WORLD ECONOMIC FORUM

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Community Paper

The A-Z of the Energy Transition: Knowns and Unknowns

In collaboration with the Global Future Council on Energy 2019-2020

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Introduction

The 2019 report on the Speed of the Energy Transition by the World Economic Forum Global Future Council on Energy described two diverging trajectories for gradual or rapid change in the global energy system. The paper received substantial attention and the discussion is ongoing. As a next step, we believe it is useful to highlight some of the road signs that are pointing the way in this debate. Some facts about the energy landscape are increasingly clear; these are, therefore, the things we already know. On other points there is continuing high uncertainty; these are the things we do not (yet) know.

Like all technology-led transitions, the energy transition will unleash significant creative destruction,[1] create large new opportunities for wealth formation, and will ultimately lead to greater prosperity and major societal benefits. Nevertheless, there will also be transition costs that need to be minimized and taken into account.

In this paper, we highlight some areas of relative certainty (the knowns) in the energy transition, driven largely by technological development and market forces. These trends are driving continuing declines in the cost of renewable energy, encouraging low-carbon solutions to be implemented across the energy mix, and leading to tipping points in those areas where demand for fossil fuel energy is peaking.

In the second part, we highlight areas of more complex uncertainty (the unknowns), mostly related to questions of political economy. Unlike the relatively predictable trends in technology and markets, the manner in which governments, companies and societies react to fundamental changes in the energy industry is difficult to forecast. Resistance to change may have the effect of slowing the transition in certain geographies or sectors, while conversely a more aggressive approach to change can accelerate the transition in other regions or industries. Ultimately, the speed of transition will depend on an interconnected feedback loop of policy, finance, technology, cost and consumers that can either speed up or slow down transition. It will also depend on whether a leapfrog to a more sustainable, secure and inclusive energy system would translate into electoral gains for political representatives. In this process, facts on what we know and what we don't yet know can contribute to overall energy literacy and more scientific evidence-based decisions on the energy transition.

As we go to press, the world faces the trauma of COVID-19 and the deep uncertainty this introduces into any forecasts. Our hearts go out to those impacted by this and the issue will be the subject of a separate piece of analysis.

Knowns of the energy transition

A. We need an energy transition.
As set out in the recent IPCC report on the impact of global warming of 1.5 degrees[2], business as usual will use up the Paris Agreement carbon budget within 20-30 years and bring us towards a hothouse earth. We need a transition from energy that emits greenhouse gases to renewable energy to avoid this fate.

B. We know what we need to do.
The broad shape of the energy transition[3] is to reduce demand where possible through energy efficiency and behavioural change,[4] decarbonize electricity, electrify everything you can[5] and use some variety of renewable-based hydrogen for the rest.[6] To transition at the necessary pace may also require the use of biomass and emissions removal technologies. Analysts such as Jacobson have set out high-level energy roadmaps to 100% renewable energy systems in 143 countries.[7]

C. The energy transition will be difficult.
However, fossil fuels provide around 80% of global energy supply and are the foundation of modern society. Many countries and companies are dependent on the wealth generated by fossil fuels[8] and the Bank of England has noted that up to $20 trillion of assets are at risk from the energy transition.[9] The forces of incumbency and inertia resisting change are powerful and will seek to ensure the continuity of the current fossil fuel system.[10]

D. The forces of transition are likely to prevail.
Those who would benefit from a transition vastly outnumber those who benefit from continuity; 80% of people live in countries that import fossil fuels. Just 1% of the global workforce works in the fossil fuel industry[11] and a large share of the rents from fossil fuels[12] flow into the hands of a small number of fossil fuel exporters. Meanwhile, parts of the fossil fuel industry are already pivoting to renewables and reducing their carbon footprint.

E. The energy transition is just.
Fossil fuels are used mainly by the rich and the few, while their costs are shouldered mainly by the poor and the many.[13] In contrast, renewables are everywhere, can be deployed at any scale and are being used to solve last-mile problems and provide electricity to the 1 billion people who lack it.[14] A hothouse earth would render much of the planet uninhabitable,[15] destroy the livelihoods of the poorest and create tens of millions of climate refugees.[16] According to the International Renewable Energy Agency (IRENA), an energy transition would create 17 million more new energy jobs than fossil fuel jobs would be lost.[17] Religious and moral leaders of our world are calling for transition.[18]

F. Energy transition is the cheaper option.
As a result of the collapse in renewable energy costs and other technology improvements over the past decade, the cost of an energy transition is lower than that of business as usual. According to the Boston Consulting Group, the costs of a transition are around 1% of GDP and the costs of no transition are at least 30% of GDP. [19]

