

World Energy Scenarios | 2019



EXECUTIVE SUMMARY

Exploring Innovation Pathways to 2040

In Collaboration with Accenture Strategy and the Paul Scherrer Institute



EXECUTIVE SUMMARY

The world of energy is being reshaped by a set of fundamental drivers, which we term the “Grand Transition”. These drivers provide the broader context for determining global energy pathways to 2040.

Since the World Energy Council last published its World Energy Scenarios in 2016, we have experienced three years of comparatively high, carbon-centric energy demand and a marked acceleration in renewable energy developments. A new pattern of geostrategic competition is emerging that is further straining the multilateral system and impacting global trade. What has changed most, however, is the speed and volatility of changes and unevenness of impacts. Fragmentation and polarisation of leadership and poor economic returns limiting the license to invest for market players are emerging as some of the biggest risks in managing successful energy transition. Meanwhile, energy leaders are also challenged to make sense of the fast-shifting landscape of innovation and the new spirit of entrepreneurialism in energy. A fresh focus on energy systems innovation and the emerging phenomenon of “disruption-as-usual” is both timely and relevant to energy transition leaders within and beyond the energy sector.

The energy system implications of this 2019 scenario-based update include:

- 1 ALL THREE WORLD ENERGY SCENARIOS HAVE BEEN VALIDATED** by signals in all regions and are perceived as more relevant than ever.
- 2 GLOBAL PRIMARY ENERGY DEMAND MOMENTUM REMAINS** in line with the 2016 scenario modelling, with per capita energy consumption projected to peak in the 2020s.
- 3 ELECTRIFICATION EXTENDS TO MORE USES AND USERS**, driving decarbonisation rates; however, the question of hard-to-abate sectors and non-electrified uses remains open.
- 4 A NEW MOBILITY REVOLUTION**, which is dependent on infrastructure, is gathering momentum, with the potential to disrupt the entire energy landscape in the longer term.
- 5 ENERGY EFFICIENCY GAINS ARE CRITICAL** to manage energy demand from industrial, residential and commercial sectors and to avoid reducing climate change momentum.
- 6 NEW OPPORTUNITIES ARE EMERGING** to provide energy-plus services in an increasingly consumer-centric energy system.
- 7 INFRASTRUCTURE INNOVATION AND INVESTMENT**, and proactive policies are necessary to secure affordable decarbonisation and socially just energy transitions.
- 8 NEW NET-ZERO CARBON TECHNOLOGIES PATHWAYS** (including hydrogen) and carbon abatement mechanisms (including Carbon Capture, Usage and Storage (CCUS)) emerge and start to scale by 2040.
- 9 ACHIEVING PARIS AGREEMENT TARGETS REMAINS ELUSIVE**, with none of the 2019 scenarios meeting the 2°C target agreed to in the UNFCCC Paris Agreement.

Recommendations for business leaders and policy makers are presented with a clear call to avoid complacency and fragmented action, to address connected challenges and to intensify collaborative innovation.

THREE SCENARIOS FOR FUTURE ENERGY PATHWAYS

In 2016, the World Energy Council (the “Council”) and its scenarios partners, Accenture Strategy Energy and the Paul Scherrer Institute, published a new set of World Energy Scenarios describing three different plausible pathways for energy transition. The scenarios adopted a time horizon to 2060 to focus on the responses to the challenge of global climate change.

Over the last three years, this scenario framework has been validated by input from the Council’s extensive energy expert member community and annual surveys of energy leaders. The three scenarios are perceived by these experts to be more relevant than ever. Discussion of member input has added interesting nuances to each scenario archetype. In this round, the Council has adopted a medium-term time horizon of 2040 and focused on the implications of broader and disruptive innovation for the energy industry.

The 2019 scenarios are summarised as follows:



Modern Jazz. A market-led, digitally disrupted world with faster-paced and more uneven economic growth. Recent signals suggest that this entrepreneurial future might accelerate clean energy access on both global and local scales, whilst presenting new systems integration, cyber security and data privacy challenges.



