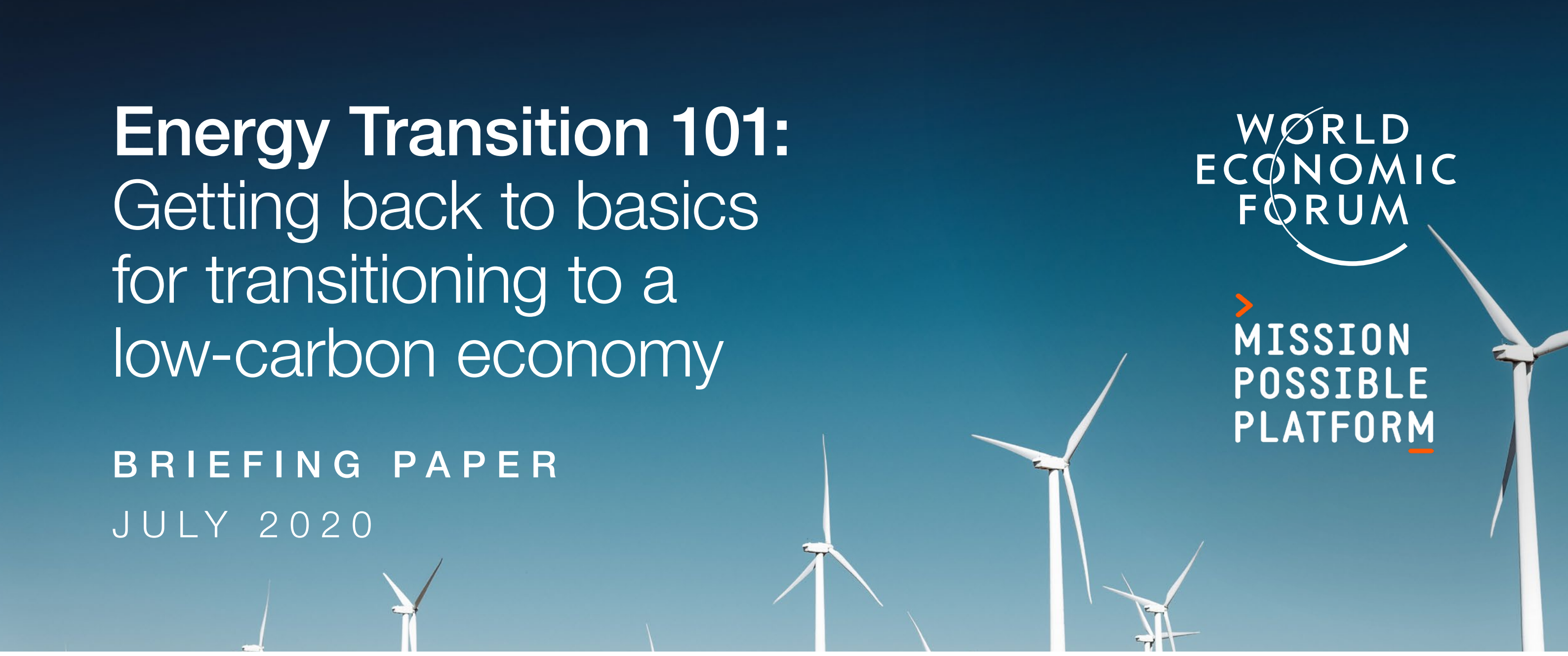

Energy Transition 101: Getting back to basics for transitioning to a low-carbon economy