G. Key actors are mobilizing for transition.
Many financial institutions, major corporations, civil society representatives and governments are demanding change. Managers of $120 trillion of assets have signed up to the principles of the Task Force on Climate-Related Financial Disclosures (TCFD). Blackrock, the world's largest asset manager, has noted that we are "on the edge of a fundamental reshaping of finance" and that "we will see changes to capital allocation more quickly than we see changes to the climate itself".[20] The European Union has set out a plan for a Green New Deal,[21] India has set its sights on 450 gigawatts of renewables (far greater than the size of its entire electricity system) and Pakistan plans to quadruple the share of variable renewables in its energy system.[22] Corporations are signing up to Paris-compliant targets as set out by RE100, and opinion polls show consistent public demand for action to reduce global warming.[23] Oil companies such as Shell and BP have announced energy transition strategies.[24]

H. We have technology solutions.
There are rising numbers of technology solutions available to start the transition in a cost-effective manner. Efficiency gains have already curbed energy demand growth from 3% to around 1% on average and could drive growth still lower.[25] Renewable electricity costs less than fossil fuel electricity in two-thirds of the world, according to BloombergNEF,[26] renewable integration technologies keep lifting the ceiling of what level of variable renewables is possible,[27] and the cost of electricity-based light transport will shortly be lower than that of fossil-based light transport.[28]

I. Technology solutions are getting cheaper fast.
Key renewable energy technologies of solar, wind, batteries and electrolysers are on technology learning curves whereby their costs fall by 15%-20% for every doubling in capacity.[29] This means they are rapidly falling below the costs of existing fossil fuel technologies in an increasing number of locations.[30] And, in turn, this gives policy-makers more space and opportunity to act.

J. Peaks have already started.
As a result of the rapid cost falls, key renewable energy technologies are growing very rapidly on exponential growth curves known as S curves, making it possible for them to supply incremental energy demand in specific sectors and countries. As a result, existing fossil fuel technologies are already seeing peaks. European fossil fuel consumption peaked in 2006 and is down by 17%. Global coal demand peaked in 2013,[31] and global demand for ICE cars may never surpass the levels reached in 2017.[32] According to the World Resources Institute (WRI), by 2017 49 countries with 36% of emissions had already seen peak emissions.[33]

K. Incumbents are at risk.
Peaking demand and technological competition put incumbent players in the energy system at considerable risk of lower prices and stranded assets if they fail to react in time.[34] We have already seen hundreds of billions of dollars of write-downs among incumbent fossil fuel players[35] and stock price collapses in sectors from coal to electricity, turbines to oil exploration.[36]

L. We need more policy action to reach Paris goals.
Policy-makers need to take much more assertive action[37] if they wish to drive the transition fast enough to meet the aspirations of the Paris Agreement.[38] There is tremendous scope for major policy action. According to the IEA,[39] fossil fuel subsidies in 2018 were $428 billion ($13 per t of carbon dioxide released by the energy sector), not much less than the total direct[40] and indirect taxes on fossil fuels, which were €517 billion in 2018, according to the OECD.[41] Meanwhile, the externality cost of health and global warming is at least $100 per tonne.[42]

M. Policy-makers need to plan for change.
As change courses through the system, a failure to plan ahead is dangerous. Policy-makers need to retool fossil fuel dependent states and systems, to retrain workers in order to ensure that the transition is just, to plan for new sources of tax revenue[43] and to hold back from investing capital in assets which are likely to be stranded by the transition.[44]

Unknowns of the energy transition

N. How will the political economy play out in each country?
Every country is different and there is no single solution. Moreover, in some countries fossil fuel interests have been able to seize the reins of government to try to hold back an energy transition.[45] At the same time, the energy transition will also create new constituencies that benefit from investment and growth as well as jobs in the wider economy.[46] Even in hard-to-abate heavy industries (such as iron and steel, fertilizers or petrochemicals) there is potential for a very large workforce in alternative fuels such as the hydrogen supply chain.[47]

O. What are the non-linear impacts of transition?
There are likely to be many non-linear and highly unpredictable consequences of changing the energy system. For example, consumer behaviour may change dramatically as the result of concerns about global warming, climate activism and other social changes like remote networking. And feedback loops may hasten the process of change.[48] The fact that we cannot forecast these is another reason to be cautious about seeking to model in excessive amounts of detail.

P. When is peak fossil fuel demand?
The exact date of peak fossil fuel demand depends on so many variables that it is not easy to calculate with any certainty, and there will be differences between coal, oil and gas in each location. At current growth rates of new energy technologies and global efficiency gains, the peak will come in the 2020s.[49] If new energy supply suddenly stops growing and global energy demand rises faster, then the peak will not come until the 2040s.