Unfinished Symphony. A strong, coordinated, policy-led world, with long-term planning and united global action to address connected challenges, including inequitable access and affordable decarbonisation. Recent signals suggest increased activism and commitment to addressing climate change at the sub-national level, and an expansion of the focus from climate change mitigation to a broader, socially inclusive and economically affordable sustainable development agenda.



Hard Rock. A fragmented world with inward-looking policies, lower growth and less global cooperation. Recent signals, such as the rise of populist leaders and uncertainty about the outlook for international cooperation, imply that this scenario is also evolving into a story of regionally firmer security foundations rather than total fragmentation and “harder rocks.”

The focused refresh of the scenarios provides new insights into the broader and fast-shifting landscape of innovation, which is emerging from within and beyond the energy system and includes not only new energy technologies but also non-energy technological innovations and a new spirit of entrepreneurialism in energy. The scenarios redirect energy leaders’ attention to other non-technological innovations such as new consumer behaviours and innovative business models that disrupt existing value chains and can reshape the whole energy system.

ENERGY SYSTEM IMPLICATIONS

1

ALL THREE WORLD ENERGY SCENARIOS HAVE BEEN VALIDATED BY SIGNALS IN ALL REGIONS AND ARE PERCEIVED AS MORE RELEVANT THAN EVER.

This 2019 update confirms the general direction of the three scenario pathways of the 2016 report. Signals of each scenario have been detected in all regions of the world through the use of a variety of leadership surveys and systematic horizon-scanning methods. There has been a marked shift in perception about the scenario **Hard Rock**, which is no longer seen as an extreme scenario. Perspectives are also more divided about the outlook for effective global cooperation, which is assumed in the scenario **Unfinished Symphony**. The entrepreneurial scenario **Modern Jazz** has generated a lot of questions about new societal dynamics relating to increasing inequality, active consumers and effective market design.

2 GLOBAL PRIMARY ENERGY DEMAND MOMENTUM REMAINS IN LINE WITH THE 2016 SCENARIO MODELLING, WITH PER CAPITA ENERGY DEMAND PROJECTED TO PEAK IN THE 2020S

The rate of growth of primary energy demand per capita is highly dependent on the scenario. The strong global policy effects of **Unfinished Symphony** can achieve a near-flat primary energy demand through to 2040, while **Modern Jazz's** technology-driven efficiency gains are overwhelmed by strong GDP growth with primary energy demand increasing by 13% over the period. **Hard Rock's** fragmented and nationalistic approaches lead to a 21% growth, which is still less than half of the growth of the past twenty years.

Fossil fuels will continue to provide over two-thirds of global primary energy in 2040. Coal's contribution falls, whereas gas grows its share in all scenarios. Oil demand peaks between 2025 and 2030 in **Modern Jazz** and **Unfinished Symphony**, with the former scenario seeing a slow decline afterwards and the latter experiencing a rapid drop by 2040 to demand levels last experienced in 2000. **Hard Rock** oil demand rises till 2040 with a long plateau beyond. Compared with 2016 projections, the first two scenarios experience a notably lower oil demand by 2040, which is offset by an equally higher gas demand.

At a regional level, Central Asia (including India) is the largest driver of primary energy demand growth, while East Asia (including China) succeeds in curbing growth in all scenarios but **Hard Rock** by 2040. Europe and North America are set to experience peak primary energy demand in the twenties and thirties respectively under all scenarios.

3 ELECTRIFICATION EXTENDS TO MORE USES AND USERS, DRIVING DECARBONISATION RATES; HOWEVER, THE QUESTION OF HARD-TO-ABATE SECTORS AND NON-ELECTRIFIED USES REMAINS OPEN.

Demand for electricity grows at its fastest rate in **Modern Jazz** and **Unfinished Symphony** from 2020 to 2040 – at 45% and 60% respectively – as heating, manufacturing and mobility pivot to electrons. By 2040, 20-31% of the energy system will be electrified, the higher figure being achieved in **Unfinished Symphony**. This marks an acceleration of electrification compared to our 2016 report. While the majority of growing demand will continue to be met by fossil fuel generation, the electricity mix increasingly shifts towards renewable sources.