BRIEFING PAPER

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MISSION POSSIBLE PLATFORM

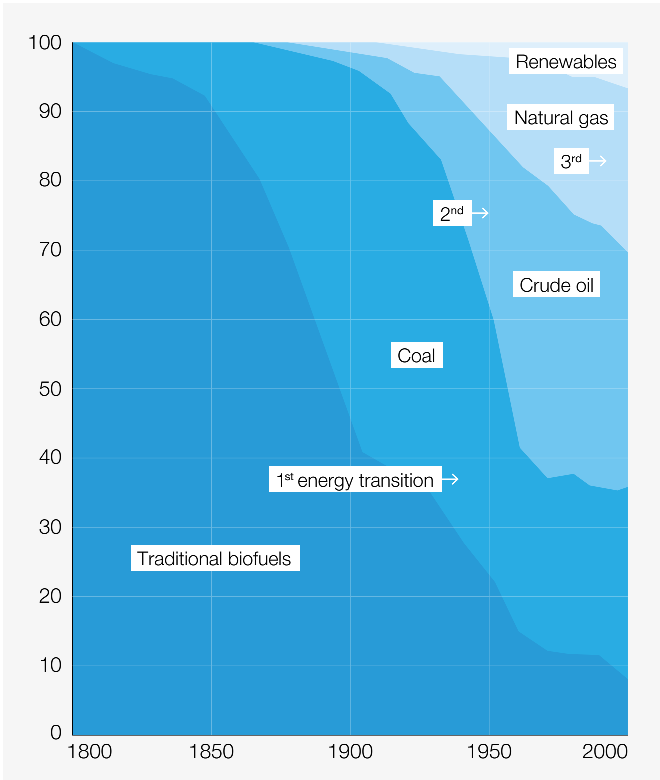
Introduction

At the launch of the World Economic Forum's Energy Transition Index 2020 (ETI 2020),[1] the authors warned that although the world's energy transition has made progress in the past five years, the COVID-19 crisis risks derailing its long-term progress. It is therefore imperative that the momentum around the energy transition is not lost and the world remains focused to achieve the objectives of the Paris Agreement to combat climate change.

Similar to the COVID-19 health crisis response, a successful energy transition is driven by science and innovation, involves a variety of solutions developed by a broad coalition of public and private actors, and needs to overcome technical, economic and political challenges, while taking into consideration regional differences that exist.

A successful energy transition also requires broad support from society to implement the measures necessary to bend the curve. This starts with creating a general understanding of the challenges involved, potential solutions and measures, and the science behind those measures. However, with today's barrage of articles, opinions and reports, it can be hard to see the forest for the trees. Therefore, this article aims to get back to the basics and discuss the **what, why, where, when, who and how of the energy transition**.

FIGURE 1 **Global energy sources (%) and previous energy transitions**

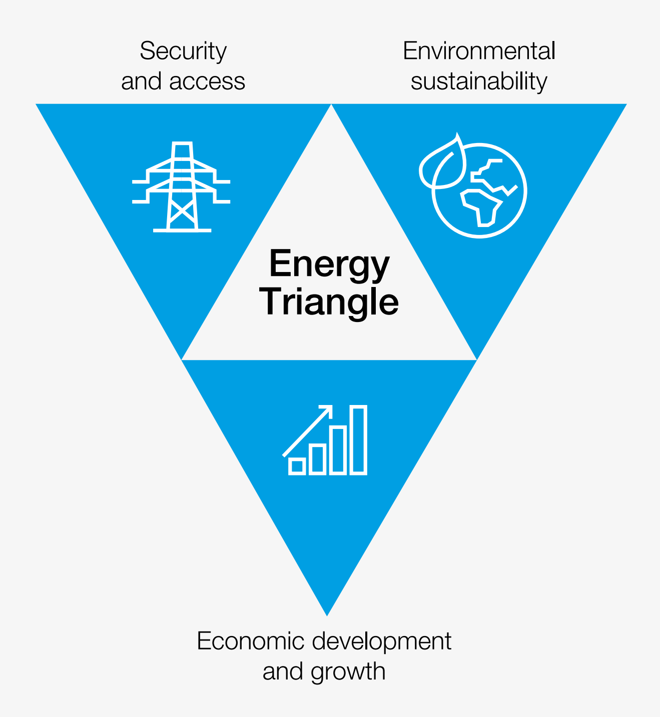


The 'what'

In generic terms, an energy transition involves a shift in the sources of energy that satisfy global energy demand. The current energy transition – from fossil fuels to low-carbon energy – is not the first energy transition the world has experienced. In fact, this is the fourth major transition to different energy sources. The first (1830-1950) was the shift from traditional biofuels (primarily wood) to coal, the second (1950-1980) consisted of the development and adoption of refined oil products, and the third (1980-2020) involved an increased reliance on natural gas.[2,3]