Q. Which new innovations are coming?
We need to distinguish between those technologies which are proven at scale and cost, such as solar and wind, those which are on clear learning curves which are likely to lead to disruption such as batteries and green hydrogen, and those which are still searching for paths to low costs and mass deployment such as CCS[50] or nuclear fusion. Incumbent forecasts for the future of energy tend to be conservative about future innovation.[51] However, this is highly likely to be excessively conservative; the experience of spectacular renewable energy cost falls in the past decade,[52] the urgency for action and the increasing resources devoted to finding solutions would suggest that learning curves will be maintained and that new innovations will materialize.

R. How long is the gas bridge?
Gas is often put forward as a bridge to a renewables future by companies that produce it. However, it faces the dual threat of high fugitive emissions and the rapidly falling costs of renewable alternatives, which are already threatening the profitability of new gas assets.[53] There is uncertainty whether the whole gas system (infrastructure and gas supply) is a bridge. Some argue that the pipes will act as a bridge, but filled with different molecules.

S. How to solve the last part of the energy transition?
Much has been made of the difficulty of providing the last 20% of energy supply with renewables. But this is no impediment to the start of the energy transition given that non-fossil energy sources today are only 20% of global energy supply. The energy transition, like any transition, will take place in phases — a period of experimentation for new energy, a peaking phase for fossil fuels,[54] a long period of growth for new energy and, finally, an endgame where the last areas of unabated fossil fuel usage are replaced. And as technology evolves, so it will become easier to solve the more complex areas. The challenge of this decade is to drive a peak in fossil fuel demand.

T. How to solve the hard-to-abate sectors at scale?
The Energy Transitions Commission (ETC) has put forward a series of solutions[55] for the harder-to-abate sectors such as trucking and petchem, airlines and cement.[56] And more recently, Bloomberg New Energy Finance (BNEF) showed how to electrify transport, industry and buildings in Europe.[57] It remains to be seen how the shift can be done at scale but, as noted above, these endgame sectors do not need immediate solutions for the energy transition to begin.

U. Will emerging markets leapfrog or copy?
Most incumbent energy producers assume that the emerging markets will copy the energy path taken by the developed markets. However, this seems unlikely for those countries that have major pollution problems, high levels of energy dependency and good governance. As cheaper renewable solutions become available, so they are more likely to use them, especially when they are also faster and easier to deploy.[58] China and India are taking the lead and other markets are highly likely to follow. Those with very large fossil fuel resources (a minority) are, of course, less likely to make the shift.[59]

V. Will emerging economies get lower-cost finance?
An energy transition at scale will not be driven by policy commitments alone. According to the Centre on Energy, Environment and Water (CEEW), the cost of finance is the largest component of present-day renewable energy tariffs in India and even higher shares in other developing countries where the risk premium is higher.[60] When emerging economies are able to overcome the availability and affordability constraints for sustainable finance depends on their domestic policy conditions but also on reforms in how the global financial system assesses risk, how premiums are correctly priced and how risks are hedged across many countries.

W. What are the best policy tools to effect change and will they be adopted more widely?
There are a host of policy tools being used to drive change[61] and some will be more effective than others. Successful ones include renewable energy auctions, efficiency regulation and the setting of targets. This is the subject of a separate paper by the World Economic Forum's Global Future Council on Energy.[62]

X. When do we get to net zero emissions?
The timing of net zero is dependent on a very large range of variables and uncertainties and is decades ahead. Today, we need to focus on much more real issues such as peak demand, policies for effective transition and ways to tackle sectors such as cement with long lead times.

Y. What incumbents should do to transition?
Every incumbent company will face its own set of challenges and opportunities from the transition, and it is important not to confuse the specific problems of individual companies with the general solution of transition. In general, as with other technology shifts,[63] it is innovators and outsiders that are driving the change, often in conjunction with supportive government policy. However, some incumbents are likely to be able to play an important role in the transition.[64]

Z. What will be the impact of COVID-19 and the policy reaction to it?
COVID-19 introduces uncertainty into all forecasts. Some argue that the crisis will curtail enthusiasm for climate-change solutions and that demand for fossil fuels will increase thanks to the much lower prices. Others argue that the cyclical slowdown will pull forward the peak in fossil fuel demand, create space for policy-makers in energy-importing countries to remove fossil fuel subsidies and to tax externalities and so act as midwife to the energy transition. This will be the subject of a separate paper.

