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ONS ENERGY AGENDA PREVIEW VOL.2

How much can change?

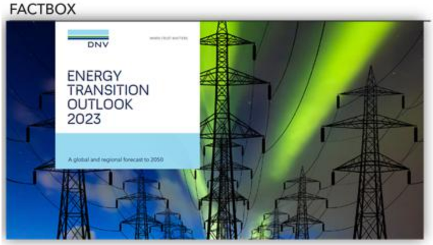
THE SHAPE OF THE ENERGY INDUSTRY IN 2040

How much can the world energy system change in 16 years? If we go back 16 years to 2008, we have events like the birth of the iPhone, the financial crisis, and Barack Obama elected as US president. All events, which, while not quite feeling like 'yesterday', still seem recent enough. How much can change in a decade-and-a-half? 2040 is just 16 years away, and from an energy perspective, we will see fundamental change, states Remi Eriksen, Group President and CEO at DNV.

By Remi Eriksen, Group President and CEO at DNV

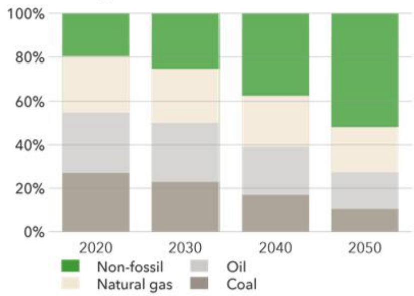
That is a bold assertion, given that transition so far in 2024, appears to be partly in stall mode. Record emissions from fossil energy last year are on track to move even higher this year. High oil and gas prices are fuelling an exploration surge, while many renewable projects are experiencing an increase in cost due to inflationary and supply-chain pressures. Geopolitical developments over the past two years have brought energy security into sharp focus with the disruption of energy supplies and price shocks for energy importers. Local sourcing of both energy and energy infrastructure is emerging as a prominent national objective.

FACTBOX



Fossil vs. non-fossil in primary energy supply

Units: Percentages



The analysis in this chapter is based on DNV's Energy Transition Outlook - a regional and global forecast to 2050. The figure illustrates that 2040 marks a pivotal year in the energy transition, signaling an accelerated transition to non-fossil energy sources. By 2050, these sources are expected to comprise slightly more than half of the global energy mix.

 Historical data source: IEA WEB (2023)

However, amidst these short-term perturbations, the long lines of development are clear: the energy landscape will look very different by 2040. There are three major themes to keep an eye on: solar PV; electrification; and fossil fuels. These are themes executives and boards should address now in order to position and diversify their operations to thrive in the energy transition. Should countries and regions choose to reinforce their energy and climate policies beyond our anticipated measures, the associated trends and consequences would intensify at an accelerated pace.

A world becoming more efficient - delivering more useful energy with less waste!

According to our latest Energy Transition Outlook (2023), electricity demand is set to grow by 60% between now and 2040. The shift to the use of electricity as an energy carrier, brings enormous system efficiencies that will fundamentally alter how humanity uses energy. As the world's population increases and the global economy expands, it's clear that humanity will need more energy services (heating, cooling, transport etc.). Yet, energy demand will grow at a rate much slower than economic growth and even level off in the 2040s. The key to understanding this paradox lies in distinguishing between 'useful energy' and 'final energy.'

Useful energy is the energy output that serves a specific purpose, such as heating a stove, propelling a vehicle, lighting a room, or running a machine. In our forecast, useful energy grows by 50% between now and 2040. What will not be growing nearly so fast is so-called final energy – i.e. the total amount of energy required to meet various needs, which, crucially, includes both useful as well as wasted energy. Final energy demand refers to the energy delivered to end-use sectors (e.g. transportation, buildings, or manufacturing) and includes losses, mostly in the form of heat. In our forecast, global final energy demand grows by just 10% before flattening after 2040, see Figure 1.

The difference between useful energy and final energy demand is clearly illustrated in the case of an internal combustion engine vehicle (ICEV), which is typically only 25% to 35% efficient – meaning that much of the chemical energy in the form of diesel or gasoline (the final energy demand) is wasted as heat, incomplete combustion, and friction before it provides the useful work of propelling the vehicle (useful energy). As ICEVs are replaced by electric vehicles (EVs) that have much higher efficiencies (>90%), enormous energy losses will be eliminated. As a consequence, as energy end use becomes increasingly electrified, there will be a lot less demand for oil.

Solar PV

2023 saw an almost 50% increase in the amount of new renewable projects coming online. Global annual renewable capacity additions amounted to 510 gigawatts (GW) in 2023, with solar PV alone accounting for three-quarters of the total additions. This is the fastest rate of growth of renewable capacity additions in the past two decades and the growth will continue. A few regions stand out, like Europe, the United States and Brazil which hit all-time highs, whereas China's acceleration was extraordinary - which we have detailed in a recent report, DNV Energy Transition Outlook China 2050 (released April 2024).