Whereas the current energy transition is primarily driven by sustainability reasons, the previous transitions were mainly the result of a push for economic prosperity, which is in turn closely linked to energy access and consumption. To illustrate this last point, the average energy consumption per capita in OECD countries is 183 gigajoules, whereas for non-OECD countries the average is 54 gigajoules.[4] Particularly for developing nations, economic prosperity is as much a priority in the energy transition as is the need to decarbonize. And this is an important point: more than 800 million people – predominantly in sub-Saharan Africa – are still living without access to electricity, and hundreds of millions more only have access to very limited or unreliable electricity.[5] So increased energy supply and access to energy is a good thing; however, this needs to be addressed in parallel with lowering the emissions.

FIGURE 2 **Energy transition**



The current energy transition does not only involve a transition to a low-carbon economy; it is much more complex than that. The World Economic Forum defines an effective energy transition as “a timely transition towards a more inclusive, sustainable, affordable and secure energy system that provides solutions to global energy-related challenges, while creating value for business and society, without compromising the balance of the energy triangle.”

In other words, although the current energy transition is mainly driven by environmental sustainability concerns (i.e. climate change concerns), it will only be successful if it simultaneously provides energy security and access, and facilitates economic growth and development.

The enormity of the task is also highlighted by the current COVID-19 crisis. The International Energy Agency (IEA) expects global CO_2 emissions to decline by 8% in 2020, which is a bit more than the required 6% annual reduction required to achieve the Paris Agreement.[6] However, the decline in 2020 is not because of structural changes, but rather driven by a temporary reduction in demand, as global energy demand is expected to decline by 6% in 2020. So, the challenge a hand is how to achieve a 6% reduction in emissions, while retaining economic growth and ensure the remaining 800 million people get access to energy.

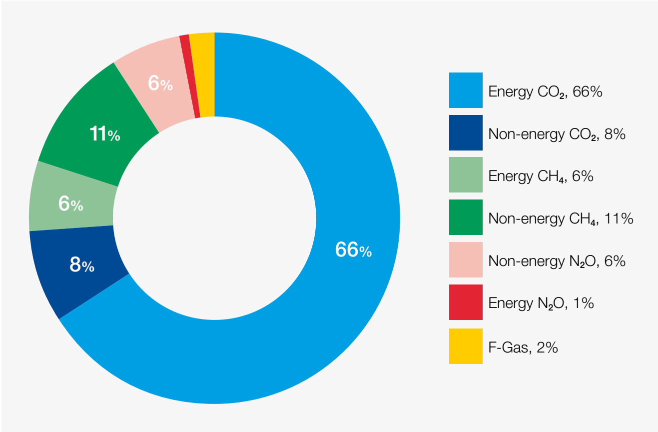
The ‘why’

The transition of the energy system towards low-carbon energy is driven by the need to address climate change. The science supporting the need for decarbonization starts with the Intergovernmental Panel on Climate Change (IPCC), which is the United Nations body for assessing the science related to climate change. In its 2018 Special Report,[7] it explains that **human activity is likely responsible for about 1˚C of global warming above pre-industrial levels**, and global warming is likely to reach 1.5˚C between 2030 and 2052, if current activity levels continue.

Simply stated, global warming means that “there is more energy radiating down on the planet than there is radiating back out to space”.[8] This amount of retained energy is influenced by a variety of climactic factors, including greenhouse gases (GHGs), aerosols (both anthropogenic, i.e. due to human activity, and natural, i.e. from volcanic eruptions) and others.[9] Models not only indicate a strong correlation between observed temperature increases and increased levels of such radiative forcing, but also show that **factors with the strongest impact on temperature increases are anthropogenic GHGs**.[10]

Here it must be noted that GHGs are not just CO_2. In the energy transition debate, the focus is mostly on energy-related CO_2 emissions, as they cover about two-thirds of global GHG emissions.[11] Other energy-related emissions are methane (CH_4 – 6% of overall GHG emissions), which is mainly emitted through natural gas leakage and flaring, and some nitrous oxide (N_2O – 1% of overall GHG emissions). The remaining, non-energy GHG emissions are primarily caused by agriculture.