We note that the electrification pathways differ between the scenarios, with renewable power rising from 26% of total power generation in 2020 to 43% in **Unfinished Symphony** and 33% in **Hard Rock**, which is only slightly lower than **Modern Jazz** at 36% in 2040.

4 A NEW MOBILITY REVOLUTION, WHICH IS DEPENDENT ON INFRASTRUCTURE, IS GATHERING MOMENTUM, WITH THE POTENTIAL TO DISRUPT THE ENTIRE ENERGY LANDSCAPE IN THE LONGER TERM.

Transport demand for energy is highly dependent on the scenario, but in all cases there is a dynamic tension between population and GDP growth that is offset by improvements in efficiency. The co-development of EVs, ICE efficiency, ride sharing, autonomous vehicles and new modes of transport is already fundamentally reshaping personal transport demand. The pace of change is a function of the scenario and, in particular, depends on wider infrastructure developments, including storage. The combined impact of these new developments on commercial transport energy demand is assumed to be proportionally lower, however, given the capital intensity of assets and the reduced scope for new efficiency gains. As such, despite the increasing momentum of a new mobility revolution in meeting new passenger mobility demands, overall energy demand in transport continues to grow in all three scenarios.

New developments in technology, policies and consumer behaviour have the greatest impact on energy consumption in the transport sector in **Unfinished Symphony** and **Modern Jazz**. Modelling of both scenarios indicates limited growth to 2040, based on rapid price reduction of EVs, which achieve parity in sales prices with ICEs by 2030. This price parity accelerates the penetration of EVs, and their share of mileage for private cars crosses over with ICE vehicles by 2040. The ensuing efficiency gains offset the increased total population of vehicles. Commercial transportation (other land transportation, shipping and aviation) experiences decreasing energy intensity thanks to lighter materials, more efficient engines, more stringent efficiency standards and a rise in the use of alternative fuels such as biofuels and hydrogen.

With these changes, by 2040 electricity and hydrogen capture 10-16% of total energy consumed by transport in **Unfinished Symphony** and **Modern Jazz**.

Hard Rock differs notably in that the weaker global policy coordination of fuel and efficiency standards and limited technology transfer result in a much slower uptake of EVs and alternative fuels. As a result, the transport sector experiences energy demand growth of 28%, and oil remains the dominate fuel.

5 ENERGY EFFICIENCY GAINS ARE CRITICAL TO MANAGE ENERGY DEMAND FROM INDUSTRIAL, RESIDENTIAL AND COMMERCIAL SECTORS AND TO AVOID REDUCING CLIMATE CHANGE MOMENTUM.

In both **Modern Jazz** and **Unfinished Symphony**, the industrial, residential and commercial sectors generate the majority of the primary energy demand growth from 2020 to 2040. This would be significantly higher if not for the expected acceleration of new energy efficiency solutions.

In **Modern Jazz**, the use of advanced digital solutions helps optimise industrial processes and end-product designs, thus minimising energy consumption while reducing waste. In **Unfinished Symphony**, connected devices and distributed power generation behind the meter combine with new high thermal efficiency construction materials to significantly reduce energy intensity of buildings; additional gains are achieved through effective policies and efficiency standards.

In contrast, the primary energy demand growth in **Hard Rock** is nearly double that of **Unfinished Symphony**, despite a lower GDP growth as improvements in energy efficiency progress much more slowly within this time frame.

6 NEW OPPORTUNITIES ARE EMERGING TO PROVIDE ENERGY-PLUS SERVICES IN AN INCREASINGLY CONSUMER-CENTRIC ENERGY SYSTEM.

Consumer-centricity of the energy system increases in all scenarios. This increase is most prominent in **Modern Jazz**, where demand-side pressure for transparency and value-adding services emerge and deliver co-benefits in terms of cost, health and the environment. A positive feedback loop develops in which greater engagement of consumers leads to better awareness of consumers' energy needs and, in turn, more relevant services and a growth of trust in energy providers.

