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Strengthening Energy Security and Building Resilience in the Asia–Pacific

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Strengthening Energy Security and Building Resilience in the Asia–Pacific

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Acronyms and Abbreviation

AI	artificial intelligence
CCS	carbon capture and storage
CCUS	carbon capture, use and storage
CEIs	critical energy infrastructures
CIs	critical infrastructures
COVID-19	coronavirus disease 2019
CRMs	critical raw materials
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
EVs	electric vehicles
GHG	greenhouse gas
Gt	gigatons
GW	gigawatt
GWh	gigawatt-hours
ICS	industrial control systems
IEA	International Energy Agency
IoTs	internet of things
mt	metric tonnes
Mtoe	million tonnes of oil equivalent
MW	megawatt
OECD	Organisation for Economic Cooperation and Development
OT	operational-technology
SCADA	supervisory control and data acquisition
SLOCs	storage locations
SDGs	Sustainable Development Goals
TWh	terrawatt hours
WEC	World Energy Council

References to dollars ($) are to United States dollars unless otherwise stated.

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Chapter 1

Introduction

1.1. The changing environment of energy ecosystems and energy security

Energy is the cornerstone of economic development and a key contributor to human well-being and progress. Ensuring energy security, and energy resilience to future shocks, are long-term strategic objectives of all economies across the Asia-Pacific region and worldwide. The traditional concepts of energy security have revolved around the first oil crisis in 1973 and incumbent technologies and fuels, notably fossil fuel-based energy. The focus has been on securing uninterrupted supplies of commodities such as coal, oil and gas and ensuring the integrity of energy infrastructure such as pipelines and power grids.

Over the last decade, several geopolitical developments have highlighted the importance of energy supply security is to the global economy, and how vulnerable individual states as well as consumers can be to supply disruptions and energy price shocks. At a first glance, this appears simply as a function of the growing imbalance in the supply of, and demand for, energy world-wide. But energy supply challenges (such as supply disruptions) also reflect the dependence of many countries on energy imports from often politically unstable regions. Those geopolitical risks have further increased over recent years.[1]

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[1] McKinsey & Company, May 2016, “Geostrategic risks on the rise”.

While globalization has increased the worldwide economic interdependence by stretching supply chains across the globe, the worldwide economic interdependence has not ended strategic competition and geopolitical rivalry.

Moreover, the present energy transition affects the global electricity sector particularly, which is being transformed by the three reinforcing strategic trends through the '3 Ds': decarbonization, digitalization and decentralization. This energy transition is based on the integration of renewable energy sources and other distributed energy resources. It is highly dependent on modernizing energy infrastructures (especially electricity grids) and fundamental reforms of regulatory frameworks to accommodate the shifting energy supply structure at a time when societies are becoming ever more dependent on the stable functioning of Critical Energy Infrastructures (CEIs). But political decision-making and regulators are often unable to adapt quickly enough to disruptive technology innovations to benefit from these new technological options such as enhancing safety, accessibility, connectivity, productivity, efficiency and sustainability of the energy transition.[2]

Implementing many new technologies bring new challenges. Digitalization and automation are also heightening new energy security risks such as privacy, data, reduced infrastructure redundancies and threatening particularly sufficient mid- and long-term investments. These risks highlight the need for new resilience concepts as well as strategies for maintaining the ever more complex system reliability of energy supply in the 21st century.[3] Increasing internet interconnectivity and a vast amount of sensitive data have all dramatically increased risks and vulnerabilities of national and global energy infrastructures due to sophisticated cyberattacks.[4] Those

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2 IEA, 2017, "Digitalization & Energy", Paris: IEA/OECD, p. 15. Available at https://www.iea.org/reports/digitalisation-and-energy

3 Austin, F.,"How to Solve the Energy 'Trilemma'", 27 November 2017. Available at https://www.greenbiz.com/article/how-solve-energy-trilemma, (accessed on 30 January 2018).

4 Umbach, F., 'Critical Energy Infrastructure and Risk of Attack', KAS-International Reports, September 2012, pp. 35-66; idem, 'Cyber Security – Dossier', Geopolitical Information Service (GIS). Available at www.geopolitical-info.com, August 2013, 35 pp.; idem, 'The Fog of Cybersecurity", GIS, 10 July 2017; and idem, 'Schutz kritischer Infrastrukturen im Zeitalter von Cybersecurity" ('Protection of Critical Infrastructures in the Age of Cybersecurity'), Mittler-Brief 2/2017.

threats might multiply with the next digitalization wave in the energy sector (i.e. electricity generation and distribution grids), the further global expansion of renewables and the electrification of the transport, heating and industrial sectors ('industry 4.0'). Due to these unprecedented changes, opportunities and risks the International Energy Agency (IEA) warned in 2017: "The interest in this topic is strong, but the world's current understanding of the scale and scope of its potential remains limited, particularly when it comes to analytically-rigorous assessments."[5]

A major argument for expanding renewables, for instance, is that they will substantially reduce the Asia-Pacific region's and the world's import dependency on fossil fuels.[6] Geopolitical risks and vulnerabilities, as well as supply disruptions have been considered traditionally as exclusively linked with fossil fuels.[7] Now the expansion of renewables has also promoted the overall decentralization of energy supplies which is widely perceived as enhancing energy security. They may not just reduce the dependence on often politically unstable fossil fuel suppliers (both state and corporate), but also the political and geo-economic power of major fossil fuel exporters in international relations. The loss of their previous geo-economic and geopolitical influence has contributed to the emergence of global 'buyers' markets' instead of the traditional 'sellers' markets. In addition, expanding renewables and ushering in 'energy abundance' will depoliticize markets by decreasing traditional geopolitical risks of supply disruptions and, thereby enhancing national, regional, and global energy supply security in our traditional understanding and defined concepts.

However geopolitical risks do not just end with decarbonization and the proclaimed end of the fossil fuel age by 2050.[8] The

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5 IEA, 2017, Available at https://www.iea.org/newsroom/news/2017/april/iea-examines-critical-interplay-between-digital-and-energy-systems.html

6 APEC, *Energy Demand and Supply Outlook – 7th Edition*, Vol. I, May 2019, pp. 143ff.

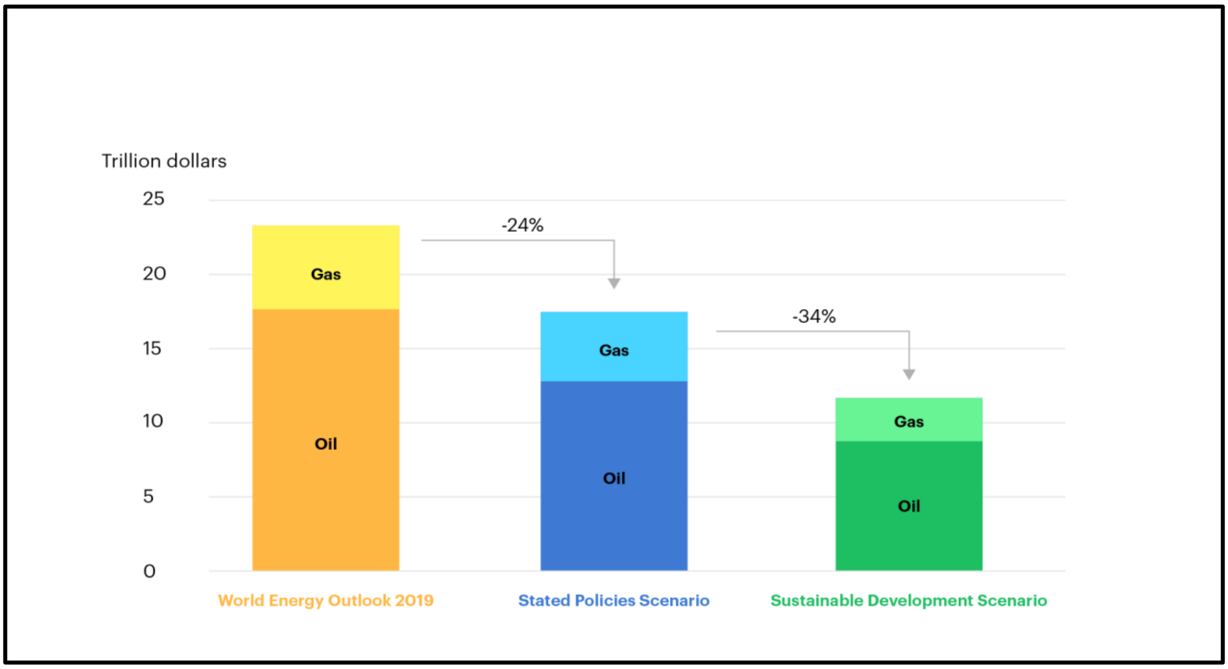
7 De Vries, A. and S. Ghouri, March 2017, 'Should Energy Security Go Green?', Energy Intelligence.

8 The end of the fossil fuel age by 2050 does not necessarily mean that in all countries of the world coal, oil, and natural gas use would cease. Natural gas, for instance, is often being viewed as a "transition bridge". But the big majority of the world's energy mix would be based on Renewable Energy Source (RES) and other clean energy sources. Beyond, to the new energy security and geopolitical risks see also O'Sullivan, M., I. Overland and D. Sandalow, "The Geopolitics of Renewable Energy", Columbia: SIPA, Belfer Center/Harvard and Norwegian Institute of International Affairs (NPI) 2017; Scholten D.,

changing energy systems from the traditional framework focusing on scarcity challenges to one based on abundant renewables, for instance, will inevitably be to the detriment of some energy sector participants such as the leading oil and gas producer superpowers.[9] Figure 1 illustrates scenarios that chart declining values of oil and gas production to 2040.

FIGURE 1

Decreasing revenues of oil and gas production of today's value to 2040



Source: IEA, 2020.

Many oil and gas producer countries, whose state budgets are dependent on high oil and gas prices, rising exports and revenue flows, are not well prepared for coping with a dramatic decline of fossil fuel prices and a rapid worldwide

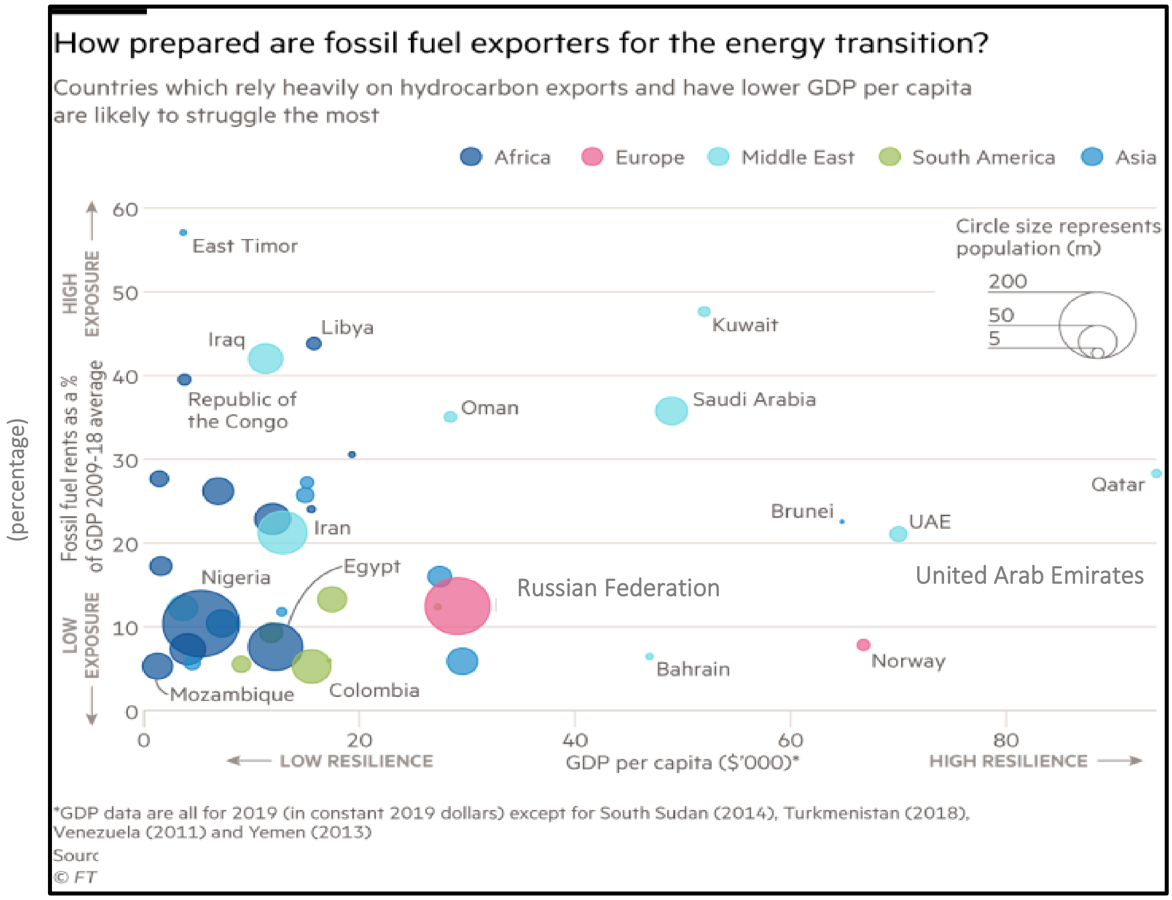
'Renewable Energy Security', EUCERS-Newsletter, Issue 64, April 2017, pp. 2-4; Scholten D. and R. Bosman, 'The Geopolitics of Renewables: Exploring the Political Implications of Renewable Energy Systems', Technological Forecasting & Social change, 103/2016, pp. 273-283; O'Sullivan M., 'Renewables Won't End Geopolitics of Energy', Japan Times, 24 August 2017, and Morris I., 'Imagining a World after Fossil Fuels', Stratfor, 22 March 2017.

9 Tricks, H., "Clean Power Is Shaking up the Global Geopolitics of Energy', *The Economist*, 15 March 2018, p. 3.

decarbonization as their economies are hardly diversified[10] (Figure 2).

FIGURE 2

The relative preparedness of fossil fuel producing countries for the energy transition



Source: Financial Times, 2021, [11]based on World Bank Development indicators.

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10 IRENA, 2019, "A new World. The Geopolitics of the Energy Transformation", Global Commission on the Geopolitics of Energy Transformation; Umbach F., 'Energy Security in a Digitalized World and its Geostrategic Implications', Study of the Konrad Adenauer Foundation (KAS)/Regional Project: Energy Security and Climate change Asia-Pacific (RECAP), Hong Kong, September 2018. Available at http://www.kas.de/wf/doc/kas_53447-1522-2-30.pdf, pp. 136ff., and Hook, L. and H. Sanderson, 'How the Race for Renewable Energy is Reshaping Global Politics" Financial Times, 4 February 2021.

11 'How the race for renewable energy is reshaping global politics'. Financial Times. Available at https://www.ft.com/content/a37d0ddf-8fb1-4b47-9fba-7ebde29fc510 , 4 February 2021.

The faster the worldwide energy transition takes place, the bigger the threats and potential instabilities of the oil and gas exporting countries relying on oil and gas revenues[12] – unless they prepare in advance, promote their own energy transformation, and diversify their economies.

But also for all other countries, the energy transition to a non-fossil fuel age, determined by the interplay between the geopolitics of fossil fuels and renewables in the forthcoming decades, is a challenging, risky and vulnerable process.[13] An unprecedented pace of the energy transition is accompanied by a high degree of unpredictability, "tsunamis of innovation" and non-anticipated disruptive developments and implications. Given the fact that almost every aspect of the complex energy system is changing simultaneously, it is becoming less predictable.[14] Figure 3 outlines some of the key energy market changes and their impacts.

FIGURE 3

Recent and forthcoming changes of the global energy sector

Energy market changes and impacts

Recent changes in global energy markets	*Forthcoming changes due to:*	*Impacts*
• Expansion of renewables • Energy efficiency technologies and strategies • Decarbonization/disinvestment in fossil fuels • United States shale oil and gas revolution • LNG revolution • Rising cyberattacks on critical energy infrastructures • Decreasing public acceptance of energy infrastructure investments (i.e. in fossil fuels)	• Electrification of the transport and heating sectors • Digitalization – Energy utilities and electricity/power sectors (smart grids, smart metering, internet of things/smart home etc.) – Fossil fuel production • Blockchain technology • Decentralization • Battery storage solutions • Quickening decarbonization	• Energy prices and competition between fossil fuels and renewables • Additional rise of worldwide and European electricity demand (already growing much faster than global primary energy consumption) • Increasing need for battery or other storage solutions • Rising cyber risks and vulnerabilities of critical energy infrastructures due to internet linkages and digitalization • Socioeconomic and political stability of oil and gas producers • Risks and vulnerabilities of the rising critical raw material demand for supply security

Source: Umbach, F./Geopolitical Intelligence Service (GIS), 2018.

12 Manyley, D.and P. R.P. Heller, February 2021, "Risk Bet. National Oil Companies in the Energy Transition", Natural Resource Governance Institute.

13 Raimi, D. and A. J. Krupnick, "Decarbonization: It ain't that Easy", Resources for the Future. Available at http://www.rff.org/blog/2018/decarbonization-it-ain-t-easy.

14 Quoted from Connelly, Q., 18 April 2018, 'Energy Transitions? Not so Fast', RealClearEnergy.

1.2. New geopolitical risks of renewables, electrification, digitalization, and the energy transition to a non-fossil fuel age

Electricity is emerging as the strategic energy carrier of the 21st century. Its new strategic importance is boosted by electrification of end uses and proliferation of low-cost renewable power generation technologies.[15] These new paradigms open up new benefits, but also create new vulnerabilities of supply and security risks. Cyber security of Critical Energy Infrastructures (CEIs), supply chains for Critical Raw Materials (CRMs) and stranded assets are just three examples of the new challenges of future energy security. Those cyberattacks during the last decade do not just threaten electricity supply security but have also targeted oil and gas infrastructures as well as power plants, which also have become increasingly digitalized during the last decade. Hence an evolution of the traditional energy security concepts is needed to prepare for the new energy landscape in the 21st century.[16]

The creation of 'prosumers' (energy consumers simultaneously becoming energy or electricity producers) and the redistribution of economic as well as political power offers new opportunities for participation, investment and strategic influence to new centralized powers (i.e. internet giants such as Facebook, Amazon, Netflix, Google and others) as well as to new players on the local level. But this brings with it "new, unfamiliar supply chains from unfamiliar [17] sources" such as CRMs.[18]

The unfolding energy transition and the digitalization of energy systems are prompting existing energy security paradigms to be reviewed, rethought, and redefined. New energy technologies are emerging, which are low carbon, digital and often decentralized.

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15 Minsky, C., "Internet of Energy Powers up Hackers -Threat to Electricity Grids", Financial Times, 25 November 2020.

16 Umbach, F., 2018, "Energy Security in a Digitalized World and its Geostrategic Implications", pp. 42ff. and 104ff.

17 IRENA, Global Commission on the Geopolitics of Energy Transformation, "A New World. The Geopolitics of the Energy Transformation", 2019, p. 15.

18 Patterson, W., "How Renewables Will Change the Geopolitical Map of the World". Available at www.energypost.eu, 9 February 2018.

The world is moving towards a long-term energy future by 2050, which will be increasingly carbon constrained and dominated by renewables and other clean energy sources as a "powerful vehicle of democratization", as countries seek to reduce emissions in line with globally agreed climate targets. These efforts for decarbonization have increased in Europe with its newly proclaimed "European Green Deal" and its new ambitious emissions reduction target of -55 per cent by 2030 (instead of the previous -40% one).[19] The new US-Biden administration has announced to spend more than US$2 trillion for decarbonization of the United States energy mix and 'greening' the United States industry.[20] China is also expected to fasten the energy transition in the forthcoming years beyond its announced plans and targets of the past years.[21]

A United States study in 2017 has identified seven major geopolitical implications of the worldwide expansion of renewables, cleaner energy mixes and low-carbon energy systems.

BOX 1

Major geopolitical implications of renewables & low-carbon energy system expansion

(1) Rising dependence on CRMs and their supply chains as the result of the global energy transition and the worldwide race for the best technologies.

(2) New technologies and options for financing them.

(3) A new resource curse as oil and gas producing countries lose their hard currency revenues, which may lead to internal instabilities. On the other side new renewable powers and the major raw material producing countries may also be confronted with implications of the resource curse;

(4) A decreasing global oil and gas demand, which may either lead to growing domestic instabilities or can be a driver for economic reforms and more diversified economies.

(5) Transnational grid networks and increasing electricity import dependencies.

(6) Reduction of climate change impacts as result of more successful global climate change mitigation efforts which can reduce conflicts and instabilities; and

(7) Sustainable access to modern and cleaner energy resources as well as energy technologies as a major condition for a more sustainable worldwide economic development and global energy supply security.[22]

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19 Umbach, F., 'The European Green Deal Faces Huge Challenges', Geopolitical Intelligence Service (GIS), 10 February 2020, and idem, 'Europas Plan für Klima und Umwelt' (Europe's Plan for Climate and Environment'), Internationale Politik, July 2020, pp. 78-82.

20 Brower, D., 'Biden Opens a new Era of American Energy', Financial Times, 21 January 2021.

21 State Council Information Office of the People's Republic of China, December 2020, 'Energy in China's new Era'.

22 O'Sullivan, M., I. Overland and D. Sandalow, 2017, 'The Geopolitics of Renewable Energy', Columbia/SIPA, Belfer Center/Harward and Norwegian Institute of International Affairs (NPI).

The author's 2018 study arrived at similar five geopolitical implications for energy security in the 21st century as the result of the accelerating energy transition: (1) Rising new cyber threats and the need for critical energy infrastructure protection; (2) Increasing dependencies on raw material supply security; (3) Uncertainties for political stability of oil and gas producing countries as the potential losers of the worldwide decarbonization and the green energy transition; (4) the rising dependence on the electrification of the transport sector and other industries; (5) the need for batteries and other electricity storage options for guaranteeing daily supply security alongside the expansion of renewables.[23]

In January 2018, a 'Global Commission on the Geopolitics of Energy Transformation', was established under the auspices of the International Renewable Energy Agency (IRENA) to study the geopolitics of renewable energy in effectively shaping global energy diplomacy. Renewables are considered as a 'game changer' for interstate energy relations as geographic and technical characteristics are fundamentally different from those of fossil fuels. In contrast to fossil fuels with their finite nature, unequal geographic distribution and the separation between net-exporter and net-importers, renewables are to a large extent abundant and indigenous to most countries globally which will lead to more decentralized electricity generation. The transition to renewables and the associated decentralization and digitalization "will reshape strategic realities and policy considerations" as two experts warned in 2018.[24]

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23 Umbach, F., 2018, 'Energy security in a digitalized world and its geostrategic implications'.

24 Scholten, D., 'The geopolitics of renewables – An introduction and expectations'; idem, "The Geopolitics of renewables", Lecture Notes in Energy, *Cham: Springer*, Vol. 61, 2018 (), pp. 1-33 (1).

The 2019 report of IRENA's 'Global Commission on the Geopolitics of Energy Transformation' came to similar conclusions as the previous analyses had already outlined. On one hand, the report foresees a decline of traditional geopolitical risks related to fossil fuels (such as import dependence on politically unstable oil and gas exporters, stability of Storage Locations (SLOCs) and Choke points).

On the other hand, it warns against an increase of cybersecurity risks for critical energy infrastructures, rising instabilities of oil and gas producing countries (due to a dramatic decline of export revenues and a failing economic diversification) as well as an increase of import dependence on critical raw materials and new politically unstable exporting countries.[25]

1.3. The global COVID-19 pandemic – a new threat to energy security and a sustainable development

In addition, from 2020, COVID-19 has also brought with it a series of new challenges for the world and the Asia-Pacific region, which can impact upon the energy sector and has opened up new debates on the need for resilience, not just in energy and infrastructure, but in our economies and societies too. The virus has caught worldwide governments off guard though the previous H1N1 swine-flu outbreak (2009) or the SARS (2002-2004) and MERS (2012) epidemics had already highlighted major insufficiencies and shortcomings. In reality, COVID-19 is not just one, but multiple pandemics ("polypandemic"). They have caused a global multifaceted crisis and have undermined development progress, exacerbating state fragility and eroding existing international cooperation. The international community needs to balance short-term immediate needs with investment in countries for long-term crisis resilience.[26]

The COVID-19 pandemic has caused more economic disruption and increased financial debts to the worldwide energy sector than the worldwide financial crisis in 2008, the economic depression in the

[25] IRENA, 2019, 'A New World. The Geopolitics of the Energy Transformation'.

[26] Eisentraut, S., et.al., 2020, 'Polypandemic'. Munich Security Report, Special Edition on Development, Fragility, and Conflict in the Era of Covid-19, Munich.

1930s or any other event in peace time history with lasting impacts for at least the next decade.[27] The pandemic has also exposed a major lack of regional and global cooperation, national preparedness and major vulnerabilities of the national healthcare sectors on global supply chains by causing shortages and supply disruptions of medical equipment as well as basic chemical materials for generic medicine.[28] Figure 4 on the next page summarises some of the worst epidemics in recorded history.

In addition to the worldwide energy transition, the global COVID-19 pandemic is not just threatening the energy security of many countries. It also undermines the sustainable development of developing countries and the Sustainable Development Goals (SDGs) agreed by member countries of the United Nations. Since the 1970s sustainable development has grown in prominence and now represents the most important development theory shift. It was a successor of the eco-development theory, which dedicated more attention to socio-economic and anti-poverty issues and became known in 1968.[29]

Even though there is no commonly accepted definition of sustainable development, the one that is given in the Brundtland Report is the most acknowledged. It defines it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[30] In 1987, the Brundtland Commission has also described three dimensions of the sustainable development: "economic growth, environmental protection and social equity." It underlined the interdependence between each of them and the necessity of their consideration in policymaking. According to this report, the goals 'economic viability, the security of supply and environmental protection', deriving from sustainable development, have been

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[27] Ellinas, C., 'Groping towards the light', Natural Gas World, Vol. 5, Issue 20, 20 October 2020, pp. 21-27.

[28] Umbach, F., 4 May 2020, 'Supply Chain Security: The Energy Sector's Lessons for Healthcare', Geopolitical Intelligence Service (GIS).

[29] Barrow, C.J., 2018, 'Sustainable Development', The International Encyclopaedia of Anthropology, p. 2.

[30] Rachel, E., 2015, 'The Concept of Sustainable Development: Definition and Defining Principles', Florida International University. Available at https://sustainabledevelopment.un.org/content/documents/5839GSDR%202015_SD_concept_definiton_rev.pdf. (Accessed 31 October2020).

called 'energy trilemma' in energy policy framework.[31]

Figure 4

Worst Epidemics in Recorded History

Rank	Epidemic	Cause	Period in history	Estimated fatalities
1	The Black Death	Bubonic Plague	1346-1353	75,000,000-200,000,000
2	Plague of Justinian	Bubonic Plague	541-542	25,000,000-100,000,000
3	HIV/AIDS	HIV virus	1960-present	36,000,000 - 39,000,000
4	1918 Spanish Flu	Influenza	1918-1920	20,000,000 – 50,000,000
5	Modern Plague	Bubonic Plague	1894-1903	12,000,000
6	Antonine Plague	unknown	165 AD-180 AD	5,000,000
7	Asian Flu	Influenza	1956-1958	2,000,000
8	Sixth Cholera Pandemic	Cholera	1899-1923	1,500,000
9	Russian Flu	Influenza	1889-1890	1,000,000
10	Hong Kong Flu	Influenza	1968-1969	1,000,000
11	Third Cholera Pandemic	Cholera	1852-1859	1,000,000
12	Fifth Cholera Pandemic	Cholera	1881-1896	981,899

Source: Geopolitical Intelligence Service (GIS), 2020.

The 'Sustainable Development Scenario (SDS)' developed by the IEA lays out a pathway to reach the 'Sustainable Development Goals (SDGs)' most closely related to energy: achieving universal energy access (SDG7), reducing the impacts of air pollution (SDG3.9) and tackling climate change (SDG13). The SDS is designed to assess what is needed to meet these goals, including the Paris Agreement, in a realistic and cost-effective way.

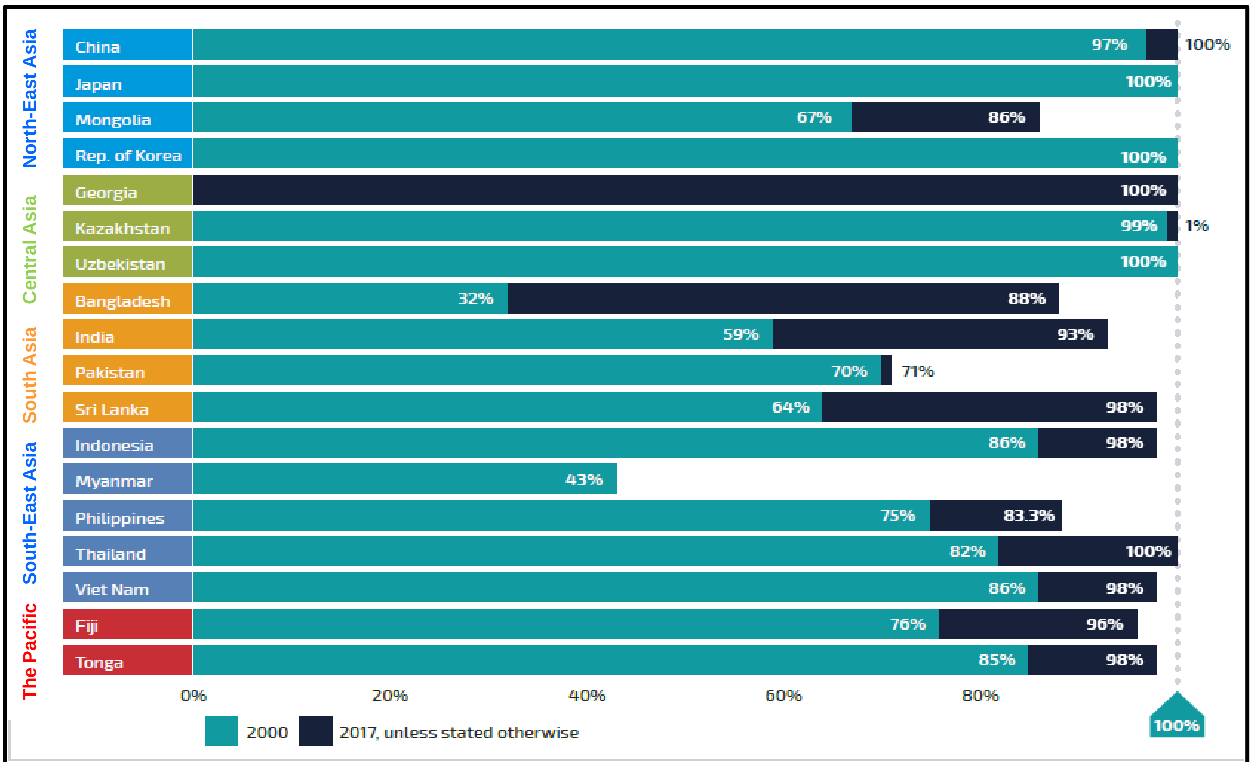
Worldwide, more than 1 billion people have gained access to electricity since 2010. In 2018, over 200 million people (5 per cent of the population) had still no access to electricity, and some 1.8 billion people (nearly 40 per cent of the population) had still to rely on polluting and unhealthy cooking fuels and technologies. The Asia-Pacific region accounts for some 60 per cent of the global total CO_2 emissions. Almost two-thirds of the emissions are from the energy sector, which is heavily reliant on fossil fuel

31 Ibid.

consumption. In 2018, the region was responsible for 80 per cent of the world's total coal consumption.[32] Figure 5 outlines the progress in electricity access in selected Asia-Pacific countries between 2000 and 2017.

Figure 5

Electricity access in selected Asia-Pacific countries, 2000 and 2017



Note: The 64% figure for Sri Lanka is as of 2001; the 43% figure for Myanmar is as of October 2018.

Source: ESCAP/REN21, 2019.

An ESCAP report of 2020 concluded that despite of the advances toward SDG7 and SDG13 and making the economies greener and resilient, "overall efforts are falling well short of the scale required to reach the SDG7 targets by 2030"[33], and that far more needs to be done to achieve the 1.5°C target of the Paris Agreement, including strategies to phase-out coal-fired power plants. They are responsible for about 30

[32] ESCAP, 2020, 'Accelerating SDG7 Achievement in the Time of COVID-19: Policy Briefs in Support of the High-Level Political Forum 2020', United Nations.

[33] ESCAP, 2018, 'Energy Transition Pathways for the 2030 Agenda in Asia and the Pacific: Regional Trends Report on Energy for Sustainable Development 2018', p. 20.

per cent of the worldwide CO_2 emissions. Despite this need, there is no other region than in the Asia-Pacific with more new coal-power plants are still being built and newly planned.

Both advanced economies and developing countries have also experienced newly discovered vulnerabilities of complex global supply chains with the outbreak of the global COVID-19 pandemic. In particular 'just-in-time supply chains' of private and state-owned companies have reduced or eliminated redundant supply capacities in favour of short-term profits, cost optimization and cheapest prices as well as supply chain efficiency. This has come at the expense of supply security, diversification of suppliers, redundancy of industrial manufacturing capacities for medical equipment and long-term stability considerations for worst-case global challenges like pandemics. By ignoring geopolitical risk management strategies for years, as experts have warned prior to COVID-19, the global supply chains have not been able and flexible enough to substitute one supplier or component for another as needed for the global healthcare sector and other national Critical Infrastructures (CIs). It is also the result of a worldwide globalization trend of specialization at the expense of substitution and redundancy, which traditionally plays an important role in energy security concepts.[34]

The COVID-19 crisis has three phases – rescue, recovery, and transformation to a new form of growth.[35] Each phase has its own problems, challenges, and need for specific responses to address the challenges. But at present, it is unclear how long the worldwide pandemic will last as the second wave (or the third wave in some locations) of the pandemic is currently affecting many economies again. How long the COVID-19 economic downturn will last and how large the impacts on the world economy will be as well as for the energy demand and greenhouse gas (GHG)-emissions is almost impossible to forecast concretely. The impacts vary between the various countries and regions as well as within societies. In general, one can already conclude that the overall economic costs have been greater for the younger generation, the unskilled, minorities and women. The financial fragility is increasing in already highly indebted sectors even in high-income economies, but of course in emerging and developing countries alike or

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34 ibid.

35 Bhattacharya, A., and N. Stern, 2020, 'From rescue to recovery, to transformation and growth: building a better world after COVID-19'. Grantham Research Institute on Climate Change and the Environment.

even more and questioning the progress they have made in sustainable developments during the last decade.

The second and third wave of the pandemic could be economically even more damaging as many sectors with small companies or self-employed people, who have already struggled in the first wave, will not survive the second wave. It might lead to much higher jobless rates and much more social as well as economic-financial difficulties.[36] While China's economy is currently experiencing an impressive bounce back and might become again an engine of growth for the world economy,[37] if the rest of the world is undergoing a deepening economic recession, it will also impact China's export industry and wider economy negatively.

The 'polypandemic' might have more long-term implications on economic recovery, the countries' resilience and the world energy sector than anticipated last year.[38] The worldwide vaccination will take substantial time not just for the OECD countries, but even more for the developing world. The vaccine supply is insufficient for the world and at least some of the new vaccines offer less protection against the new mutations of the COVID-19 pandemic.[39] According to new research, a group of developed countries, accounting for just 16 per cent of the world's population, have secured 60 per cent of the global vaccine supplies for themselves.[40] Only a fifth of the targeted population will receive a vaccine in 2021. The bulk of the needed vaccinations will take place only in 2022 and 2023.[41] In the meantime, it could increase the further risks for much more mutations of COVID-19 resulting into even more dangerous new pandemics.

The financial implications of the pandemic have already exposed a stark divide across the Asia-Pacific region with geopolitical implications. Half of the external assistance to Asia's developing countries comes from the Asian Development Bank (ADB), 20 per cent from the World Bank, 10 per cent from the Asian Infrastructure Investment Bank (AIIB), 8 per cent from the International

36 Wolf, M., 'The threat of long-term COVID looms', Financial Times, 20 October 2020.

37 John, P., 'Chinese economy outstrips US despite Beijing bashing', Financial Times, 2 November 2020.

38 To the economic impacts of the pandemic on ASEAN see also Calvin Cheng, 'Prospects and Risks for Malaysia's Economy in 2021', Insights-ISIS Malaysia, 5 February 2021.

39 Boseley, S. and J. Murray, 'Study Shows Oxford COVID Vaccine has less Protection against South African Variant', The Guardian, 7 February 2021.

40 Dhar, B., 'India's Vaccine Diplomacy for the Global Good', East Asia Forum, 8 February 2021.

41 Wolf, M., 'We must Vaccinate the World – now', Financial Times, 9 February 2021.

Monetary Fund (IMF) and 5 per cent from bilateral aid (primarily from the United States of America, Japan, and Australia). Improving access to finance often require more fundamental reforms at the global, regional and bilateral levels, which appears even more difficult in times of a deepening regional economic recession.[42]

The worldwide economic recession has decreased the growth of CO_2 emissions since the beginning of 2020. In the first half of 2020, restrictions on movement and economic activity as the result of the pandemic caused an 8.8 per cent fall of the worldwide emissions.[43] But methane emissions rose by nearly a third due to a rise of the number of methane leaks from the oil and gas industry in the first eight months of 2020 despite the pandemic and worldwide reduced economic activities.[44]

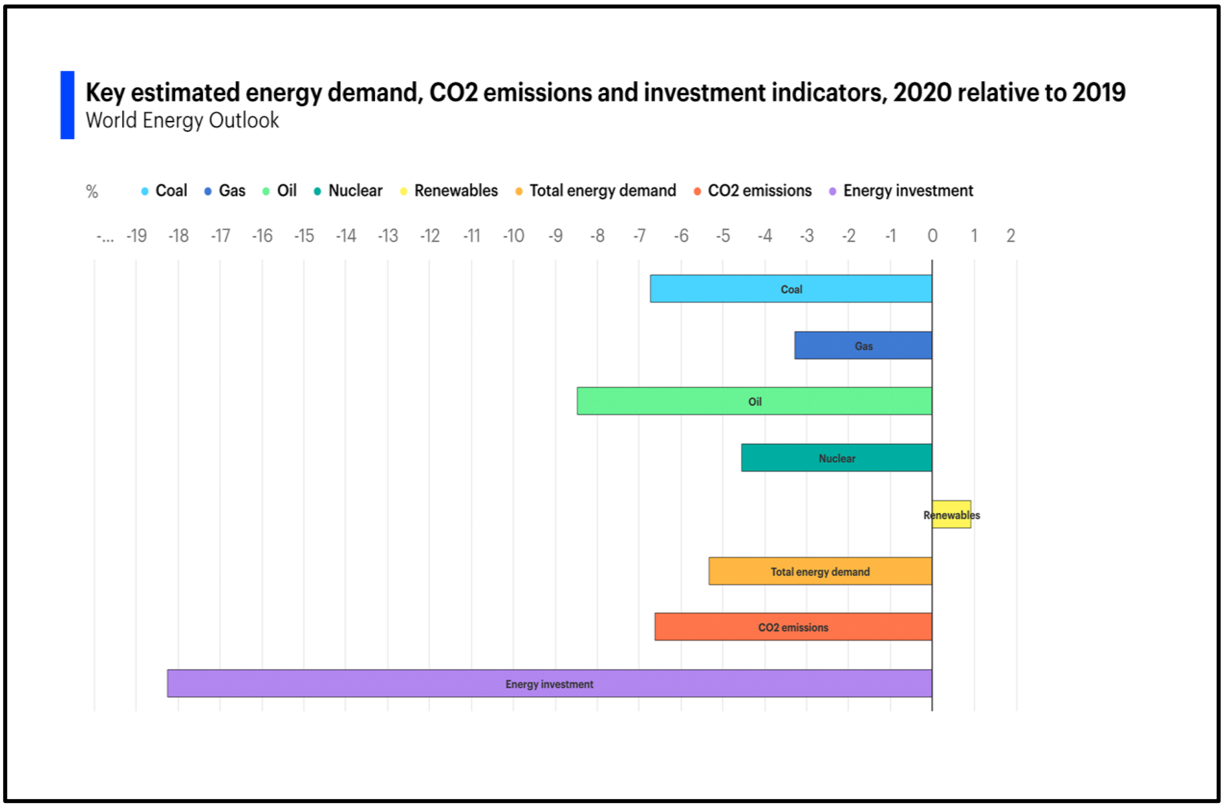
42 Editorial Board, 'Paying for a pandemic', East Asia Forum, 19 October 2020.

43 Hook, L., 'Global emissions fell 8.8% in first half of 2020, study shows', Financial Times, 14 October 2020.

44 'Energy sector's methane leaks rise despite green plans: Kayrros', Reuters, 14 October 2020.