FIGURE 3 **Global GHG emissions, 2016**



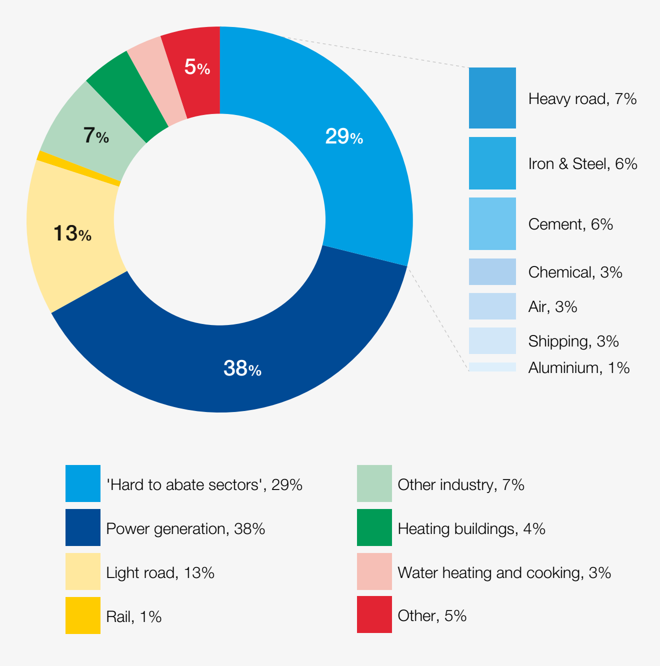
The ‘where’

Just like the impacts of global warming are unequal, mostly impacting the people living in less developed nations, the energy-related CO_2 emissions are also not equally distributed. Therefore, the debate warrants a closer look at where emissions are generated, both in terms of sectors as well as countries.

When looking at energy-related CO_2 emissions through a sector lens, the focus is typically on power generation and personal vehicles. And rightfully so, as power generation is responsible for about 40% and light road transportation is responsible for about 13% of total energy CO_2 emissions.[12] Good progress has been made in these sectors. Renewable energy, such as solar and wind energy, are becoming increasingly competitive[13] and reports such as the BNEF EV Outlook[14] argue that the rapidly falling cost of batteries means that the total cost of ownership of electric vehicles is already comparable with that of internal combustion engines, and that the initial cost will reach price parity in the early 2020s.

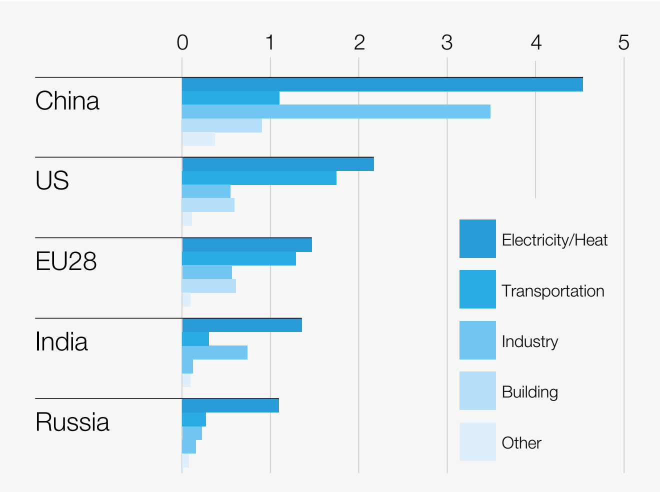
However, this does not tell the full story. **A successful energy transition needs to include solutions for the remaining 47% of energy-related CO_2 emissions**. For these so-called "hard to abate" sectors, such as heavy trucking, iron and steel, cement, shipping and aviation, scalable solutions are still being developed. To add to the complexity, scalable solutions can mean different things in different parts of the world, which is the second lens through which to look at energy-related CO_2 emissions.