By 2040, we expect solar PV to have an installed capacity of 9.7 TW and produce almost 14 TWh which is 30% of all electricity generation. Solar PV will be the cheapest new electricity

FIGURE 1

The diminishing share of losses in the global energy system

Units: EJ/yr

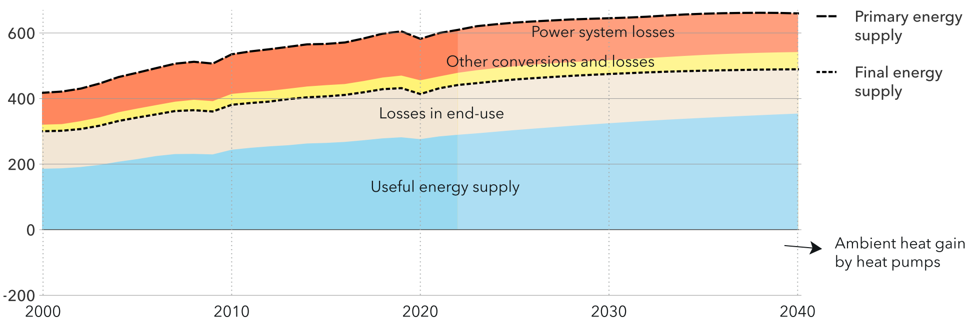
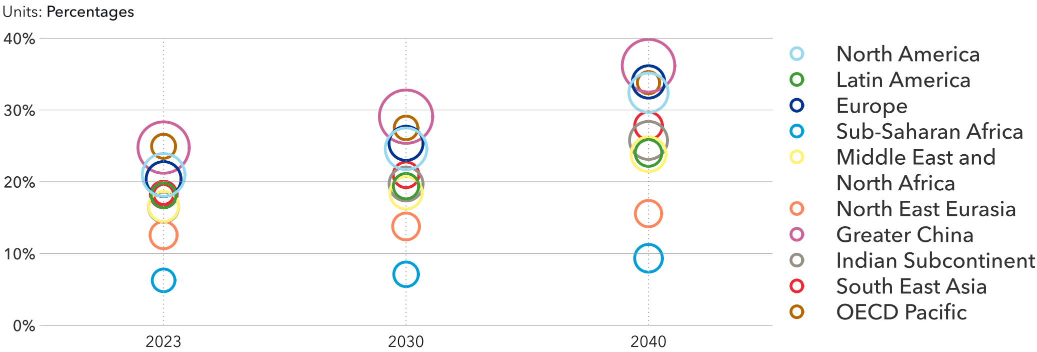


FIGURE 2

Share of electricity in final energy demand



Circle area is proportional to total final energy demand.

source globally, with exceptions only in areas with less conducive irradiation conditions like the higher northern latitudes. By 2040 the reduction in cost per kWh will be another 40% compared with today. Speed of deployment at utility scale as well as ample industrial capacity for producing panels paves the way for solar PV dominance as the major source of electricity generation.

With variable renewable energy, there will be a need for flexibility and storage in a growing electricity grid. This is where Li-ion batteries play the primary role. These batteries will either be integrated with renewables or operate as standalone systems. The ability to store excess energy during peak sunlight hours and then sell it when after-dark prices rise, gives solar + storage an edge over standalone solar PV and provides a solution to the variability problem. This means that existing thermal power plants will increasingly operate with (rather than instead of) renewables, with the viability of those thermal sources increasingly tied to their flexibility to follow demand. We expect 6.2 terawatt-hours (TWh) of lithium-ion battery storage by 2040, with a substantial part integrated with renewable energy sources and a matching amount of storage available from EVs enabled to dispatch stored electricity to the grid.

Electrification

Technology, cost, and policy factors are all driving increased electricity use, which naturally holds efficiency advantages over other energy carriers. From a decarbonization perspective, everything that can be electrified should be electrified. Because electricity is fairly easy to decarbonize compared with other energy carriers, ever-more ambitious decarbonization policies will inevitably favour electricity. Additionally, the costs of solar and wind power are expected to continue decreasing (global average by 45% mid-century), making electricity increasingly more cost-effective compared with other fuels, especially hydrocarbons which will increasingly be subject to carbon tax in most jurisdictions.

The delivered cost of electricity is of course highly dependent on market designs and on the manner in which grid buildout is supported and funded. New applications requiring modern energy are also emerging — for example, AI, communication appliances, and air conditioning — for which there are few or no alternatives to electricity.