Figure 6

Projected impacts of COVID-19 on the global energy demand, CO_2-emissions and worldwide energy investments, 2020 versus 2019



Source: IEA, 2020.

The worldwide decrease of CO_2 emissions may be a rather short-term development as emissions may increase again due to a worldwide economic recovery. Energy-related CO_2 emissions grew by 1.9 per cent in 2018.[45] In 2019, while economic growth in advanced economies still averaged 1.7 per cent, total energy-related CO_2 emissions fell by 3.2 per cent after years of increases. But few believe that a worldwide peak of CO_2 emissions has already been achieved. Moreover, climate scientists have noted that greenhouse gas (GHG)emissions need already to fall by 7.6 per cent every year between now and 2030 of achieving the 1.5° goal for preventing severe climate change.

[45] IEA, 'World Energy Outlook 2019', p. 79.

The pandemic has also affected and impacted Critical Infrastructures (CIs) such as those of the energy sector. All these phases may differently influence the energy sector and it is useful to explore how energy security concepts could be impacted by COVID-19 and its aftermath. Oil, gas, and coal prices have plummeted, presenting challenges to these industries and to the fossil fuel exporting countries. COVID-19 has also served as a reminder of the need to review and reform global supply chains for medical products and basic medicines for enhancing resilience. Thereby the healthcare sector may even learn from the energy sector and its experiences as well as concepts of energy supply security and resilience of energy infrastructures.[46]

But in the face of COVID-19 and future pandemics as well as more frequent natural disasters, the uninterrupted supply of energy is critical and a pre-condition of energy resilience. Energy resilience can also be considered as a pre-condition of energy security. Electricity supply is particularly critical for hospitals and other healthcare services, teleworking and remote learning. Energy systems must be able to offer resilience to pandemics, natural disasters and other shocks that can disrupt supply chains, affect essential workers, or close borders.

1.4. Challenges and opportunities for the Asia-Pacific region

There is new scope for regional cooperation and multilateralism in energy to support regional and interregional energy security. Like other regions, the Asia-Pacific energy sector does not operate as one single mechanism - it has unbalances and contradictions driven by different national interests. Emerging Asian economies are competing for limited resources and niches in the global market. There is no silver bullet solution for addressing all structural problems. More interconnected national energy systems can offer advantages of being more resilient, efficient, clean, and cost-effective. Political challenges and national security concerns often reduce the level of trust between neighbouring countries. The role of multilateral organizations such as the United Nations is critical to build trust

46 Umbach, F., 'Supply Chain Security: The Energy Sector's Lessons for Healthcare'.

in the region and develop the concept of a regional energy governance system that ensures uninterrupted energy supply in the cleaner and most efficient manner for the benefit of all participating countries. It will help countries in this region to achieve the 2030 Agenda for Sustainable Development and the Paris Agreement.[47] But at the same time, all countries must cope with short-term and longer-term energy as well as climate change challenges. The latter has been considered by international climate experts as ever more alarming and threatening our future social-economic and political developments.[48] In their view, they need to be addressed urgently as a short-term challenge to prevent severe and irreversible long-term developments. They can also be addressed only by enhanced multilateral cooperation on a regional as well as global level.

1.5. Purpose and structure of the study

The purpose of the study is to examine the new energy security dimensions that are emerging with the advent of the energy transition and to include the impacts of the worldwide COVID-19 pandemic on global energy markets and energy security especially in the Asia-Pacific region.

Chapter 2 will discuss the traditional energy security concepts, including of the energy triangle and its balance of three major objectives. It will also introduce the term and understanding of resilience in the energy sector and how it is conceptualized in context of energy security. Furthermore, it will also highlight new energy security dimensions (such as cybersecurity and supply of Critical Raw Materials, which hitherto have been discussed rather separately from energy security) due to the expansion of renewables, electrification of the transport, heating and industry sectors ('industry 4.0'),[49] as well as the digitalization of the energy sector.

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47 ESCAP, 2018, 'Energy Transition Pathways'; idem, United Nations, 2020, 'Accelerating SDG7 Achievement in the Time of COVID-19'; idem.'

48 Taylor, K., 'G20 Countries Projected to Miss 1.5°C Paris Target by Wide Margin: Report', Euractiv, 18 November 2020.

49 'Industry 4.0' describes the continuing automation of traditional manufacturing and industrial practices, using modern smart technology. Large-scale machine-to-machine communication – without the need for human intervention - and the 'Internet of Things (IoT)' are integrated for increased automation, improved communication and self-monitoring processes with smart machines that can analyse and diagnose issues.

Chapter 3 will analyse and summarise the global and regional energy megatrends in the Asia-Pacific region until 2020 in the light of the global climate policies and the Sustainable Development Goals (SDGs). It will also address the short-term impacts of the global pandemic on the energy markets and developments, abut also consider the implications of a longer-term recovery from COVID-19 on global and regional energy security.

Chapter 4 will analyse the future challenges of the electrification of the transport sector and industry sectors, including the rapidly rising electricity, the electrification of the transport sector and the perspectives for batteries and the importance for energy security in both sectors.

In this light, **Chapter 5** will address the future challenges for the Sustainable Development Goals (SDGs) in a post-pandemic world and to which extent global and regional energy policies need to change to achieve the SDGs and the 1.5°C target of the Paris Agreement, including the opportunities for the development of hydrogen as a major instrument for worldwide decarbonization.

Chapter 6 will take the analyses of the previous chapter into account and examine how to balance between short-term economic recovery programmes with long-term energy security and climate protection objectives. It will particularly discuss those competing objectives in the light of the new dimensions of energy security and the long-term sustainable development objectives.

Finally, on this basis, **Chapter 7** will summarize the analytical results of the study as well as will identify and recommend viable policy options for the Asia-Pacific member States.

Chapter 2

New dimensions of energy security

2.

2.1. Traditional understanding and definitions of energy security

Traditionally, energy security had been defined as "the availability of energy at all times in various forms, in sufficient quantities, and at affordable prices" in the 1980s and 1990s. But with the rising importance and need of environmental and climate protection, the IEA had defined energy security after 2001 as "the uninterrupted physical availability at a price which is affordable, while respecting environment concerns".[50] Nevertheless 'sufficient quantities' and 'reasonable' or 'affordable prices' have remained rather vague terms - and thus 'energy security' has still not precisely been defined. For measuring 'energy security', more and more indicators have been created and framed in new complex energy security concepts.[51]

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50 See the definition of 'energy security' by the International Energy Agency (IEA). Retrieved at http://www.iea.org/subjectqueries/keyresult.asp?KEYWORD_ID=4103.

51 Löschel, A., Moslener, U. and Rübbelke, D.T.G, 2010, 'Indicators of Energy Security in Industrial Countries', Energy Policy 38, pp. 1665-1671, and idem, 'Editorial: Energy Security – Concepts and Indicators', ibid., pp. 1607-1608; Marilyn A. Brown, 'Forty Years of Energy Security Trends: A Comparative Assessment of 22 Industrialized Countries',

In the light of the economic-financial crisis in 2008 and the need for timely as well as sufficient investments in new energy sources and infrastructures to cope with the dual challenge of global energy supply security as well as climate change, the IEA, for instance, has also differentiated between long- and short-term energy security.[52]

There is no widely accepted definition of (fossil fuel) energy security because of its context-dependency.[53] It has a multidimensional nature and its substance depends "on country's special circumstances, level of economic development, perceptions of risks, as well as the robustness of its energy system and prevailing geopolitical issues."[54] Thus, energy security has always had a different meaning in countries depending on their perspectives from the net producer (like Russian Federation, Australia, Malaysia in the past), net consumer (China, Japan, India, most ASEAN states and others) and transit states (like Ukraine and Turkey). Whereas net consumer nations are primarily interested at security of supply, net producer countries are more focused on 'security of demand' from foreign markets. Transit states are often equally interested in their national security of supply and demand security on neighboring markets in order to benefit from stable and higher transit fees.

Energy Research & Social Science 4/2014, pp. 64-77.

52 See the present definition of 'energy security' and its differentiation by the IEA: "long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs. On the other hand, short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance" – IEA, 'Energy Security. Ensuring the Uninterrupted Availability of Energy Sources at an Affordable Price'. Available at https://www.iea.org/areas-of-work/ensuring-energy-security (accessed on 20 October 2020). Jessica Jewell, 2011, 'The IEA Model of Short-Term Energy Security (MOSES)', Paris: OECD.

53 ASEAN Centre for Energy, 'The ASEAN Energy Outlook 2017-2040'. 6th Edition, December 2020, p.32.

54 B.W. Ang, W.L. Choong and T.S. Ng, 2015, 'Energy security: definitions, dimensions and indexes' Renewable and Sustainable Energy Reviews 42, p. 1078.

In addition, the concept of 'national energy security' depends on the individual countries' geographical location, domestic policies, and the traditional state, economic and business ties it maintains with its partners.

Since the end of the 1990s, international energy experts have stressed the increasing strategic importance of energy supply security as part and within the 'energy triangle' with its three major objectives: economic competitiveness, environmental/ climate sustainability, and energy supply security. The Asia Pacific Energy Research Centre (APERC) has introduced in 2007 the concept of the "four As of energy security": availability, accessibility, affordability and acceptability (Figure 7).[55]

But the concept has not solved the different interpretation of the '4 As' as energy security "means different things in different situations and to different people" nor can a general concept of energy security list all possible risks and vulnerabilities.[56] The complex multidimensional nature of energy security goes beyond oversimplified declared concepts of 'energy self-sufficiency' and 'energy independence'.[57] A closer specification may at least answer the following three questions: (a) security for whom?; (b) security for which values and objectives?; and (c) from what threats?[58]

The World Energy Council (WEC) suggested the 'energy trilemma', which includes energy security, energy equity and environmental sustainability dimensions.[59]

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55 APERC, 2007, 'A Quest for Energy Security in the 21st Century: Resources and Constraints, Institute of Energy Economics, Japan.

56 Cherp, A., and J. Jewell, 'The Concept of Energy Security: Beyond the four As', Energy Policy 75/2014, pp. 415-421.

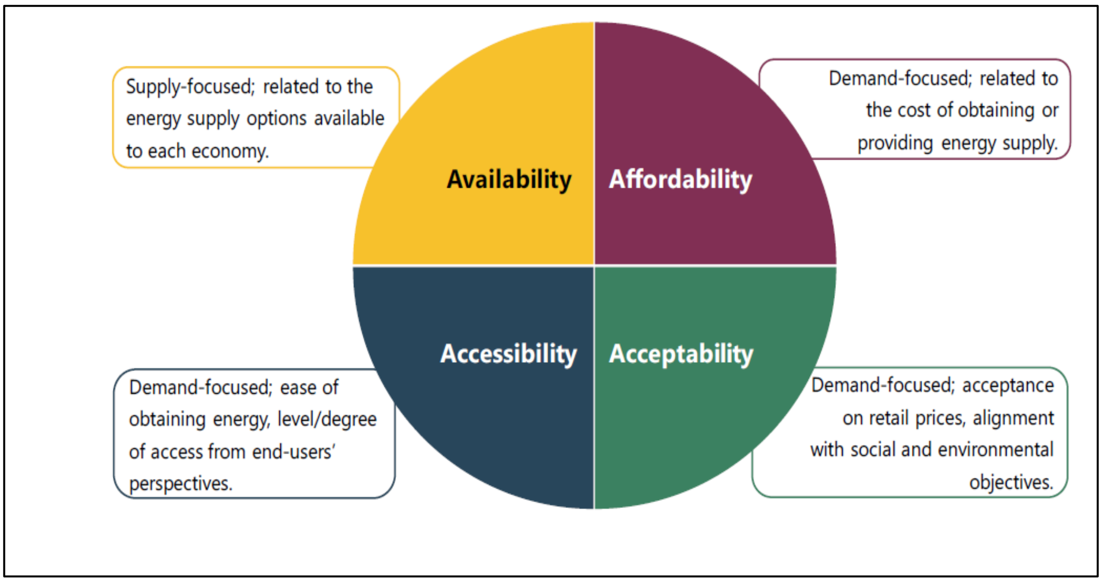
57 Hillebrand, E., 'What Is Energy Security? Definitions and Scenarios', 3 March 2016 Available at https://judithcurry.com/2016/03/03/what-is-energy-security-definitions-and-scenarios/ (Accessed on 20 March 2018).

58 Cherp, A., and J. Jewell, 'The Concept of Energy Security'.

59 The WEC defined these dimensions as follows: "energy security reflects a nation's capacity to meet current and future energy demand reliably, withstand and bounce back swiftly from system shocks with minimal disruption to supplies; energy equity assesses a country's ability to provide universal access to affordable, fairly priced and abundant energy for domestic and commercial use; environmental sustainability represents the transition of a country's energy system towards mitigating and avoiding potential environmental harm and climate change impacts" - World Energy Council, 2019, 'World Energy Trilemma Index 2019', London, p. 13.

Figure 7

The four A's of energy security



Source: APERC, 2019

It is stressed in this report that the success of the energy transition requires finding a balance between these pillars and that their high performance depends on the interconnection between many links such as "public and private bodies, governments and regulators, economic and social factors, national resources, environmental concerns, and individual consumer behaviours."[60] These dimensions include 17 indicators and their descriptions. [61]

In addition to giving different names to the dimensions of energy policy trilemma, some authors vary in the understanding of the same pillars. The most important are the diversification of the energy mix, diversification of imports and import routes or import dependencies, but also energy efficiency and other dimensions of energy policies. Renewables can further diversify the energy mix and are often seen as a domestic energy resource, which would reduce the import dependencies of fossil fuels (especially oil and gas). But producers of renewables are also becoming dependent on new import dependencies, notably Critical Raw Materials (such as rare earths, lithium, cobalt and other).

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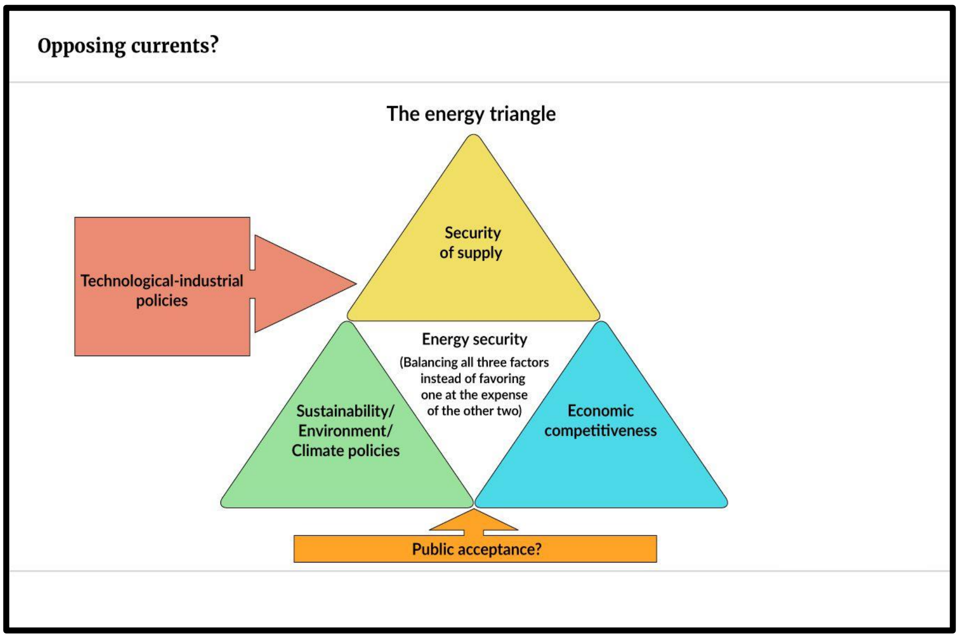
60 Ibid.

61 Ibid., p. 11. The indicators of energy security dimension are the following: "energy dependence, share of renewable energy in fuel consumption of transport; electricity generated from renewable sources; and electricity prices for medium size households and medium size businesses" – ibid., p. 12.

Figure 8

Energy triangle and objectives of energy security



Source: Frank U., GIS, 2018

The expansion of renewables can also increase cyber security risks as a new major energy security dimension alongside the electricity supply chains and its supply chains (discussed below in the following chapter and in chapter 6). They also create new supply concerns as sun and wind are not available for 24 hours and the possibilities for storing electricity at an industrial scale are still technologically constrained worldwide.

Furthermore, the energy transformation and energy transition are widely been considered as more unstable for energy security. While a sustainable energy future is often equalized with energy security or the latter been considered as a pre-condition for sustainability, it is not automatically the case.[62]

In the view of many energy security experts, the biggest challenge is seen in maintaining the balance between the three or four objectives of the 'energy triangle' or 'energy trilemma' instead of favoring one at the expense of the other two or three. Otherwise, neither national nor regional or global energy security can be guaranteed.[63]

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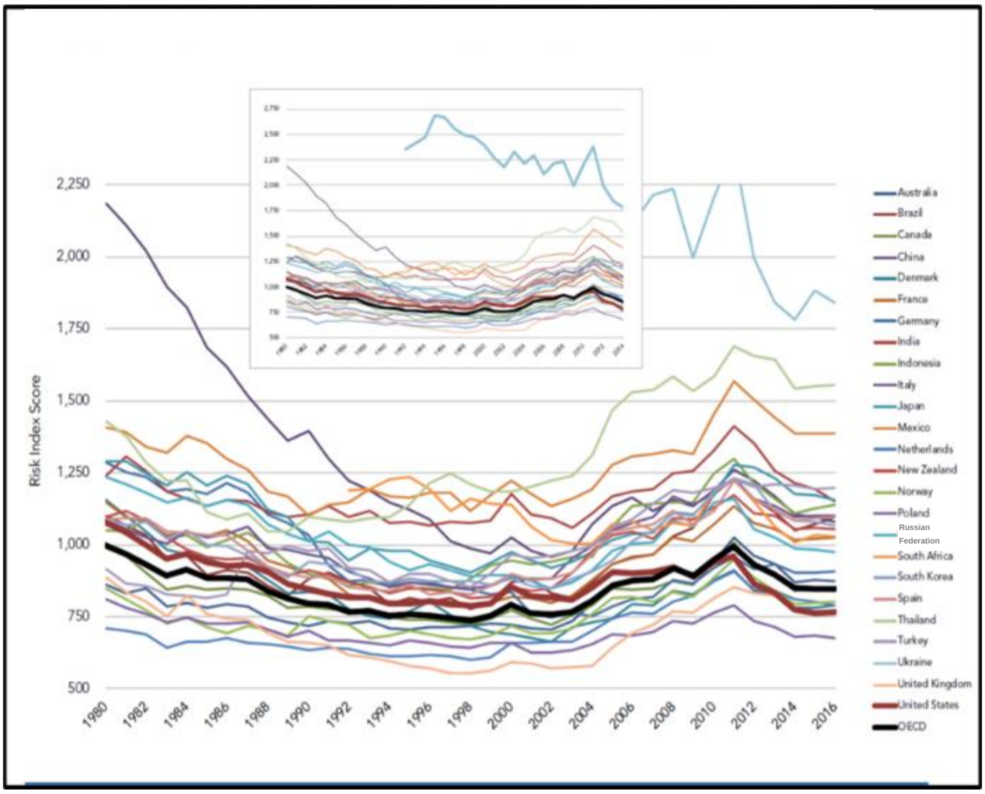
62 Also access to energy, electricity and modern energy sources or air quality (as a factor of sustainability) alone cannot be equalized with energy security as it also envisages a stable 24 hours supply – see again chapter 6.

63 Umbach, F., 'The Intersection of Climate Protection Policies and Energy Security', Journal of Transatlantic Studies, Vol. 10, N. 4, December 2012, pp. 374-387 and see, 'The Future Role of Coal: International Market Realities vs. Climate Protection?', EUCERS-Strategy Paper Six, King's College, London, May 2015.

Due to the interrelationship of improving energy (supply) security and mitigating climate change, for instance, both policy objectives can conflict with each other: on one side, the expanded use of domestic coal as the worldwide biggest emitter can strengthen energy supply security and bolster economic competitiveness as the cheapest fossil fuel, but will increase CO_2 emissions and accelerate climate change. On the other side, reducing national emissions by 5 per cent through a switch from (domestic) coal to (imported) natural gas (particularly pipe-based) can already have negative impacts on energy supply security by increasing import dependency and economic competitiveness of economies and national enterprises as hitherto coal had been the cheaper energy source.[64]

Figure 9

Energy security risk index for 25 large energy user countries 1980-2016



Source: Global Energy Institute/United States Chamber of Commerce, 2018.

64 IEA, 2007, 'Energy Security and Climate Policy. Assessing Interactions, Paris: IEA, pp. 18, 102 ff.

Maintaining the balance between all three objectives of the 'energy triangle' has also become more difficult by new industrial policies subsidizing renewables like or promoting unconventional oil and gas exploration in the United States of America. Nevertheless, the biggest challenge for many democratic governments appears today receiving public acceptance in the light of ideological positioning, and new vested interests. In the political reality, the three objectives are often competing with or even contradicting each other, creating an unstable 'energy trilemma' instead of a balanced 'energy triangle'.[65]

But due to the United States' shale oil and gas revolution and its global impacts on the oil and gas markets, the energy security risks of at least 25 analyzed large energy consuming countries have overall decreased and, therewith, their energy supply security have improved since 2010 till 2019. However, a closer look also highlights that the situation is still different between and within regions as well as in the individual energy security categories (oil, gas, coal, electricity). Thus, natural gas import risks have remained very high in Europe, Japan and the Republic of Korea in that timeframe. No country analyzed scored well in every energy risk category, but none scored very poorly in every category either.[66] The WEC's annual 'World Energy Trilemma Index 2017' report, profiling 94 WEC member countries, also confirmed some basic positive trends as access to electricity and clean cooking have both significantly increased from 7 to 87 per cent and 75 per cent perspective respectively, while renewables have increased their share up to 19.3 per cent of final global energy consumption worldwide in 2015.[67]

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65 Wyman, O., 2020, 'World Energy Trilemma Index 2017', London: World Energy Council (WEC).

66 Institute for 21st Century Energy and U.S. Chamber of Commerce, 'International Index of Energy Security Risk - 2018 Edition, Washington D.C. 2018. To the background also see Spanish Institute for Strategic Studies, 'Energy and Geostrategy 2019'. Spanish Committee of the World Energy Council/Spanish Energy Club/Ministry of Defence, Madrid, 2019.

67 WEC, 'World Energy Trilemma Index 2017', pp. 5 ff.

2.2. Resilience in the energy sector

In this context of energy security concepts, the word 'resilience' has been introduced as in many other policy fields. There are various definitions, depending on the issues and the policy context. In general, it describes the capacity and ability to withstand against attacks as well as to cope with and to respond to diverse disruptions of systems and restore them to full functioning as soon as possible. Hence resilience also includes the robustness, adequacy, adaptability, flexibility and reliability of energy systems, resources, and infrastructures. It also includes the ability to continuously change or modify delivery mechanisms if needed in the face of new risks as well as backups and disaster recovery operations as part of the process for restoring delivery mechanisms.[68] A useful definition for the energy sector is: "Resilience is the ability to prepare and plan for, absorb or mitigate, recover from, or more successfully adapt to actual or potential adverse events."[69]

Originally, the term 'resilience' has been used in context and concepts of protection of critical infrastructures. The focus was directed not so much on the ability to preventively withstand physical or cyberattacks but rather on the aspect of restoring them as soon as possible because a 100 per cent security of operation cannot be guaranteed.[70]

The concept is particularly relevant for the functioning of Critical Energy Infrastructures (CEIs) as a stable electricity supply is a precondition for the functioning of all other critical infrastructures. Thus, resilience can be considered and conceptualized as an important element and pre-condition of energy security. The 'external resilience' IEA has also differentiated between and 'internal resilience'. [71]

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68 Jewell, J., 'The IEA Model of Short-Term Energy Security (MOSES)', p. 19 ff.; Jackson, S., and T. L. J. Ferris, 'Infrastructure Resilience: Past, Present, and Future', The CIP Report, December 2012, pp. 6,7 and Debra van Opstal, 'The Resilience Imperative', ibid., pp. 2,3 and 20; Fekele, A., 'Fluid Resiliency and Risk Management Culture – Emerging Security and Risk Perspectives for Dealing with Threats to Energy Infrastructure', EUCERS-Newsletter, Issue 30, 12/2013, pp. 7-9, and Italian Association of Critical Infrastructures Experts (AIIC),Guidelines for Critical Infrastructures Resilience Evaluation', February 2016.

69 E. Flynn, S., and Sean, May 2012, 'Powering America's Resilience', Center for National Policy.

70 Due to the rapidly changing security environment, NATO, for instance, considers the resilience of civil structures, resources, and services as "the first line of defence for today's modern societies." Roepke, W., and H. Thankey, 'Resilience: the First Line of Defence', NATO-Review, 27 February 2019.

71 See Jewell, J., 'The IEA Model of Short-Term Energy Security (MOSES)', p. 10.

Figure 10

Internal and external resilience

	Risk	Resilience
External	• Risks associated with potential disruptions of energy imports	• Ability to respond to disruptions of energy imports in substituting with other suppliers and supply routes
Domestic	• Risks arising in connection with domestic production and transformation of energy	• Domestic ability to respond to disruptions in energy supply such as fuel stocks

Source: IEA, 2011

With the digitalisation of the energy sector, a stable internet access is becoming just as essential as the power grid. Smart meters, smart grids, 'industry 4.0', the Internet of Things (IoTs), cloud computing and in the future self-driving cars and Artificial Intelligence (AI) are all based on several interconnected layers of continuously operating infrastructures linked with the internet. Thus resilience, particularly of a stable electricity system, will become ever more important as the electrification of the transport, industry, and building (heating) sectors will further expand and make societies as well as economies increasingly vulnerable to supply disruptions and cyberattacks.

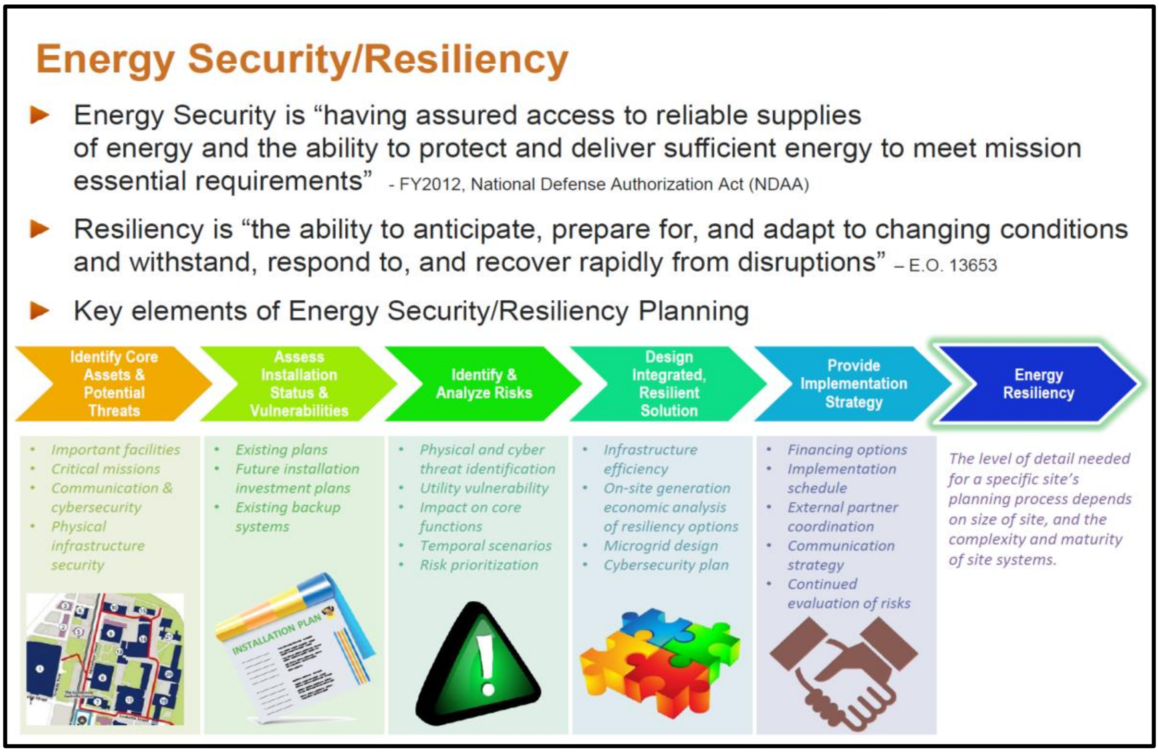
In addition, two new topics and challenges need to be detailed and included in future holistic concepts of energy security and resiliency: (1) supply security of Critical Raw Materials (CRMs), and (2) cyber security threats to Critical Energy Infrastructures (CEIs).

Greater reliance on energy-consuming technologies, intensifying weather events, and greater levels of distributed energy are also increasing the future challenges of interconnected issues such as electricity and grid security and resilience. Furthermore, climate change is increasingly impacting energy security and energy resilience as the IEA has highlighted: "Greater resilience to climate change impacts will be essential to the technical viability of the energy sector and its ability to cost-effectively meet the rising energy demands driven by global economic and population growth".[72]

[72] IEA, 'Energy Security. Ensuring the Uninterrupted Availability of Energy Sources at an Affordable Price'.

Figure 11

Energy security versus resilience



Source: Harrover, C., Pacific Northwest National Laboratory[73]

2.3. Supply security of Critical Raw Materials (CRMs)

The worldwide expansion of renewables and electrification of the transport and other industry sectors, the development of a new generation of batteries for electricity storage as well as the digitalization of industries, including the spread of robotics and artificial intelligence systems in the industry ('industry 4.0') will further boost the worldwide demand for for Critical Raw Materials (CRMs) such as rare earths, lithium, cobalt and others. As a result, this might create new, unprecedented challenges, including bottlenecks and supply shortages, for the global supply chains of the CRMs on each stage ranging from mining to processing, refining and

[73] Caroline H., Pacific Northwest National Laboratory. Available at https://www.energy.gov/sites/prod/files/2016/09/f33/campus_energy_security.pdf

manufacturing.[74] The present dependency on only a few extracting and producing countries and companies (when compared with conventional oil and gas producers) will become increasingly interlinked with the future concepts of clean energy supply security.[75] The challenge is not so much a physical scarcity of those materials, but rather their production concentrated in even fewer producer countries and companies. Compared with the conventional oil and gas resources, the production of CRMs is geopolitically even more challenging and problematic – particularly when the future rise of the global demand is taken into consideration. Currently 50 per cent of CRMs are located in fragile states or politically unstable regions.[76]

Moreover, security of supply risks is not just constrained to primary natural resources and CRMs but also to the import of semi-manufactured and refined goods as well as finished products. Global supply chains (including labour force and human capital) have become ever more complex with blurred boundaries between physical and financial markets and weakly governed market platforms. These market imperfections lead to the manipulation of prices and threatening the stability of the future security of supply of CRMs.

Given China's status as the world's largest producer and exporter of rare earths, the world's leading battery producer, and the nation leading the electrification of the national transport sector, may increase the dependencies of other countries and international automobile companies on China. The dependence on CRMs such as lithium, cobalt, graphite, rare earth and others will equally rise.

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74 UNEP, 2020, 'Mineral resource governance in the 21st century. Gearing extractive industries towards sustainable development, Umbach, F., 'The New 'Rare Metal Age'. New Challenges and Implications of Critical Raw Materials' Supply Security in the 21st Century', Working Paper No. 329, S. Rajaratnam School of International Studies (RSIS) / Nanyan Technological University NTU, Singapore, 27 April 2020 and World Bank Group, 'The Growing Role of Minerals and Metals for a Low Carbon Future'.

75 Umbach, F., 2018, 'Energy Security in a Digitalized World and its Geostrategic Implications'.

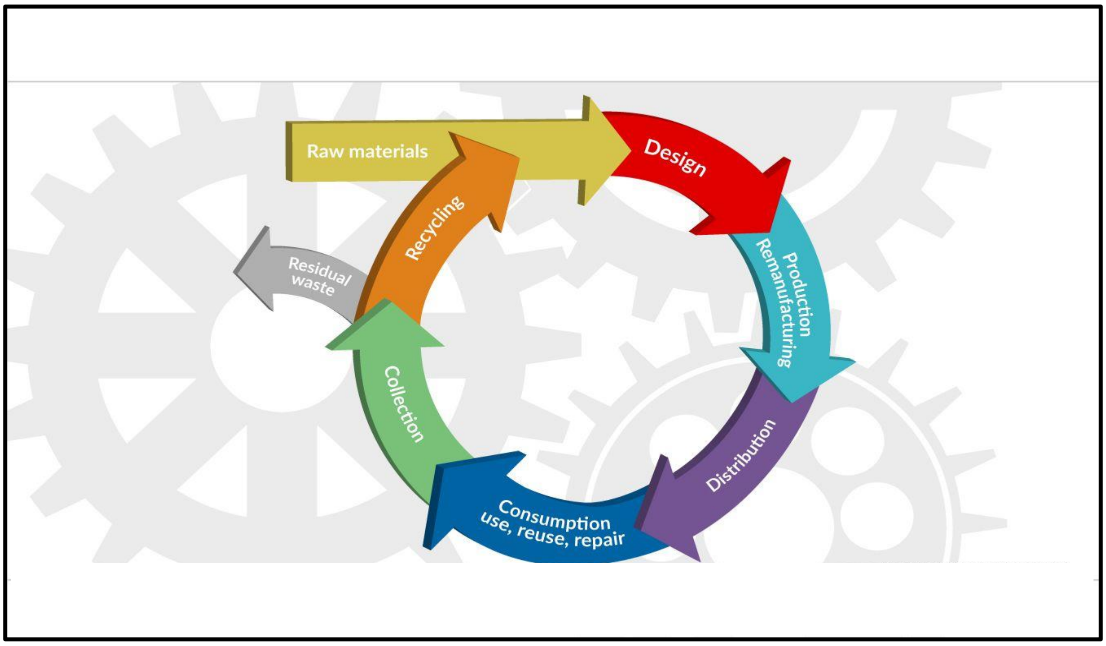
76 ibid., and World Bank Group, 'The Growing Role of Minerals and Metals for a Low Carbon Future'; Umbach, F., "The New 'Rare Metal Age. New Challenges and Implications of Critical Raw Materials' Supply Security in the 21st Century'; Jaako Kooroshy/Felix Preston/Sian Bradley, 'Cartels and Competition in Minerals Markets: Challenges for Global Governance', Chatham House, London, December 2014.

During the last years, China has further strengthened its efforts to control the entire global supply chain of lithium from owning international mines to production up to manufacturing of batteries and Electric Vehicles (EVs).

Their future supply security depends largely on timely investments, depending on adequate investment conditions, and alternative strategies such as (1) the re-use of CRMs (like in windmills, batteries etc.); (2) a reduced use of CRMs in renewables and batteries; (3) substitution with a less CRM;[77] and (4) recycling of CRMs. Using these strategies for reducing the rising imports of CRMs might allow a reduction on imported CRMs in the longer-term perspective. These options need also to be an integral part of the development of 'circular economies' as a response strategy, which will use CRMs more economically, efficiently and environmentally by reducing their mining demand in order to strengthen their security of supply and to reduce the carbon footprint.

Figure 12

Elements of a 'Circular Economy'



Source: GIS/European Commission, 2018.

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[77] Tesla, for instance, is developing a new generation of batteries without the use of cobalt - https://eepower.com/new-industry-products/teslas-4680-a-cobalt-free-silicon-battery-solution/#. Other battery designers are trying to reduce cobalt – see also Umbach, F., The New 'Rare Metal Age'. New Challenges and Implications of Critical Raw Materials' Supply Security in the 21st Century'.

But recycling options are often constrained due to poor data on both current and future recycling rates and an insufficient profitability for industry businesses. While substitutes are available for many applications, they are often generally less efficient and/or demand more energy in return. International strategies for diversifying production and imports of rare earths have often not been profitable or successful during recent years.[78]

Alternative strategies such as a diversification of future supplies (by opening new mines around the world), recycling and substitution also face other various limitations and constraints: opening new mines, for instance, often require lead times of at least 7 years, in advanced economies up to 20 years (with 10 years to build political and industrial consent on the infrastructure to make the mine operationa). In today's world and mounting public acceptance challenges in many OECD countries, it has become ever more challenging to find investors for those long-term projects due to rising political risks of those commercial projects.[79] While most studies do not predict a major long-term supply-side problem of CRMs for the global markets, they mostly agree that the supply needs to be closely monitored for avoiding any short- and mid-term supply shortcomings and other problems.

While CRM producers in Africa, Latin America and the Eurasian landmass will benefit economically and financially from the global rise of CRMs, the producers and exporters of CRMs are confronted as 'rentier states'[80] with traditional challenges of a 'resource curse' and an unprecedented international attention to the mining practices and conditions.[81] The more the world will expand 'green technologies' and becoming dependent on a rising and stable supply of CRMs, the more the international focus will be directed towards their environmental standards and energy efficient production methods. Mining companies, already fearing for their international reputation, are already increasing the share of renewables in their energy mix of production and try to reduce the accompanying negative environmental impacts.[82]

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78 Umbach, F., 'Energy Security in a Digitalized World and its Geostrategic Implications', and idem, 'The New 'Rare Metal Age'. New Challenges and Implications of Critical Raw Materials' Supply Security in the 21st Century'.

79 'GIS Dossier: China Dominates the Rare Earths Supply Chain', GIS, 7 February 2018.

80 A rentier state is a state which derives all or a substantial portion of its national revenues from the rent paid by foreign individuals, concerns or governments – see Mahdavy, H., 'The patterns and problems of economic development in rentier states: the case of Iran", in M. Cook (ed.), Studies in the Economic History of the Middle East, London: Oxford University Press, 1970, p. 428.

81 Andrew Barron, 'Meet the New 'Renewable Superpowers': Nations that Boss the Materials Used for Wind and Solar', www.energypost.eu, 26 February 2018.

82 World Bank Group, 'The Growing Role of Minerals and Metals for a Low Carbon Future', pp. XIII ff. and 26 ff.; Rocky Mountains Institute, 'Sunshine for Mines: Toward Sustainable Mining', July 2017, and S. Hill, J., 'Renewables Could Create 'Groundbreaking' Decarbonization Effort for Mining Industry',27 July 2017.

In developed countries, the environment might get cleaner with EVs and an expanded battery use for EVs and renewables. But the opposite might be true in the developing countries producing the raw materials for the industrialized world due to environmental and social costs. These countries may face even more water shortages, rising emissions and toxic pollution and other environmental problems, and have to cope with human rights abuses and international labour standards. Supply chains from mining to end products are often not fully transparent, despite many efforts to improve industry practice for responsible and ethical sourcing. However, international certification schemes such as the 'OECD Due Diligence Guidance' and conflict-free sourcing initiatives offer instruments for more transparency and international collaboration.

2.4. Cyber security of Critical Energy Infrastructures (CEIs)

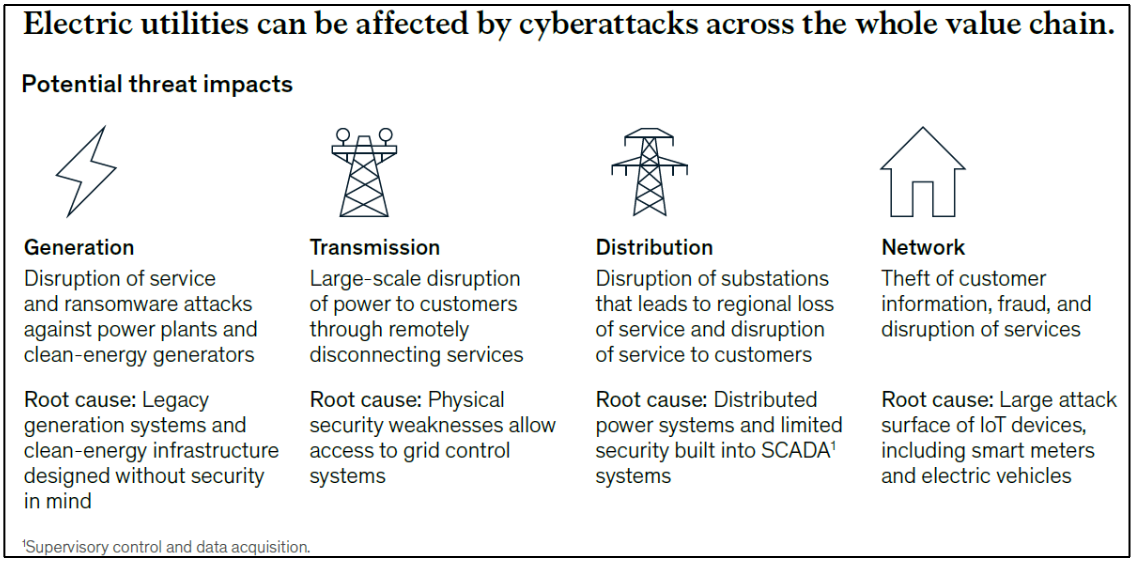
During the last years, the worldwide increase of sophisticated cyber attacks on industrial control centres has alarmed industries, governments and cybersecurity experts. As long as the identification (or attribution) of the sources of cyberattack facing increasing difficulties and offensive cyber tools are becoming commonplace and available for state actors, terrorists and cyber-criminals throughout the world, sophisticated cyber attacks on critical information and Industrial Control Systems (ICS) networks might further increase. Disruptive and destructive attacks against Critical (Energy) Infrastructures (CIs/CEIs) have increased beyond any previous forecasts.[83]

[83] Stockton, P., 'Strengthening the Cyber Resilience of North American Energy Systems', Wilson Center, September 2020; WEC, 'World Energy Perspectives. The Road to Resilience', London 2016, and Umbach, F., 2018, 'Energy Security in a Digitalized World and its Geostrategic Implications'.