FIGURE 4 **Total CO_2 emissions, 2014**



Regional differences are highlighted by the ETI 2020, which demonstrates that different regions or countries are facing different challenges in their overall energy transition. The same holds true for decarbonization efforts, as each of the world's regions has a unique energy carbon footprint.[15] There are big differences even between the five largest CO_2-emitting countries or regions. Whereas in the United State, and to a lesser extent the European Union, most emissions do indeed come from power generation and transportation (mostly light road vehicles), in China and India the focus should be more on decarbonizing industry.

FIGURE 5 **Energy CO_2 emissions in $GtCO_2$, 2016**



The 'when'

The experience of the previous energy transitions shows that these transformations do not happen overnight, but are a process that takes place over decades.[16] However, for the current energy transition, the question is how much time there is to complete it. An interesting concept called the "carbon budget" clarifies the urgency of the situation. In short, the IPCC estimates that in order to stay within 1.5˚C of global warming the world can "spend" a maximum budget of 2600-2900 $GtCO_2$ of anthropogenic emissions, of which 2200 $GtCO_2$ has already been used to date. **With current emissions of approximately 42 $GtCO_2$ a year, the remaining budget will be depleted in 10-17 years, if no transition is made.**[17,18]

Therefore, to fulfil the commitment to the Paris Agreement and keep global warming preferably below 1.5˚C, the IPCC calculates that anthropogenic CO_2 emissions need to decline by about 45% from 2010 levels by 2030 and need to reach net zero around 2050. This is the main reason why countries and companies communicate their climate targets by committing themselves to "net zero" by 2050, typically with intermediary reduction targets by 2030.[19]

The 'who'

Through lifestyle choices, every individual has a large responsibility in making the energy transition happen, very similar to the COVID-19 response. However, like with COVID-19, to be effective, **the efforts towards a successful energy transition require a multistakeholder approach involving a broad coalition of public and private actors**. Broadly speaking, these fall into four main categories:

1. *Governments and policy-makers:* Because of the unique carbon footprints, policy-makers from different regions are involved in the energy transition to ensure that measures are suitable for their country or region. Main examples of impact are climate policies such as the EU Green New Deal, carbon pricing policies and emission trading schemes.

2. *Business:* The private sector is investing heavily in the low-carbon economy, either opportunity-driven (e.g. rooftop solar providers) or because the energy transition is a threat to existing business models (e.g. oil and gas companies). To develop scalable solutions, a range of businesses are involved, including end-users (such as automotive producers), energy providers (including utilities and oil and gas producers) and enablers (such as financing companies and technology providers).

3. *International organizations:* Organizations such as the United Nations, International Energy Agency, World Bank and World Economic Forum provide analysis, policy recommendations and convening power.

4. *Think tanks, NGOs and academia:* A wide variety of organizations provides additional research and put pressure on governments and businesses to act. Examples are the Energy Transitions Commission, European Climate Foundation, World Resources Institute, Rocky Mountain Institute, the Columbia SIPA Center on Global Energy Policy and many others.

The ‘how’

From the previous sections, it becomes clear that **the task to manage a successful energy transition is an enormously complex one**. It not only needs to focus on decarbonization, but also needs to guarantee energy access and security while fostering economic development at the same time. Additionally, a unique region/sector carbon footprint highlights that there is no “one-size-fits-all” solution when it comes to the energy transition. To make matters even more complex, a large group of stakeholders need to be involved and satisfied in order to find scalable solutions, meaning solutions that are **technically, economically, socially and politically viable**. There is also limited time to complete the energy transition; the objective is to complete it in about 30 years.

All these complexities show that the energy transition challenge cannot be solved by one type of solution. Instead, there is a need for a combination of solutions to achieve net zero. Broadly speaking, solutions for decarbonization fall into one of three categories:

1. *Increasing energy efficiency:* Among all the primary energy used, only 33% is converted into useful energy; the remaining 67% is lost due to the inefficiencies in electricity generation, transport, heavy industry and buildings.[20] So, as the IEA states, energy efficiency is one of the best solutions towards an inclusive, sustainable, affordable and secure energy system: “It is one of the most cost-effective ways to enhance security of energy supply, to boost competitiveness and welfare, and to reduce the environmental footprint of the energy system”.[21] Great progress has been made in some areas (e.g. personal vehicles and aviation), but more needs to be done in other sectors (e.g. buildings).