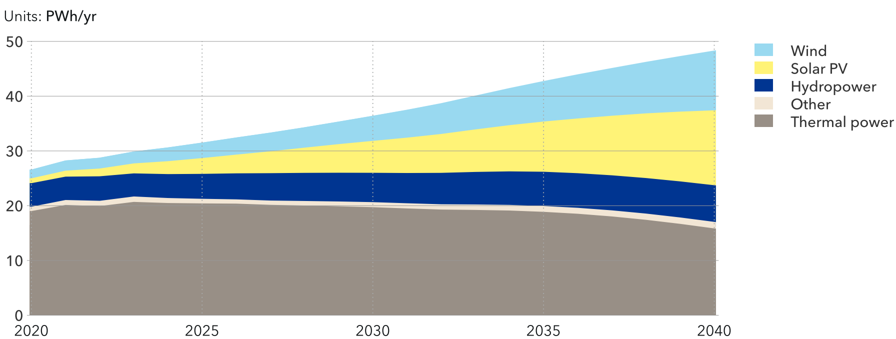
Electricity stands centrally in the ongoing global energy transition, shaping innovation and strategies in both supply and demand sectors, with China leading the way owing to its focus on achieving energy independence (Figure 2). By 2040, electricity will account for 28.4% of the world's total energy demand, a significant increase from 20% in 2023, but more importantly a guidance for how the future beyond 2040 will unfold. Renewable electricity generation will power much of this growth, increasing from 9.2 petawatt-hours per year in 2023 to 32.5 petawatt-hours by 2040. This increase means that the share of renewables in electricity generation will rise from 31% 2023 to 67% by 2040 (Figure 3).

The emergence of so-called 'new' power systems (i.e. those characterised by a high penetration of renewable sources) is a reality that deserves a great deal more attention than it is currently given. Nations stand to benefit greatly in competitiveness and security of their national energy systems if issues such as adequacy, flexibility, grid capacity, and power market design are tackled early. See, for example, DNV's report on New Power Systems (May 2024).

At present, there is a shortage of grid capacity to accommodate the coming expansion of both generation and load (i.e. demand). While enhanced transmission planning and build-out is the long-term solution to addressing a capacity-constrained electric grid, there are near-term tools at our disposal to ensure we are getting the most out of the grid we have. Their deployment does not require new gridlines and are becoming increasingly standardized and adopted in regulatory frameworks. These 'non-wire' grid enhancing technologies offer a promising pathway to rapid and cost-effectively increase grid capacity and efficiency, facilitating

FIGURE 3

World grid-connected electricity generation by power station type



Historical data source: IEA (2023), GlobalData (2023) the integration of renewable energy and enhancing grid reliability over a bridging period to the 2030s.

From a financial perspective, an implementation of this grid enhancement approach not only reduces the capital expenditure associated but also lowers operational costs by enabling an earlier penetration of renewable energy sources, which are typically cheaper to operate than fossil-fuel-based sources.

Oil and gas

Historically, oil demand has increased roughly 1% annually due to population and economic growth, maintaining a significant presence in the transportation sector where it has comprised about 70% of the energy use since 2017. However, this trend is set to shift significantly as EV adoption reaches double digit percentages of new vehicles sales in several major markets.

Our forecasts show that by the late 2020s, EVs will make up 50% of new passenger vehicle sales in Greater China and Europe. This shift will extend to the OECD Pacific and North America by the early 2030s, and it is expected to reach a market share of 50% by 2031 globally, which means that by 2040 almost 40% of the passenger vehicle fleet will be electric.

The impact of EVs is particularly pronounced in China, the world's largest passenger vehicle market. In 2023, EVs made up about 20% of new passenger vehicle sales, rising to about 25% in recent months of 2024. Mid-2023, the Chinese oil giant Sinopec unexpectedly announced that it expects gasoline demand in China to peak in 2023, two years earlier than was set out in previous forecasts. Globally, we expect oil demand to peak before the end of this decade, with its subsequent decline primarily driven by rapid EV uptake, steepening in the 2030s as other key transport sectors like shipping and aviation start their decarbonization journeys deploying alternative fuels such as ammonia, methanol and other synthetic fuels

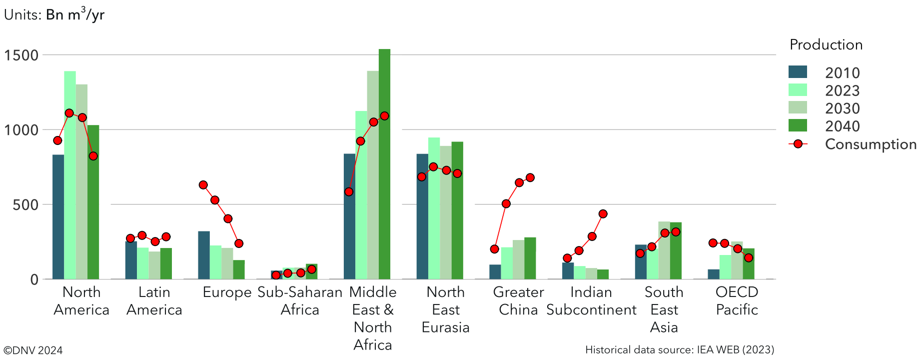
> By 2040 the global demand for oil will have dropped 22% from today's levels and will be in perpetual decline.