While hostile viruses are expanding exponentially, many industrial computer systems that control power plants (Supervisory Control and Data Acquisition/SCADA systems) as well as other CEIs are often old and outdated even in developed countries, making them very vulnerable to cyberattacks. As all CIs are dependent and directly or indirectly connected to the regular internet, and dependent on a stable supply of electricity, the energy and in particular the sectors of highly industrialized countries are considered as the Achilles heel of their political, social and economic stability.[84] The electric-power and gas sectors have unique interdependencies between physical and digital infrastructures, which make the companies vulnerable to cyberattacks and exploitation. These characteristics as well as the new (digital) technologies and organizational complexity have also heightened the risks, vulnerabilities and impacts of cyberthreats against utilities.

Figure 13

Potential cyberattacks on electric utilities



Source: McKinsey, 2020.

[84] Umbach, F., 'Critical Energy Infrastructure at Risk of Cyber Attack', KAS-International Reports 9/2012, pp. 35-66.

Almost every private or public service is directly or indirectly dependent on a secure power supply. The size and complexity of the physical, virtual, and logical networks have soared. A result of the growing mutual dependency between different CIs, the dependency and consequences of supply bottlenecks and disruptions are generally not obvious if a crisis causing a total collapse in supply does not hit. But as systems become ever more complex even smaller power fluctuations, outages and interruptions can have dramatic cascading and even transnational effects that cannot always be predicted.[85]

The rapidly expanding introduction of new technologies will multiply already existing cybersecurity risks and vulnerabilities, also due to billions of internet-connected Internet of Things (IoT) items of networks of smart-sensor-enabled devices that communicate and cooperate with each other. The rapid and often premature adoption of digital technologies and IoT devices without inherent designed cyber safety features and adequate regulations for managing the risks has already created new vulnerabilities and data breaches (i.e. the worldwide 'WannaCry'-ransomware attack in May 2017).

CEIs include installations and networks for generating electricity, but also for the extraction of oil and gas, storage and refineries, liquid gas terminals, nuclear power stations, water dams as well as transport and distribution systems. All CIs in modern industrial societies are increasingly integrated and inter-linked by two systems: electricity and the internet.[86] Any longer-term disruption to electricity and/or the internet would mean that a country could lose essential services such as energy and water supply and thus could no longer guarantee the functioning of its Critical Infrastructures.

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85 Commission of the European Communities, 'Protecting Europe from Large-Scale Cyber-Attacks and Disruptions: Enhancing Preparedness, Security and Resilience', SEC(2009)399/SEC(2009)400, Brussels, 30.3.2009, COM(2009) 149 final and Umbach, F., 2011, 'Waking Up to Cyber-Attack Threats in All Walks of Life', GIS, 13 October 2011.

86 Umbach, F. and U. Nerlich, 'Asset Criticality in European Gas Pipeline Systems – Increasing Challenges for NATO, its Member States and Industrial Protection of Critical Energy Infrastructure', in: A. Gheorghe/L. Muresan (Eds.), 'Energy Security. International and Local Issues, Theoretical Perspectives and Critical Energy Infrastructures', NATO Science for Peace and Security Series – C: Environmental Security (Dordrecht: Springer 2011), pp. 273-303 and Umbach, F., 'Critical Energy Infrastructure Protection in the Electricity and Gas Industries. Coping with Cyber Threats to Energy Control Centers', OSCE-CTN Newsletter, Special Bulletin: 'Protecting Critical Energy Infrastructure from Terrorist Attacks', Vienna, January 2010, pp. 25-28

The more an industrialized society and its CIs are linked to the internet, the greater its vulnerability and the potential risks it faces.[87]

Whilst the industry has the experience to cope with those physical attacks, increasing cyberattacks on CEIs present a rather new security threat, with little experiences in the past on which its expertise can build upon. It has fuelled a paradigm security change, in which traditional safety and security concepts are insufficient. Companies need to develop new holistic security concepts, in which safety and security will become a major management task. Only integrated comprehensive security concepts, embedded in the business development decision-making and planning, can cope with these new qualified threats.

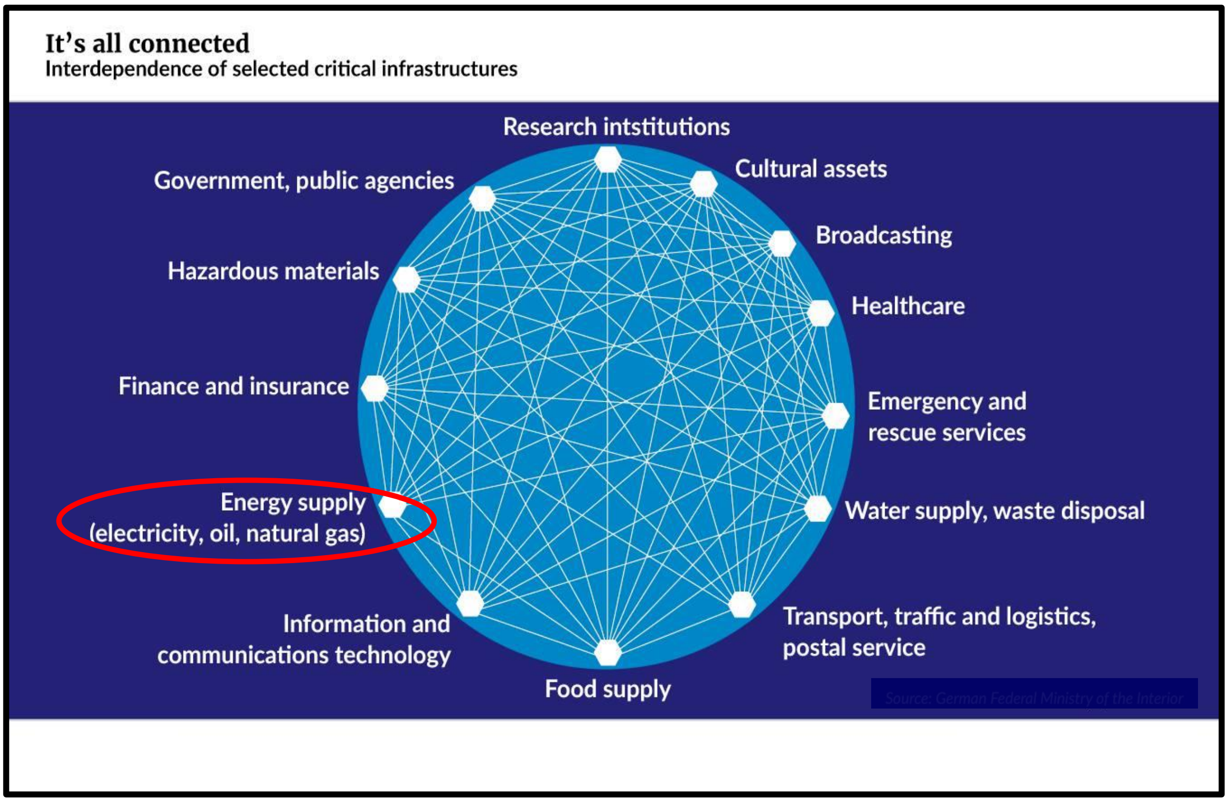
During the last years, international consciousness, awareness and preparedness and the exchange of information, as well as expertise internationally have increased. National law enforcement and intelligence agencies have also enhanced their cooperation both nationally and internationally. Despite the progress being made at the cyber fronts, the overall preparedness and defence capabilities have not yet lived up with the worldwide offensive cyberattack capabilities of transnational crime and governmental-supported hacking groups. Awareness building is also needed to cope with the manifold security myths around CEIs and operational technology systems.

While warnings of 'Digital Pearl Harbor' attacks on Critical Infrastructures (CIs) are not new, the present situation might become even more vulnerable, particularly of highly industrialized countries. In almost all of cyberattacks, any hard evidence to support the attribution is difficult to find though international digital forensics have also improved.

[87] Petermann, T.et al., 2011, 'Was bei einem Blackout geschieht. Folgen eines langandauernden und großräumigen Stromausfalls', Studien des Büros für Technikabfolgenschätzung beim Deutschen Bundestag, Berlin.

Figure 14

Interdependencies of critical infrastructures



Source: GIS, 2020.

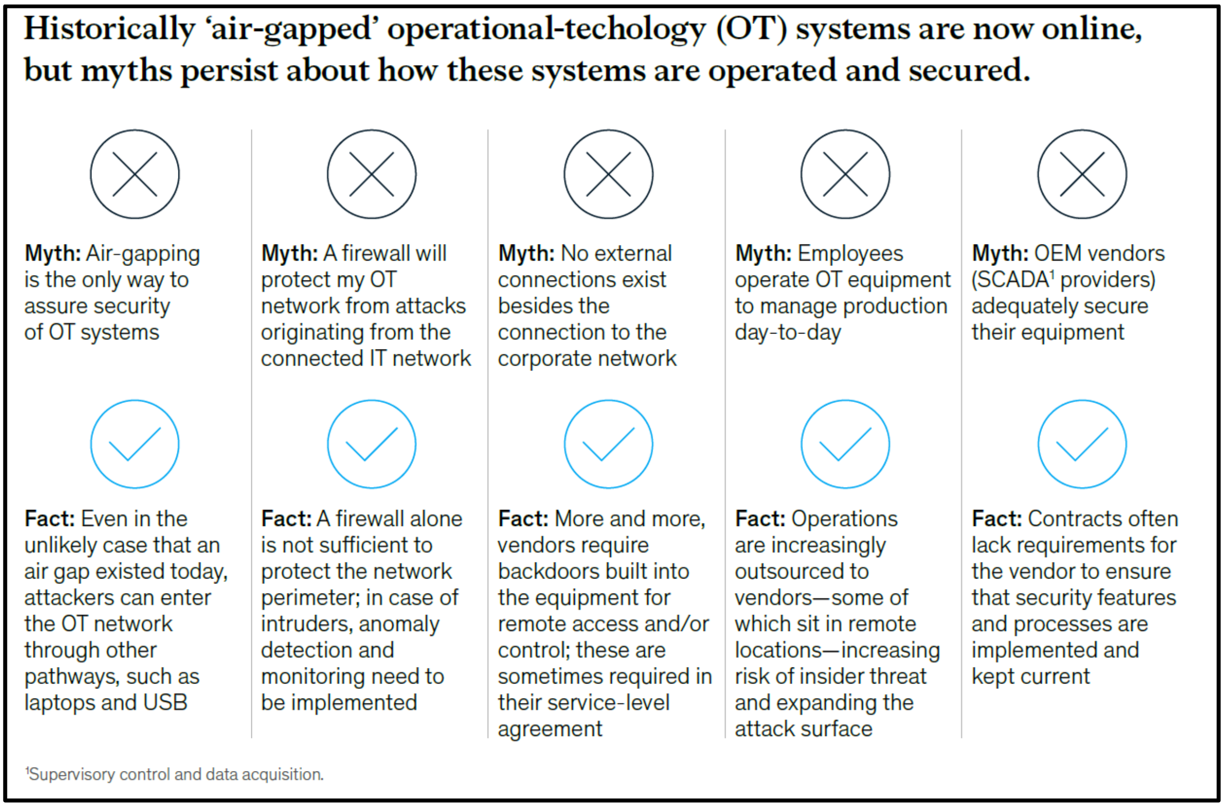
The novel 'Blackout' by Marc Elsberg described a scenario in which a collapse of the European electricity grid triggered telecommunication problems, food, and water shortages as well as an economic breakdown in various European countries. That scenario is being considered no longer as unrealistic.[88] Actually, the novel is based on a larger study of a German research institute of the Bundestag in 2011. The study concluded that after four days, a complete collapse of all state functions and the usual daily life may take place. It also highlighted and confirmed again that neither states nor societies are really prepared for coping with the cascading impacts and the amount of replacement work for sufficiently rapid restoration of the power supply.[89]

88 Elsberg, M., 2012, 'Blackout. Morgen ist es zu spät', Munich.

89 Petermann, T.et al., 'Was bei einem Blackout geschieht. Folgen eines langandauernden und großräumigen Stromausfalls'.

Figure 15

Myths and realities of Operational-Technology (OT)



Source: McKinsey, 2020.

Global cyberattacks might further increase due to new technologies of digitalization, electrification, robotics, and Artificial Intelligence (AI), which will revolutionize the energy sectors and other industries. Although AI might also significantly improve the worldwide cyber defence capabilities, the new disruptive technologies might also create numerous new risks and vulnerabilities, particularly for the CIs/CEIs and their Industrial Control Systems (ICS). More efficient, resilient cybersecurity strategies need to be based on layered 'defense-in-depth'-concepts giving much more attention to mitigate disrupting cyberattacks and restoring the operational functioning of CIs to prevent any wider cascading impacts.[90]

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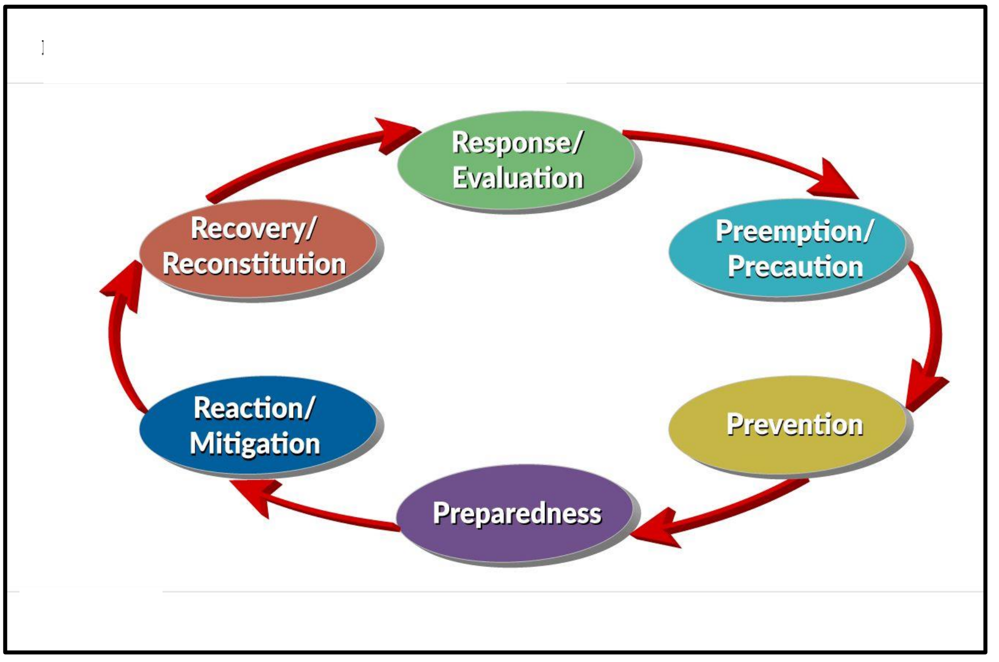
[90] Bailey, T., Adam Maruyama and Daniel Wallance, November 2020 'The Energy Sector Threat: How to Address Cybersecurity Vulnerabilities' McKinsey & Company, .

Figure 16

Layered in-depth cyber defense concept



Source: Umbach, F., GIS, 2018.

Effective cyber resilience strategies begin with making business security an organizational priority as the top management of governments and companies alike. They also include reviewing critically the overall security architecture of companies and organizations in the light of the introduction of new disruptive technologies and changing business models and companies' cultures. Even by taking into account that some technology trends - such as blockchain, AI, 'transactive energy', peer-to-peer-trading and other innovations - will enhance cyber defence and cybersecurity[91], they are not silver bullet solutions. As full prevention of sophisticated cyberattacks (i.e. Advanced Persistent Threats/APTs) is impossible, a layered 'defence-in-depth'-concept and resilience system for CIs and ICS, based on physical, organizational, electronic and cryptographic layers, need to include the elements[92] as highlighted in Figure 16.

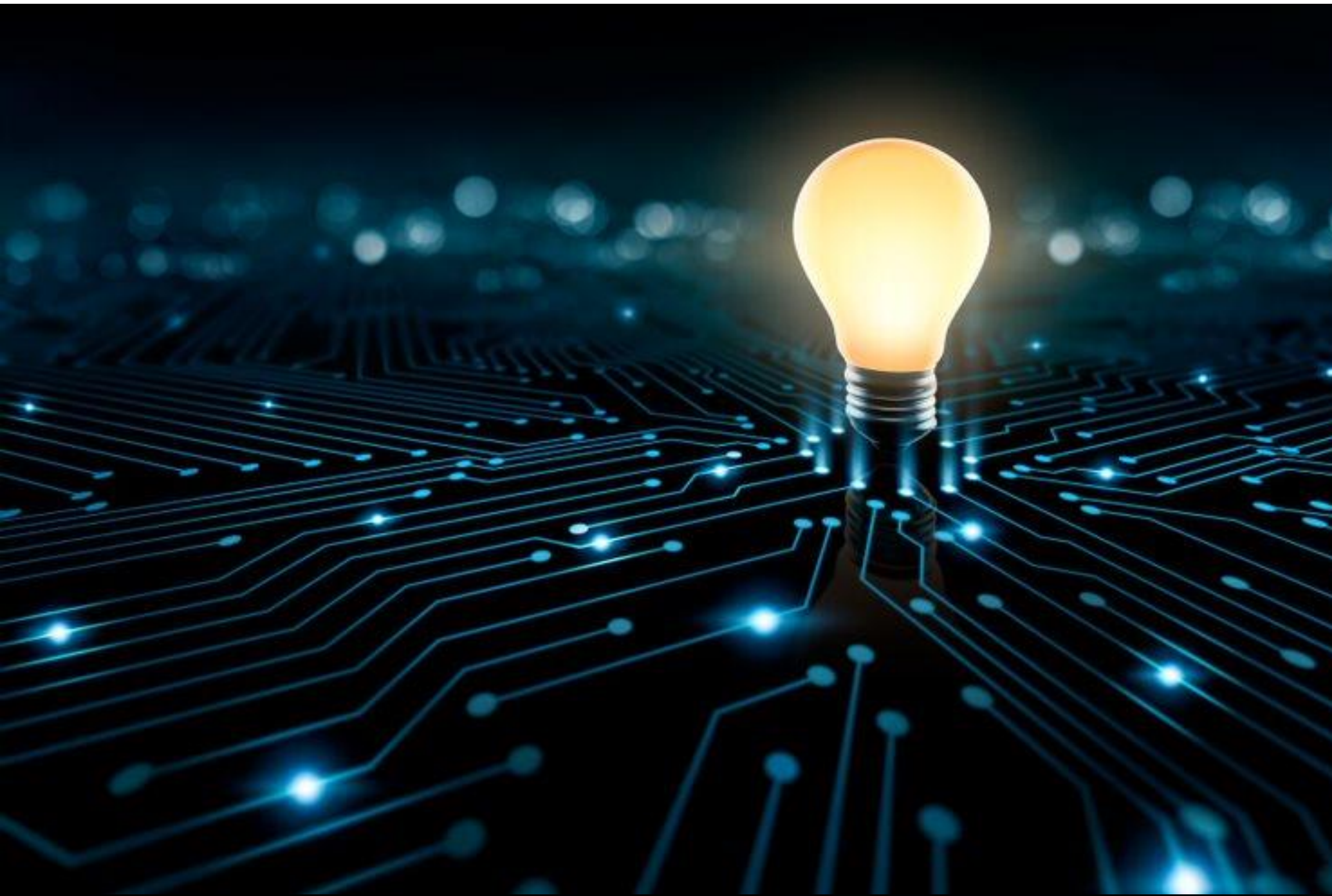
91 Galeon, D., 2017, 'How Artificial Intelligence is Making Nuclear Reactors Safer', Futurism-News, 23 November 2017. Available at https://futurism.com/researchers-training-ai-make-nuclear-reactors-safer/.

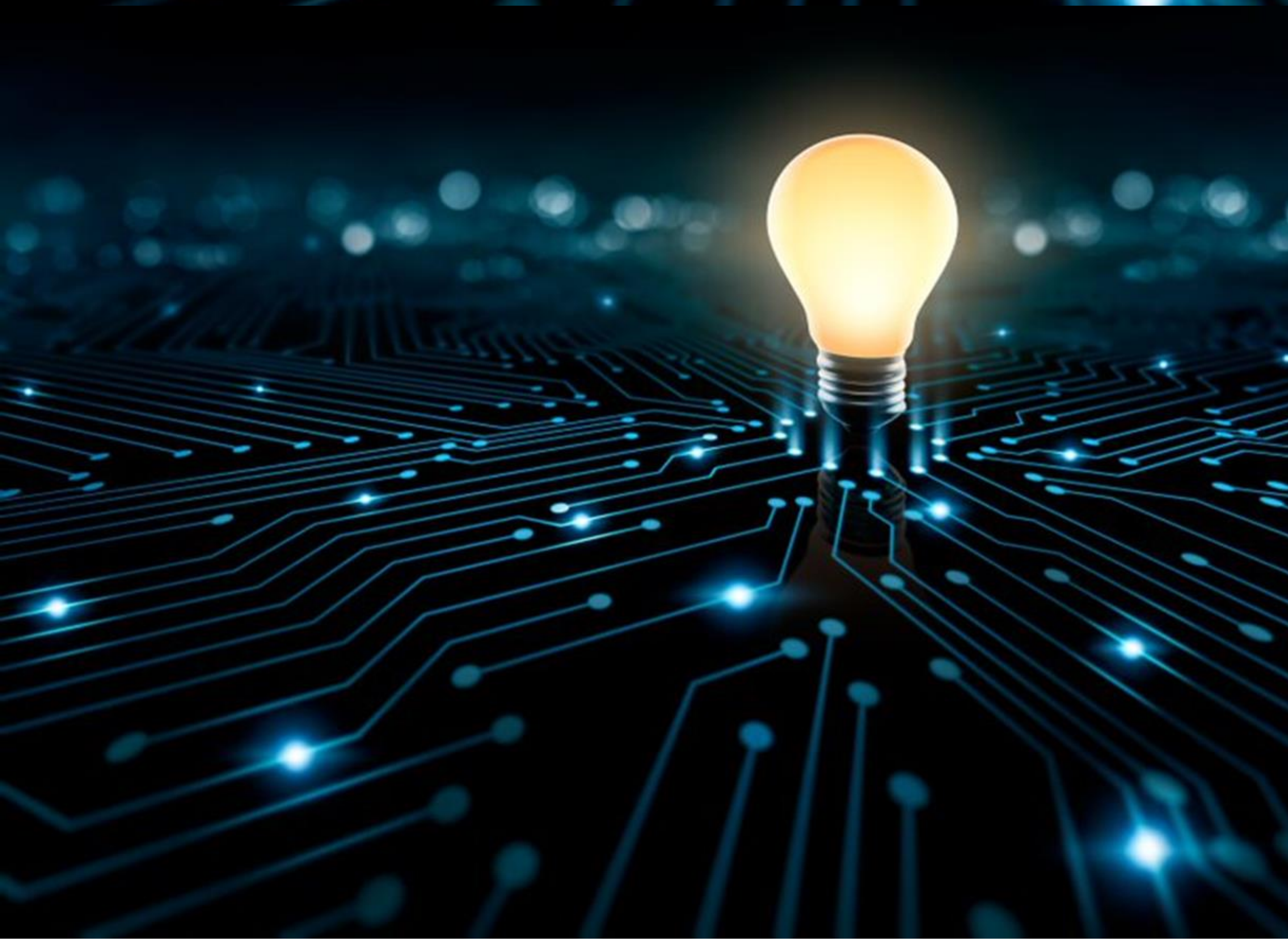
92 Umbach, F., March 2018, 'Energy Cybersecurity: The Need for Effective Resilience', Geopolitical Intelligence Service (GIS).

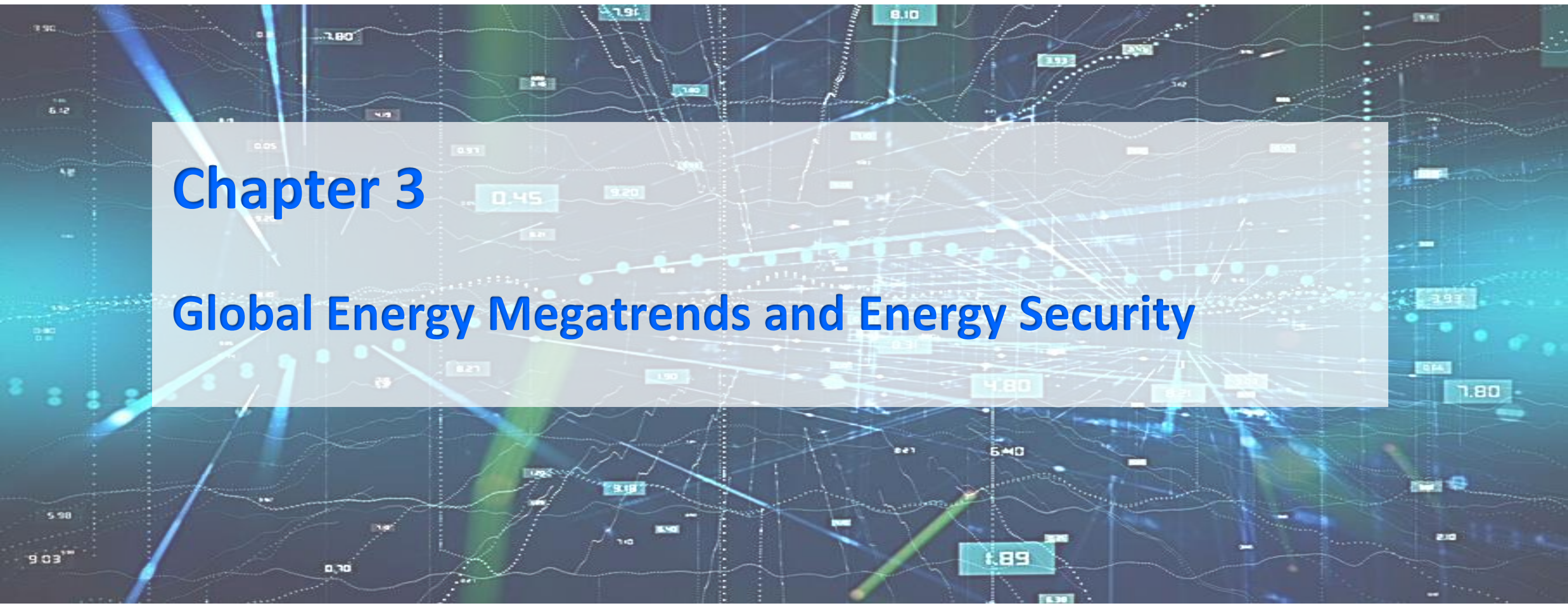
In addition, digital energy security also needs to build on two other key concepts beyond resilience: ‘cyber hygiene‘ (a basic set of precautions and monitoring to enhance awareness) and ‘security of design’ by incorporating safety and security objectives and defined standards as part of a technology and system architecture already in the design phase.[93]

Ultimately, governments, industries, businesses, and the public need to be aware that any new technology can be used for offensive crime-related purposes as well as strengthening defense and resilience in the cyberspace in an ever-escalating cyber arms race.

[93] IEA, ‘Digitalization & Energy’, p. 128.







Chapter 3

Global Energy Megatrends and Energy Security

3.1 Global energy megatrends

Fossil Fuel Markets: From Sellers' to Buyers Markets

Since around 2010, the world has experienced a parallel energy revolution with wide-ranging impacts on global energy markets: the expansion of renewables and unconventional oil and gas.

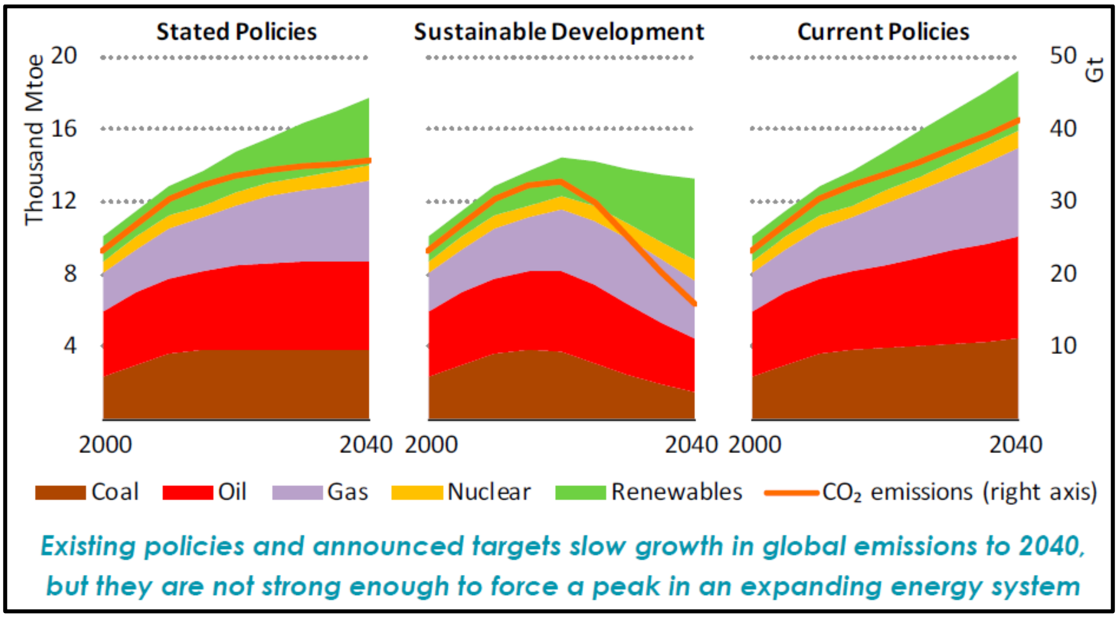
In 2019, the IEA's worldwide primary energy mix of 2040 was projected still be based on fossil fuels at around 70 per cent with its main 'STEPS'/ Stated Policies Scenario [94] - compared with its still less realistic 'Sustainable Development Scenario (SDS)' of around 60 per cent (and 40 per cent of renewables, hydro, bioenergy and nuclear compared with around 26 per cent in the 'NPS'/New Policies Scenario). China was still considered as the world's largest energy consuming country and India as the largest source of energy demand growth.[95]

[94] This is the main IEA-scenario, which considers the energy trends as well as announced future energy policy objectives and strategies until 2020 though they were not (fully) implemented.

[95] IEA, 'World Energy Outlook 2019'.

Figure 17

World primary energy demand by fuel and related CO_2-emissions by scenario



Source: IEA, 'World Energy Outlook 2019'.

In STEPS, global oil output rises by around 10 per cent and natural gas production by almost 40 per cent to 2040. The impressive shale gas and shale oil revolution not only changed the United States energy market by accelerating a coal-to-gas switch in its energy mix but also had major impacts on the worldwide oil, gas and even coal markets. While in the period of 2000 to 2007, total United States natural gas production increased by less than 1 per cent, in the following decade from 2007 to 2017, the total gas output grew about 40 per cent.[96] The United States shale industry has met almost 60 per cent of the global demand growth on the oil and gas markets over the last decade.[97] In 2011, it already became the world's largest gas producer surpassing Russian Federation.

Overall, the United States shale industry proved much more flexible to changing market conditions and responsive to declining as well as short-term pricing than traditional multibillion dollar mega

[96] Yergin, D. and Samuel Andrus, 'The Shale Gale Turns 10: A Powerful Wind at America's Back. What's ahead for the Next Decade?', IHS Market, Executive Commentary/Strategic Report, July 2018, , p. 4.

[97] IEA, 'WEO 2020', p. 20.

projects, particularly compared with conventional offshore oil and gas drilling. Since 2010, almost US$1 trillion have been invested in the upstream oil and gas production and another US$200 billion for new pipelines and other gas infrastructures.[98]

In the United States, 'cheap' gas hurt both coal and nuclear power by shutting down their electricity generation capacities. Climate change policies and the coal-to-gas shift in the United States energy mix reduced its national CO_2 emissions to the lowest level since 1985.[99] The CO_2 emissions from power generation had been reduced by 30 per cent from 2005 to 2018 – more than half by switching from coal to natural gas.[100]

Since 2012, the United States has surpassed Russian Federation and Saudi Arabia as the largest combined petroleum and gas producer.[101] In 2014, it also became the worldwide largest petroleum producer (ahead of Saudi Arabia and Russian Federation). Since December 2015, when its oil export restrictions had been lifted, United States oil exports have continuously increased. Since then, the United States has continuously expanded its oil and Liquefied Natural Gas (LNG) exports. In 2019, the United States produced more than 11 million barrels per day (mb/d) per year and was further rising up to around 13 mb/d until March 2020 before COVID-19 hit the world economy. Theoretically it was even projected that the total United States oil production could be further rising high up to 20 mb/d in the mid- and longer-term perspective, depending on the global oil demand.[102]

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98 "IEA Executive Director Holds Press Conference with US Secretary of Energy", IEA-News, 18 July 2017.

99 Clement, J, 'Thanks to Natural Gas, US CO2 Emissions Lowest since 1985', Realclearenergy.com, 6 July 2018 and also F. Umbach, 'The Limited Global Impact of Trump's 'America First' Energy Policies', GIS, 17 October 2017.

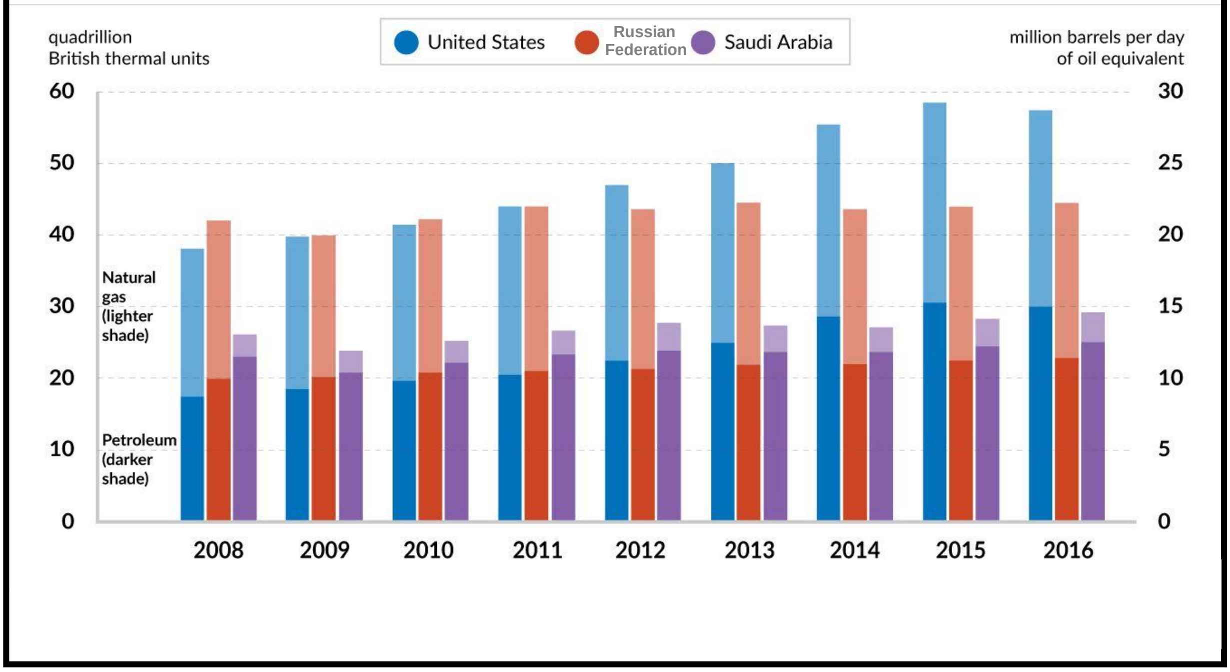
100 ibid., p.7 f.

101 EIA, 7 June 2017, 'United States Remain the World's Top Producer of Petroleum and Natural Gas Hydrocarbons', EIA-Today in Energy,.

102 Myers Jaffe, A., 2017, 'Could a U.S.-Russia Oil Showdown be Coming?', Council of Foreign Relations, 18 December 2017.

Figure 18

Estimated petroleum and natural gas production 2008-2016



Source: GIS 2018 based on Energy Information Administration (EIA), 2017.

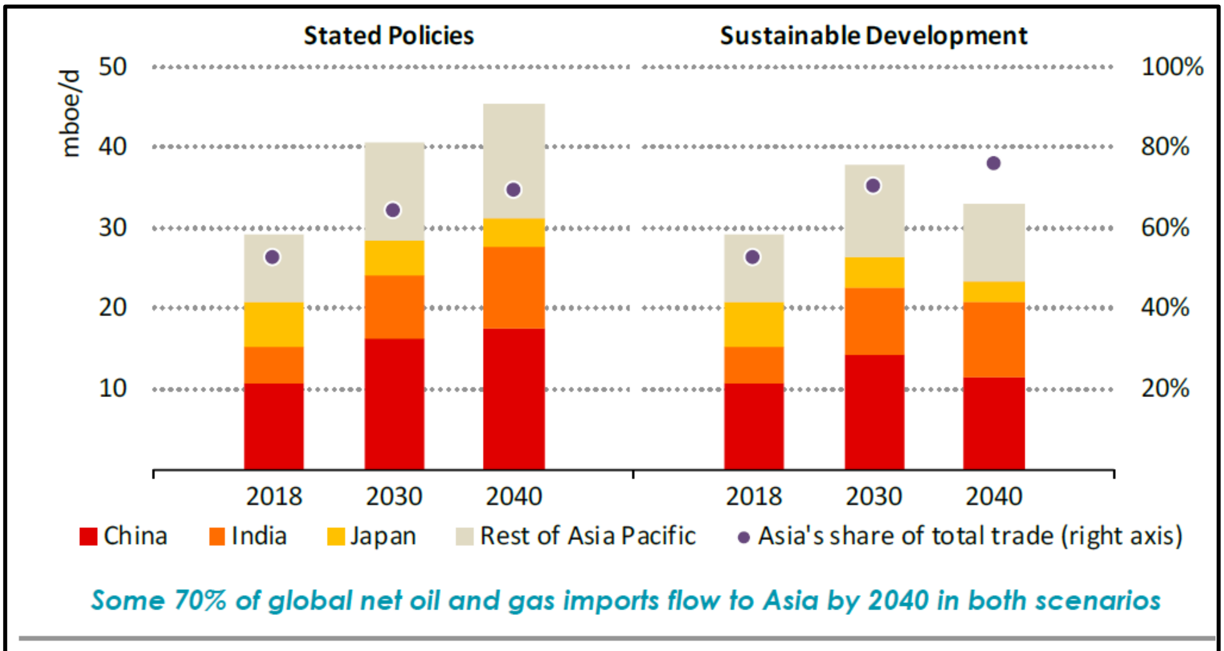
As a result, the previous expectation of a 'peak-oil'-era with an increasing worldwide shortage of oil and gas resources by around 2020 had been replaced with a perspective of a 'peak oil demand'-scenario of a longer lasting oversupply of oil and gas reserves on the world's markets with lower oil and gas prices. Prior to the COVID-19 pandemic, concerns of the 'peak oil demand' with further declining oil prices (US$40-60 until 2020) had increased. While many international oil experts conceded that a much faster electric mobility revolution may curb an even more significant global oil demand by 2040, the IEA warned not to overlook other oil demand drivers such as the petrochemical industry (+60 per cent), freight shipping and aviation, which could still outbalance any oil demand conservation impacts of the EV-revolution.[103]

[103] IEA, 'WEC 2017', pp. 153 ff.

The IEA expected in 2019 that the United States would even account for 85 per cent of the increase in global oil production, and for 30 per cent of the increase in gas to 2030 in STEPS. It would further bolster the position of the United States as a major exporter of both fuels. By 2025, total United States shale output (oil and gas) could even overtake total oil and gas production from Russian Federation, according to the IEA's 'World Energy Outlook 2019'-report. Hence, the OPEC share of the total world oil production would drop from 55 per cent in the mid-2000s to 47 per cent in 2030. China would overtake the European Union (EU) as the world's largest net oil importer through to 2040, whereas India's net oil import demand might more than double between 2018 and 2040. Its level of import dependency reaches roughly 90 per cent, one of the world's highest. India's import dependence will play a major role in global trade and energy security.[104]

Figure 19

Net oil and gas imports to Asia by scenario



Note: mboe/d = million barrels of oil equivalent per day.