What is next?

Time to act. This paper is a call to action for investors, companies, policy-makers and civil society. The time has come to seize the opportunity of the energy transition, to prepare for it and to act.

The energy transition is an evolving topic. The purpose of this paper is to encourage debate to leave behind those areas where we know the answer and to focus on those where there is greatest uncertainty – the known unknowns as it were. We would, therefore, welcome feedback and ideas.

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Endnotes

1. In the phrase of Joseph Schumpeter
2. 1.5 Degrees Report. IPCC. 2018
3. And the transition should of course be guided by science and facts and seek to minimize costs and maximize returns to humanity as a whole
4. Such as a shift from a linear economy to a circular one
5. See, for example, “Sector coupling in Europe” released in 2020 by BNEF, which examines how to electrify the transport and industry sectors. Or “Mission Possible” by the Energy Transitions Commission in 2018
6. See, for example, “Path to hydrogen competitiveness” by the Hydrogen Council in 2020
7. Source Impacts of Green New Deal Energy Plans on Grid Stability, Costs, Jobs, Health, and Climate in 143 Countries. Jacobson 2019. See also the report of the Energy Transitions Commission on the ability of China to transition – China 2050: a fully developed rich, zero-carbon economy
8. See, for example, “The carbon wealth of nations: from rents to risks”. World Bank 2018
9. Source: Avoiding the storm. Climate change and the financial system. Bank of England. 2019
10. For example, in Mexico. Despite significant gains between 2014-2018, the government has stopped clean energy auctions and gone back to fuel oil and coal. Fossil fuel supporters are now in charge of governments in countries such as the US and Australia
11. Source: IRENA calculates that there are 30 million workers in the fossil fuel industry
12. The World Bank defines fossil fuel rents as the gap between the selling price and the extraction cost. They have averaged 2.7% of global GDP over the course of the past decade
13. Source: “Large Inequality in international and intranational energy footprints”, Oswald et al, Nature Energy, 2020. This notes that the top 5% of energy users use more energy than the bottom 50%. Meanwhile, Verisk Maplecroft has an analysis of country vulnerability to climate change which shows the largest risks are faced by emerging markets. Meanwhile, poorer people live in areas more vulnerable to pollution. Sources: Brook et al, 2017; Hajat et al, 2015; Fecht et al, 2015; Marshall, 2019
14. Source: Off-grid renewable energy solutions to expand electricity access, IRENA, 2019
15. Source: Climate boundaries. Rockstrom 2015; The impact of global warming of 1.5 degrees. IPCC. 2018
16. Source: Groundswell, World Bank 2018
17. Source: Energy Transition and jobs. IRENA. 2017
18. See, for example: Pope Francis Laudato Si 2015; The Hindu declaration on Climate Change 2015; The Islamic Declaration on Climate Change 2015; Forced from home. Oxfam. 2019
19. Source: The economic case for combating climate change. BCG, 2018. IRENA argued in “Transforming the energy system” in 2019 that the incremental cost of a new energy system was 16% higher than business as usual but the incremental benefits outweighed this by 3-7 times
20. Source: Annual letter to investors by Larry Fink of Blackrock. January 2020
21. Source: European Commission. European Green Deal. December 2019
22. Source: A new dawn approaches for Pakistan’s troubled energy sector. World Economic Forum 2019
23. See, for example, Yale climate opinion maps 2019. Or Orsted green energy barometer 2018
24. BP has stated it hopes to be carbon-neutral by 2050
25. Source: How big is the energy efficiency resource? RMI, 2018
26. Source BNEF NEO 2019
27. Solar and wind are now over half total electricity supply in Denmark and over a quarter in locations from Ireland to Uruguay to South Australia
28. “Wells, wires and wheels” by BNP in 2019 argued that the total system cost of electricity-based light transport is already lower than that of fossil-based light transport as the result of the much higher efficiency of electricity. Moreover, reports such as the BNEF EV Outlook argue that the rapidly falling cost of batteries means that the total cost of ownership of EV is already comparable with that of ICE and that the initial cost will reach price parity in the early 2020s
29. Source: BNEF NEO 2019. And BNEF Hydrogen - high hurdles, huge potential 2019. DNV GL in their ETO calculate cost learning rates for solar at 18%, wind at 16% and batteries at 19%
30. Fossil fuel prices have of course collapsed in recent weeks. However, these cyclical changes are quite different from the continuous structural price declines that we observe in renewable costs
31. Source: BP Statistical review of world energy, 2019
32. Source: BNEF
33. Source: Turning Points: trends in countries reaching peak greenhouse gas emissions over times. WRI 2019
34. This self-evident truth in turn inspires incumbent fossil fuel companies to transition their business model from fossil fuels to one that can operate in a zero-carbon world. In turn, this hastens change. The most recent example is BP in February 2020