In **Unfinished Symphony** governments and their citizens align in support of socially just, affordable and deep decarbonisation pathways, and public-private investment in a broad range of clean energy technologies decouples CO₂ emissions from economic growth. Consumers' socially responsible energy behaviours result in economic growth detaching from energy demand. By 2040, the energy intensity of the economy is nearly half of today's level.

7 INFRASTRUCTURE INNOVATION AND INVESTMENT AND PROACTIVE POLICIES ARE NECESSARY TO SECURE AFFORDABLE DECARBONISATION AND SOCIALLY JUST ENERGY TRANSITIONS.

Across all scenarios, energy infrastructure planning and development is a key differentiating factor in determining the depth (that is, the reach and scale) and affordability of decarbonisation and the balance between new winners and new losers (that is, social justice outcomes) as energy transition progresses.

New investments are needed in seasonal storage, clean liquids pipelines and new port infrastructure. Investments will need to cover new build, decommissioning, repurposing and management of stranded assets. Other investments at the ultra-local level will have to occur with new business models to enable distributed generation and energy access on-demand anywhere, anytime and for anyone.

Supplying the future electricity demand alone will require an increase in power generation capacity of 26-90%, that is, 2 to 6 TW cumulative installations. Wind and solar will capture the bulk of this growth, and gas will account for about a third, while up to 33% of coal capacity will be retired. In all, investments of roughly USD 670-890 billion per year will be needed just for power generation. To enable such massive investments, supporting policies will need to be developed and implemented, sometimes against the grain of established market structures. Given the size of the challenge, infrastructure is rapidly emerging as the new frontier of innovation.

8 NEW NET-ZERO CARBON TECHNOLOGIES PATHWAYS (INCLUDING HYDROGEN) AND CARBON ABATEMENT MECHANISMS (INCLUDING CARBON PRICING AND CCUS) EMERGE AND START TO SCALE BY 2040.

Hydrogen production for use in mobility and buildings grows at a faster rate in **Unfinished Symphony**, reflecting the fact that government cooperation and policy support is critical in enabling and scaling power-to-X pathways for trading excess renewables. The rate of growth is nearly double the level in **Modern Jazz** and over ten times the level in **Hard Rock**. In reaching 10.5EJ annual production – which equates to around 2.3% of hydrogen share of final energy – the new hydrogen economy passes an important tipping point in **Unfinished Symphony** by 2040.¹

Research, development and demonstration continue in carbon abatement mechanisms (implicit and explicit carbon-pricing schemes) and a diversity of direct carbon removal and carbon capture technologies in power generations. The best-case assumption is made of 158 GW of installed capacity by 2040 in **Unfinished Symphony**. Under current technology and carbon pricing assumptions, CCUS only exceeds 10% of installed power generation capacity in the 2050s. As for the role of CCUS in industrial processes, it has potential but will at best take off in the 2030s. Significant improvements on both accounts of technology progress and policy support will therefore be required for CCUS to fulfil its role as a major lever in global decarbonisation.

9 ACHIEVING PARIS AGREEMENT TARGETS REMAINS ELUSIVE, WITH NONE OF THE 2019 SCENARIOS MEETING THE 2°C TARGET AGREED TO IN THE UNFCCC PARIS AGREEMENT.

Unfinished Symphony, which can be seen as the most plausible “high decarbonization” pathway of our three scenarios, is on an emissions reduction trajectory that would achieve a global temperature increase (to 2100) of just above 2 degrees, missing the Paris Agreement target date by around ten years. **Modern Jazz** limits the global temperature increase to 2.5 degrees, while **Hard Rock** sits higher still at 3 degrees. With some recent trends away from a globally coordinated approach to tackling climate change, it is urgent that energy leaders reverse these trends if the well-below 2 degrees target is to be met.

¹Please note that these numbers are for hydrogen use in buildings and mobility, which is on top of production of hydrogen for use in refineries, for fertilizer and in other industries, which comes predominantly from on-site production.