Source: IEA, 'WEO 2019'.

104 IEA, 'World Energy Outlook (WEO) 2019'.

The manifold uncertainties of the future global energy and oil demand are not only linked with the future United States shale revolution. They also depend on the future global fossil fuel consumption – particularly in Asia - and determined by the speed of the global energy transition, the expansion of renewables, the future climate change mitigation policies as well as the concrete energy efficiency gains.[105] In contrast to the IEA and the European gas industry, for instance, the European Commission, hoped to decrease its rise of gas consumption by enhancing its energy efficiency efforts up to 20 per cent by 2020 and 32.5 per cent by 2030 even before the declaration of the 'European Green Deal (EGD)' in December 2019. An even faster transition to a cleaner energy mix might further decrease its overall gas consumption as well as its import needs – questioning the 'golden age of gas'[106] for Europe as well as in other regions by replacing conventional natural gas with hydrogen and other green gases (such as biomethane).[107]

Like the global oil market during the last decade, the global gas markets have undergone dramatic changes since 2010, leading to a present worldwide oversupply on the markets, a significant decline of gas prices and a shifting business environment with new rules, legislation and contract schemes. The natural gas demand has also been growing fast as a fuel for both industry and (in China) for residential consumers. It has promoted a worldwide wave of investment in new LNG supply and pipeline connections. The IEA projected in 2019 that 70 per cent of the increase in Asia's gas consumption would have to be imported – largely from LNG, though dependent on its future competitiveness.[108]

In general, the previous gas 'sellers' market' had been transformed to 'buyers' markets', changing the power balance from gas producers and exporters to gas importers and buyers in the light of a global gas glut. These changes on the global gas

105 APEC, 'Energy Demand and Supply Outlook. 7th Edition, Vol. I'; and ASEAN Centre for Energy, 'The ASEAN Energy Outlook 2017-2040'.

106 IEA, 2012, 'Are We Entering a Golden Age of Gas?', World Energy Outlook 2011. Special Report, Paris: IEA/OECD).

107 Umbach, F., 2020, 'The European Green Deal faces huge challenges", Geopolitical Intelligence Service (GIS), 10 February 2020, and idem, 'Europas Plan für Klima und Umwelt' ('Europe's Plan for Climate and Environment'), in: Internationale Politik, July 2020, pp. 78-82.

108 IEA, 'WEO 2019'.

markets are primarily the result of two revolutions: (a) the shale gas revolution in the United States, and (b) an often overlooked revolution of the LNG-markets. Both revolutions are to a large extent the result of newly emerging technologies with wide-ranging strategic impacts on global markets.[109] While in Europe, the liberalisation and other reforms of its single gas market has made significant progress since 2010, the Asian gas markets are lacking behind and have repeatedly exposed the need for faster reforms.[110]

The present oversupply of the global gas markets is the result not just of the rapidly increasing worldwide gas production, but also of the slower economic growth in China and India, increasing energy efficiency, the restarts of nuclear reactors in Japan as well as the Republic of Korea, and cheap coal in the Asia-Pacific region during the last years.[111] Asia had been considered as the world's biggest consumer of LNG. Japan and the Republic of Korea consume a combined 125 mega tonnes per annum of global LNG exports and account for 70 per cent of all Asian LNG imports.[112] The IEA forecasted in 2019 that developing Asian economies would account for half of the global growth in natural gas demand and almost all of the increase in traded volumes. By 2040, they would consume some 25 per cent of the world's gas production, much of it would be sourced from other regions. LNG was expected to overtake pipeline gas supplies

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[109] Umbach, F., 2017, 'Rising U.S. LNG Exports Could Lead to European Gas Price War', GIS, 21.2.2017; Rudolf Huber/Frank Radtke, 'Schlachtfeld Europa: LNG trifft auf Pipeline Gas – ein Preiskrieg?', in: Energy and Geopolitics. Monthly Report. Berlin, No. 1/2016, March 2016, S. 35-39 und Sylvie Cornot-Gandolphe, 'The US Natural Gas Exports. New Rules on the European Gas Landscape', IFRI, June 2016.

[110] Dubreuil, J., 2021, Asia's Record Gas Prices Expose the Ned for Faster Market Reform', Energypost.eu, 2 February 2021 and Umbach, F., 'The Changing Global and European Gas Markets and its Implications for Trading Gas Hubs – European Views and Experiences', April 2014, presented at at the international symposium 'The Gas Trading Hub. Present Status and Future Prospects', organized and hosted by the Ministry for Foreign Affairs (MOFA) and the Korean Gas Union (KGU), Seoul/the Republic of Korea, 5 March 2014.

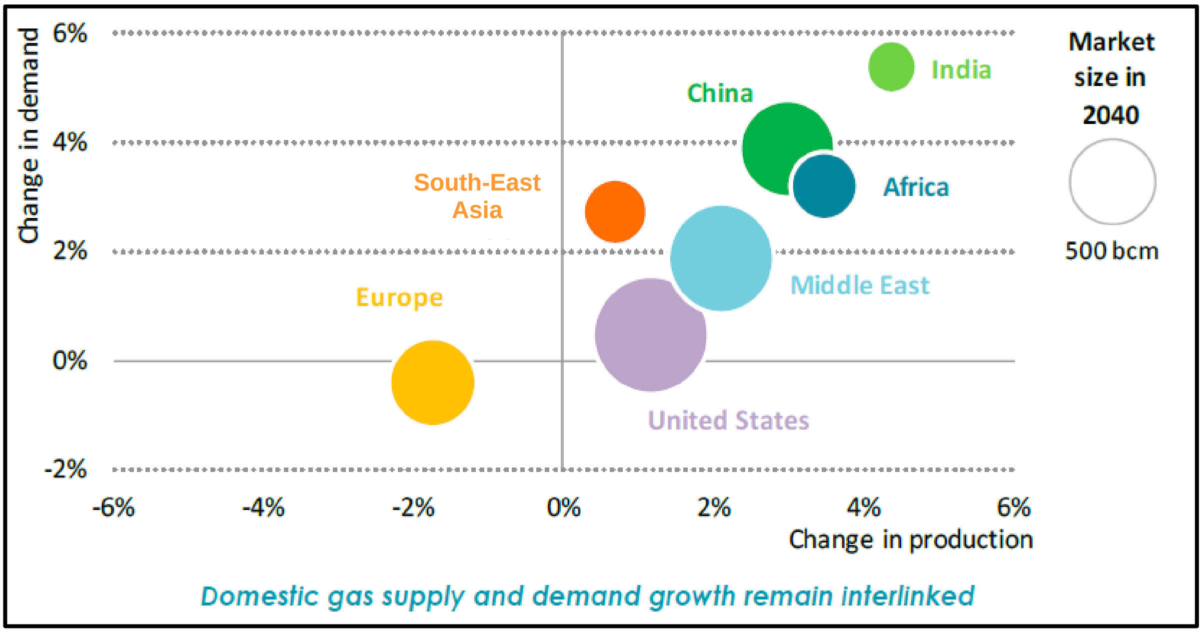
[111] To the global and in particular Asian (i.e. China) coal developments see Umbach, F. and Ka-ho Yu, 'China's Expanding Overseas Coal Power Industry – New Strategic Opportunities, Commercial Risks and Geopolitical Implications', EUCERS-Strategy Paper No. 11, September 2016, 64 pp. and F. Umbach, "The Future Role of Coal: International Market Realities vs. Climate Protection?', EUCERS-Strategy Paper Six, King's College, London, May 2015, 66 pp.

[112] Umbach, F., 'Rising U.S. LNG Exports Could Lead to European Gas Price War'.

in the global gas trade by the late 2020. Australia, Qatar, and the United States had been projected as the world's leading LNG supplier in addition to new suppliers such as Canada, Russian Federation, and African countries like Mozambique.[113]

Figure 20

Annual average change in gas demand and production in selected regions in the 'Stated Policy Scenario (STEPS)', 2018-2040



Source: IEA, WEO 2019.

Over the past 20 years, Asia accounted for 90 per cent of all coal-fired capacity built worldwide. Coal fired power plants usually have operational lifetimes of 30-40 years. The IEA already projected in 2019 that the worldwide coal production would decline, though a higher output (mainly from India) would almost offset declines in other countries and regions, including a peak in production in China. In the Sustainable Development Scenario (SDS), however, coal production in 2040 was even forecasted to be more than 60 per cent lower than today as renewables would

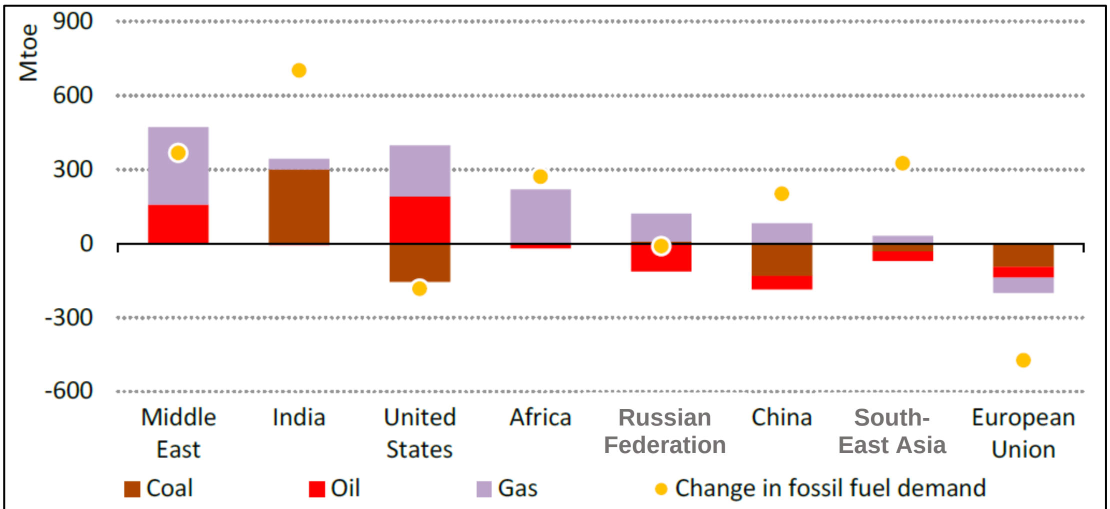
[113] IEA, 'WEO 2019', pp. 175 ff.

challenge coal in Asia's power sector (especially in China and India).[114]

In developing economies in Asia, existing coal plants had been on average just 12 years old in 2019, which are likely to operate for three to four decades to come. Asia accounted for 90 per cent of all global coal-fired capacity over the past 20 years– with China (880 GW), followed by India (173 GW) and South-East Asia (63 GW). Elsewhere there were only smaller additions of coal-fired capacity in Europe (45 GW), the Republic of Korea (28 GW), the United States (25 GW), Japan (20.5 GW) and Africa (10 GW).[115]

Figure 21

Change in fossil fuel production and demand in selected regions in the STEP-Scenario, 2018-2040



Gas output rises to 2040 in all major regions except the EU, oil growth is concentrated in the Middle East and US, and India is one of the few countries where coal production grows

Source: IEA, 'WEO 2019'.

By reviewing these worldwide trends, the IEA noted in 2019 an alarming gap between expectations of a fast, renewables-driven energy transition and the reality of today's energy systems, in which reliance on fossil fuels would remain high. It still forecasted

114 Ibid., pp. 45 ff.

115 Ibid., p. 284.

a 30 per cent increase of the global energy consumption by 2040 from today, though rising more slowly than previously estimated in its 'Stated Policies Scenario (STEPS)'.[116] The 30 per cent-growth is an equivalent of adding the combined present energy consumption of China and India to the current global energy demand. Worldwide electricity generation was even projected to increase by 60 per cent and would have made up 40 per cent in final consumption to 2040 – equivalent to the share of oil during the last decades.[117]

The overall decarbonization trends had been no longer questioned as such yet. But the anticipated speed of the energy transition to a 'greener' energy system could not really been forecasted, which makes any investment decision highly risky. It can be explained by the manifold uncertainties of global climate mitigation policies, the disinvestment movement of phasing out all fossil fuels (implicating 'stranded assets' being 'literally unburnable') and the impact of disruptive technologies such as electric mobility, battery development, digitalization and automatization, robotics and artificial intelligence, and the resulting increase of electrification on the entire global energy system.

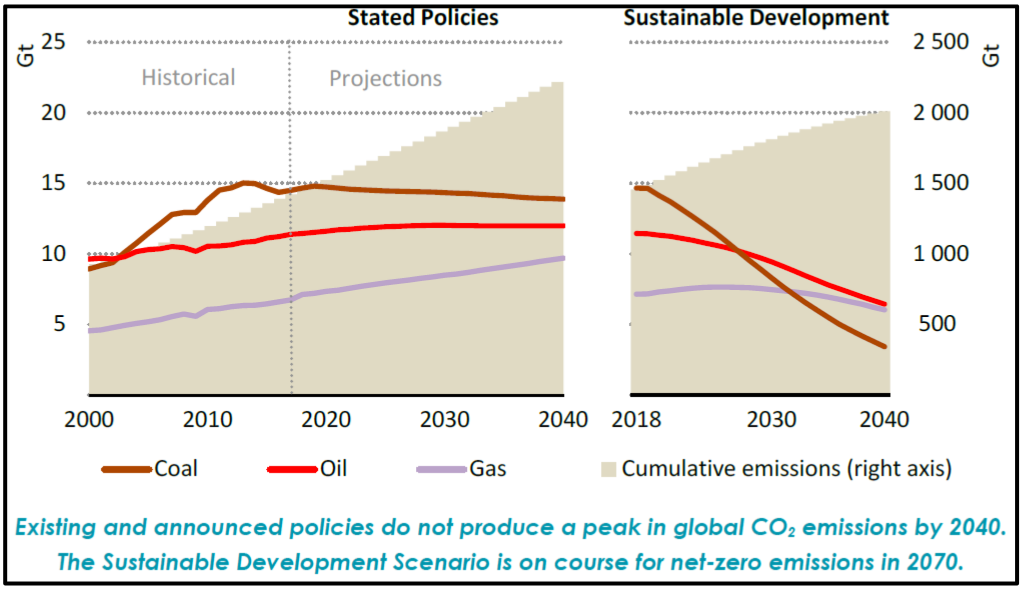
The IEA recognized a three-way race being underway among coal, natural gas, and renewables to provide power and heat particular to Asia's fast-growing economies. In most developing Asian countries, coal remained the incumbent energy source. But also in Asia, new investments in coal-using infrastructure slowed. The large stock of existing coal-using power plants and factories (and the 170 GW of capacity under construction worldwide in 2018), however, would give coal a lasting energy power as 60 per cent of the existing coal fleet was 20 years old or less. It contradicts the needs for a decarbonization of the energy system and the needs for decreasing the coal consumption more rapidly for achieving the international climate change goal of reducing the GHG-emissions to the 1.5°C target.

116 The Stated Policies Scenario, previously called 'New Policy Scenario/NPS', incorporated the newest policy intentions and targets.

117 IEA, 'WEO 2019', pp. 1 ff.

Figure 22

Cumulative energy-related CO_2 emissions (since 1890) and annual emissions by fuel and scenario



Source: IEA, 'WEO 2019'.

While addressing the legacy of the large fleet of global coal-fired power plants is challenging, it also offers numerous opportunities to cut CO_2-emissions by more than 50 per cent by 2030 with retrofitting, repurposing or retiring of them in a cost-effective way.[118]

Given these uncertainties, the energy transition to decarbonize the worldwide energy system could also come faster than presently anticipated as the following recent developments highlight: in 2018, 20 countries and two states of the United States joined the 'Powering Past Coal' alliance to phase out coal. The World Bank stopped lending to any oil and gas projects after 2019. Since May 2019, also United Nations Secretary-General António Guterres has repeatedly urged the world's governments to stop building new coal power plants by 2020.[119] The bank would only make exceptions for gas projects in poor developing countries where fuel is needed to provide energy to local communities. The World Bank had already stopped the financing of coal power projects in these countries in 2013.[120]

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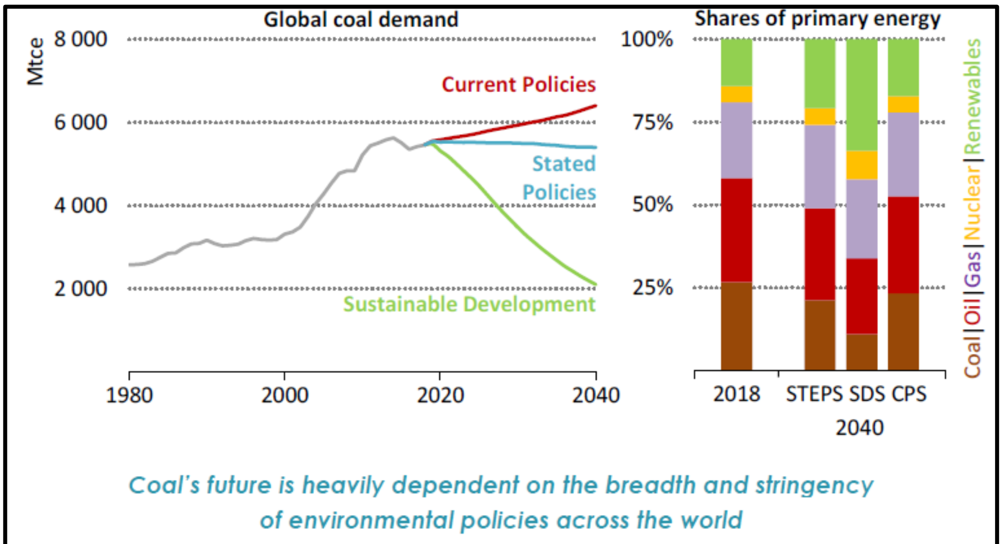
118 IEA, 'WEO 2020', p. 107 f.

119 Lo J., 2020, 'Who will build the world's last coal plant?', Climatechangenews.com, 28 October 2020.

120 Umbach, F., 2015, 'The Future Role of Coal: International Market Realities vs. Climate Protection?', EUCERS-Strategy Paper Six, King's College, London, May 2015; and idem, Ka-ho Yu, 'China's Expanding Overseas Coal Power Industry – New Strategic Opportunities, Commercial Risks and Geopolitical Implications', EUCERS-Strategy Paper No. 11, September 2016.

Figure 23

Global coal demand by scenario



Note: Mtce = million tonnes of coal equivalent; STEPS = Stated Policies Scenario; SDS = Sustainable Development Scenario; CPS = Current Policies Scenario.

Source: IEA, 'WEO 2019'.

While the IEA and others have forecasted a moderate increase, stagnant or even a declining global oil demand by 2040, the worldwide natural gas demand is considered as the only fossil fuel that will experience substantial growth by 45 per cent. The United States might add some 300 billion cubic metres (bcm) over the next 25 years, followed by China with 200 bcm and Russian Federation as well as Islamic Republic of Iran with nationally another each 145 bcm. The present gas oversupply on the world's largest gas market will last for a few years as another 140 bcm of LNG capacity is currently under construction and will enter the markets soon.[121]

While the growth rate by 2020 is dominated by the United States. and Australia, the production growth might be much more diversified afterwards, with East Africa and Argentina becoming new major gas producers and exporters alongside of rising production in the Middle East, China, and Russian Federation. The share of natural gas in the world primary energy mix will increase from 23 per cent in 2019 to 25 per cent by 2040, becoming the

121 IEA, 'WEO 2017', pp. 333 ff.

second-largest energy resource in the global energy mix after oil (28 per cent) and ahead of coal (19 per cent) in the IEA's major 'Stated Policies-Scenario (STEPS)'.[122]

The worldwide LNG trade has increased in volumes and shares versus global gas pipeline transports. It has become more standardized and shipped by an increasing pool of market players: rising from 9 importing and 8 exporting countries in 1990 to 34 importing and 19 exporting countries in 2015. New price indices are no longer been tied exclusively to the oil price but have become more destination flexible and weakened linkages to oil prices by reflecting more market realities. The global pricing formulas have shifted away from oil-indexation from around 76 per cent for contracts signed before 2010 towards more gas-to-gas linkages of around 50 per cent of newer contracts. Fixed destination clauses in LNG contracts declined from 60 per cent in 2014 to 40 per cent in 2015. Technological innovation - such as the modularization of liquefaction plant facilities and small-scale 'Floating Storage Regasification Units (FSRU)' - has contributed to the LNG revolution.[123] At present, Qatar is the world's largest LNG supplier, rivalling Australia. Qatar seeks to maintain is world's status by having lifted its self-imposed development moratorium on its North Field. But by the mid-2020s, their leading position as the world's largest LNG exporters might be replaced by the United States becoming the leading global LNG supplier. The market share of LNG versus pipeline gas will increase of presently 39 per cent in 2016 to around 60 per cent by 2040.[124] The rising LNG supplies and trading opportunities will help the Asian and other countries to diversify gas imports. The Asia-Pacific region might account for around 85 per cent of the global growth in net imports, highlighting a major shift in gas flows from the Atlantic basin to Asia. The shift will also be the result of new importers in South and South-East Asia as well as their significant gas demand growth.[125]

China will remain the biggest wildcard for balancing LNG supply and demand in the

122 ibid., and p. 648.

123 Umbach, F., 2017, 'Rising U.S. LNG Exports Could Lead to European Gas Price War', GIS, 21 February 2017.

124 IEA, 'WEO 2017', pp. 367 ff.

125 ibid., pp. 355 ff.

region and globally. If China's expansion of its domestic gas production will prove to be insufficient and result in a much higher gas import demand, it might lead to higher gas prices in the region compared with those in Europe.[126]

3.2 Decarbonization trends and the transition to clean energy futures

In Europe, China, the United States, and increasingly in many other countries of the world, renewables have expanded due to dramatic shrinking costs - particularly of solar and wind power. Since 2010, costs of solar PV have decreased by 70 per cent, wind by 25 per cent and battery costs for electric vehicles by 40 per cent.[127] In 2017, renewable-based electricity generation grew worldwide at 6.3 per cent. It is the highest growth rate of any energy source. They now account for 25 per cent of global electricity generation.[128] By 2040, they could account for at least 34 per cent of the worldwide electricity generation[129] and even 50 per cent by 2050. According to Bloomberg New Energy Finance (BNEF), solar and wind costs might further drop 71 per cent and 58 per cent respectively by 2050.[130]

But new global investments in clean energy have also fallen during the last years, being in 2016 with US$287.5 billion around 18 per cent lower than in 2015 (with a record investment of US$348.5 billion).[131] After worldwide clean energy investment slightly increased by 3 per cent up to US$ 333 billion in 2017, it declined again in the first quarter of 2018 by 10 per cent compared with the same period a year ago.

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126 Umbach, F., 'Rising U.S. LNG Exports Could Lead to European Gas Price War'.

127 IEA, 'WEO 2017', pp. 281 ff., and Editorial Board, 'Renewable Energy at a 'Tipping Point', Christian Science Monitor, 26 June 2017.

128 IEA, 'Global Energy & CO_2 Status Report 2017', Paris: IEA/OECD, 20 March 2018 and IRENA/IEA, 'Renewable Energy Policies in a Time of Transition', Paris: IEA/OECD, April 2018.

129 Crooks, E., 2018, 'Wind and Solar Expected to Supply Third of Global Power by 2040', FT, 15.6.2017. Tim Buckley, 'Cheap Renewables Are Transforming the Global Electricity Business', www.energypost.eu, 14 February 2018.

130 Walton R., 2018, 'World on Track for 50% Renewables by 2050, Says Bloomberg Energy Outlook', Utilitydrive.com, 19 June 2018.

131 Lynch M., 2017, 'The 'Unstoppable' Renewable Energy Revolution Keeps Faltering', Forbes, 29 June 2017.

Despite this, annually installed capacity has grown steadily, increasing by 7.4 per cent in 2019 over the previous year. The rapid decline in technology costs is a factor in overall investment dips as less investment is required to install the same capacity each year.[132] Contrary to widespread perception particularly in Europe, the new BNEF data highlights the ups and downs of the failing smooth transition away from fossil fuels. Conversely, it also confirmed again that (with some exception of coal) fossil fuels are not yet in a steady and irreversible decline.[133]

According to the IEA's World Energy Outlook 2019 report, solar PV had already projected to become the largest component of global installed capacity in the STEP-scenario. The expansion of generation from wind and solar PV helps renewables was anticipated to overtake coal in the power generation mix in the mid-2020s. By 2040, low-carbon sources would provide more than 50 per cent of total electricity generation. But also, hydropower (15 per cent) and nuclear (8 per cent) would retain major shares in the worldwide electricity generation by 2040.[134]

The Sustainable Development scenario (SDS) of 2019 envisaged 20 per cent higher investments than in the STEP-scenario, rising up to US$3.2 trillion to 2040. The power sector will absorb two-thirds of the overall spending, investments in renewables would almost double and nuclear power by nearly 80 per cent.

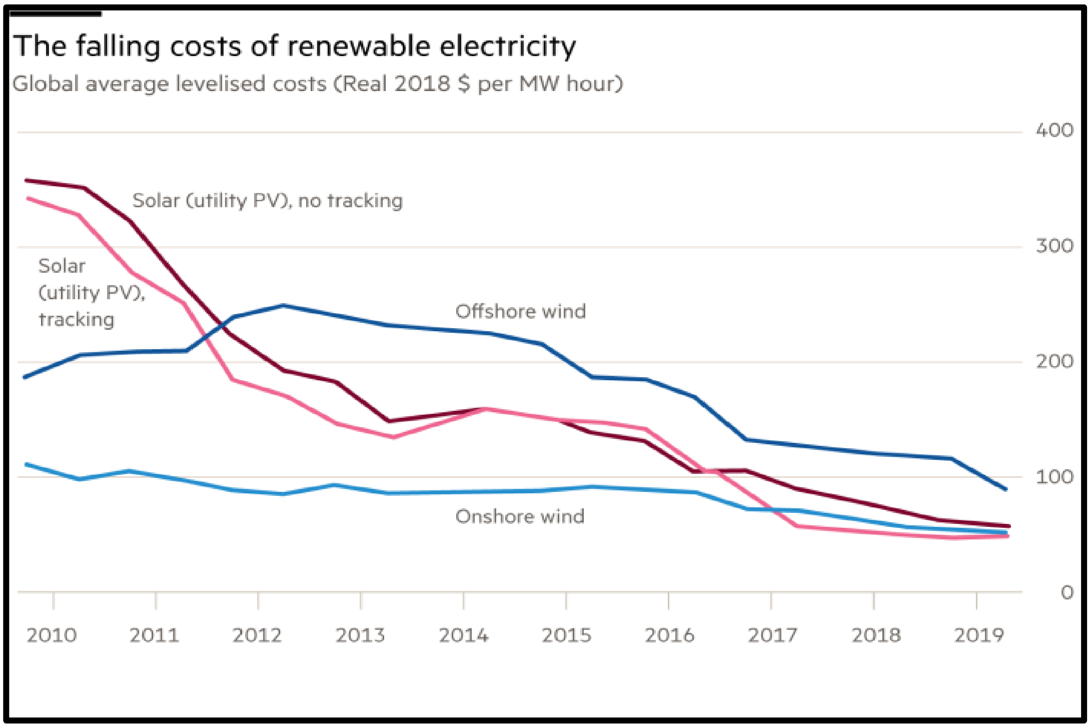
132 IRENA, Renewable capacity highlights 31 March 2020".

133 Louw, A., 'Clean Energy Investment Trends 1.Q 2018', BNEF, 11 April 2018.

134 See again IEA, 'WEO 2019'.

Figure 24

Falling costs of renewables-generated electricity, 2010-2019



Source: Financial Times, 2020, based on data from Energy Transition Commission.

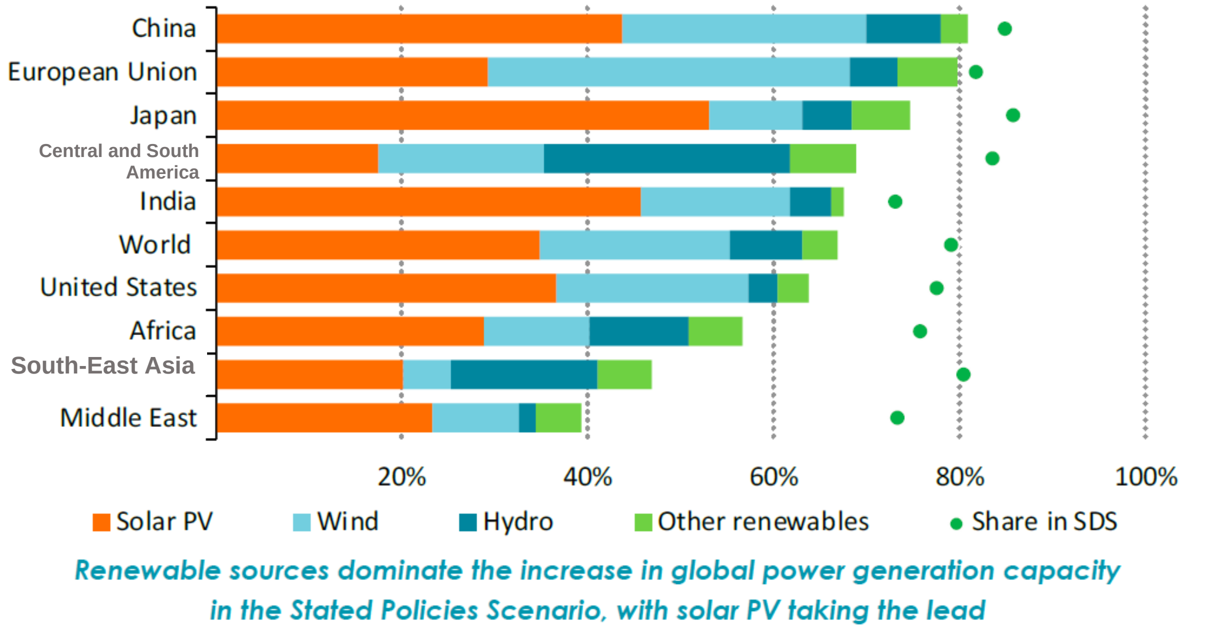
The IEA expected in 2019 that wind and solar PV provide more than half of the additional electricity generation to 2040 in the STEP-scenario and almost all the growth in the SDS. But it also warned that the expected cost reductions in renewables and advances in digital technologies would open huge opportunities for energy transitions as well as create some new energy security dilemmas. Furthermore, it also stated the backdrop in energy efficiency improvements of just 1.2 per cent in 2018 (just 50 per cent of the average rate since 2010) in heating, cooling, lighting, mobility, and other energy services.

Furthermore, declining costs for renewables do not include a number of hidden (or 'systemic') extra costs for the modernization of grid, rising grid interven-tions and the subsidized back-up of conventional power plant capacities for grid stabilization and baseload stability due to the rising intermittency problems of renewables as the example of the German

'Energiewende' highlights.[135] Thus, an expanded use of batteries is needed for guaranteeing stability of the electricity supplies and grids as well as boosting flexibility and supplementing renewables for peaking capacity. In this regard, the sole reference to declining costs of renewables and batteries is also misleading as the expansion of renewables results in higher overall costs and investments into the entire (changing) energy system. These huge systemic investments alongside of the expansion of renewables are often overlooked and need to receive more attention in the worldwide affordability of ambitious energy transition strategies.

Figure 25

Share of renewables in total capacity additions by region and scenario, 2019-2040



Notes: C&S America = Central and South America; SDS = Sustainable Development Scenario. Other renewables includes geothermal, concentrating solar power, bioenergy and marine.

Source: IEA, 'WEO 2019'.

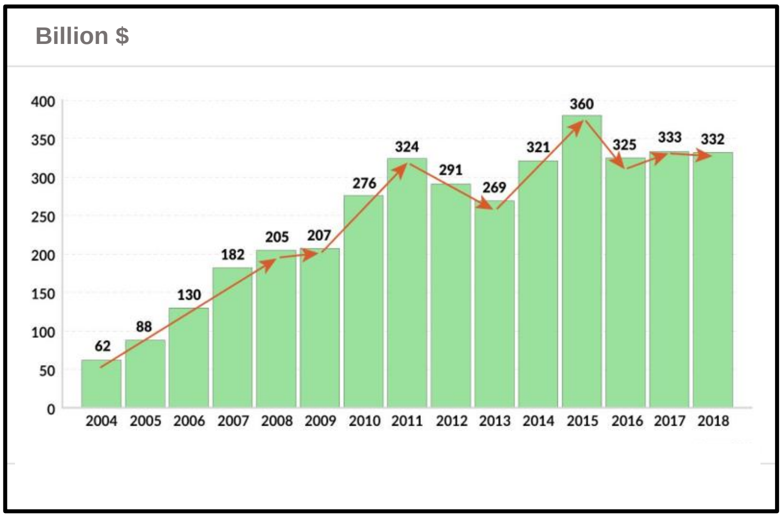
[135] Ford, J., 'The Hidden Costs of Renewable Power', Financial Times, 21 August 2018.

Alongside of the insufficient global investment in clean energies for a faster transition to a non-carbon energy system, also total worldwide energy investment decreased by 2 per cent to US$1.8 trillion in 2017 – primarily explained by the 6 per cent decline in the global power generation sector to around US$750bn. The potential exists for the economic impacts of the global pandemic to be long-lasting as well as its worldwide impacts on energy demand and oil and gas oversupply on the markets. A new report has warned national oil producing companies and governments of the risk of more than $400 billion in projected investments in oil and gas projects in an environment of low process and intensifying climate policies.[136]

China became ever more important for the global energy megatrends as it was responsible for more than one-fifth of the global total energy investments in 2018.[137] At the same time, an IEA report of 2018 warned that improvements in global energy efficiency "slowed down dramatically in 2017, because of weaker improvement in efficiency policy coverage and stringency as well as lower energy prices".[138]

Figure 26

Global new investments in clean energy, 2004-2018



Source: Umbach, F/GIS, based on Bloomberg New Energy Finance (BNEF), 2019.

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136 Manyley D., and P.R.P. Heller, 'Risk Bet. National Oil Companies in the Energy Transition'.

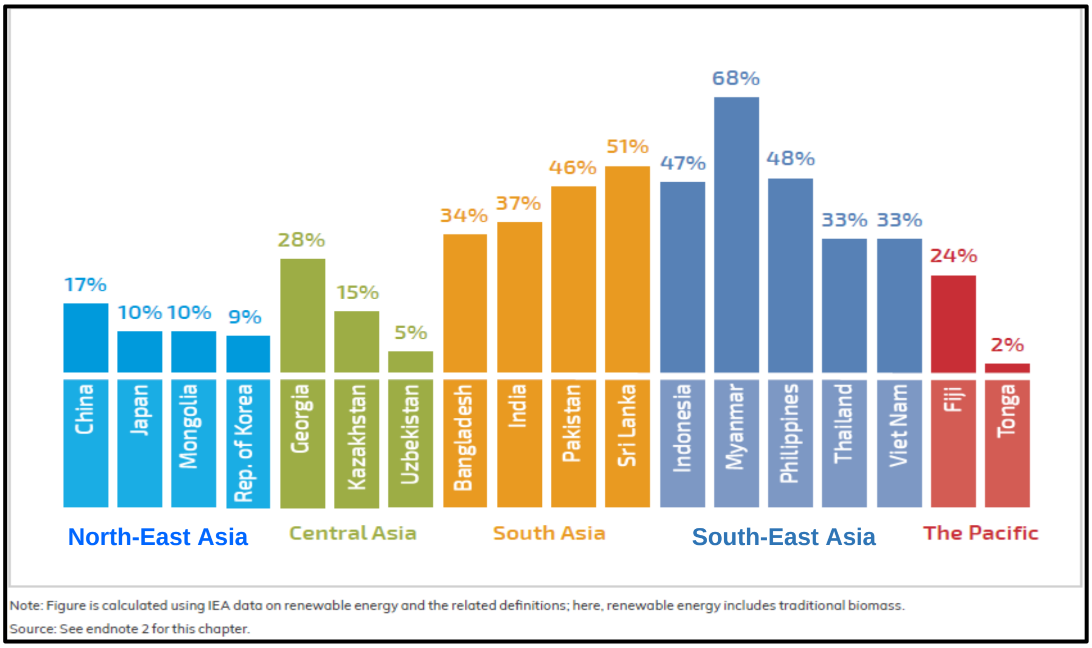
137 IEA, 'World Energy Investment 2018', 2018.

138 IEA, 'Global Energy & CO_2 Status Report 2017', Paris: IEA/OECD, 20 March 2018, p. 1.

But despite the impressive expansion of renewables during the last years with solar power growing by 50 per cent last year and might add another 660 GW just by 2022, the overall share of solar and wind power was still just 2 per cent of the world's primary energy demand (compared with 5 per cent nuclear, 9 per cent bioenergy, and 3 per cent hydro) in 2019.[139] Even by increasing annually 7 per cent in the IEA's leading 'STEPS', by taking agreed but not (fully) implemented energy reforms and strategies for the mid-term perspective into account, the overall share of solar and wind power might only increase up to 8 per cent by 2040 despite new policies and ambitious targets.[140] In consequence, despite the Paris climate accord of December 2015, the continuing ambitious climate mitigation policies and an accelerating expansion of renewables, bolstered by further cost reductions of renewables compared with fossil fuels, the worldwide energy mix was still based on the fossil fuels oil, gas and coal at 80 per cent in 2019.[141]

Figure 27

Renewable share in total final energy consumption in the selected Asia-Pacific countries, 2016



Source: ESCAP/REN21, 2019.

139 IEA, 'WEO 2020', p. 342.

140 ibid.

141 Ibid.

Developing countries in Asia accounted already for over half of the global growth in electricity generation from renewables during the last years. The region represented three quarter of the worldwide 570 million people, which received electricity access between 2011 and 2017.

But half of the population in Asia and the Pacific – almost 2 billion people – still relies on traditional biomass, coal and kerosene for cooking and heating. Although per capita greenhouse gas emissions in the Asia-Pacific region remained below the global average, five countries in the region – China, Japan, the Republic of Korea, India, and Indonesia – were among the world's largest absolute emitters. They accounted together for around 40 per cent of the global total.[142]

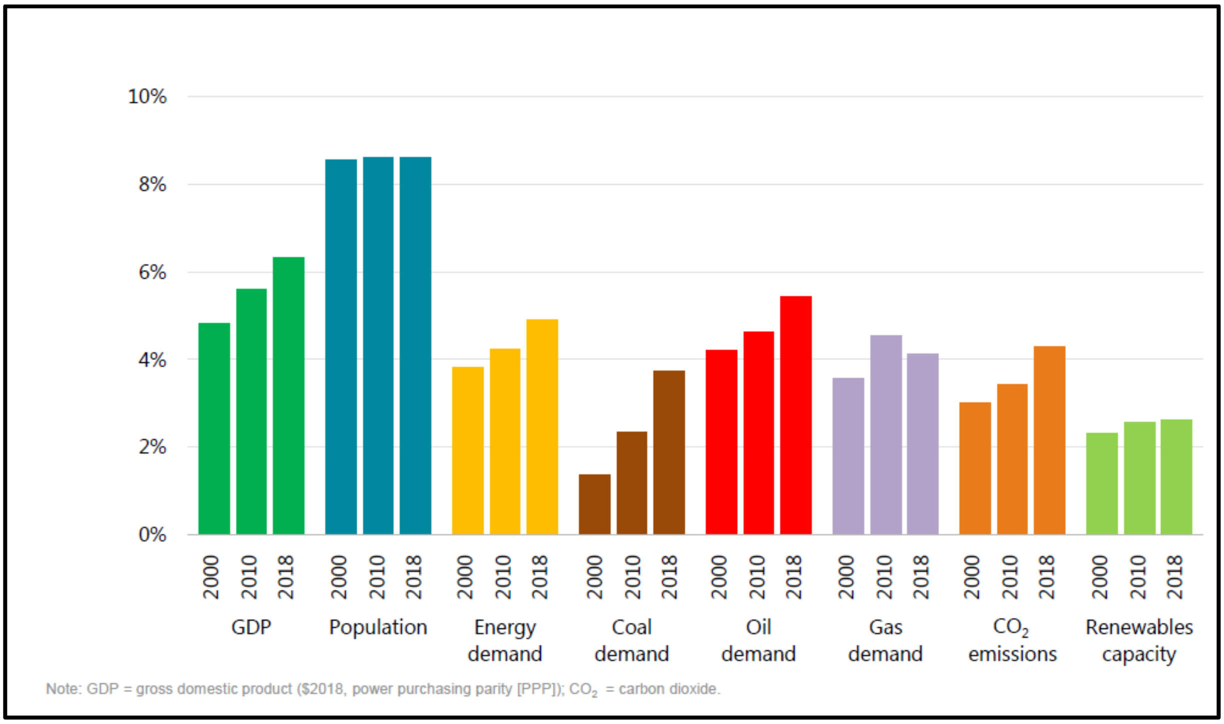
Most of the regional renewable generation, is still concentrated in just three countries (92 per cent in 2016): China (71 per cent), India (12 per cent) and Japan (9 per cent). But despite being the leader of expanding renewables domestically and abroad, even China's share of Total Final Energy Consumption (TEFC) was below 20 per cent (India: 40 per cent) in 2016 (Figure 28).[143] Furthermore, the region's overall renewable energy share is still based heavily on hydropower and bioenergy. Most of the planned, constructed, and operated coal power plants are in the Asia-Pacific region. The share of solar PV and wind power was still marginal (with exception of China) with huge potential to grow. But it depends on political decisions, support and to adopt more ambitious national as well as targets, energy efficient practices and new financing options.