35. The IEA calculated that electricity sector write-downs in 2010-2016 were $150 billion in Europe and $46 billion in the US; and GE took a write-down on its turbine division of $23 billion in 2018. 2019 saw a raft of fossil fuel write-downs, from Schlumberger ($13 billion) to Chevron ($10 billion) to Repsol ($5 billion)
36. See, for example, the stock price performance of Peabody, RWE, GE or Schlumberger. There is still some debate whether this is cyclical or structural
37. The Global Carbon Project calculates that the current NDC commitments under the Paris Agreement will lead to global warming of 2.5 to 2.8 degrees by 2100
38. The UN PRI argues that there will be an inevitable policy response (IPR). https://www.unpri.org/inevitable-policy-response/what-is-the-inevitable-policy-response/4787.article
39. Source: Tracking the impact of fossil fuel subsidies. IEA 2019
40. Source: State and trends of carbon pricing. World Bank 2019. It calculates direct taxes on carbon dioxide in 2018 at $44 billion
41. Source: Taxing energy use, OECD, 2019
42. The externality costs of fossil fuels are health and global warming (known as the social cost of carbon or SCC). The IMF (Parry 2015) calculated the health cost at $92 per tonne, and the Centre for Research on Energy and clean air (CREA) calculated it at $87 per tonne in "Quantifying the economic costs of air pollution", 2020. Jacobson, based on Stern, calculates the SCC at a minimum of $125 per tonne
43. Taxes on road transport in many countries are a significant source of government income and make up 84% of all direct and indirect carbon taxes, according to the OECD in Taxing Energy Use, 2019. The OECD notes that the average tax on road transport emissions (15% of total emissions) is €89 per t of CO2, compared with €3 per t of CO2 on the rest
44. See, for example, "How to waste over half a trillion dollars", Carbon Tracker, 2019
45. The situation is further complicated by the fact that many governments rely on income from the fossil fuel sector and some pension funds are heavily invested in fossil fuels. Nothing is easy
46. For more on this, see work of Dmitri Zenghelis in, for example, the report to the Committee on Climate Change May 2019
47. https://www.ceew.in/publications/sustainable-manufacturing-indias-low-carbon-transition
48. See, for example, the concept of Reflexivity as popularized by George Soros in "The alchemy of finance", 1987. As financial markets perceive systemic change, so they allocate capital out of old industries and into new ones, hastening the process of change
49. Peaking demand for fossil fuels in the 2020s is a feature of many forecasts, including: Energy Transition Outlook. DNV GNV GL, 2019; 2020 vision. Carbon Tracker, 2018; Global energy perspective, McKinsey, 2019
50. CCS can be applied in large production facilities and petrochemical plants. At the micro level, technologies like mobile carbon capture can be used to capture emissions all the way down to the individual vehicle level
51. For example, in the 2019 WEO the IEA argues that "The SDS does not assume any breakthroughs that will lead to the deployment of technologies that have not yet been demonstrated" and "There is no guarantee that this learning rate will be maintained in the future"
52. BNEF notes in its NEO 2019 that over the period 2010 to 2019, the cost of electricity from wind fell by 49%, solar electricity by 85% and batteries by 85%
53. See, for example, notes by the Rocky Mountain Institute. "Prospects for gas pipelines in an era of clean energy" and "The growing market for clean energy portfolios". RMI. 2019
54. Often accompanied by the "sailing ship effect" whereby the old technology has a final burst of efficiency gains
55. Source: Mission Possible. ETC. 2018
56. With the judicious use of biomass, tree planting, soil sequestration of carbon and CCS
57. Source: Sector coupling in Europe. BNEF. 2020
58. The infrastructure to get a gas molecule every single day from one end of the planet to another to produce electricity is self-evidently much larger than that needed to put up a solar panel next to the source of demand to harness the sun for 30 years
59. There are of course some notable exceptions to this observation such as Norway or the UAE
60. https://www.ceew.in/publications/greening-new-pastures-green-investments
61. According to BNEF, there were 615 live energy transition policies as of January 2020, grouped into 8 categories
62. Source: The Global Future Council on Energy: policy recommendations. 2020
63. See, for example: "The Innovator's Dilemma" by Christensen or "Engines that move markets" by Nairn 2018
64. Many energy incumbents have deep expertise, excellent technology and financial firepower to be able to drive new carbon-free energy technologies

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