RECOMMENDATIONS

The emerging trends and new insights highlighted in this report make it clear that disruptive innovation is opening up significant new business opportunities for those energy leaders and organisations that are prepared to seek and create them. Scenarios provide a stage for exercising better strategic judgement and equip energy leaders with a tool for clarifying strategic choices, informing better decisions and enabling new action. Paralysis-in-analysis of complexity is not a real option; instead, we have identified new imperatives for more effective leadership action.

Energy business leaders should:

- Actively prepare for the migration of value from peak resources (commodity volume) to unlimited energy-plus services and for new competition beyond the energy value chain;
- Identify new customer-centric growth opportunities in electrification, storage, power-to-X and the new hydrogen economy;
- Understand and position for disruption in the shift to consumer-centric energy systems in order to maintain the social license to operate.

Policy makers should:

- Identify integrated policy innovation opportunities and implement sector-coupling policies to enable faster, socially affordable and deeper decarbonisation of the whole economy;
- Establish a “new economics” of whole energy system transition that looks beyond zero marginal cost pricing and enables a level playing field in comparing new and better options;
- Encourage demand side participation through policymaking that enables energy system integration, better connectivity among actors (consumers, prosumers and suppliers) and improved consumer access;
- Implement proactive energy infrastructure action plans and enhance systems resilience.

The international community should:

- Renew efforts to facilitate technology transfer, secure new investment and progress regional integration in order to accelerate efficiency and cost gains through common standards;
- Recognise and enhance adaptability and resilience of interdependent food-energy-water systems by preparing energy systems for inevitable global environmental shocks and cyber security threats;
- Reduce the risk of fragmentation by encouraging cross-border, cross-sector and cross-vector strategic partnerships to accelerate progress along net-zero carbon pathways and to secure new opportunities for global trade in clean electrons and clean molecules (gas and liquids), including hydrogen.

The Council promotes and uses plausibility-based, technology-neutral scenarios to support well-informed, globally inclusive and better-quality strategic dialogue and decision-making in relation to emerging and common energy challenges. It invests in ways of using these scenarios, recognising the multiple barriers – including cognitive, cultural and capability constraints – that business leaders and government officials face when working with plausibility-based energy scenarios.

ABOUT THIS REPORT

Scenarios provide an inclusive and strategic framework that enables big-picture thinking. They are designed to be used as a set to explore and navigate what might happen and support a better-quality global strategic dialogue on the future of energy systems.

In 2016, the World Energy Council and its scenarios partners, Accenture Strategy Energy and the Paul Scherrer Institute, introduced the World Energy Scenarios which explore three plausible pathways for energy transition to 2060.

Over the last three years this scenario framework has been validated by input from the Council's extensive energy expert member community. The three scenarios are perceived to be more relevant than ever.

In this scenarios refresh, the Council has adopted a medium-term time horizon of 2040 and focused on the implications of broader and disruptive innovation for the energy industry.

The report, "Exploring Innovation Pathways to 2040," presents three global storylines to 2040, with supporting systems thinking maps, comparative analysis and regional summaries. It includes a discussion of new insights, reflecting deeper shifts in the energy system innovation landscape, and provides a broader view on "how to use" the scenarios.

Refreshed scenarios were informed by insights from more than 100 deep-dive leadership interviews across 14 themes, regional workshops and wide experts' engagements.

Produced in collaboration with: Accenture Strategy as Project Partner, Scenarios
Paul Scherrer Institute as Project Partner, Scenarios: Energy Modelling and Scenario Quantification

THE WORLD ENERGY COUNCIL

The World Energy Council is the principal impartial network of energy leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system for the greatest benefit of all.

Formed in 1923, the Council is the UN-accredited global energy body, representing the entire energy spectrum, with over 3,000 member organisations in over 90 countries, drawn from governments, private and state corporations, academia, NGOs and energy stakeholders. We inform global, regional and national energy strategies by hosting high-level events including the World Energy Congress and publishing authoritative studies, and work through our extensive member network to facilitate the world's energy policy dialogue.

Further details at www.worldenergy.org and [@WECouncil](https://twitter.com/WECouncil)

The full report can be found at www.worldenergy.org/publications

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