142 ESCAP/REN21, 'Renewable Energy. Status Report Asia and the Pacific 2019', Paris: REN21, 2019.

143 Ibid.

Figure 28

Share of selected global economic and energy indicators in South-East Asia 2000-2018



Source: IEA, 2019.

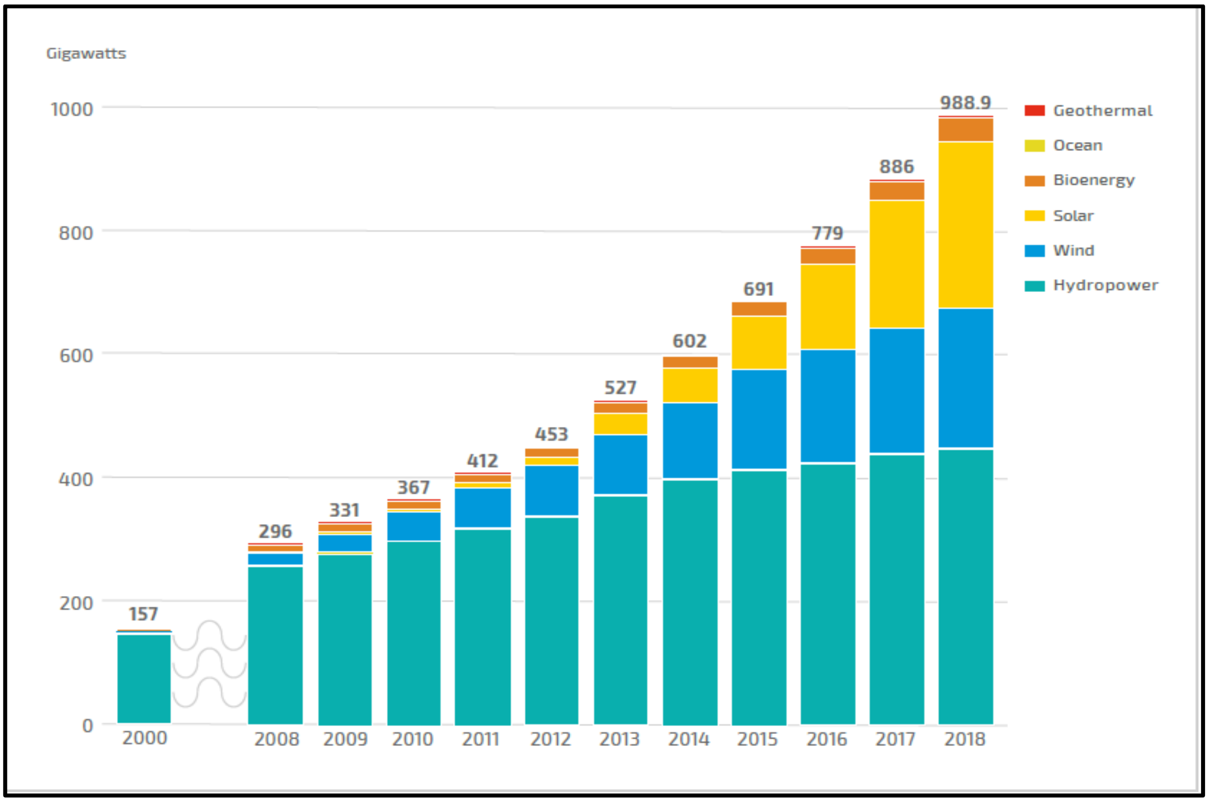
ASEAN has aims to achieve an ambitious share of renewables in the energy mix of its member states and reducing energy intensity 30 per cent by 2025.[144] Hydropower is still the most important renewables and its capacities have quadrupled since 2000. Even with hydropower, renewables met presently only 15 per cent of the regional energy demand. Electricity consumption may even double due to the rising air-conditioning. The per-capita basis of the energy demand is still relatively low in several ASEAN countries compared with the world average. With an increasing population of 120 million (concentrated in urban areas) in addition to the present 650 million people, a projected energy demand growth of 60 per cent to 2040, ASEAN is on the verge of becoming a net-importer of fossil fuels for the first time. It may result in a net-deficit in payments for energy trade of over US$300 billion annually by 2040.[145]

144 Ibid., and ASEAN Centre for Energy, 'The ASEAN Energy Outlook 2017-2040'.

145 IEA, 'Southeast Asia Energy Outlook 2019', Paris: OECD/IEA; and ASEAN Centre for Energy, 'ASEAN Energy Outlook 2017-2040'.

Figure 29

Renewable power generation capacity in selected Asia-Pacific countries by technology, 2000 and 2008-2018



Source: ESCAP/REN21, 2019.

Even during the last months of the global pandemic, the investors' interest for funding renewables projects have remained strong (in contrast to many fossil fuel projects) thanks to their declining costs, which allows renewables to compete increasingly at fossil fuels (including coal), though with lower returns and rising market risks due to manifold economic and political uncertainties. The IEA expects a growth of renewables for electricity generation by almost 7 per cent in a striking contrast to all other fuels. The net installed capacity will increase 4 per cent and reach almost 200 GW. For 2021, the added renewables capacity has been projected by another 10 per cent and described as "resilient to the COVID-19 crisis". Globally, renewables may overtake coal to become the largest source of electricity generation in 2025 supplying one-third of the worldwide one.[146]

[146] IEA, 'Renewables 2020. Analysis and forecast to 2025' (Paris: OECD/IEA, 2020).

Newly developed technologies might prove to be disruptive such as the next battery generation for both EVs and becoming an integral component of future solar PV and wind power projects. The present expansion of renewables has already transformed energy markets and broken traditional business models and strategies with great damages to European and particularly German utilities. A faster transition will also increase uncertainties for investment decisions, political governance, and geopolitics. The worldwide revolution of EVs, for instance, depends on the future capacity of battery production, more powerful batteries overcoming its present constraints of the driving range and time-consuming reloading but as well as on a sustainable and timely supply of many CRMs, concentrated in few (and often politically unstable) producer countries and mining companies.

In 2019, the global fleet of EVs amounted to over 5 million. In the STEP-scenario of 2019, the global EV fleet will increase annually from 2 million up to 20 million by 2025 and more than 30 million in 2040. In the SDS, the global fleet will grow more rapidly up to 900 million by 2040. But the positive forecast had been counterbalanced by the consumer's preference for sport utility vehicles (SUVs) in global car sales in the United States, China, Europe, and many other countries. They are heavier and more difficult to electrify due to their higher weight and about a 25 per cent higher fuel demand for a given distance than a medium-size car.[147]

These unprecedented and mostly non-anticipated changes of technological innovations may fasten in the forthcoming years with the digitalization, automatization, electric mobility, robotics, and artificial intelligence entering and changing the entire energy sector.[148] But it may also result in an even higher global and regional electricity demand though the IEA projected already a 60 per cent growth by 2040.

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147 IEA, 'WEO 2019'.

148 To the digitalisation technologies and their impacts on the energy sector see also DNV-GL, 'Sustainable Energy and Digitalisation: Practices and Perspectives in Asia-Pacific'. Study on behalf of the Regional Project Energy Security and Climate Change Asia-Pacific (RECAP) of the Konrad Adenauer-Foundation (KAS), Hongkong, February 2020.

3.3 The Impacts of COVID-19 on the global energy sector

The pandemic is causing huge short-term uncertainties about the future of global energy for both governments as well as energy investors. The IEA already warned in May 2020 that the "energy sector will never be the same" when the global pandemic will end and the world returning to normal times.[149] It may translate into the weakest decade of energy demand growth at least since the 1930s or even in the history of the last 100 years. At the end of this year, the global energy consumption has been projected by the IEA to decrease by 5 per cent and the GHG-emissions by 7 per cent in 2020. But it might only be a temporary development due to the worldwide economic recession and the direct impact of the pandemic. A peak of global emissions has not been achieved and might not be realized prior to 2030. According to its new 'World Energy Outlook 2020 (WEO 2020)' report, however, the worldwide emissions need to fall by 40 per cent on the path to 2050 and need to start now to decline every year for realising the long-term 2°/1.5°C target of the Paris Agreement.[150]

According to the IEA's forecasts for 2020 (made in the summer of 2020), the worldwide oil and gas consumptions might decline by 8 and 4 per cent and coal by 7 per cent. Energy investments could even decrease by 18 per cent.[151] Therewith, the economic impact of COVID-19 is threatening the massive investments needed for achieving the goal of global carbon neutrality by 2050. Without radical changes in the energy consumption and production as well as in the worldwide consumer behaviour, the global temperature will further increase by another 1.65°C as the IEA has warned. Around 40 per cent of cumulative emissions reductions needed for the net-zero goal in 2050 rely on commercially non-existent technology for large-industrial scale (including hydrogen, batteries, and Carbon Capture, Use and Storage (CCUS)).

The EU seeks to use the COVID-19 pandemic as an opportunity for a global green recovery and has materialized its 'European Green Deal (EGD)' by detailing concrete pathways for achieving its new

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149 Mammoser, A., 'IEA: The energy sector will never be the same', Oilprice.com, 15 June 2020. To the COVID-19 impacts until April see IEA, 'Global energy review 2020. The Impacts of the Covid-19 crisis on global energy demand and CO2 emissions' (Paris: OECD/IEA, April 2020).

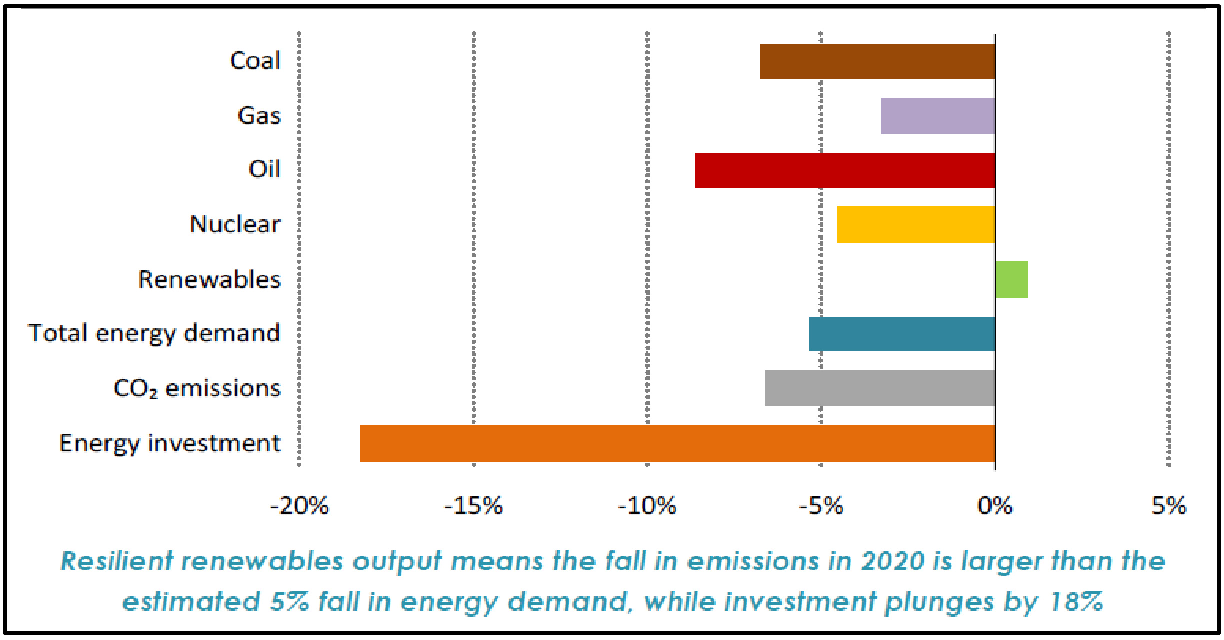
150 IEA, 'Energy Technology Perspectives 2020' (Paris: OECD/IEA, September 2020).

151 IEA 'WEO 2020' pp. 59 ff.

emissions mid-term target for 2030 by reducing them by 55 per cent (previously 40 per cent) and by devoting 30 per cent (some €225 billion) of its €750 billion 'Next Generation Recovery Fund' to green objectives and programmes, only few other countries have followed Europe's example.[152]

Figure 30

Key estimated energy Demand, CO_2-emissions, and investment indicators, 2020 compared with 2019



Source: IEA, 'WEO 2020'.

Most other countries, including China, India, and the United States, have poured more than 50 per cent new investments as part of their pandemic rescue packages in their fossil fuel economies in 2020, according to a new analysis. Neither environmental considerations nor climate change have been a core part and major factors for defining their economic recovery plans of the pandemic. The IEA has calculated that the countries' planned emission cuts still amount to just 15 per cent of the reductions needed to implement the Paris Agreement. Many

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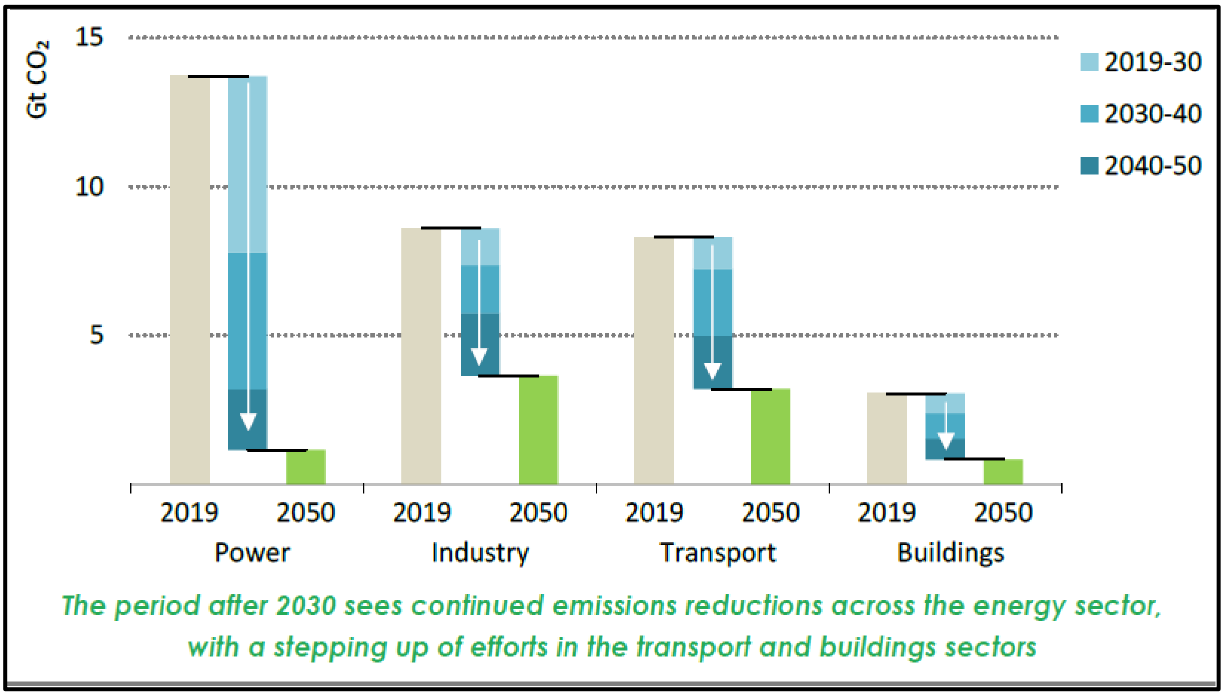
[152] Umbach, F., "The European Green Deal Faces Huge Challenges', and idem, 'Europas Plan für Klima und Umwelt" ('Europe's Plan for Climate and Environment').

governments have also used the pandemic to roll back environmental and climate regulations as well as to bail out their fossil fuel industries.[153] In other words: the gap between ambitious green energy policies for achieving the Paris Agreement and its 1.5°C target and the worldwide energy policy realities has been widening and not shrinking as the result of the global pandemic.

Figure 31

Direct CO_2-emissions reductions in selected sectors in the Sustainable Development Scenario (SDS)



Source: IEA, 'WEO 2020'.

If the COVID-19 pandemic will last longer and hit the world economic development beyond 2023, then the overall impact on the global energy demand and megatrends could be even much severe and at the same time even more challenging for a sustainable development of developing countries in Asia and beyond. Thus, the hopes are more than ever directed towards China and its newly declared goal for a zero-carbon economy by 2060 and whether it will implement more ambitious green energy policies as well as green targets. But despite efforts to accelerate a green energy transformation, China added

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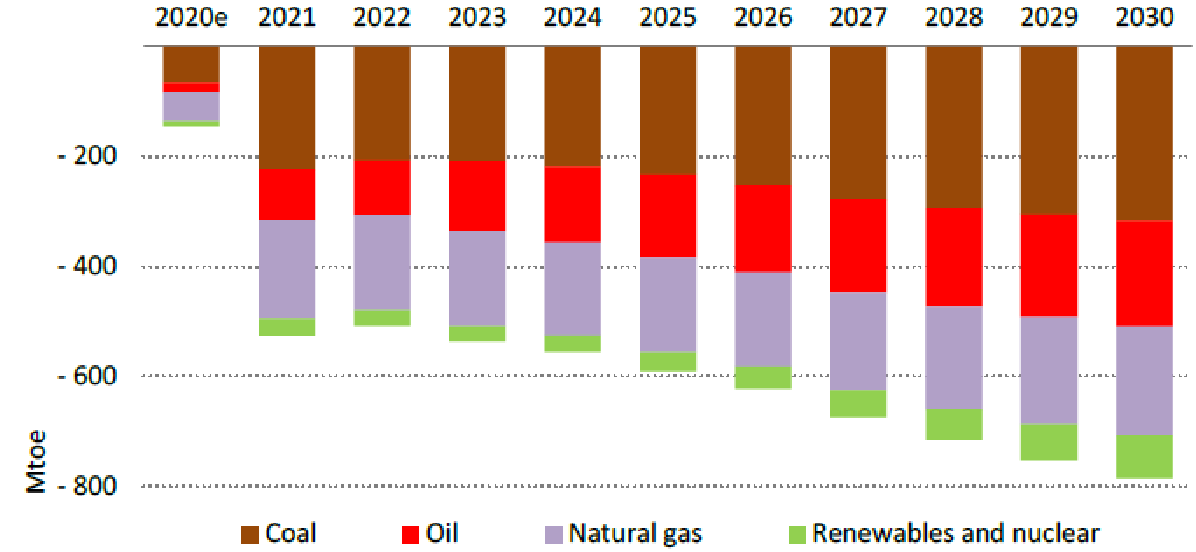
153 Harvey F., 'Revealed: COVID recovery plans threaten global climate hopes', The Guardian, 9 November 2020, and 'Foreign Coal Producers Get Boost from Coronavirus', Oilprice.com, 23 March 2020.

38.4GW capacity of coal-fired capacity - three times than the rest of the world according to new international research. It approved the construction of another 36.9GW of coal-fired capacity last year, with the total now under construction of 88.1GW – equivalent the whole energy supply of Germany.[154]

At the same time, the pandemic is threatening the progress the developing countries in Asia and Africa have made during the last decade in improving access to electricity and modern energy sources.

Figure 32

Change in energy demand in the IEA's 'Delayed Recovery-Scenario (DRS)' relative to the 'Stated Policies-Scenario (STEPS)'



The prolonged battle with the pandemic and slower economic growth pull energy demand in the DRS below the level in the STEPS, and all fossil fuels suffer large declines

Note: 2020e = estimated values for 2020.

Source: IEA,'WEO 2020'.

[154] Stanway, D., ‚China's New Coal Power Plant Capacity in 2020 more than Three Times Rest of the World. Study', Reuters, 3 February 2021.

Chapter 4

Challenges in Perspective: Moving Towards Electrification of Transport and other Industry Sectors

4.1 Rising electricity demand

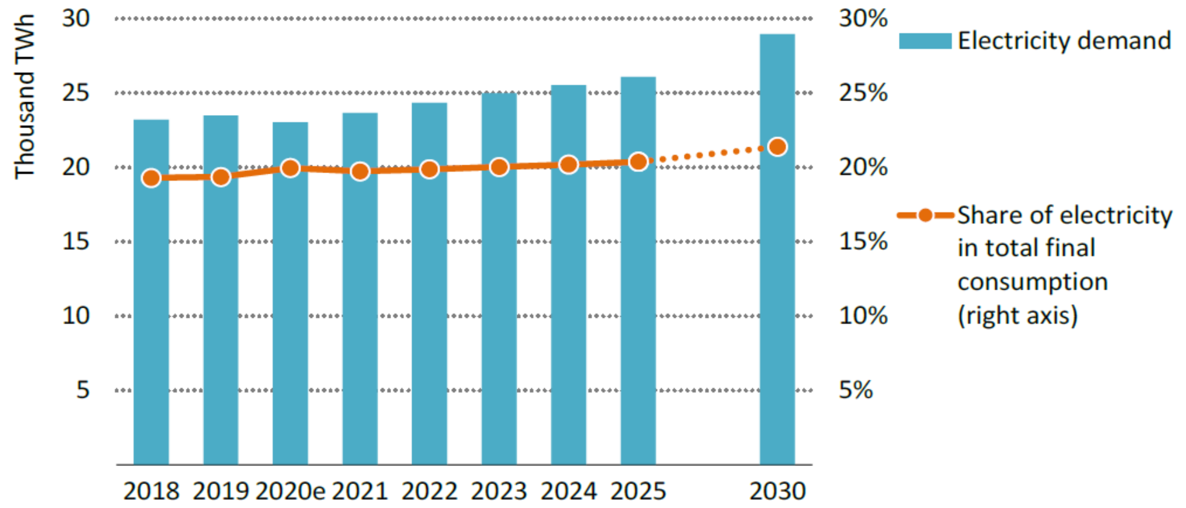
Electrification and digitalization of the transport and heating sectors as well as the 'industry 4.0'-revolution, based on automation, robotics, and artificial intelligence systems, will significantly increase the role and demand of electricity in final energy consumption.[155] The IEA has forecasted since a rise of 60 per cent in the global electricity demand in its major policy scenarios twice the estimated total demand growth.[156] 85 per cent of it will come from developing countries. The dramatic growth of electricity demand can be explained by the growing world population from 7 to 9 billion to 2040, rising living standards and ownership of household appliances, air conditioners, as well as increasing consumption of goods and services.

155 DNV-GL, 'Sustainable Energy and Digitalisation: Practices and Perspectives in Asia-Pacific'.

156 IEA, 'WEO 2017' and idem, 'WEO 2020'.

Figure 33

Global electricity demand and share of electricity in total final consumption in STEPS



Electricity has proven to be more indispensable than ever during the Covid-19 pandemic, and meets an increasing share of energy demand growth as economies recover

Note: 2020e = estimated values for 2020.

Source: IEA, 'WEO 2020'.

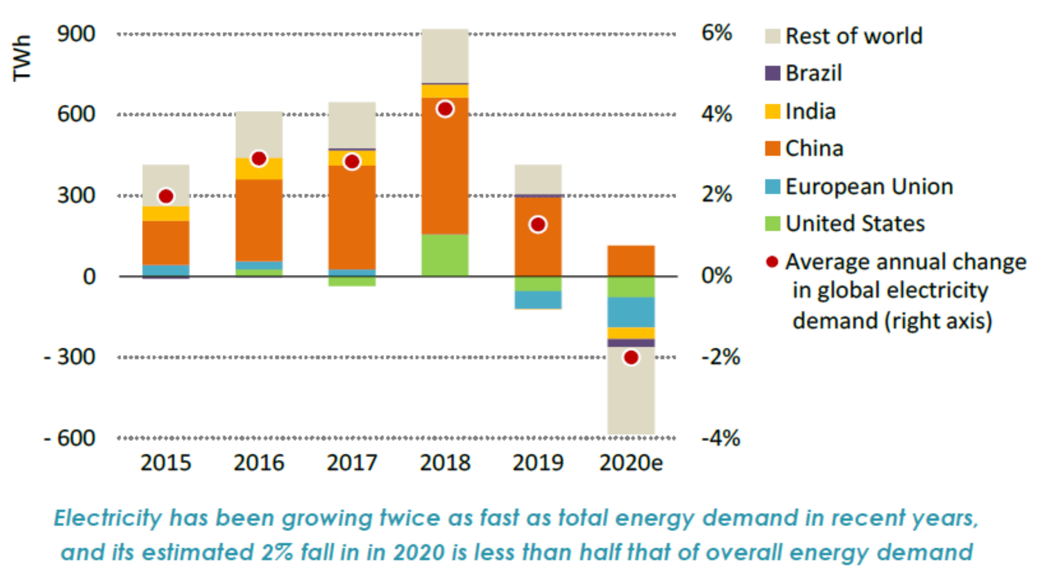
The COVID-19 crisis has highlighted the strategic importance of a reliable, affordable, and secure as well as resilient electricity supply for all Critical Infrastructures (CIs). The resilience of electricity supply needs to be able to cope with sudden changes in energy and economic activity while continuing its supply for CIs, including hospitals and government institutions. In 2020, global electricity demand is anticipated to fall by around 2 per cent.

The fall of the worldwide electricity demand has varied by country and region, depending on the economic impact of COVID-19 and the experienced length of the lockdown.

The electricity sector will also have to play a key role in supporting economic recovery of the countries, and an increasingly important long-term role in providing the energy that the world needs for a sustainable development. But if the power and electricity sector is to evolve into an energy system with lower CO_2 emissions, a more resilient infrastructural ecosystem and enhanced 24 hours' flexibility are needed.

Figure 34

Short-term COVID-19 impact on the global electricity demand by region



Note: TWh = terawatt-hours; 2020e = estimated values for 2020.

Source: IEA, 'WEO 2020'.

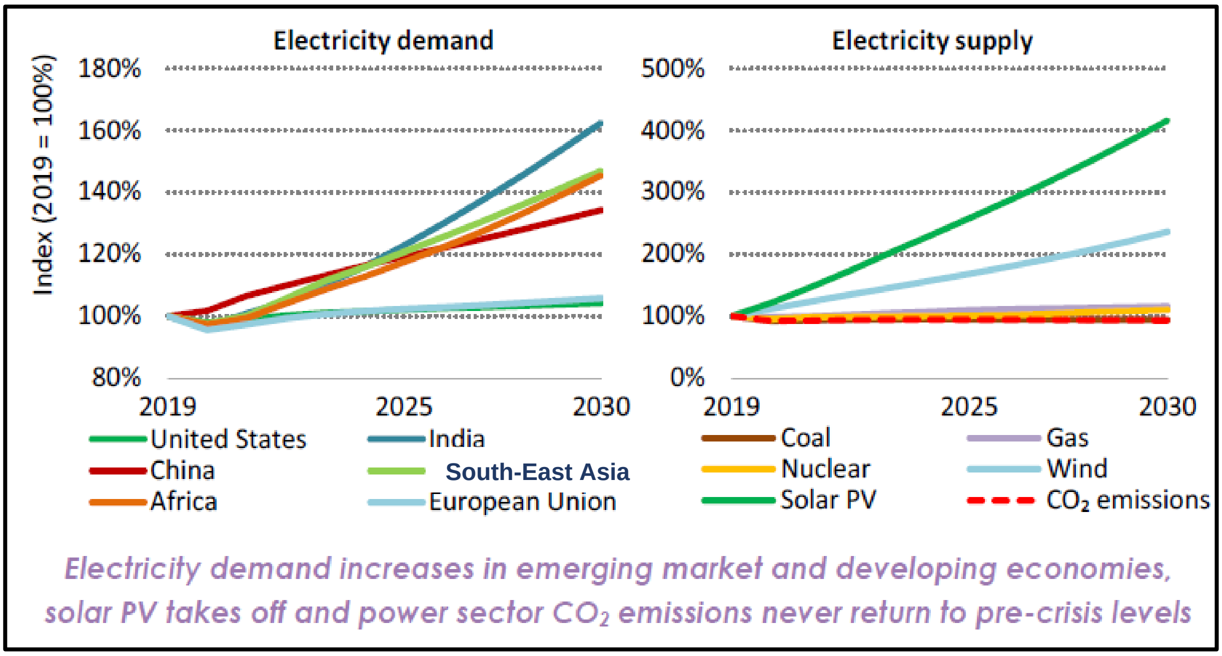
The IEA's newest major STEP-scenario has projected a global electricity demand that recovers and surpasses pre-COVID-19 levels already in 2021. As in the past years, electricity demand growth will globally outpace all other fuels. Electricity demand growth is expected to be fastest in India to 2030, followed by South-East Asia and Africa. The share of electricity will rise from just under 20 per cent today to 24 per cent in final consumption by 2040 in STEPS, 23 per cent in the Delayed Recovery Scenario (DRS), but reached even 31 per cent in Sustainable Development Scenario (SDS). The latter reflects a much wider electrification of various industry sectors and the overall importance of electrification with lower emissions in the energy transition.

Renewables will meet 80 per cent of the worldwide electricity demand growth during the next decade. They might overtake coal by 2025 as the primary energy source of producing electricity ahead of fossil fuels. By 2030, renewables will provide nearly 40 per cent of electricity supply. China will expand electricity generation from renewables by almost 1,500 TWh to 2030 – equivalent to the electricity generated in France, Germany, and Italy combined in 2019.[157]

[157] Ibid., pp. 213 ff.

Figure 35

Electricity outlook in the Stated Policies-Scenario (STEPS), 2019-2030



Source: IEA, 'WEO 2020'.

In STEPS, the share of coal for global electricity generation has been projected to fall from 37 per cent in 2019 to 35 per cent in 2020 and to 28 per cent in 2030. Due to changing market conditions and climate change mitigation policies, 275 GW of coal-fired capacity will retire by 2025 (13 per cent of the 2019 total) – with 100 GW in the United States and 75 GW in the EU. 16 out of 27 EU member states, for instance, are currently aiming to phase out all unabated coal. Those global coal retirements are nearly offset by new additions through to 2025. In China, India, and South-East Asia alone, 130 GW of capacity is under construction.[158]

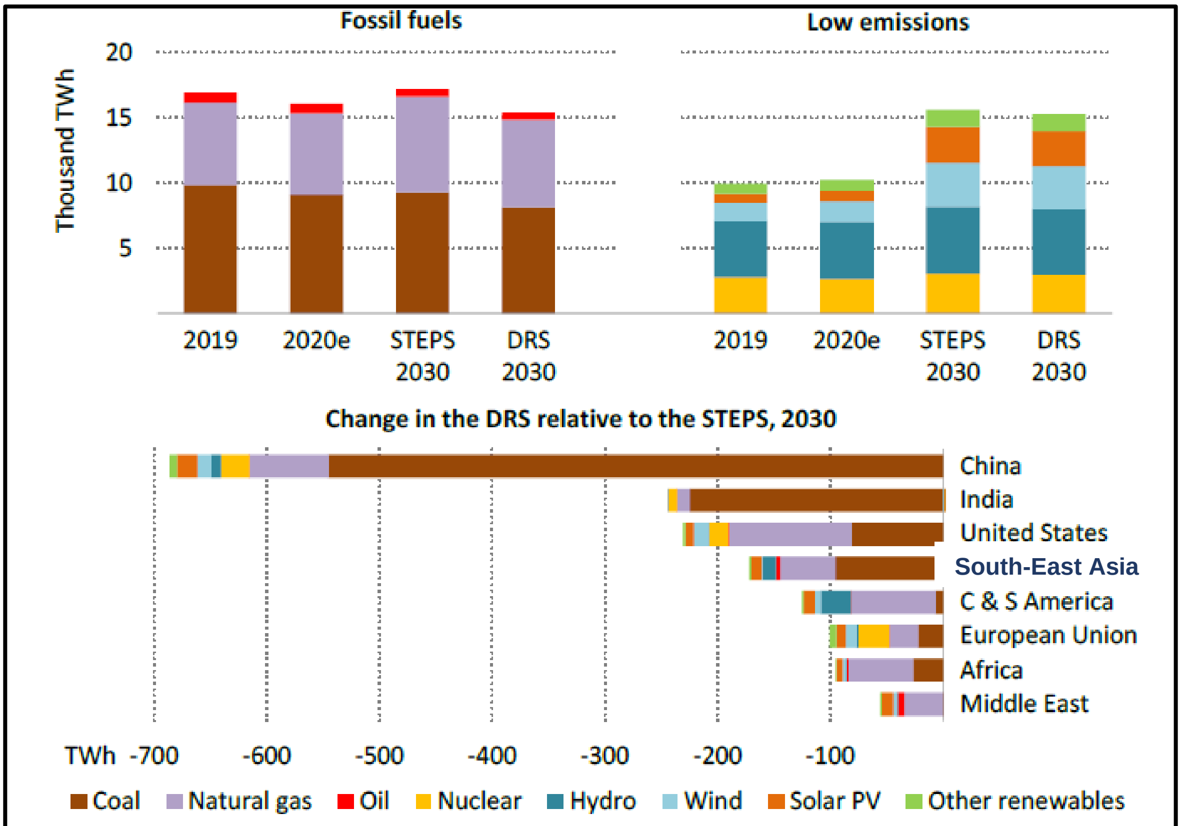
In SDS, the worldwide electricity demand grows 1.6 per cent annually or around 400 TWh per year on average to 2030. This is equivalent to the current electricity demand of India (the fourth-largest global electricity market) to the worldwide power mix every three years.

[158] Ibid.

In the Net-Zero Emissions by 2050 (NZE2050), generation from low emission technologies is even higher than in the SDS. In a more rapid expansion, renewables will have to shoulder much of the growth in the global electricity demand and a rapid worldwide phase-out of coal. The largest ever single-year increase so far in global renewables electricity generation was about 440 TWh in 2018 – in the NZE2050, the average annual increase is around 1,100 TWh from 2019 through to 2030.[159] In the longer-term, electricity could represent up to 70 per cent (today 20 per cent) of final energy demand by 2050.[160]

Figure 36

Electricity generation mix in the 'Delayed Recovery-Scenario' relative to the 'Stated Policies-Scenario (STEPS)'



A delayed recovery hits coal-fired power hardest; renewables see robust growth, and low gas prices provide some support for gas-fired power

Notes: 2020e = estimates values for 2020; C & S America = Central and South America. Other renewables includes geothermal, concentrating solar power, bioenergy and marine.

Source: IEA, 'WEO 2020'.

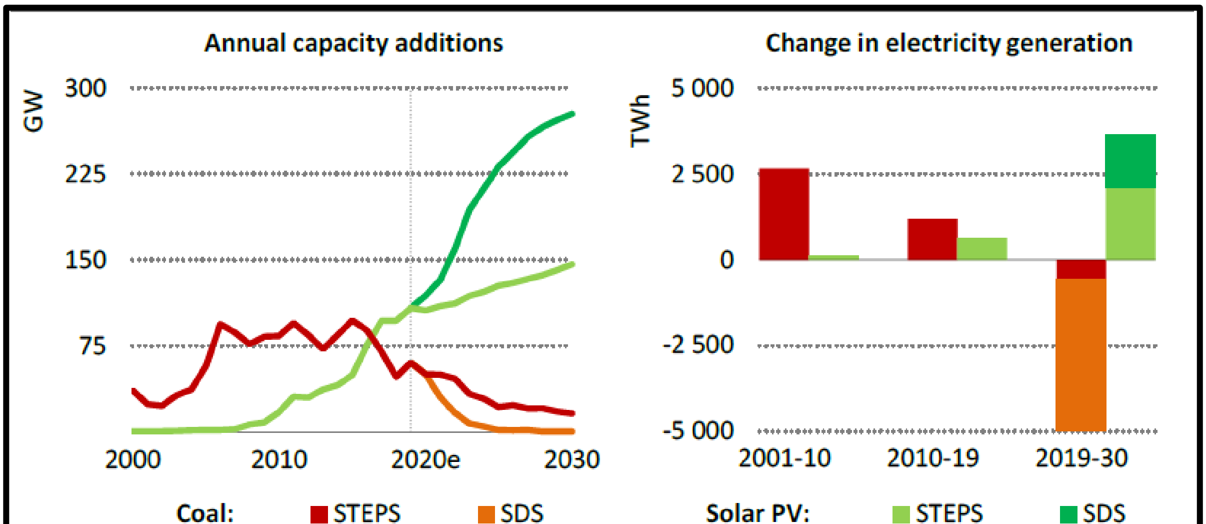
159 IEA, 'WEO 2020', p. 132 f.

160 Energy Transitions Commission, 'Making mission possible. Delivering a net-zero economy', September 2020

But a stable supply of electricity on a rising growth level is dependent on the modernization and expansion of smart long-distance and distribution grids. Those networks need massive and often underestimated investments in time, which need to be modernized and expanded. In 2030, projected investments may reach up to US$460 billion – up to two-thirds from the 2019 level. But the risks of insufficient timely investments in electricity grids to ensure the future reliability and security of electricity systems might also increase to the manifold uncertainties of the regulatory systems, underestimated demand developments and deteriorating financial conditions of energy utilities, particularly in many developing countries. Those risks are particularly high in SDS and the NZE2050-scenario. In the latter, investment in the power sector would nearly triple from $760 billion in 2019 to $2.2 trillion in 2030. The level of investment in renewables, rising up to US$1.1 trillion in 2030, is three times the largest level of investment in renewables historically.[161]

Figure 37

Average annual solar PV and coal annual Capacity additions worldwide and electricity generation by scenario, 2001-2030



Solar PV becomes a preeminent force in electricity supply in the STEPS due to falling costs and policy support, but the potential is there for much more rapid growth

Note: 2020e = estimated values for 2020.

Source: IEA, 'WEO 2020'.

[161] ibid., p. 136.

In addition, flexibility from power plants, energy storage and demand-side resources are becoming the cornerstone of electricity security and resilience in modern power and electricity ecosystems. Technology innovations and their implementation in other sectors might be fueled by the accelerating digitalization. The worldwide spread of cryptocurrencies, blockchain, cloud systems and other disruptive technologies, for instance, has proved to be very energy intensive and threatened many energy forecasts. EU's and IEA's projected electricity demand growth appears to overlook or at least marginalise those combined impacts of various technological developments. Thus, the EU's targets of its integrated energy and climate policies for 2030/2040 might be too optimistic if not unrealistic. While electrification and digitalization also promise substantial prospects for energy conservation and enhancing energy efficiency, many new technology developments and the electrification do not take energy efficiency sufficiently into account. As a result, underestimating the increase of electricity demand could have wide-ranging implications for the future energy mix, climate targets and the agreed and defined energy conservation as well as efficiency targets on the national, regional and global levels.

The international discussions of the energy transition and a 'global Energiewende' have focused on the expansion of renewables and decarbonization of the worldwide energy system as well as new prospects for enhancing energy efficiency and conservation. The increasing electrification and fastened digitalization of the entire energy systems, including transport and heating sectors, alongside the expanded introduction of robotics and AI systems as well as billions of IoT-devices in smart homes have raised the question, whether the forecasted worldwide electricity demand might not be underestimated despite the fact that the introduction of various new technologies will also increase energy efficiency and conservation. Those technologies include smart metering and smart grids, blockchain, smart home and Internet of Things (IoTs), battery storage for EVs and renewables, self-driving cars, Bitcoin and other cryptocurrencies, digitalization of the Industry ('Industry 4.0').[162] One of the latest examples is the worldwide

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[162] Umbach, F., 'Energy Security and its Geostrategic Implications' pp. 92 ff.

introduction of 5G, which could dramatically increase network electricity consumption as it was already the experience with the deployment of 3G and 4G. Some experts have estimated a doubling of the energy consumption of communication service providers.[163]

All these new technologies have been and are designed with almost no attention to energy efficiency and cyber security requirements. Only the EU has adopted a regulation 'security of design', which demands from the industry designers of new technologies to build in a defined minimum level of cyber security requirements instead of addressing cyber security risks of new technologies after they have already been introduced into the markets. But addressing energy efficiency as part of a regulation for newly designed and developed technologies are even not existing in the EU up to now as technologies might become more costly, which could undermine the global competitiveness of the European industry.