2. *Developing alternative, low-carbon energy:* Well-known examples are the switch from fossil fuels to renewable energy sources such as wind and solar for power generation, or the switch from internal combustion engines to electric vehicles. But scalable solutions to replace kerosene for aircrafts, bunker fuels for ships, or naphtha for chemical production are still being developed.

3. *Capturing unavoidable emissions:* Ultimately, there will likely be instances where increased energy efficiency or alternative low-carbon energy sources are not viable,either from a technical, economic, political, or social point of view. In these cases, carbon capture plays a role, either mechanically through carbon capture and storage (CCS) facilities, or with nature-based solutions, such as reforestation.[22]

Case study: Shipping

To capture a glimpse of how this works in practice, the **Mission Possible Platform** provides a good starting point.[23] The Platform is an initiative focused on delivering emission-reduction measures and innovations in order to decarbonize seven of the hard-to-abate sectors, including steel (~6.5% of global energy CO_2 emissions), chemicals (~3%), aviation (~2.7%) and shipping (~2.6%). For each of these sectors, a broad coalition of public and private actors is developing scalable solutions.

One of these initiatives is the Getting to Zero Coalition, which focuses on decarbonizing the shipping industry and was launched as a response to the International Maritime Organization’s ambition to halve global shipping emissions by 2050. It clearly demonstrates the need to address some of the complexities mentioned in this article.

For example, one challenge is that ships have a long operating life of 20 years or more. That means that to reach the net zero target in 2050, scalable solutions need to be found in the next 10 years, adding significant complexity to the challenge.

Economically speaking, to scale solutions after 2030 the infrastructure investment needed between 2030 and 2050 amounts to approximately $1-1.4 trillion, or an average of $50-70 billion annually for 20 years, depending on the production method.[24] Notably, 87% of these investments will need to take place on land, instead of the ships themselves, which shows the economic impact beyond the maritime industry.

From a social point of view, the shipping challenge provides an enormous opportunity to ensure no country is left behind. A “power-to-x” model, where renewable energy is being used to produce green hydrogen, has the potential to drive investments in energy projects in developing and middle-income countries with access to abundant untapped renewable resources. The Getting to Zero Coalition is exploring pilots for these models with Morocco and Chile.

To address these challenges, Getting to Zero involves a broad coalition in the four categories that were mentioned. The coalition currently consists of a group of 110+ companies from a range of sectors such as shipping (end-users), oil and gas companies (energy providers) and finance (enablers). Additionally, it is supported by various NGOs and international organizations and is endorsed by 14 national governments. The coalition also looks at a variety of solutions. Although technologies to increase energy and operational efficiencies will be indispensable in reaching its target, they will likely be insufficient. As a result, Getting to Zero works towards developing scalable zero-carbon options for international shipping, including fuels derived from zero-carbon electricity (such as green hydrogen), biofuels, or fossil fuel feedstocks coupled with CCS.

Conclusion

As with the COVID-19 response, a successful energy transition requires broad support from society, which begins with a basic understanding of what the energy transition actually is. Once the basics are understood, it becomes clear that managing a successful energy transition is enormously complex and entails much more than simply replacing thermal coal with renewable energy for power generation, or replacing petrol cars with electric vehicles. A broad coalition of public and private actors is needed to address the unique region/sector carbon footprint, and to develop a mix of solutions that are technically, economically, politically and socially viable in every part of the world.

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Endnotes

1. World Economic Forum, Energy Transition Index 2020: from crisis to rebound, 2020, https://www.weforum.org/reports/fostering-effective-energy-transition-2020.

2. Smil, Vaclav, “Energy (r)evolutions take time”, World Energy, 44:10-14, 2019. Note that Smil also mentioned a revolution with the invention of electricity, however, this article focuses on transitions of energy sources instead of distribution

3. Ritchie, Hannah and Max Roser, “Energy”, Our World in Data, July 2018, https://ourworldindata.org/energy; Underlying sources: Smil, Vaclav, “Energy Transitions: Global and National Perspectives”, BP Statistical Review of World Energy, 2017.

