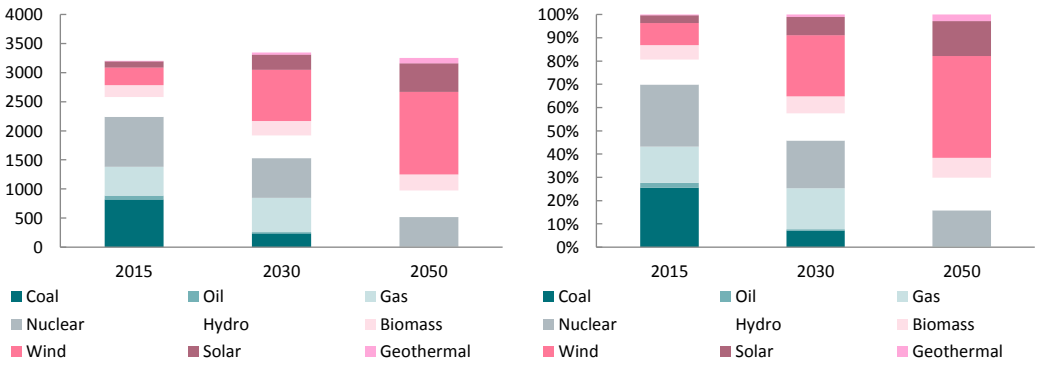

Figure 7: EU Electricity Generation by Source in TWh (left) and Generation Mix (right)