4.2 Electrification of the transport sector

The electrification of the transport sector and replacing internal combustion engines (ICEs) with EVs and batteries have become a key instrument for the worldwide decarbonization efforts and achieving the climate change long-term goal of at least 85 per cent emission reductions by 2050. While the overall direction of the electrification of the global transport sector is no longer be disputed as such, the pace of the electricity transition and what can realistically be implemented and how much oil consumption can be decreased have remained a matter of international controversy. The unfolding electricity revolution in the worldwide transport sector highlights another major energy shift and game changer together with the digitalization and autonomous car driving. They can displace the oil's major role especially in motor vehicles. More than 50 per cent of the global oil market is based on road transportation. But neither the European car industries nor the governments or existing infrastructure for EVs (i.e. universal supercharging points, upgraded power grids at national and local

[163] Janssen, D., 'Ericsson: 5G could 'dramatically increase' network energy consumption', Euractiv, 24 July 2020. To perspectives to reduce this energy demand see Pal Frenger and Richard Tano, 'More Capacity and Less Power: How 5G NR can reduce network energy consumption', IEEE Xplore 2019,

levels) had been really prepared for a rapid transition until few years ago.[164] Up to now, EVs have been more expensive, and have still to cope with a shorter driving distance and in insufficient infrastructure in place for recharging the batteries – particularly in the countryside and on highways. A new generation of batteries with a much longer range and shorter charging times are expected to become commercialised in the early or mid-2020s. Even with 'smart charging' opportunities in place, the additional investment costs of the peak of worldwide electricity demand for EVs have been calculated at US$100-280 billion in electricity infrastructure.[165]

In 2019, more than 1.1 billion passenger cars had been on the road today, which had been increased by nearly 50 per cent towards just a decade ago. Cars are currently accounting for just under one-quarter of global oil demand. The level of private car ownership in developing economies is still far below that of most advanced economies. But it also indicates that a continued growth in the global car fleet can be expected. In 2018, by contrast, just over 5 million electric cars were on the road, though the number had increased nearly 65 per cent from 2017.[166]

Today, the battery in electric cars costs less than $180 per kilowatt-hour (kWh), down from around $650/kWh five years ago. In STEPS, this falls to less than $100/kWh in the mid-2020s. Between 2025 and 2030, electric cars in several key markets could be cost competitive with conventional cars on a total cost of ownership basis. However, consumer preferences for SUVs could offset the benefits from electric cars. The growing consumer appetite for bigger and heavier cars (SUVs) have already added volumes of barrels to global oil consumption. SUVs are more difficult to electrify fully, and conventional SUVs consume 25 per cent more fuel per kilometre than medium-sized cars. If the popularity of SUVs continues to rise in line

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164 Finance ministries, for instance, need to replace the lost revenue from fuel tax for petrol and diesel cars and to adopt new incentives as well as regulations for investors of the power infrastructure for EVs. Supercharging points, for instance, are relatively expensive. They are also implying peak-time charging with higher electricity prices. They may require expensive electricity transmission to remote locations - at least in countries with large territories and a lower population density. In UK, EVs might create an additional electricity demand as much as 18 GW (the equivalent of almost six Hinkley Point nuclear power stations) at peak times by 2050 –Nathalie Thomas, 'Electric Cars Forecast to Create Extra 18GW Demand for Power in UK', Financial Times, 13 July 2017.

165 IEA, 2017, 'Digitalization & Energy', Paris: IEA/OECD, p. 95.

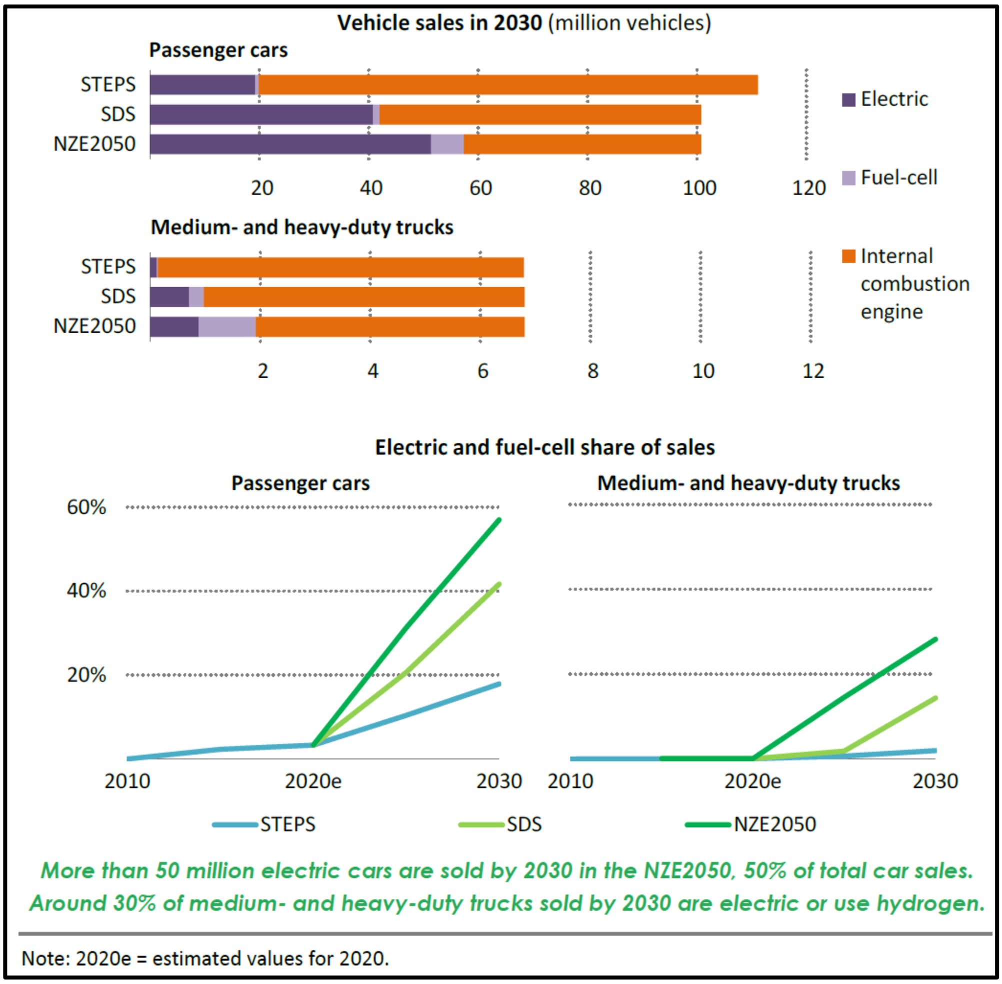
166 IEA, 'WEO 2019'.

with recent trends, this could add another 2 million barrels per day to the IEA's projection for 2040 oil demand.

In contrast to other countries, German EV sales have increased the first half of 2020 thanks to massive subsidies. However, 80 per cent of all sold cars in Germany during the first six months of this year have still a combustion engine due to the shortages of range and a lack of fast recharging stations across the country. But Volkswagen (VW) plans to introduce 70 new EV models over the next 10 years with an €33 billion investment offensive. By 2029, it hopes to produce 26 million EVs.[167]

Figure 38

Annual electric and fuel cell vehicle sales in the three IEA scenarios



Source: IEA, 'WEO 2020'.

[167] Umbach, F., 2020, 'Europe's Battery Strategy', GIS, 16 September 2020.

In the most optimistic NZE2050 for energy transition, over 50 per cent of passenger cars sold as EVs (compared with 40 per cent in the SDS) by 2030. In 2019 this figure was just around 2.5 per cent. In this scenario, the number of electric passenger cars sold rises from 2 million in 2019 to 25 million in 2025 and more than 50 million in 2030. At the same time, also a rapid growth in other zero emissions vehicles (such as fuel cell vehicles) would take place.[168]

A faster deployment EVs would certainly decrease the worldwide oil demand and could support the climate change mitigation efforts of the Paris accord. APEC, for instance, has projected a decline of net oil imports from 799 Mtoe in 2016 to 173 Mtoe in 2050 in its 2-Degree Celsius Target-Scenario (2DC).[169] But if lifecycle analyses are taken into account, emissions of the battery production for EVs based on a heavily based fossil fuel energy production, the overall climate balance is very questionable.[170] In this case, the total emissions of EVs depend very much on the electricity mix that fuels the EVs. The battery production itself creates significant CO_2 before the battery leaves the factory.[171] This is still a huge problem in countries (such as China and Germany), whose electricity generation is still largely based on coal-based power plants. In the mid-and longer-term future, the CO_2 balance of EVs will improve alongside a greener energy mix.[172]

168 IEA, 'WEO 2020', p. 138 f.

169 APEC, 'Energy Demand and Supply Outlook 7th Edition-Vol. I'.

170 Umbach, F., 'Energy Security and its Geostrategic Implications', pp. 81 ff.

171 Kristensson, J., 'New Study: Large CO_2 Emissions from Batteries of Electric Cars', The Global Warming Policy Forum, 12 June 2017; 'Umweltsau Tesla? 17 Tonnen CO2 bei der Produktion der Akkus? Es ist komlizierter', 4 August 2017. Available at https://www.mobilegeeks.de/artikel/umweltsau-elektromobilaet-akkus-co2/; (accessed on 31 August 2017); Vetter, P., 'Zweifel am sauberen E-Auto', Welt, D., 22 June 2017,p. 9; 'E-Auto-Batterie', Welt, D., 14.6.2017; McGee, P., 'Electric Cars' Green Image Blackens beneath the Bonnet', FT,8 November 2017, and Watts, A., 'Tesla Car Battery Production Releases as Much as CO2 as 8 Years of Gasoline Driving', 20 June 2017. Available at https://wattsupwiththat.com/2017/06/20/tesla-car-battery-production-releases-as-much-co2-as-8-years-of-gasoline-driving/; (accessed on 23 August 2017).

172 Bay, L., 'Die umstrittene Klimabilanz des Elekroautos', Handelsblatt, 6 July 2017; Glover, C., 'Pollution Studies Cast Doubt on China's Electric-Car Policies', Financial Times, 20 May 2018; Sanderson, H., 'Electric Car Growth Sparks Environmental Concerns, Financial Times, 7 July 2017; Winterhagen, J., 'Schützen Elektroautos das Klima?', Frankfurter Allgemeine Sonntagszeitung, 3 September 2017.

Technological improvements of battery chemistry, the reuse of batteries for stationary storage purposes[173], and the development of a recycling industry for EV batteries will improve the future sustainability and environmental performance of the battery production and the overall EV emissions towards ICEs.[174]

Supply chains from mining to end products are often not fully transparent despite many efforts to improve industry practice for responsible and ethical sourcing. In advanced economies, the environment might get cleaner with EVs and an expanded battery use for EVs and renewables. The opposite might be true in the developing countries producing the raw materials for the rich world as environmental and social costs are increasing with expanded mining of these CRMs. The Rise of batteries for EVs, the energy and other industrial sectors

Ensuring the rate of growth in EVs will require a massive expansion in battery manufacturing capacity and a major increase in the capacity of supply chains to provide CRMs such as lithium cobalt, rare earths, and others. The development of a new generation of batteries does not just matter for the electrification of the worldwide transport sector, but also offer new storage perspectives, including in other sectors (such as power plants/electricity sector and heating). Further improvements of lithium batteries will also allow to use them for trucks, busses, and increasingly also for air and sea transport.

[173] Nissan batteries, for instance, are already used for stationary storage options, which can extend the lifetime of batteries before they are being recycled. It will also reduce the emissions of the battery production as their amortisation over a longer period is higher and decreased the demand for critical metals.

[174] European Commission, 'Electric Vehicle Life Cycle Analysis and Raw Material Availability', Briefing, Transport & Environment, Brussels, October 2017 and Neslen, A., 'Electric Cars Emit 50% Less Greenhouse Gas than Diesel, Study Finds', The Guardian, 25 October 2017.

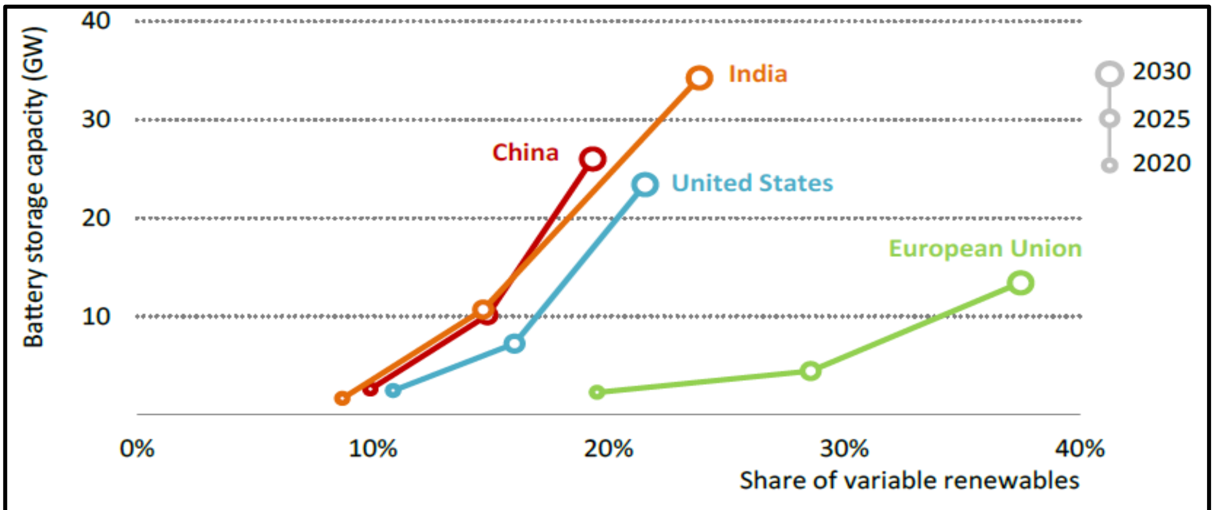
Energy utilities have already begun to use utility grade lithium-ion batteries for large industry storage systems and grid-scale energy storage applications. Battery storage systems are well suited to short-duration storage that involves charging and discharging over a span of hours or days. This makes them a good partner for variable renewables. Battery storage is increasingly paired with solar PV and wind. In addition, battery storage is also the fastest growing source of power flexibility costs. It can also reduce the need for coal and gas-fired peaking plants. Declining battery costs are both a challenge as well as an opportunity for energy utilities. If batteries are becoming a cheap storage option for private and industrial consumers and build into intermittent solar and wind power stations of the electricity system - as an integrated part build-in retrofitted storage option - countries and utilities do no longer need conventional backup capacity by traditional coal and gas power plants.[175]

Modular battery storage systems allow a wide range of industry applications beyond the transport sector. They also offer a storage technology for power generators as it enhances overall utilisation of power system assets based on intermittent renewable energy sources. The future electricity supply will need more flexibility than ever to adopt to rapid changes in the power supply and demand. Batteries decrease the risks of overcapacities and offer higher average revenues. The availability of second-use batteries (such as from EVs after the end of their regular lifecycle) are widespread. They have increased three times during the last three years, largely been driven by lithium-ion batteries for providing short-term storage, which account for just over 80 per cent of all battery capacity. But for longer-term storage, different batteries are needed. It suggests various battery developments, including as build-in units for solar PV and wind power as they increase their dispatchability.

[175] IEA, 'WEO 2020', p. 246 f.

Figure 39

Battery storage capacity and share of variable renewables in selected regions in the 'Stated Policies Scenario (STEPS)'



As the share of variable renewables rises, more flexible resources will be needed; battery storage plays a crucial role in providing fast response and ensuring security of supply

Source: IEA, 'WEO 2020'.

The increasingly wide range of applications also enhance the overall industry competition and decrease the prices of batteries. Between 2010 and 2018, battery production costs have already decreased by 45 per cent. By 2040, cost reduction by large-scale production and intensive research could make batteries up to 70 per cent less expensive than today. As the world's top global battery producer, China had already a capacity of 230 GWh in 2019. With a global market share of 45 per cent, it is also the world's larger manufacturer of EVs. For the EU a strong EV market and industry is dependent on a complete European battery supply chain and to enable large-scale battery production. Hence the EU aims to build as many as 25 battery gigafactories across Europe with a capacity of some 400 GWh by 2025. Last year, around 260 industrial and technology innovation had already joined the 'European Battery Alliance' created in 2017. For realising Volkswagen's ambitious programme of introducing 70 different EV models by 2030, it needs more batteries than the total currently produced globally or building 40 gigafactories in size of the one Tesla and Panasonic have built in Nevada.[176]

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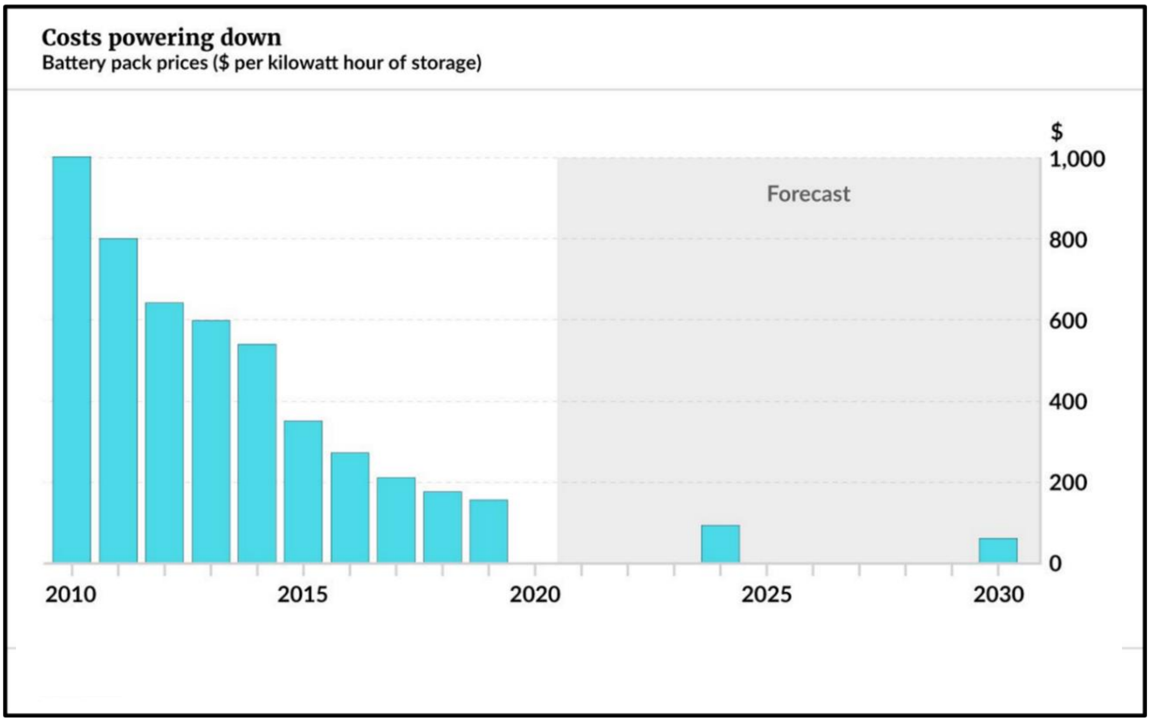
[176] Umbach, F., 'Europe's Battery Strategy'.

In recent years, global battery manufacturing capacity has doubled every three-to-four years. In the IEA's NZE2050-scenario, capacity would need to double every two years.[177] In 2019, over 10 GW of batteries had been are connected to electricity networks. But utility-scale storage installations dropped some 20 per cent in the same year. Although further market expansion was on track for 2020, the COVID-19 crisis could delay battery storage deployment over the next years due to given temporary factory shutdowns and supply chain disruptions. With technological innovation advances and a new battery generation, prospects for battery storage systems look set to improve. The IEA has projected a 20-fold increase of global utility-scale battery storage capacity between 2019 and 2030 - with 130 GW in STEPS. The growth largest market might be India, where batteries absorb peak output from solar PV during the day, store it for several hours, and then discharge to help meet electricity demand peaks in the evening.

Figure 40

Declining battery Costs in Perspective 2010-2030



Source: GIS, 2020, based on Energy Transitions Commissions, Bloomberg, Financial Times.

[177] IEA, 'WEO 2020', p. 139.

China and the United States are considered as the next largest markets for batteries, with 26 GW and 23 GW respectively. But the IEA and international experts have warned that it will be important to monitor the security of supply for various CRMs, which are needed for both battery storage systems and batteries in EVs.[178] The number of EVs could increase up to 200 million by 2028 and up to 900 million by 2040 (Figure 42). McKinsey has projected in 2019 that the battery demand in Europe from EVs will reach a total of 1,200 GWh per year, which is more than five times of the projects confirmed last year.[179]

Another problem is the lack of recycling capacities.[180] At present, about 90 per cent of lead-acid batteries used in conventional gasoline cars are recycled – compared with less than 5 per cent of lithium batteries. An estimated 11 metric tonnes (mt) of spent lithium-ion battery packs will be discarded till 2030. But recycling processes are technically challenging and expensive. For making battery recycling economically profitable, the utilization rates of recycling facilities must be sufficiently high. For the first generation of EV batteries to reach the end of life, present timely investments are insufficient to have the much-needed recycling infrastructure in place.[181]

China and the EU have already introduced rules that will hold carmakers responsible for recycling their batteries. But while the cost of fully recycling a battery is also falling, the value of the recycled raw materials is often still a third of that. A more attractive option is the reuse of car batteries for home and other energy storages rather than recycling. These batteries can still have up to 70 per cent of their capacity, when they end their usual lifetimes in electric cars.[182]

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178 ibid., 247 and F. Umbach, 'The New 'Rare Metal Age'. See again chapter 2 of this study.

179 Umbach, F., 'Europe's Battery Strategy'.

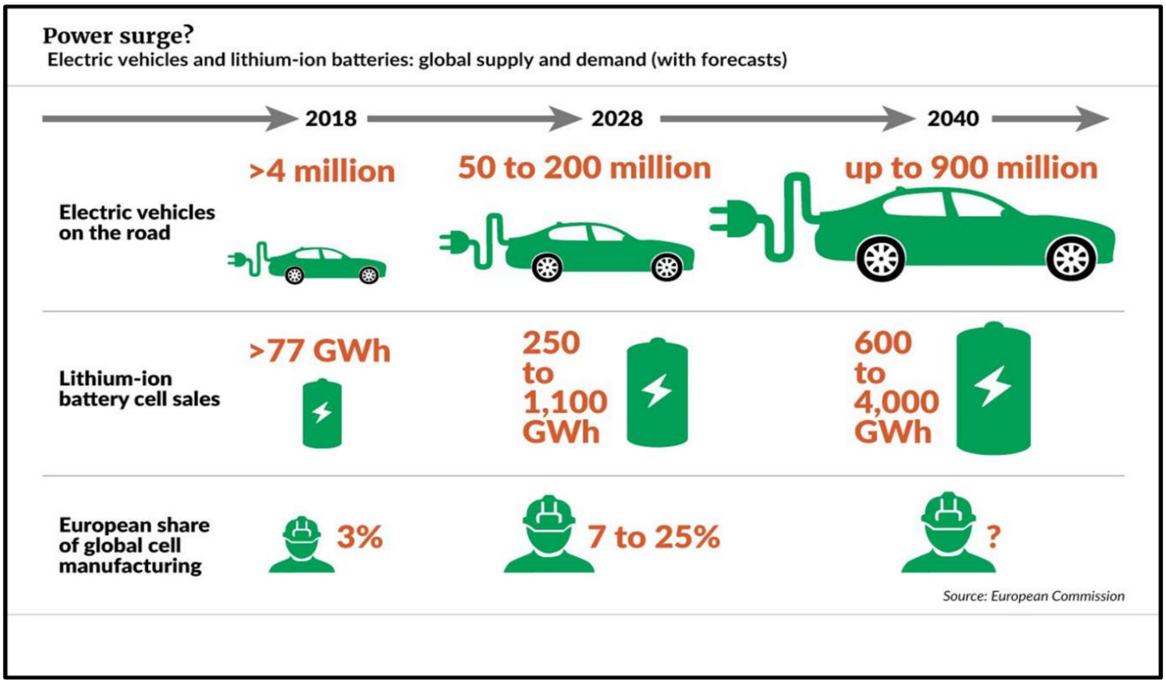
180 'Battery Recycling Technology Essential to the Electric Vehicle Revolution', Investing News, 1 November 2017; Sanderson, H., 'Rise of Electric Cars Poses Battery Recycling Challenge', Financial Times, 3 September 2017; Gardiner, J., 'The Rise of Electric Cars Could Leave Us with a Big Battery Waste Problem', The Guardian, 10 August 2017; Echo Huang, 'China's Booming Electric Vehicle Market Is About to Run into a Mountain of Battery Waste', 28 September 2017. Available at https://qz.com/1088195/chinas-booming-electric-vehicle-market-is-about-to-run-into-a-mountain-of-battery-waste/; (accessed on 29 September 2019).

181 Sanderson, H., 'Electric Car Growth Sparks Environment Concerns', Financial Times, 7 July 2017.

182 Umbach, F., 'Energy Security and its Geostrategic Implications', pp. 133 f.

Figure 41

Electric vehicles, lithium battery supply and European share of global cell manufacturing



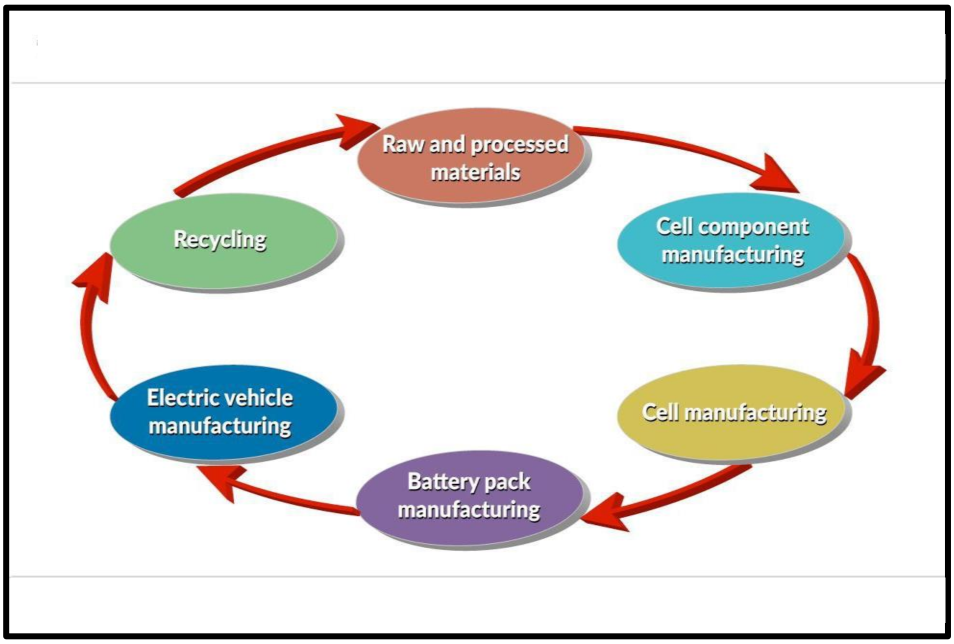
Source: GIS, 2020, based on the European Commission.

Forced by regulations, the older lead-and nickel-based batteries have a life-end-recycling rate of 99 per cent in Europe and North America. The high recycled content of lead batteries is more than 85 per cent. In the future, new EVs may only be sold in the EU if they may be reused, recovered, and recycled in line with its 'end-of-life vehicles (the 'ELV-Directive')'. Some companies have already begun investing of used EV batteries in Europe.

But many recycling options are often constrained due to poor data on both current and future recycling rates and insufficient profitability and commerciality for industry businesses. Nevertheless, the worldwide Research and Development (R&D) and new battery development has intensified during the last years. An important development towards fast charging for EV batteries is making EVs more attractive for customers. Improved longevity, including for second-life appliances, is also important for the future competitiveness of EVs and various battery appliances. Some progress has been made for the buildout of the Li-ion ecosystems that demands enhanced collection, testing, recycling, and processing of batteries, but needs further efforts and innovation.

Figure 42

Battery value chain



Source: GIS, 2020.

However, the future worldwide EV battery demand could also be influenced by the ambitious hydrogen plans, which also drive investments into green hydrogen projects as well as fuel cells developments particularly for tracks and buses. Other technology developments can also influence the future demand of batteries such as 'distancing charging', 'wireless power' and 'energy harvesting' by using the small amounts of local energy that would otherwise be lost. It will allow to reduce the costs and risks of an ever-increasing number of power-dependent remote assets (such as a health monitoring systems) and IoTs. But like other new emerging technologies, it still faces limitations that hamper a more widespread adoption up to now.

Nonetheless, together with the hydrogen development, batteries will also change geopolitical dynamics regionally and globally as they require new supply chains, trade routes and strategic partnerships, including for CRM supply security, and result in new geopolitical alliances as well as strategic rivalries which need to be anticipated in advance for the EU's common foreign and security policies.[183]

[183] Umbach, F., 'Europe's Battery Strategy'.

Chapter 5

Coping with New Challenges for the Sustainable Development Goals in a Post-pandemic World: Where Do We Go from here?

5.1 Introduction

While the short-term impacts can be analysed with some kind of certainty, the mid- and longer-term energy trends with all the already described technological and political uncertainties have become even more challenging to forecast – particularly when the worldwide pandemic may last longer and having even more economic fallout. Hence, the IEA's newest 'WEO 2020' of October is based for the first time on four scenarios, but does no longer contain a 'Current Policies'-scenario as the last years and instead a 'Delayed Recovery Scenario' of the worldwide pandemic:

A. the 'Stated Policies Scenario (STEPS)' is based on all policy declarations and targets announced to date. It assumes a control of the virus and a worldwide economic recovery already in 2021 to a pre-crisis level, though the GHG-emissions will continue to rise;

B. the 'Delayed Recovery Scenario (DRS)' is also based on the policy assumptions as in STEPS but suggests a prolonged pandemic and world economy only be back to pre-pandemic levels by 2023. It will slow the green energy transition with a systemic under-investment in new cleaner energy technologies. Positively, it will cause a fall in GHG-emissions due to the economic stagnation and may weaken the oil demand growth. But it also highlights a persistent natural gas supply surplus;

C. the 'Sustainable Development Scenario (SDS)' envisages a much faster expansion of green energy technologies, including Carbon Capture Use and Storage (CCUS) and closing coal power plants worldwide. Sufficient investments are providing a pathway for achieving sustainable energy objectives such as the Paris Agreement, anergy access and air quality goals. Simultaneously, the global oil demand growth would have to end within the next 10 years, though its use in the transport sector might still rise by 3-5 mb/d until 2030. But the net-zero emissions goal will only be achieved by 2070; and

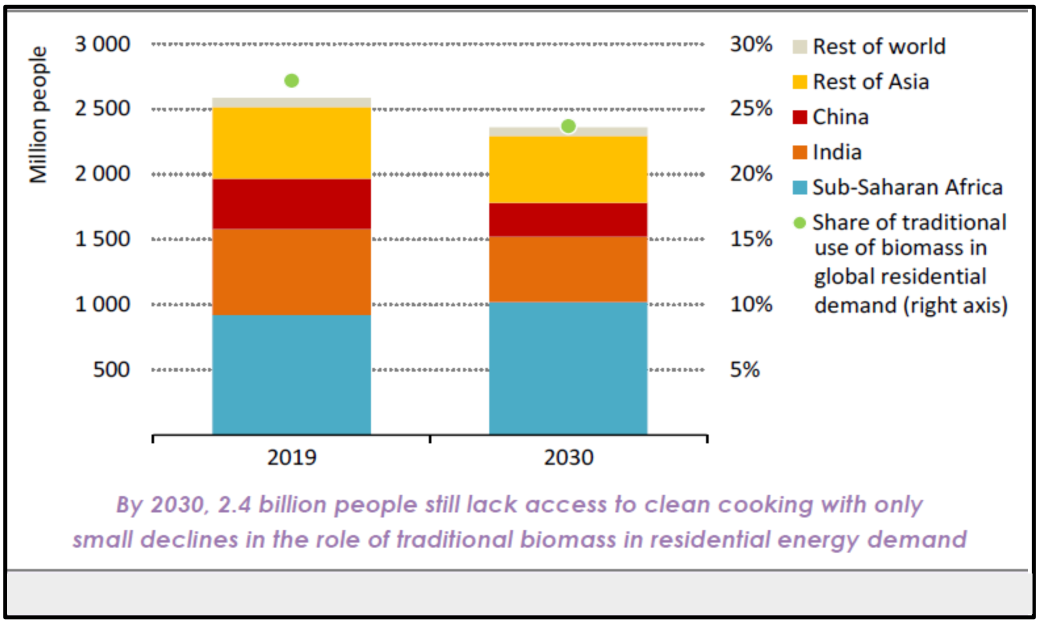
D. the 'Net-Zero Emissions by 2050-Scenario (NZE 2050)' extends the SDS and includes a detailed IEA analysis what would be needed in the next decade to put the worldwide carbon emissions on track for the net-zero goal by 2050. Like many international energy experts, the IEA is rather pessimistic about realising the pace and scale of the decarbonization efforts and the deployment of sufficient clean energy sources as well as the wide-ranging worldwide changes of consumer behaviour.

5.2 Perspectives by scenarios for SDG7

Developing Asia is home to 65 per cent of the global population that lacks access to clean cooking facilities. Recent progress of a sustainable development in Asia and the rest of the world has been mixed, and so are prospects for improvement given the presently existing and proposed policies as well as the manifold uncertainties of the future global economic and pandemic's development. The number of people without access to electricity fell from 980 million in 2017 to 860 million in 2018. But the lack of electricity access remains a major concern. Current and planned policies deliver universal electricity access in many parts of the world but are insufficient to fully electrify by 2030 (see 'STEP-scenario' of next figure).

Figure 43

Global population lacking access to clean cooking, 2019 and 2030 (STEPS)



Source: IEA, 'WEO 2020'.
Note: IEA analysis and data based on World Health Organization Household Energy Database, 2016.

In 2019 across the Asia-Pacific region some 200 million people still did not have access to electricity and almost 1.8 billion people remained without access to clean cooking.[184] The recent pandemic has highlighted the need to expand energy access to help populations mitigate the effects of the crisis due to the large inequalities existing around the world in terms of access to reliable energy and healthcare services - especially in rural and peri-urban areas. For making the situation even worse, many governments have shifted their policy priorities, whilst they have also to cope with supply-chain disruptions and social distancing measures. They have slowed access programmes and hindered activities in the decentralised energy access areas.

Furthermore, more than 80 per cent of privately owned decentralised energy companies have indicated that, without financial support, they will struggle to survive beyond the end of the year: Jobs have already been lost, and a third of these companies have reported that they have laid-off at least 30 per cent of their staff. The pandemic has hit the poor countries at most and is widening the divide

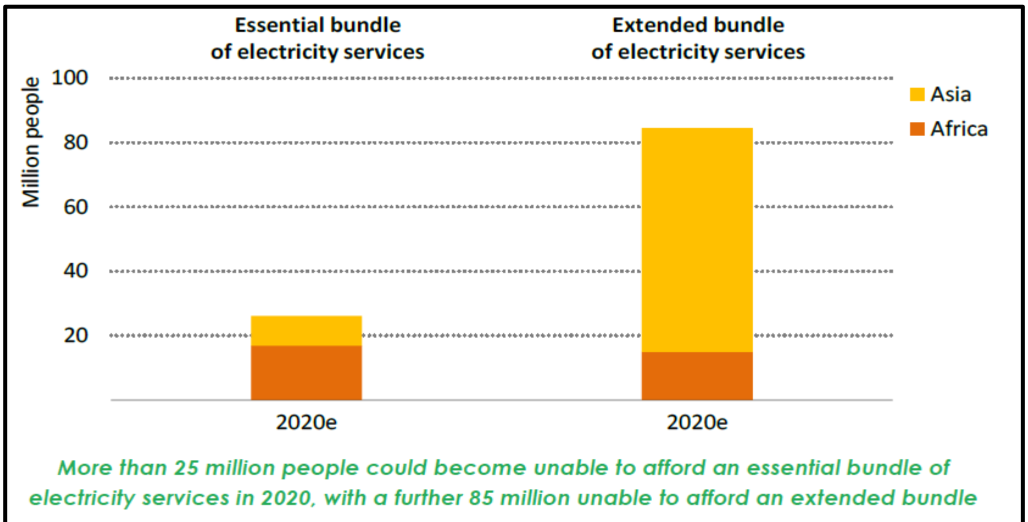
[184] ESCAP, Asia Pacific Energy Portal www.asiapacificenergy.org; (accessed 14 December 2020).

between richer and poorer countries as the combined result of the pandemic and global recession, corruption as well as economic mismanagement, leading to a full-blown crisis with lasting impacts. In contrast to the progress of improving energy poverty, COVID-19 is increasing it again.

In addition to immediate impacts, the IEA has warned that two mutually reinforcing risks can increase further energy inequality: (1) the risk of the economic slowdown caused by COVID-19 will increase poverty. It makes energy less affordable for already struggling populations and can cause reversals in recent progress on energy access, and (2) the risk that those countries with the greatest need to improve access to energy and clean cooking will face even more problems with financing any new energy access projects. It would hamper their capacity for any improvement of their short-term situation. Many other vulnerable households that currently have access to electricity will be increasingly unable to pay their bills.[185]

Figure 44

People with access to electricity in Asia and Africa at risk of losing the ability to pay for basic electricity services in 2020



Notes: 2020e = estimated values for 2020. The number of people at risk of being unable to afford the essential bundle is not a subset of the people at risk of being unable to afford the extended bundle.

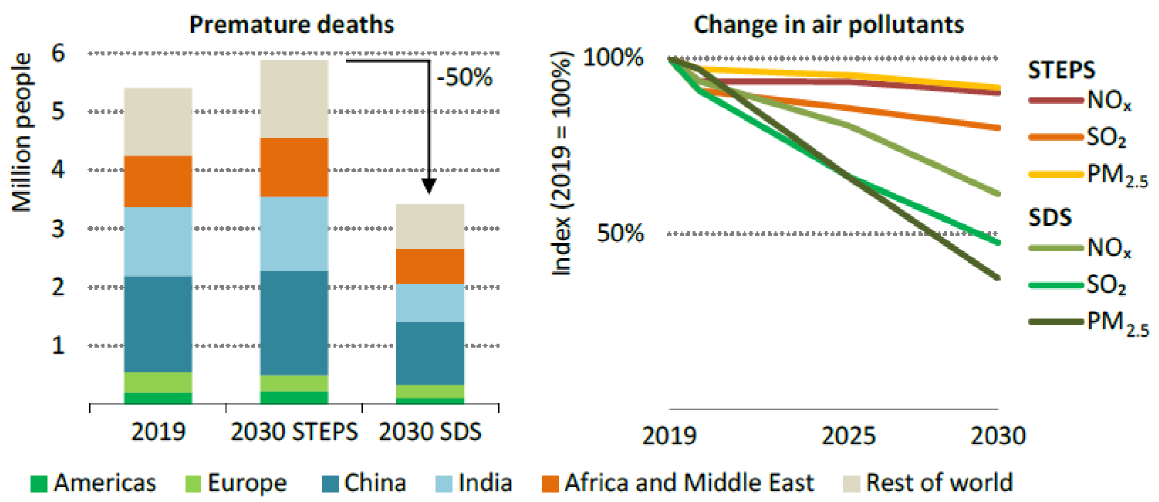
Source: IEA, 'WEO 2020', based on IEA analysis and Lakner et al. (2020).

[185] ibid., p. 92.

Thereby, a difference between losing access to the essential supply of electricity services in sub-Saharan Africa and to the one in Asia needs to be recognized as they reflect different circumstances: in sub-Saharan Africa relatively more people are at risk of being pushed into extreme poverty (less than US$1.90/day) due to COVID-19, while in Asia (and particularly India) the crisis might result in more people are falling from higher poverty levels (US$3.20/day or US$5.50/day).[186] Moreover, annual premature deaths linked to household and outdoor air pollution stand at around 5.5 million globally. This figure is set to rise to around 7 million by 2050.[187] Also in this regard, the expansion of clean energy sources is becoming ever more important to improve air pollution and not just mitigate global climate change.

Figure 45

Premature deaths from air pollution by region and air pollution emissions by pollutant and scenario, 2019 and 2030



Emissions of the three main air pollutants drop by 40-60% in the SDS by 2030, cutting premature deaths from air pollution by over one-third compared to 2019

Note: Americas includes South America, Central America, North America and the Caribbean.

Source: IEA, 'WEO 2020', based on IEA analysis and International Institute for Applied Systems Analysis.