4. BP Statistical Review of World Energy 2019.

5. Ogunbiyi, Damilola, “Here’s why energy security is a vital tool in tackling a pandemic”, Forum Agenda, 6 April 2020, https://www.weforum.org/agenda/2020/04/pandemic-energy-access-coronavirus.

6. “The impact of the Covid-19 crisis on clean energy progress”, IEA, 11 June 2020, https://www.iea.org/articles/the-impact-of-the-covid-19-crisis-on-clean-energy-progress.

7. IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.

8. Chandler, David, “Explained: Radiative forcing”, MIT News, 10 March 2020, news.mit.edu/2010/explained-radforce-0309.

9. “Analysis: Why scientists think 100% of global warming is due to humans”, Carbon Brief, 13 December 2017, https://www.carbonbrief.org/analysis-why-scientists-think-100-of-global-warming-is-due-to-humans.

10. Merbold, Lutz, “How do we measure greenhouse gases?”, Forum Agenda, 4 December 2015, https://www.weforum.org/agenda/2015/12/how-do-we-measure-greenhouse-gases.

11. CAIT Climate Data Explorer, Historical Emissions [Country GHG Emissions dataset], http://cait.wri.org/historic.

12. Based on data from the International Energy Agency, Energy Technology Perspectives 2017, www.iea.org/etp2017; representation is based on https://www.economist.com/technology-quarterly/2018/11/29/what-would-it-take-to-decarbonise-the-global-economy.

13. See, for example, Lazard’s levelized cost of energy analysis, version 13.0, https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf.

14. “Electric Vehicle Outlook 2020”, BloombergNEF, https://about.bnef.com/electric-vehicle-outlook.

15. CAIT Climate Data Explorer, Historical Emissions [Country GHG Emissions dataset], http://cait.wri.org/historic. Three categories are different than the original classification: (1) Industry includes Manufacturing/Construction and Industrial Processes; (2) Transportation includes Transportation and Bunker Fuels; (3) Other includes Other Fuel Combustion and Fugitive Emissions.

16. Smil, Vaclav, “Energy (r)evolutions take time”, World Energy, 44:10-14, 2019.

17. As the IPCC notes, there are uncertainties in the size of these estimated remaining carbon budgets. The point is that it is not an option to continue “‘as is” for 10-17 years before taking action, as emissions cannot suddenly go down to zero. It is encouraged to read the IPCC report at https://www.ipcc.ch/sr15/chapter/spm/.

18. For a real-time countdown of the carbon budget – based on the IPCC AR5 report, which uses slightly lower carbon budgets and focuses on a 2˚C global warming – see https://www.theguardian.com/environment/datablog/2017/jan/19/carbon-countdown-clock-how-much-of-the-worlds-carbon-budget-have-we-spent.

19. As stated by the ETI2020, the concept of “net zero” has different interpretations and has been used interchangeably with terms such as “carbon neutral” and “climate neutral”. Net zero needs a consistent definition in order to clearly set milestones, measure progress and compare efforts by countries and companies. See also https://carbontracker.org/reports/absolute-impact.

20. “Systemic Efficiency”, World Economic Forum, https://www.weforum.org/projects/systemic-efficiency.

21. IEA, World Energy Outlook 2019, November 2019, https://www.iea.org/reports/world-energy-outlook-2019/energy-efficiency.

22. “Natural Climate Solutions: Practical, cost-effective climate action”, Natural Climate Solutions Alliance, https://www.weforum.org/natural-climate-solutions-alliance.

23. “Mission Impossible Platform: Delivering industry pathways to net-zero emissions”, World Economic Forum, https://www.weforum.org/mission-possible.

24. Christensen, Johannah, “How green stimulus measures could fuel the decarbonization of shipping”, Forum Agenda, 12 May 2020, https://www.weforum.org/agenda/2020/05/green-stimulus-policy-decarbonization-shipping-industry-renewable-energy-transition-fuel.