Looking ahead, we forecast that by 2040, oil demand in China's road sector will decrease by 75%, which will have major repercussions for both domestic oil production and the global oil market. By 2040 the global demand for oil will have dropped 22% from today's levels and will be in perpetual decline.

Natural gas demand will vary by region, typically growing in low- and medium-income regions and declining in OECD regions (Figure 4). Furthermore, there will be demand for natural gas in new sectors, particularly with increasing use in maritime transport, and as a feedstock for making blue hydrogen and ammonia. Over the past 10 years, power generation accounted for 35% of gas use. This share will rise to 37% in 2026 before receding to 30% by

FIGURE 4

Natural gas production and consumption by region



Historical data source: IEA WEB (2023)

2040, a shift driven by the expansion of renewable energy sources. However, global demand for natural gas increases to 5,035 billion m³ around 2027 and plateaus for about a decade before gradually declining to 4,800 billion m³ in 2040.

Gas consumption in Europe and the OECD Pacific is projected to decrease to approximately 55% and 40% of 2023 levels by 2040, respectively. This significant reduction is largely due to the natural gas supply constraints following Russia's invasion of Ukraine. In Greater China, gas demand is expected to increase by 28% by 2030, but it will level off as it approaches 2040. Both Greater China and the Indian Subcontinent are characterized by high demand and limited domestic natural gas resources and will import larger amounts via LNG. In contrast, gas production in North America and Europe is projected to decrease by half, which corresponds to a 10% reduction in their market shares.

The Middle East and North Africa, along with Russia, have long been net exporters of gas and are anticipated to continue in this role. Notably, export volumes from the Middle East and North Africa are expected to double by 2040, with its market share also rising from todays 10% to reach 35% in 2040.

Conclusion

According to our Energy Transition Outlook, by 2040, the world's energy system will be distinctly more non-fossil – roughly a 40/60 non-fossil/fossil ratio compared with today's 20/80 ratio.

Solar PV will have led the charge for renewables penetration, followed by wind. By then, there will also be a large share of dedicated renewables (almost 7 PWh) for green hydrogen. Fossil sources will still be dominant in the energy mix, with gas exhibiting staying power due to its dispatchability and relatively low emissions, but starting to diminish; oil, one the other hand, will be in sharp decline.

This sets up two very important considerations.

1. Start planning for less oil. The world has never seen a permanent reduction

in oil demand; shrinking demand is likely to gravitate production to lowest cost sources, and a reduction in prices.
2. Start planning for New Power Systems. This requires action on grids – in the short-term exploring non-wire transmission enhancement, with longer-term plans for massive grid expansion, and for the introduction of new power market designs to optimize conditions for a high penetration of renewables in the power mix.

The dark horse underlying all of this is AI. It is already clear that AI is playing and can play an increasing role in each step of the energy value chain – including optimized design of renewable component; better renewables siting; enhanced operation of renewable generation; transmission decongestion (for example through dynamic line ratings); demand response; and, not least, end-use efficiency.
The potential application of AI is so deep and wide that the world has yet to place any precision on the dimension of its impact. Nevertheless, it will be considerable, if the numbers starting to emerge about the isolated impact of AI on GDP are any indication. Intriguingly, the economic uplift promised by AI is likely to be delivered with low carbon intensity, adding momentum to an energy transition already characterised by improving carbon intensity numbers everywhere.

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Ultimately however, it is policy which will have the main impact of decarbonization. One thing we can predict with confidence is that by 2040, the urgency to respond to global warming will have moved far beyond partisan debate. The DNV energy forecast to 2050, that I have used as reference throughout this article, is a ‘most likely’ forecast of our energy future. It is very far from a ‘net zero’ future, and hence leads to a global warming of 2.2°C by the end of this century. Limiting global warming below 1.5°C requires a much faster transition. That is still, barely, within the grasp of policymakers worldwide. Should they choose to do so, the trends I have outlined in this brief overview of the energy landscape in 2040 will accelerate greatly. The precautionary principle alone dictates that all stakeholders should start planning for a faster transition.

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