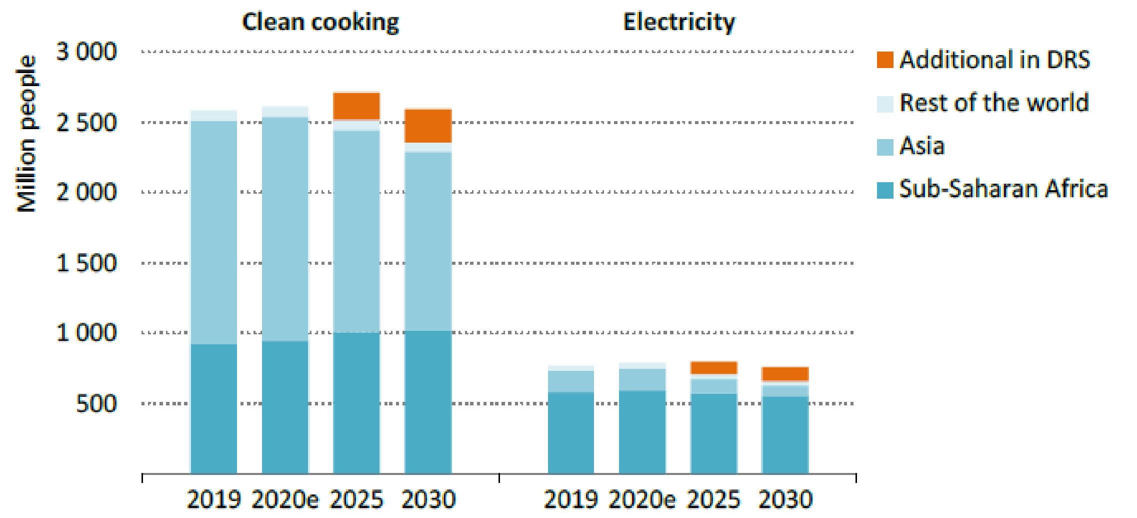
186 IEA, 'WEO 2020', p. 93.

187 IEA, 'WEO 2020', pp. 87 ff.

Any longer-term impacts of the global pandemic might cause even bigger problems for improving the sustainable development and getting access to modern and clean energy sources as outlined in the IEA's 'Delayed Recovery-Scenario (DRS)'. While in STEPS the worldwide population without access to electricity will be decreasing (-15 per cent) from 771 million in 2019 to 658 million by 2030, in DRS the population will just fall (-2 per cent) to 759 million. Equally, global population having still no access to electricity and clean cooking will fall (-9 per cent) in STEPS from 2.58 billion in 2019 to 2.35 billion in 2030, the number will even increase (+0.3 per cent) to 2.59 billion in DRS.[188]

Figure 46

Population without access to energy in the 'Stated Policies'- and 'Delayed Recovery'-Scenarios by region, 2019-2030



In 2030, 660 million people remain without electricity and 2.4 billion without clean cooking in the STEPS; the numbers are worse in the DRS

Note: 2020e = estimated values for 2020.

Source: IEA, 'WEO 2020', based on IEA analysis and WHO (2020).

Providing access to renewables and other clean energy sources, are an important pre-condition for a sustainable social-economic development as well as for coping with the worldwide climate change.

188 IEA, 'WEO 2020', p. 324.

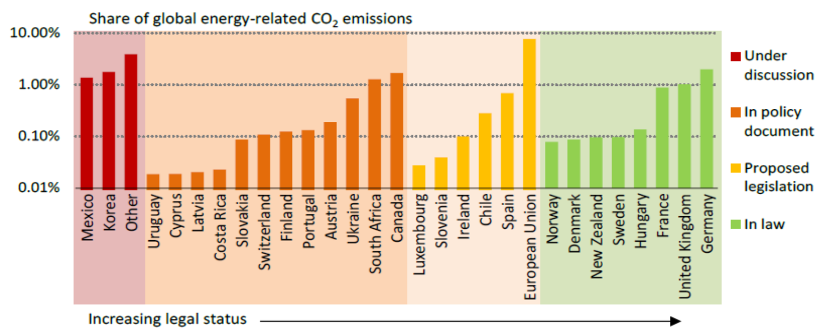
But as described in the previous chapter, the much-needed international investments in clean energy sources and energy infrastructures is also been threatened in advanced economies. This may widen the gap between what is needed for achieving the targets of the Paris Agreement and what is actually taking place on the global energy markets. The call of the United Nations Secretary-General in May 2019 to stop all investments into new coal power plants and to use the global pandemic as a vehicle for a faster worldwide energy transition and decarbonization needs still to be followed by the United Nations Member States.

5.3 Perspectives for energy policies and climate change targets

A lasting global pandemic and delayed economic recovery might also have consequences for the global climate policies and the implementation of strategies for its sustainable development goal (SDG13) and the Paris Agreement. The global 'COP26'-summit has already been postponed into 2021. Up to now, only the EU has taken new more radical steps with its 'European Green Deal (EGD)' of December 2019 for achieving the 2°C/1.5°C goal and to reduce its GHG-emissions by -55 per cent (previously -40 per cent) until 2030. It is the only region which has offered an ambitious mid-term perspective by 2030 and a pathway as well as strategies for implementing its new targets, including using 30 per cent of its €750 billion 'Next Generation Fund' for green projects.

Figure 47

Announced net-zero CO_2 or GHG-Emissions by 2050 reduction targets



More than a dozen countries and the European Union, which accounted for around 10% of global CO_2 emissions in 2019, have net-zero emissions targets in law or proposed legislation

Notes: *In law* = a net-zero target has been approved by parliament and is legally binding. *In policy document* = a net-zero target has been proposed but does not have legally binding status. *Proposed legislation* = a net-zero target has been proposed to parliament to be voted into law; *Under discussion* = countries that have signalled an intent to put forward net-zero targets (UNFCCC, 2019), e.g. as part of the Climate Ambition Alliance or the Carbon Neutrality Coalition. Fiji, which accounts for less than 0.01% of global CO_2 emissions, has a target in proposed legislation which is not shown. The Marshall Islands, Iceland and Liberia, which each account for less than 0.01% of global CO_2 emissions, have targets in policy documents which are not shown.

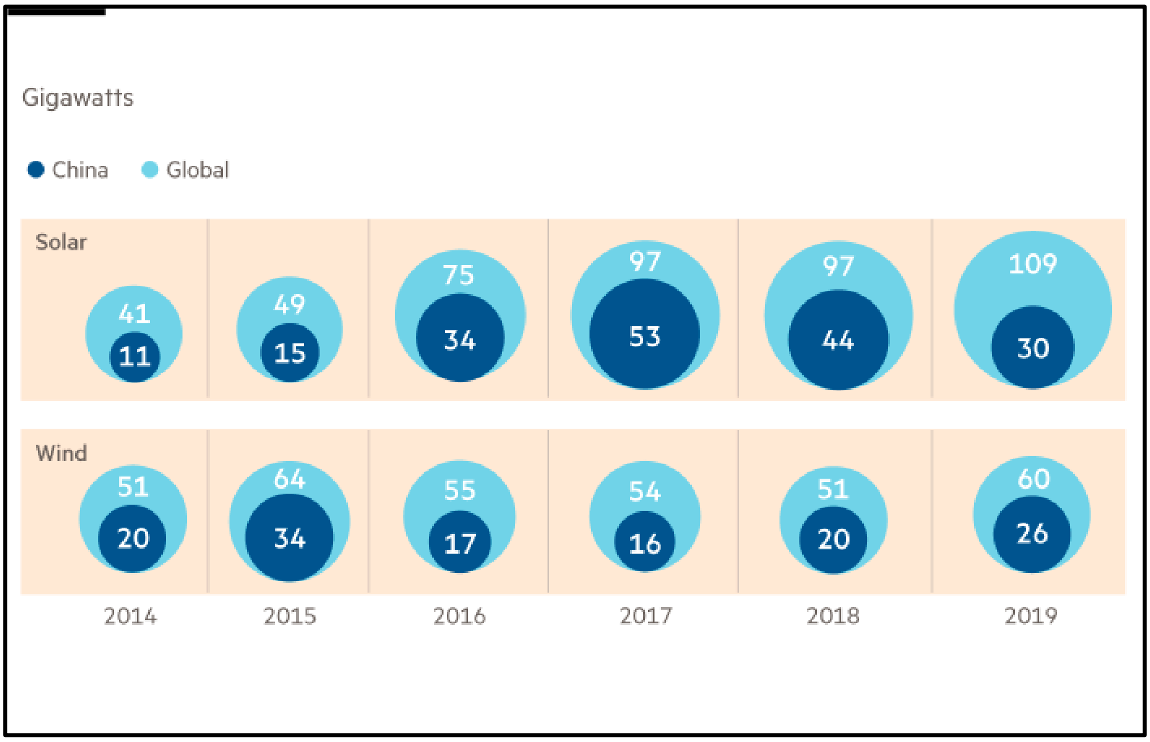
Source: IEA, 'WEO 2020'.

Even China, enjoying an economically sound GDP growth, had to cope with declining exports and mounting political pressure to restructure loans of its Belt and Road Initiative (BRI)-projects for developing countries in 2020.[189] The country still consumes more coal than the rest of the world together, but is also the world's largest investor in renewables projects domestically as well as abroad.

Furthermore, at the end of 2020, onshore wind and solar PV subsidies expire in China, while offshore wind support will end as planned in 2021. Whether subsidy-free renewables projects will expand further so strongly as in the past years, remains to be seen. China's total renewables additions have declined by 40 per cent in the first half year of 2020.[190]

Figure 48

China as the world's largest investor in solar and wind power capacity



Source: Financial Times, 2020, based on the data from National Energy Administration, Global Wind Energy Council, and IEA.

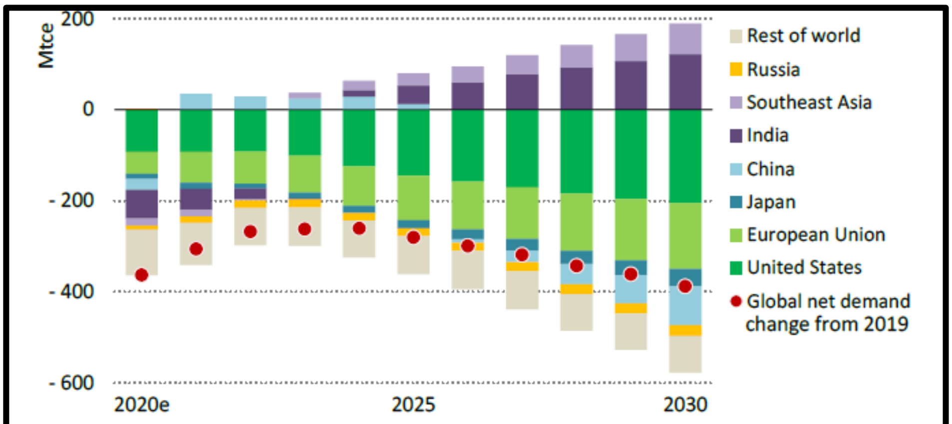
189 Wihtol, R., 'China's problematic lending comes home to roost', Lowvy-Institte,6 November 2020 and idem, 'China faces mounting pressure to restructure developing-world loans', The Maritime Executive, 13 November 2020.

190 Brunetti, B., et al., 'Covid-19 could make 2020 crucial for renewables', S&P Global Platts Analytics, September 2020, p. 4.

With a present share of around 29 per cent of global emissions (more than the United States, the EU and India combined), China has recently committed itself to reaching net-zero emissions by 2060, which could lower climate warming projected by 0.2-0.3°C. What is clear is the fact that China's future energy and climate policies will play an ever more important role for global energy security as well as for the pace of mitigating climate change. Between 2000 and 2019, 40 per cent of all China's overseas power plants financing was for coal power plants and only 11 per cent was for renewables projects.[191] That has changed in 2020 for the first time when investments in renewables were higher than in coal in its BRI-projects.

Figure 49

Change in coal demand relative to 2019 by region in the 'Stated Policies Scenario (STEPS)'



The world sees a rebound in coal demand after 2020, before demand falls. Europe and the United States lead the declines, and coal use in China peaks in the middle of the decade

Note: Mtce = million tonnes of coal equivalent; 2020e = estimated values for 2020.

Source: 'WEO 2020'.

Even with China's newly declared goal of carbon neutrality by 2060 of September 2020 and achieving a peak of emissions before 2030 (instead by 2030 which China's

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191 Shepherd, C., Z. Emma, and K.Manson, 'Climate Change: China's coal addiction clashes with Xi's bold promise', Financial Times, 3 November 2020; Weijun, S., 'China's 40-Year Carbon Plan', Natural Gas World, Vol. 5, Issue 19, 12 October 2020; Pearl, H., China's carbon neutral energy pledge adds more weight to 14th five-year-plan for 2021-2025', SCMP, 24 September 2020; Yang, Y., 'Chinese leadership meets to set policy direction for next 5 years', Financial Times, 26 October 2020; Hook, L., 'China pledges to be 'carbon neutral', Financial Times, 22 September 2020; Pearl, H., 'China's coronavirus recovery drives boom in coal plants, casting doubt over commitments to cut fossil fuels', SCMP, 21 July 2020; Green, F., 'Xi Jinping's pledge: will China be carbon neutral by 2060?', East Asia Forum, 26 October 2020 and Shearer, C., et.al., 'Boom and Bust 2020: Tracking the Global Coal Plant Pipeline', March 2020.

government already declared in 2014)[192], at present 250 GW of new coal-fired power plants (with long-term 'lock-in'-impacts of polluting emissions) are under development – more than the entire coal-fired electricity generation capacity in the United States. Despite new declarations to accelerate its energy transformation away from the heavy coal use by expanding renewables, natural gas and nuclear power and other new options (such as hydrogen) in the light of the new 14th 5-year plan for 2021-2025,[193] it increased its coal-capacity by almost 40 GW and approved another 37 GW in 2020[194] - offering a striking contrast to the EU and United States policies.[195] In December 2020, China's emissions surpassed 2019 levels for the first time all year according to new data.[196] Its coal output was the highest since 2015.[197]

India's renewables sector as a worldwide key market has been hit at most due to reduced construction and have declined 40 per cent year-to-year in this pandemic year. Already before India's renewables sector had struggled with structural constraints such as slowing growth in power demand, high counterparty risks, land scarcity and transmission bottlenecks.

192 Hook, L., 'China Lays out Steps towards Climate Targets at UN Summit', Financial Times, 12 December 2020, and idem, 'China Pledges to be 'Carbon Neutral' by 2060', Financial Times, 22 September 2020.

193 The State Council Information Office of the PRC, 'Energy in China's New Era'.

194 Stanway, D., 'China's New Coal Power Plant Capacity in 2020 more than Three Times rest of the World: Study'; Brunetti, B., et al., 'COVID-19 could make 2020 crucial for renewables'; Hale, T., 'China Expands Coal Plant Capacity to Boost Post-Virus Economy', Financial Times, 25 June 2020; Myllyvirta, L., S. Zhang and X.Shen, 'Will China Build more Coal to Stimulate the Economy?', Energypost.eu, 6 April 2020.

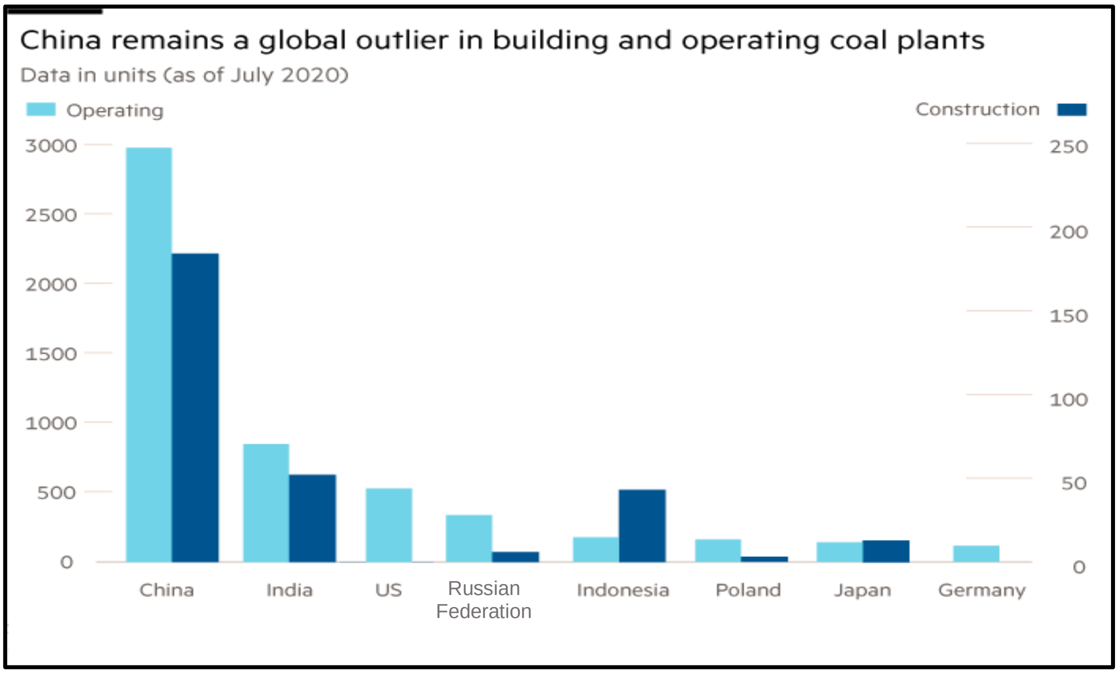
195 Podesta, J., and D. Sandalow, 'China must take action now on net zero pledge', Financial Times, 13 October 2020; Tooze, A., 'Did Xi just save the world?', Foreign Policy, 25 September 2020.

196 'China's COVID Comeback is bad News for Climate as Emissions Rise', Bloomberg-News, 3 February 2021.

197 Xu, M., and S. Singh, 'China's 2020 Coal Output Rises to Highest since 2015 Undermining Climate Pledges', Nasdaq.com, 17 January 2021, and Clyde Russell, 'China Scores Coal own Goal as Domestic Import Prices Surge', Reuters, 7 December 2020.

Figure 50

Leading countries of building and operating coal power plants in 2020



Source: Financial Times, 2020, based on data form the Global Energy Monitor.

Japan and Republic of Korea followed China's 2060 pledge and declared to become even a net-zero emissions country by 2050.[198] As the world's third-largest economy and getting a third of its energy supplies from coal, Japan is currently considering to shutting or mothballing 100 ageing coal power plants by about 2030, which would indicate a major shift in its energy and wider industrial policies.[199] It is currently the only G7 country that has officially still a plan to build new coal power plants. It will also stop the much-criticized financing of any new coal power plants in developing countries - with the exception building most efficient ultra-critical ones in the buying country which has a decarbonization strategy.[200] The Republic of Korea has announced it will close 30 more coal-fired power plants by 2034 in addition to 10 by the end of 2022.[201]

198 'Suga to declare Japan will go carbon neutral by 2050 in policy speech', The Japan Times, 22 October 2020, and Harding, R., 'Japan to be carbon neutral by 2050, insists prime minister', Financial Times, 26 October 2020. See also more sceptically Patrick, P., 'Japan's carbon neutral pledge looks like a load of hot air', Spectator, 28 October 2020; Sugiyama, M., 'The fine print of Japan's commitment to carbon neutrality', East Asia Forum, 18 November 2020, and McCracken, R., 'Japan slow to tackle coal', Natural Gas World, 2 November 2020.

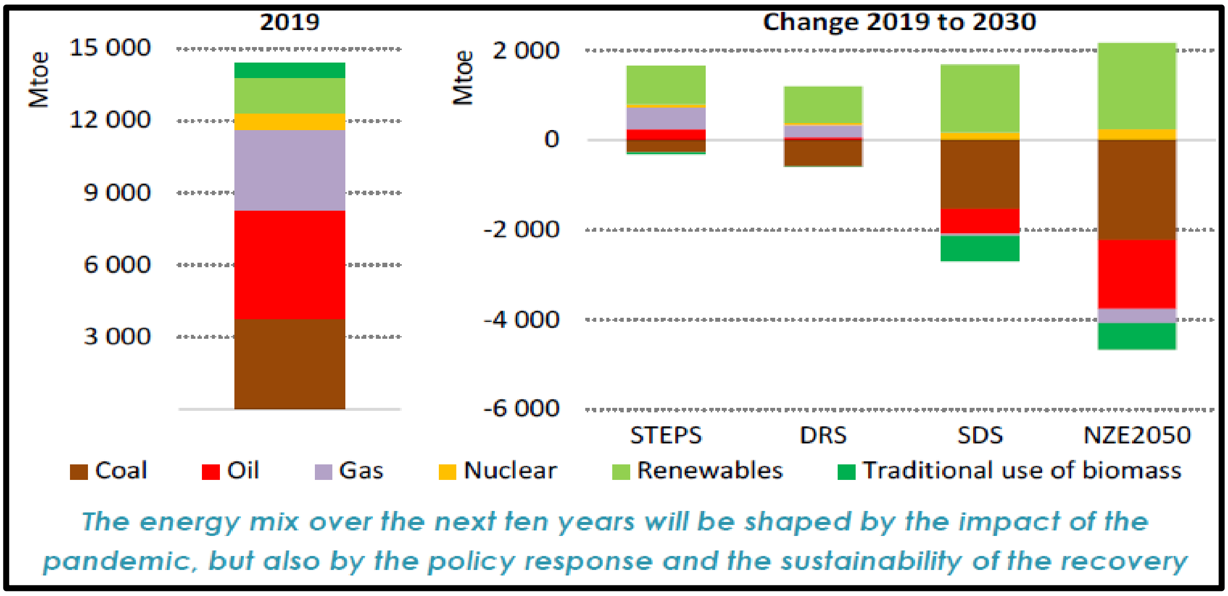
199 'Japan to shut or mothball 100 ageing coal-fired power plants-Yomiuri', Inside Power, Gas & Caron, 3 July 2020.

200 Harding, R., 'Japan vows to slash financing of coal power in developing world', Financial Times, 13 July 2020, and Eurasia Group, 'Coal/Japan – Japan's policy shifts deal another blow to coal', 12 July 2020.

201 Jun-tae, K., 'Moon Vows to Shut down 30 more Coal Plants to Bring Cleaner Air and Battle Climate Change', Koreaherald.com, 8 September 2020 and White, E., 'South Korea Urged to Follow Japanese Lead on Coal Finance Ban', Financial Times, 23 August 2020.

Figure 51

Total primary energy demand by fuel and scenario



Source: IEA, 'WEO 2020'.

In both the STEPS and SDS (but much less), the global primary energy demand in 2040 remains to be covered largely by oil and gas. Only the world's coal consumption will drop continuously, but only in the SDS and NZE2050 also significantly and is being replaced by renewables and nuclear power.

Although European and the United States oil companies have recently made strong commitments for achieving net-zero emissions by 2050, they are producing less than 10 per cent of global oil output.[202] The worldwide state-owned oil companies of Russian Federation, China and the OPEC countries have not declared yet any comparable long-term commitments for CO_2 reductions.[203] Despite the present decline of GHG-emissions, they might increase again above the 2019 level in 2027.

The SDS would require "unparalleled changes across all parts of the energy sector" and hitherto unknown large-scale investments in renewables, electric mobility, technological innovation, and a change of unpopular consumer behaviour worldwide (especially in the transport sector) as outlined in the IEA's new 'NZE 2050'-scenario.[204]

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202 Derek Brower/Myles McCormick, 'Breaking down BP's clean energy pivot', Financial Times, 6 August 2020, and Gregory Meyer, 'Clean energy group NextEra surpasses ExxonMobil in market cap', Financial Times, 2 October 2020.

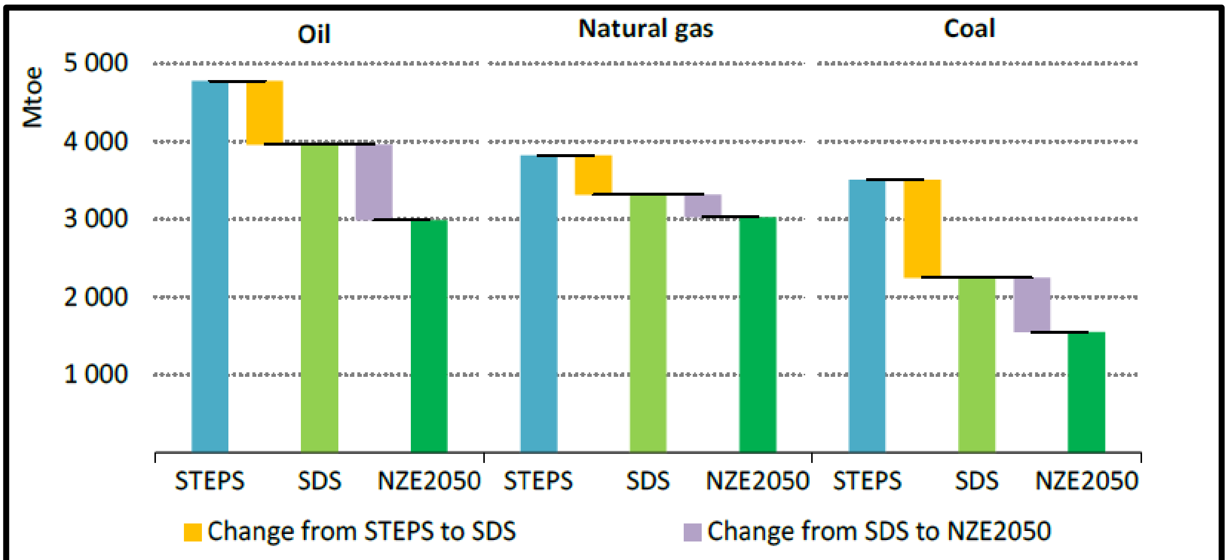
203 Sheppard, D., 'Will 'Black April' prove a turning point for energy?', Financial Times, 20 October 2020.

204 Lo, J., 'IEA outlines global path to net-zero emissions by 2050', Euractiv, 14 October 2020.

Renewables have become consistently cheaper than coal- and gas fired plants nowadays and may meet 80 per cent of growth in electricity until 2030. Solar photovoltaic has become the 'new king of electricity supply' and is forecasted to expand massively by at least 13 per cent worldwide in the next decade according to the SDS. Costs of offshore wind is also expected further to fall.

Figure 52

Differences in fossil fuel demand in the scenarios in 2030



Declines in fossil fuel use in the SDS are further extended in the NZE2050. By 2030, coal use is 55% lower in the NZE2050 than the STEPS, oil is 40% lower and natural gas is 20% lower.

Source: IEA, 'WEO 2020'.

Even in STEPS, the future coal consumption will not return to the pre-pandemic levels. Its share might fall below a fifth of the present one by 2040. It will fall in STEPS and SDS from 37 per cent in 2019 of the global power generation mix to 28 per cent and 15 per cent respectively in 2030.[205]

Renewables are forecasted by the IEA to grow in all of its scenarios. Even in 'STEPS', they will boom up to 80 per cent of the growth in global electricity demand to 2030. But challenges arise regarding the reliability and security of supply of the electricity grids, which also need to be modernised alongside of the capacity growth of renewables. The question of affordable short- and longer-term storage of electricity will play an ever-important role in ensuring the grid stability as well as decreasing the mounting hidden costs of expanding renewables.

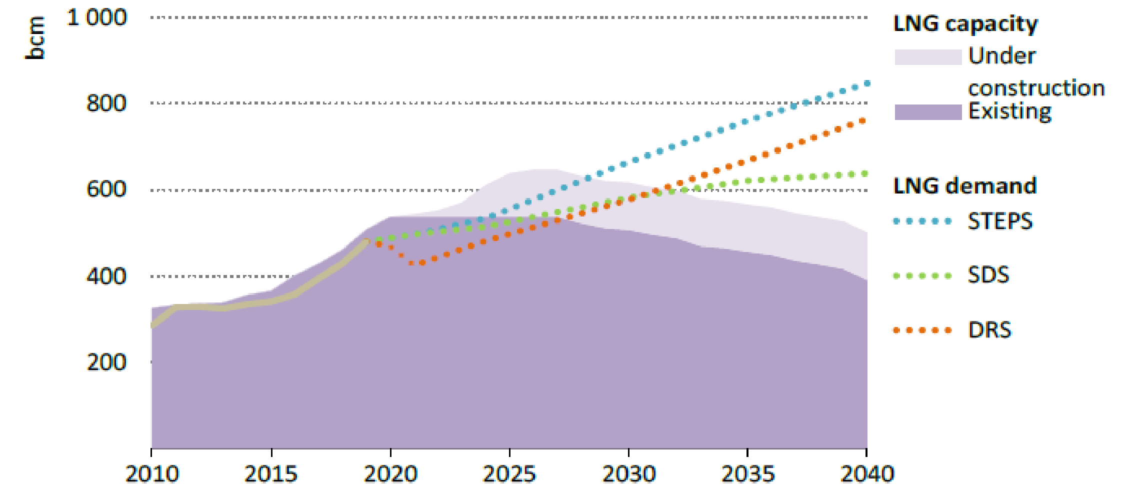
[205] IEA, 'WEO 2020'.

Underpinned by low prices and surplus production, natural gas will also increase by 30 per cent in global demand by 2040. In 2030, the natural gas demand might already be 15 per cent higher than in 2019 and may reach 4.6 trillion cubic meters. As confirmed by previous IEA reports, the gas demand growth might be concentrated in South and South-East Asia.[206]

Whether the markets will move again from a 'buyers' one' to a 'sellers' one after 2020 remains highly uncertain given the present over-supplies on the worldwide gas markets and the introduced additional capacities (especially LNG with another 140 bcm liquefaction capacity under construction and additional 250 bcm in the planning stage) over the next years, though some of these new capacities may enter the markets few years later than planned some years ago.[207] Methane emissions along the entire gas supply chains, its transparency and the global emissions policies are challenging the rather positive forecasts of natural gas as a longer source for the 'energy bridge'. New EU and United States efforts for curbing methane emissions will also increase the political pressure on Russian Federation and OPEC countries to follow.

Figure 53

Global liquefaction capacity versus total LNG demand by scenario



Existing and under construction liquefaction capacity could satisfy LNG demand in different IEA scenarios until the mid-2020s, after which the need for new capacity varies by scenario

Notes: LNG demand values show total global LNG trade, in contrast to results from the IEA World Energy Model, which reports LNG trade based on flows between 20 macro regions only. Capacity available is assumed to be 90-95% of nameplate capacity. Under construction capacity does not include Qatar's planned 68 bcm North Field Expansion.

Source: IEA, 'WEO 2020'.

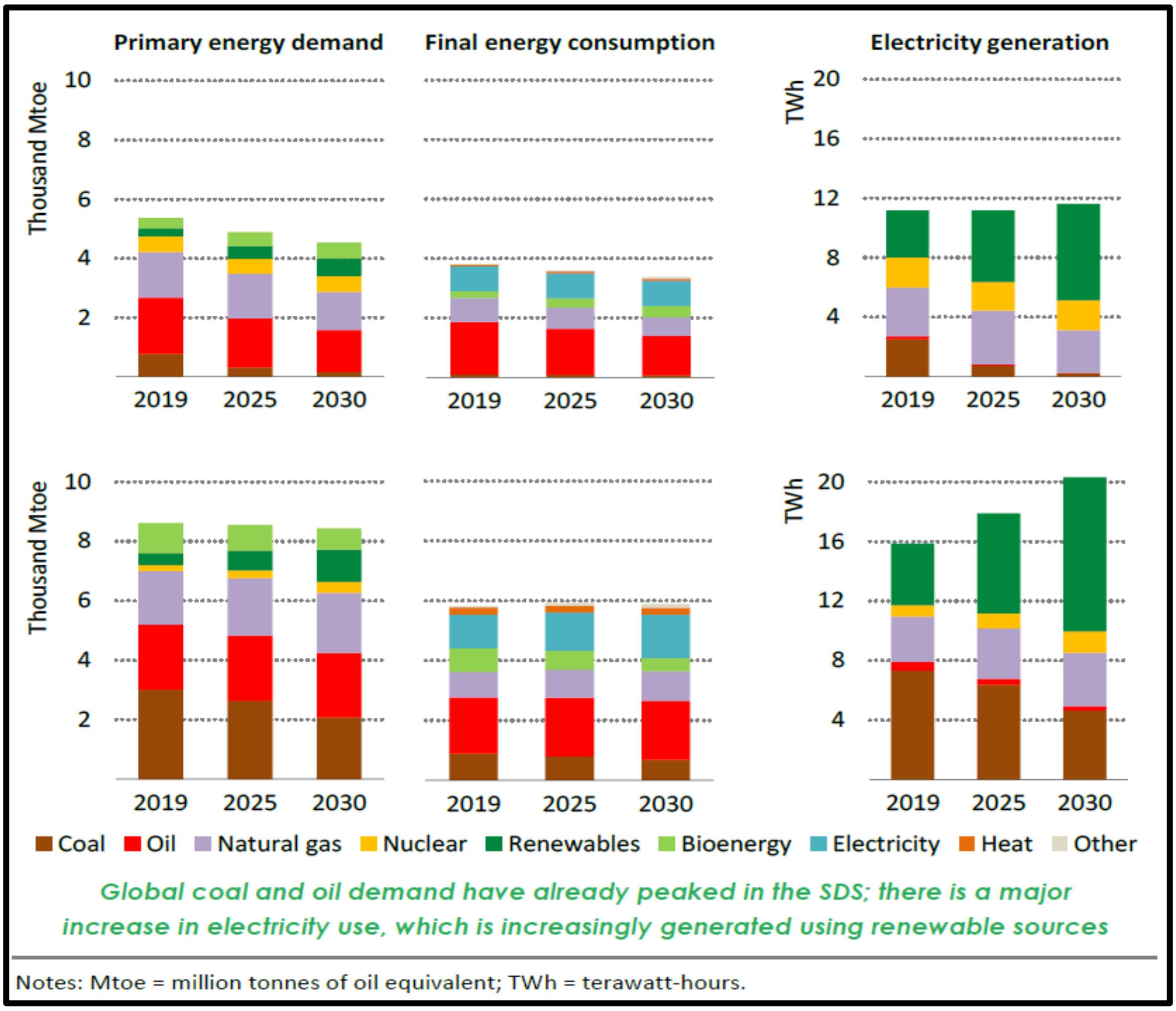
[206] IEA, 'WEO 2020', pp. 187 ff. and 270 ff.

[207] IEA, 'WEO 2020', pp. 275 ff.

The present ultra-low interest rates of international banks might also help to finance clean energy technologies in the years to come. But unfortunately, the much-needed change in the energy policies for decarbonization and green energies coincides with the worldwide impacts of COVID-19 when most of these countries (especially developing economies) will not have the funds for any more radical change of their energy policies and to diversify their economies in a short-term future.

Figure 54

Energy sector transformation in advanced economies (top) and emerging markets and developing Economies (bottom)

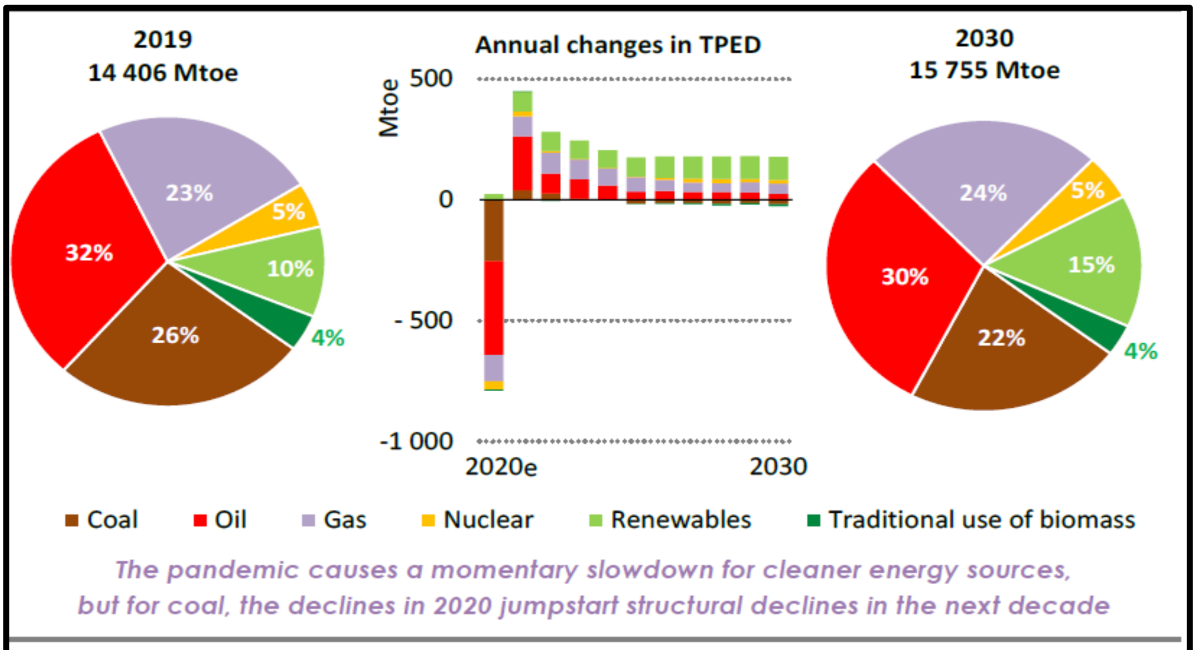


Source: IEA, 'WEO 2020'.

Even the OPEC and other oil producing countries struggle with the triple crisis of low oil and gas prices due to the oil and gas glut, the worldwide decarbonization needs and efforts and the pandemic's economic impacts that shift political and economic priorities of governments and industries.[208] These 'petrostates' had already prior to the pandemic to cope with dramatically declining revenues of their oil and gas exports, which provide 50-90 per cent of their state budgets and being a guarantee for social as well as political stability.[209] BP already stated in 2020 that due to the global pandemic, 'peak oil demand' is already happening. Other experts believe that 'peak oil demand' will take place between 2025 and 2030 in contrast to previous forecasts for 2030 or later.[210]

Figure 55

Total primary energy demand in STEPS, 2019 and 2030



Note: Mtoe = million tonnes of oil equivalent; 2020e = estimated values for 2020.

Source: IEA, 'WEO 2020'.

In STEPS, global coal demand would largely stagnate between 2020 and 2030 but vary between countries and regions. The United States and Europe would undergo the largest relative and absolute declines in

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208 Sheppard, D., 'Will 'Black April' prove a turning point for energy?'.

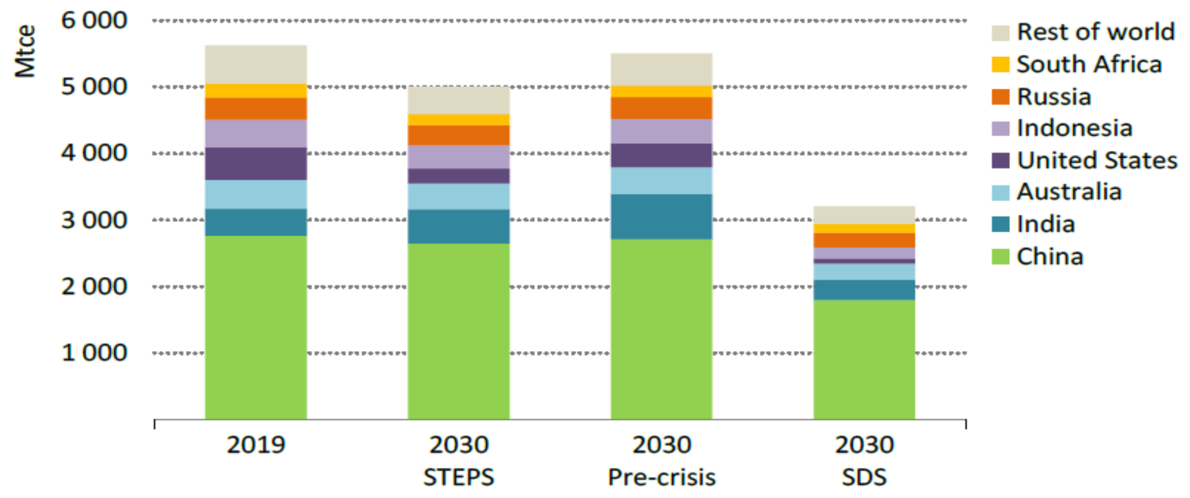
209 To the competing interests of decarbonization and fossil fuel producing countries and their unpreparedness of diversifying their economies see also Umbach, F., 'Energy Security and its Geostrategic Implications', pp. 136 ff.

210 McKinsey has projected peak oil demand by 2029 and of the global gas demand by 2037. The peak coal demand may already had happened in 2018 – see McKinsey, 'Global Energy Perspective 2021', January 2021.

demand, while coal demand levels in China would decline. However, it could be balanced off by the growing coal demand in emerging markets and developing economies (notably in India and South-East Asia) despite some regional coal-to-gas-switching. But even within ASEAN, the Philippines, Viet Nam, and Indonesia – together with Bangladesh - have plans to decrease up to 62 GW of planned coal power– an 80 per cent reduction from the 125GW planned five years ago.[211] Growth is projected to be highest in India, which might account for over 14 per cent of global demand by 2030 (compared with 11 per cent in 2019). It is expected that India will still invest US$55 billion in clean coal projects.[212] But despite this partial phase-out of coal, the IEA has recently forecasted that the global coal demand in 2021 might rise again by 2.6 per cent after a record decline of 5 per cent last year.[213]

Figure 56

Coal production by key countries and scenarios, 2019 and 2030



While coal production falls through to 2030 in the STEPS, it would need to decline much further to be on a pathway consistent with international climate goals

Notes: Mtce = million tonnes of coal equivalent. The pre-crisis value is represented by the *WEO-2019* Stated Policies Scenario projection.

Source: IEA, 'WEO 2020'.

[211] Global Energy Monitor, 'South and South-East Asia's Last Coal Plants', Briefing, December 2020, and Edward White, 'Asia's Developing Economies Shun Coal', Financial Times, 23 December 2020.

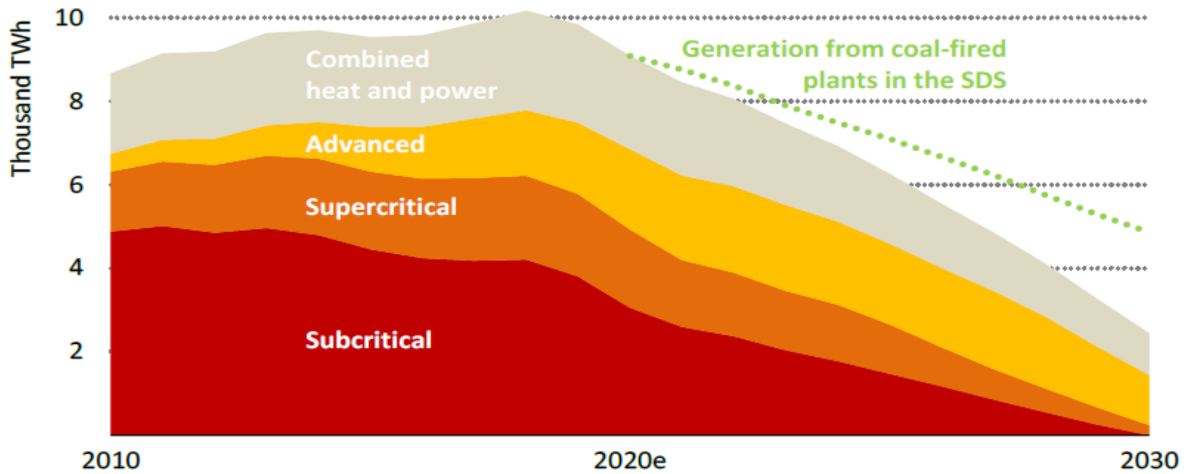
[212] Kumar Singh, R., and A. Chaudhary, 'India Sees $55 Billion Investment in Clean Coal over next Decade', Bloomber.com, 11 January 2021; IEA, 'WEO 2020', p. 195 ff., and Parkin, B., 'India Energy Demand Set to Grow Fastest in the World', Financial Times, 9 February 2021.

[213] IEA, 'Coal 2020. Analysis and Forecast to 2025', December 2020.

In addition, by focusing just on building new, more efficient, and cleaner power plants, the IEA has warned also to address emissions from the world's legacy of vast fleets of inefficient coal power plants, steel, and cement factories (particularly in emerging economies) as otherwise the energy and climate goals for 2050 cannot be realistically implemented. For all countries, finding new financing ways and options – particularly for emerging economies and developing countries - to access cheaper investments for supporting a faster decarbonization and clean energy futures will be most critical in the forthcoming years and decades.

Figure 57

Coal-fired electricity generation by technology in the 'NZE 20250'



There is a major reduction in coal-fired generation and related CO_2 emissions in the NZE2050, with the use of the least efficient coal power plants falling to zero by 2030

Note: 2020e = estimated values for 2020.

Source: IEA, 'WEO 2020'.

On this energy transition pathway, Carbon Capture Utilisation and Storage (CCUS)[214] and hydrogen could play a major role for a green energy transition. However, both are not yet commercially viable and industrial-wide scalable. Furthermore, Carbon

[214] To CCUS see IEA, 2020, 'Energy Technology Perspectives 2020. Special report on Carbon Capture Utilisation and Storage. CCUS in clean energy transitions, Paris: OECD/IEA; and IEA, 'WEO 2020', pp 292 ff.

Capture and Storage (CCS) and CCUS have not been popular in the view of European, Japanese and some other populations and lack public acceptance, which might prove difficult to change for governments and industries.

5.4 The worldwide hydrogen boom – need for a realistic outlook

For two years, hydrogen is increasingly enjoying an unprecedented political and industry support around the world.[215] From 2017 until July 2020, the number of companies joining the international 'Hydrogen Council', for instance, increased from 13 to 92. Hydrogen is being viewed as a clean, secure and affordable energy carrier (like electricity rather than an energy source) and an industrial raw material, which can play a key role and the 'missing link' as feedstock in hard-to-abate sectors such as steel-making and refineries, ammonia production and chemical industry in decarbonized energy systems. In the future it can also fuel buses, trains, and trucks and even ships and planes. By mid-2019, worldwide 50 new targets mandates and policy incentives have been initiated for directly supporting hydrogen as a clean, sustainable and resilient chemical energy carrier. The World Energy Council (WEC) started a 'Hydrogen Global Initiative' in 2019. Of the G20 member countries in 2019, 9 had already national roadmaps and 11 had support policies for hydrogen in place. Meanwhile, 20 countries had adopted a national hydrogen strategy or are on the verge of doing so. Another 31 countries (44 per cent of global GDP) are supporting national projects and/or discussing concrete policy proposals and action plans.

The main drivers are seen in the global climate change policies and its targets, the integration of renewables, diversification of energy supply, and new opportunities for economic growth by including other sectors of the economy and industry than the energy sector. The main actors in Asia are China, Japan, the Republic of Korea, and Australia.

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[215] The following sub-chapter is a n updated version of my previous publications on hydrogen – see Umbach, F., and J. Pfeiffer, 'Germany and the EU's hydrogen strategies in perspective – The Need for Sober Analyses', Periscope-Occasional Analysis Brief Series No.1, Konrad Adenauer-Foundation-Australia, Canberra, August 2020, and Umbach, F., 'Hydrogen: decarbonization's silver bullet?", GIS, 2 July 2020.

Figure 58

Hydrogen options based on energy resources

Green hydrogen:	Produced without CO_2 emissions (by nuclear or renewable electricity based on solar and wind).
Blue hydrogen:	Commonly used term for the production of hydrogen from fossil fuels (mostly from natural gas) with CO_2 emissions reduced by the use of Carbon Capture, Use and Storage (CCUS).
Turquoise hydrogen:	Made by pyrolysis with carbon black as a by-product.
Gray (or brown) hydrogen:	Produced with fossil fuels (hard or lignite coal or natural gas) without CCUS.
White (or natural) hydrogen:	Discovered by chance, when wells were drilled for oil and gas in Mali. It is estimated that its cost of exploitation is much cheaper than manufactured hydrogen from fossil fuels or from electrolysis.

Note: *the environmental effects cannot only vary considerably due to the energy source used for hydrogen production, but also due to production routes and supply chains, as well as the type of CCUS applied.*

Source: GIS, 2020.

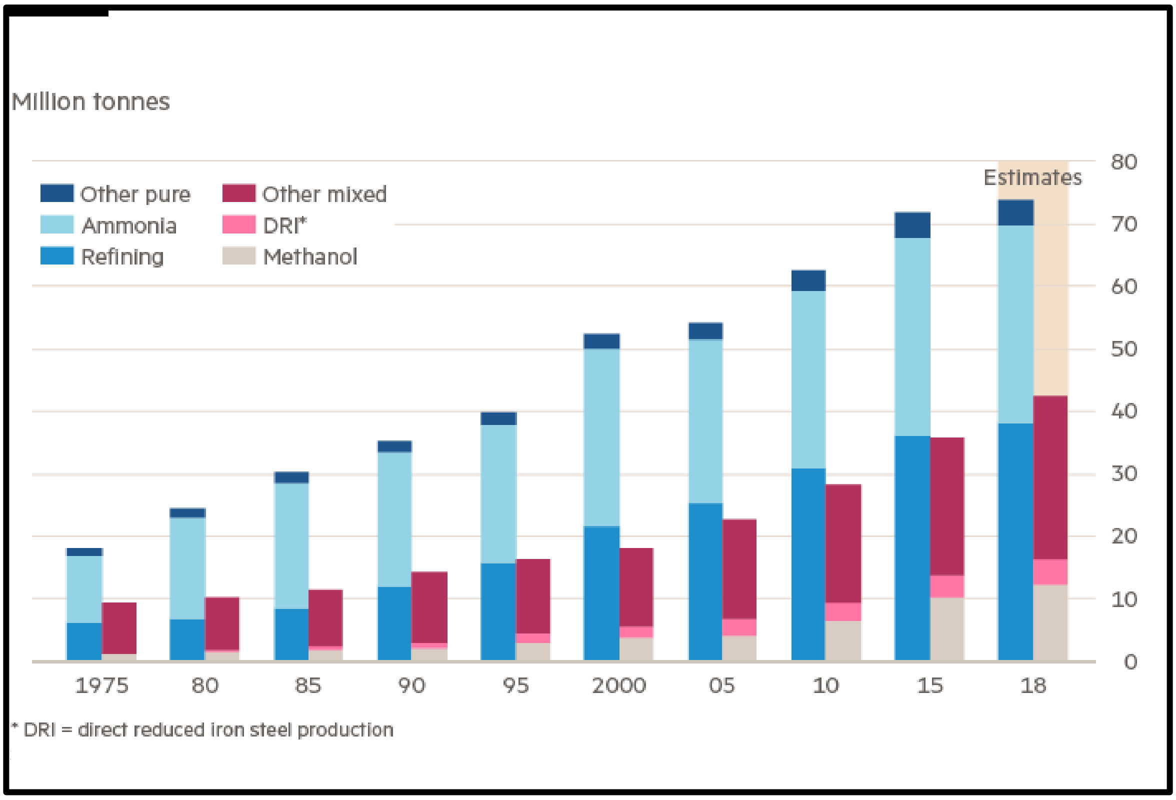
Already existing technologies allow hydrogen being produced, stored, moved, and used in different ways and for various purposes. Hydrogen can be produced by renewables, biomass, nuclear as well as fossil fuels (oil, gas, coal). It is seen as the leading and currently only realistic option for storing electricity from renewables for a longer time. In Europe, the focus is particularly on green hydrogen – though it is also the most expensive option at present.

Since 1975, the worldwide hydrogen production has already increased three times up to 70 metric tonnes (mt) per year or 330 mt of oil equivalent - larger than Germany's primary energy demand. At present, more than 60 GW of capacity are already underway to be created. For the net-zero emissions goal by 2050, the IEA envisages an expansion of hydrogen production from 0.2 GW up to 3,300 GW by 2050 – which amounts to consuming twice of the entire electricity consumption of China today.

The WEC expects even a hydrogen demand of up to 9,000 TWh or around 270 mt of hydrogen per year by 2050 – comparable with the entire worldwide annual primary energy demand by renewables.[216]

Figure 59

Demand rise of hydrogen 1975-2018



Source: Financial Times, 2020, based on data of IEA 2019.

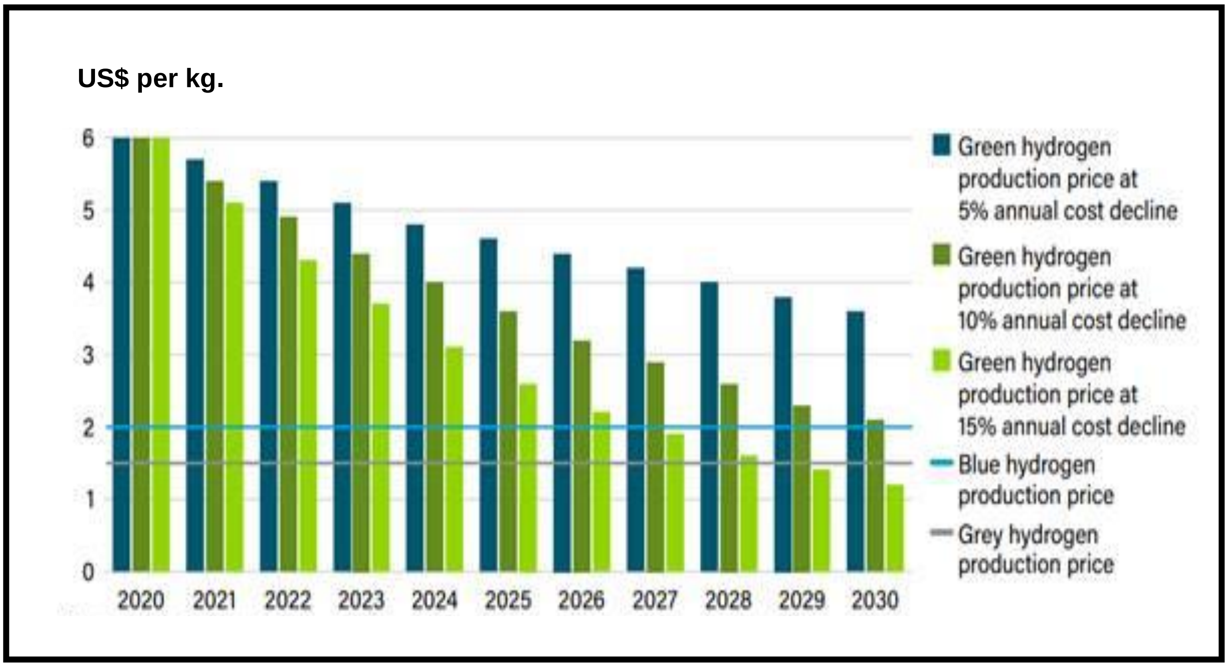
In many energy transition strategies, low-carbon hydrogen is rising in importance. Several countries are already accelerating efforts to scale up infrastructure, demand, and expertise. In 2020, hydrogen has emerged as a focus for economic stimulus spending in several countries. In response to the COVID-19 pandemic, an increasing number of governments have enhanced or accelerated their efforts to scale up hydrogen infrastructure, demand, and expertise.

216 WEC/Ludwig Bölkow Systemtechnik, 'International Hydrogen Strategies', September 2020.

Some of the plans are ambitious. The EU, for instance, seeks to scale up the manufacturing and installation of electrolysers to reach its defined 40 GW target by 2030. It would require the addition of almost 1 GW of factory capacity each year from 2023, in addition to the 1.7 GW already in operation or under construction in Europe.[217] The hydrogen ambitions between the EU and China have significantly increased in 2020, which offers concrete pathways for realization of their ambitions and scaling up perspectives for decreasing overall costs by 2030.[218]

Figure 60

Development of green versus blue and grey hydrogen costs, 2020-2030



Source: Eurasia Group research, 2020.

While bridging the cost gap with competing fuels is a key near-term challenge, the gap is projected to narrow considerably by 2030. While low-carbon hydrogen is expensive today, costs are expected to decline as production expands and as the necessary infrastructure is rolled out. But at present, the cost gap between electrolysis hydrogen and merchant hydrogen from natural gas reforming has

217 to the hydrogen strategies of the European Commission and Germany as a leading country with the world's most ambitious hydrogen strategy – see Umbach, F., and J. Pfeiffer, 'Germany and the EU's hydrogen strategies in perspective – The Need for Sober Analyses', and Umbach, F., 'Hydrogen: decarbonization's silver bullet?'.

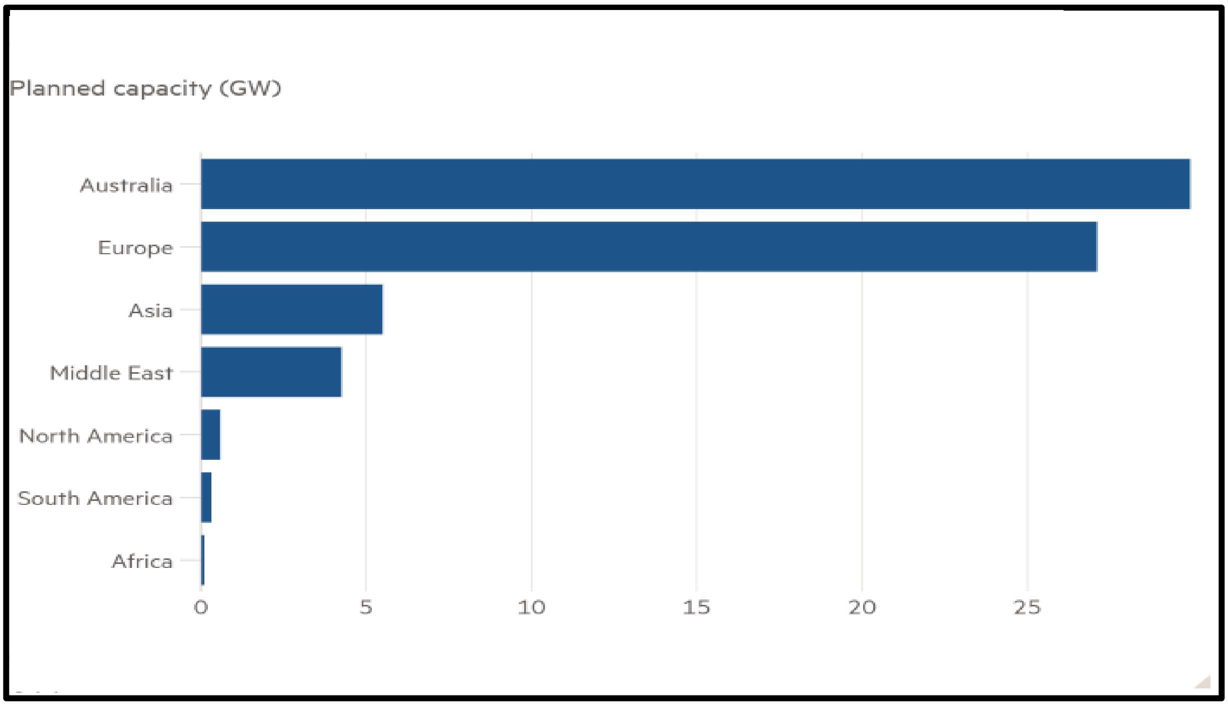
218 Mathis, W., 2020, 'Hydrogen Wars' Pit Europe v. China for 700 Billion Business', Bloomberg.com, 1 November 2020.

recently grown wider for key hydrogen-using sectors that could provide near-term end-uses (such as refineries, ammonia, methanol, and steel production) as a result of low natural gas prices. As a result, policies in Europe and Asia may need to ensure that a gap of $50/MBtu or more can be bridged by consumers or taxpayers in order to incentivise new electrolysis hydrogen. Electrolyser costs might also fall as manufacturing and installation scales up and efficiencies are expected to increase.[219]

Natural gas is currently used for three-quarters of the global hydrogen production of some 70 mt per year with amount of 205 bcm annually (or 6 per cent of global natural gas consumption). Coal currently accounts for 23 per cent of global hydrogen production with some 107 mt (or 2 per cent of global coal use). Only 4 per cent of the worldwide hydrogen production in 2018 was based on renewable energy sources (renewables). By 2050, clean hydrogen could meet some 24 per cent of the global energy demand with annual sales of around €630 according to some analytical estimates.

Figure 61

Green Hydrogen ambitions of selected countries and regions



Source: Financial Times, 2020.

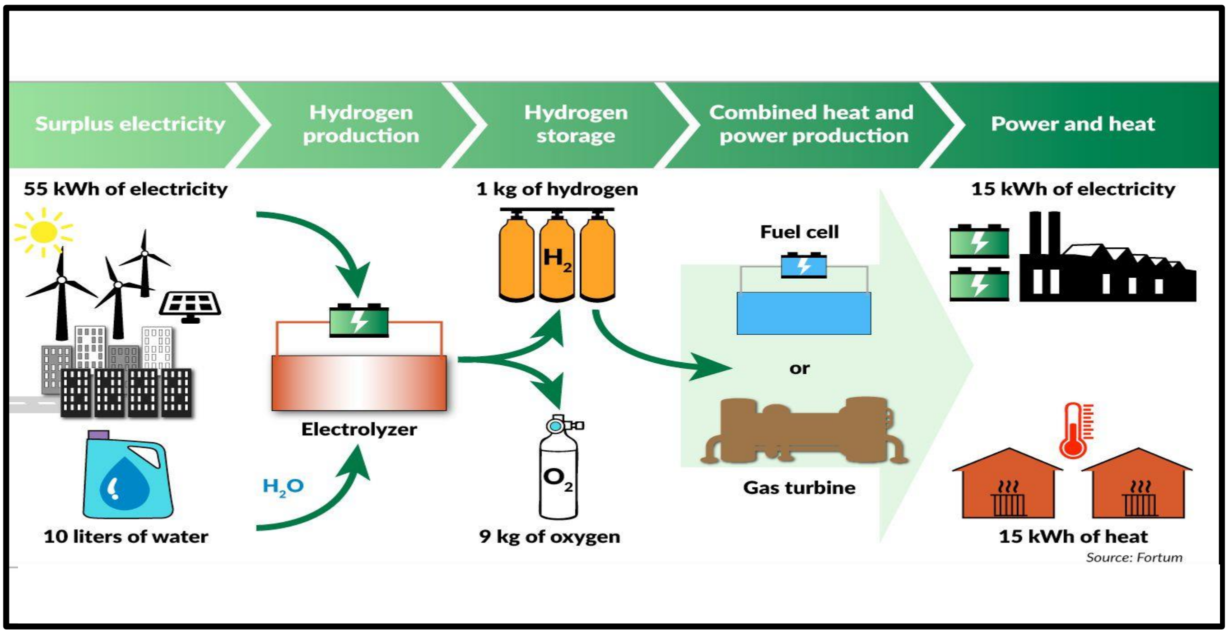
[219] IEA, 'WEO 2020', pp. 289 ff.

Power from biomass is currently considered as the most expensive option due to the complex processing and most limited by the availability of cheap biomass. But it could theoretically become an option with CCUS as it would offer the prospect for 'negative emissions' in the future. In the short-term perspective, blue and grey hydrogen might remain the most cost-competitive option for many countries with larger coal and gas reserves as well as cheaper production costs. At present, renewable hydrogen is 2 to 3 times more costly than fossil-fuel based hydrogen though electrolyser costs have already decreased five times compared to 5 years ago. Blue hydrogen would need a carbon price between US$45 to US$74 per tonne of CO_2 for making it competitive with grey hydrogen.

In contrast to the past, with the rapidly declining costs for renewables, batteries and EVs as well as other new technology innovation, hydrogen has now become a real option for solving the storage problem of electricity, and also to decarbonize the hard-to-abate sectors of the economy, such as the energy-intensive industry. 'Power-to-X'-projects can convert electricity to other energy carriers or chemicals – generally referred to hydrogen produced by the electrolysis of water.

Figure 62

The renewable hydrogen value chain



Source: GIS, 2020 based on Fortum.

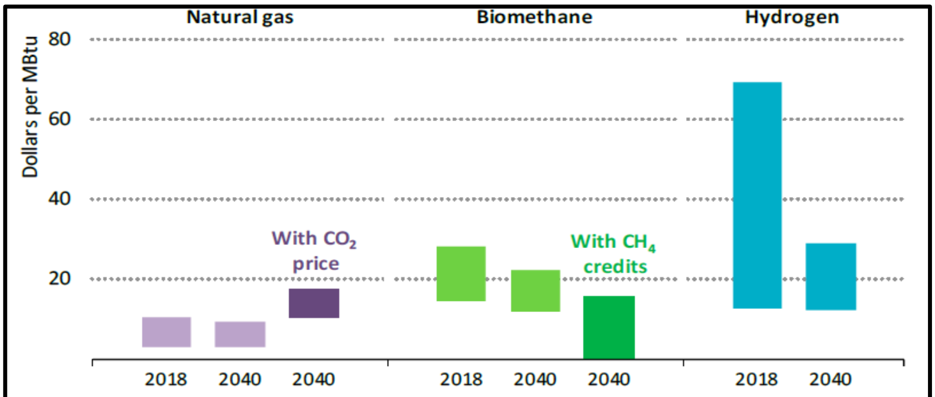
However, despite the worldwide hype on hydrogen, it still faces the following four major challenges:

- **Energy efficiency**: Producing hydrogen is still very energy-extensive and not energy-efficient – particularly with still costly renewables. But an IEA analysis concluded that the costs for producing it can decrease by around 30 per cent by 2030 due to mass manufacturing of fuel cells refuelling equipment and electrolysers. Nevertheless, as most applications for low-carbon hydrogen are not cost-effective without direct government subsidies, technological innovations and improvements of costs energy efficiency and other performance factors are needed and demand much more international cooperation in times when economic nationalism is on the rise. Energy efficiency is particularly challenging for converting hydrogen into synthetic fuels and feedstocks (such as ammonia - a compound of nitrogen and hydrogen and can be used as a refrigerant and as a chemical feedstock for nitrogen fertilizers) as 45-60 per cent of the electricity for the hydrogen production is lost in the process. Likewise, converting electricity to hydrogen, shipping and storing it, and then converting it back to electricity in a fuel cell, the delivered energy can be below 30 per cent of the initial electricity input. If the entire worldwide hydrogen production would be based on electrolysis, it would result in an electricity demand of 3,600 terrawatt hours (TWh) – more than the annual electricity generation of the EU.

- **Hydrogen with CCUS**: At present, hydrogen is almost completely produced by natural gas and coal. But it emits worldwide around 830 million tonnes of CO_2-emissions comparable with the combined emissions of Indonesia and the United Kingdom of Great Britain and Northern Ireland. For climate reasons, this option of 'blue hydrogen' (gas) or 'grey hydrogen' (coal) appears only realistic when CCUS can be used for producing hydrogen from fossil fuels and making it clean. But in Germany and many other EU member states, public acceptance of CCUS has been a major challenge as it lacks public and political acceptance despite previous political and government support.

Figure 63

Supply costs of natural gas, biomethane and hydrogen in the 'Sustainable Development Scenario (SDS)', 2018 and 2040



By 2040, the supply costs for decarbonised gases are closing in on those for natural gas, especially if externalities are taken into account

Notes: MBtu = million British thermal units; CH_4 = methane.

Source: IEA, 'WEO 2019'.

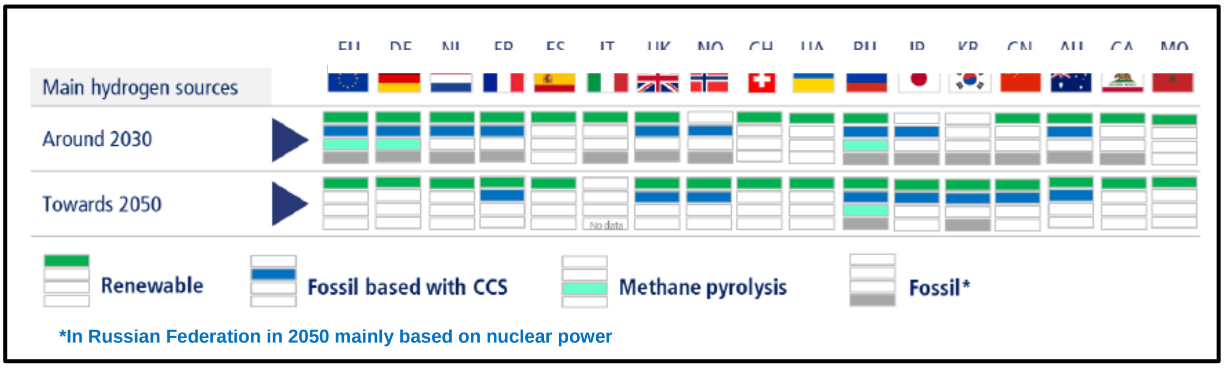
- **Hydrogen Infrastructure**: The development of hydrogen infrastructure such as refuelling stations requires some national or regional master plans for planning, cooperation and coordination between industry, local and national governments, and investors. The use of existing infrastructures could make the transition pathway easier and cheaper than building entirely new ones. In Germany, for instance, of the planned 1,200 km long gas pipeline network for transporting hydrogen, only 100 km need to be newly built by 2030 and 1,100 km of the existing network needs just to be modified. For longer distance transport, shipping is the more cost-efficient option for transporting hydrogen beyond 1,500 km. But at present, no liquefied hydrogen ships are in operation.

- **Hydrogen Regulations**: Present policies and regulations do not support the expansion of a clean hydrogen industry, which often constrain larger investments. The development and harmonisation of international standards for storing large volumes of hydrogen, adequate environmental protection and safety of transporting hydrogen needs to be fastened worldwide.

As with other clean energy sources, the perspectives depend on supportive policies by both governments and industry. But the costs are still too high, threatening capacity building efforts. Lighthouse projects and government support will be of crucial importance if at least half of this planned capacity is to come online by 2035.[220]

Figure 64

Considered medium-and long-term hydrogen production options by country



Source: WEC, 2020.

According to various forecasts, green hydrogen based on renewables could capture up to 24 per cent of the global energy demand by 2050. But the electrolysis of hydrogen conversion requires sufficient water and electricity supply. It is still the most expensive option accounting for less than 3 per cent of hydrogen production. A worldwide expansion of and shift to hydrogen in the international energy system and as a major instrument of decarbonisation will create new value chains – and therewith new geopolitical winners and losers as well as result in new challenges for energy supply security such as a rising dependencies on new partly politically unstable hydrogen producers. Thereby the geopolitical implications for a 'green' or 'blue' hydrogen future are different for hydrogen net-importers and exporters.[221]

The German and EU hydrogen strategies and the hope that they will become leading hydrogen technology suppliers will largely be dependent on technology innovation and technology-neutral pathways, which

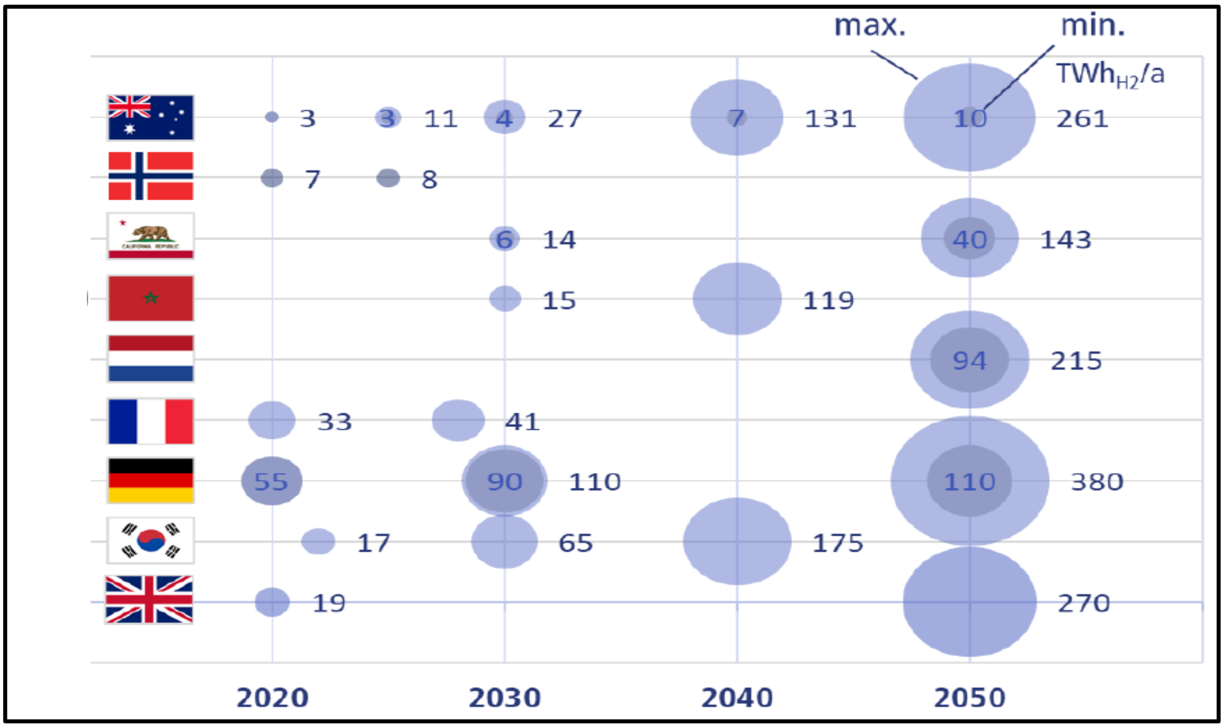
220 Brower, D., and M. McCormick, 'How the IEA sees the future of energy', Financial Times, 13 October 2020.

221 See again Umbach, F., and Joachim Pfeiffer, 'Germany and the EU's hydrogen strategies in perspective – The Need for Sober Analyses', and Umbach, F., 'Hydrogen: decarbonization's silver bullet?'.

do not disclose any technology option from the beginning. A 'technology-neutral' position is not just contested in Germany and the EU, but also in the United States of America, Australia, New Zealand as a myth to "underwrite fossil-fuel-projects with public funds" and subsidising the old 'dying' oil and gas industries. Turquoise hydrogen with gas pyrolysis, for instance, is a dry process without any water requirement and produces carbon black as a by-product. It can be transported by rail or truck, promises comparable advantages, and does not need CCUS (as 'blue hydrogen') and might prove a cost-competitive option. But the technology is still in the early stages.

Figure 65

Expected annual hydrogen consumption in TWh_{H2} per year, 2020-2050



Source: WEC, 2020.

Chapter 6

Balancing Short-Term Economic Recovery Programmes with Long-Term Energy Security and Climate Protection Objectives

6.

Balancing energy supply security with economic competitiveness and climate as well as environmental protection objectives has always been difficult for governments around the world for defining a sustainable development. Introducing renewables in national energy mix of a country, for instance, may have primarily environmental and climate reasons, but it also serves industrial interests (like in the Chinese, Japanese and German case) of renewables exporting countries. These countries are often also heavily dependent on fossil fuel imports and do not have a leading global oil and gas company (as the United States, Russian Federation, Saudi Arabia, the United Kingdom of Great Britain and Northern Ireland. and the Netherlands). For governments it is always more difficult to maintain the balance between the three or four objectives of the 'energy triangle' or 'energy trilemma' instead of favouring one at the expense of the other two or three. But without balancing the three objectives, neither national nor regional or global energy security can always be guaranteed.[222]

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222 Umbach, F., 2015, 'The Intersection of Climate Protection Policies and Energy Security', and idem, 'The Future Role of Coal: International Market Realities vs. Climate Protection?', EUCERS-Strategy Paper Six, King's College, London, May 2015.

Due to the interrelationship of improving energy (supply) security and mitigating climate change, both policy objectives can conflict with each other: on one side, the expanded use of domestic coal as the worldwide biggest emitter can strengthen energy supply security and bolster economic competitiveness as the cheapest fossil fuel, but will increase CO_2 emissions and fasten climate change. On the other side, reducing national emissions by 5 per cent through a switch from coal to gas (particularly pipe-based) can have negative impacts on energy supply security and economic competitiveness of economies and national enterprises.[223]

In addition, maintaining the balance between all three objectives of the 'energy triangle' has become even more difficult by new industrial policies subsidizing renewables like in Europe or promoting unconventional oil and gas exploration in the United States. An even bigger challenge nowadays for many democracies is public acceptance in the light of increasing ideological positioning, and new vested interests. Hence the three objectives often compete with or even contradict each other, creating an unstable 'energy trilemma' instead of a balanced 'energy triangle.[224] These dilemmas are added if one differentiates between short- and longer-term interests by defining and promoting the energy transition to a non-fossil fuel age:

(1) **An expansion of renewables allows the countries to reduce their fossil fuel import dependency and related geopolitical risks, diversify their energy mix and strengthen energy supply security. But as analysed in chapter 2, many countries in Asia and elsewhere (especially developing countries) then are also becoming dependent on new global value chains and suppliers** – either on exporters of renewables and hydrogen or on producing and refining countries of CRMs if they produce the renewables themselves. In the short- and mid-term perspective, renewables and the worldwide energy transition to a global decarbonised energy system may offer diversification of the energy mix by adding various renewables to the energy mix. In longer-term perspective, an electrified energy system will rely rather on a single transport modality and a less diversified energy system with subsystems being all

[223] International Energy Agency (IEA), 2007, 'Energy Security and Climate Policy. Assessing Interactions, Paris: IEA, pp. 18, 102 ff.

[224] Wyman, O., 2017, World Energy Council (WEC)/, 'World Energy Trilemma Index 2017', London.

dependent on a stable supply of electricity, the internet and a resilient cybersecurity environment.

(2) **A wider expansion of renewables in the energy and electricity mix demands massive investments in other energy infrastructures (such as smart grids and smart metering)** as well as subsidizing fossil fuel power plants as they are not operating 24 hours a day, but are still needed for peak-times due to the variability of renewables for a continuous electricity supply around the clock. The expansion of renewables ultimately is changing the entire energy system, which needs to be modernized. The often overlooked hidden (or systemic) costs by expanding renewables are particularly challenging for developing countries, which need access to electricity and modern energy sources. But by advancing their economies, they are also becoming increasingly dependent on a stable supply of electricity for 24 hours a day. Thus, the storage of electricity, along with flexibility in use of electricity, energy forecasting and cross border exchanges of power, becomes an ever more important solution for expanding renewables. Declining battery costs have allowed to address at least the short-term challenges of storage in the power sector. Batteries however are unable to store electricity at scale and for longer-term use in the energy intensive industries. Despite the declining costs of batteries, the question of affordability of batteries in developing countries will remain a challenge for years to come. In this light, governments and the management of utilities need to take into account not just the direct costs of renewables, but also the cascading costs throughout the entire energy system in the longer energy transition process.

(3) **This task has become ever more challenging for the energy transition with the widespread introduction of digitalization technologies, which will further increase new value chain dependencies, including to finance new disruptive technologies.** The IEA warned in its annual 'World Energy Out 2019'-report: "The faster the transformation required – and the scientific evidence shows that this push needs to be very rapid indeed – the greater the risk of poor co-ordination or unintended consequences for the reliability or affordability of supply."[225] Thus accelerating the energy transition to a non-fossil fuel age as a consequence of the international climate change policies and targets is further complicating the balance between shorter- and

[225] IEA, 'WEO 2019', p. 78.

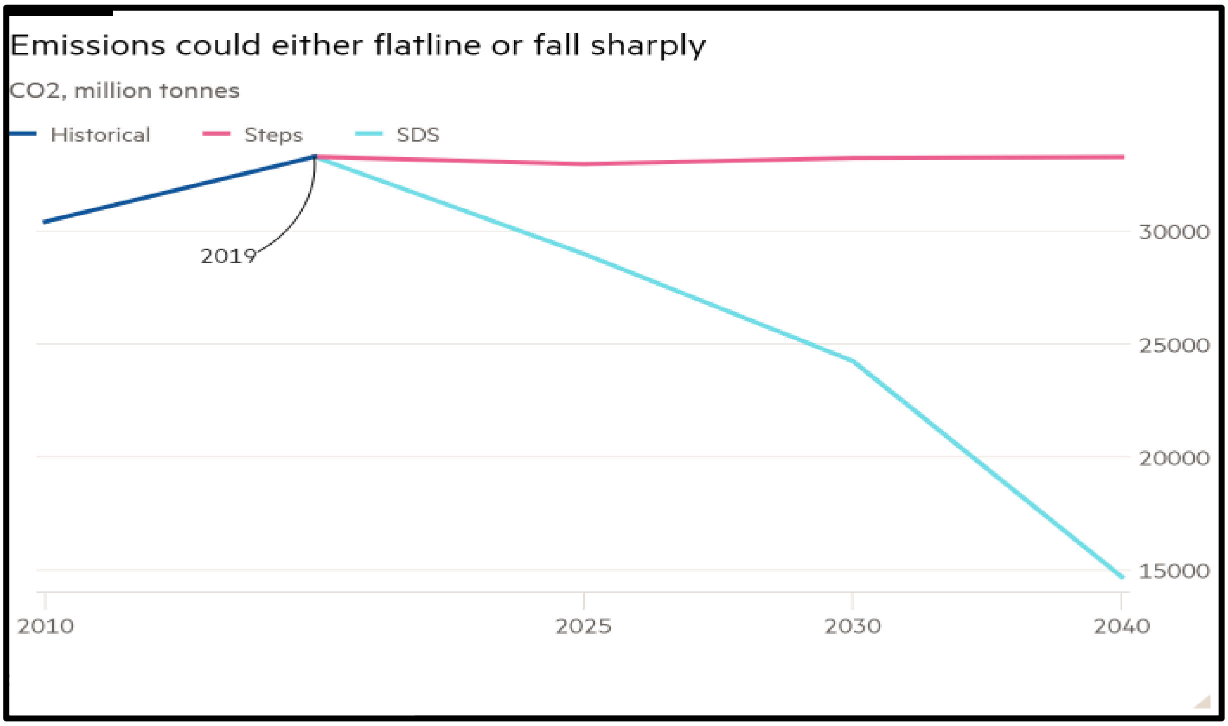
longer-term objectives in the energy policies and particular in regard to the much needed massive investments in renewables, electricity grids and other infrastructures as well as subsidizing the energy system for guaranteeing baseload stability and energy supply security.

(4) **Despite declining costs of renewables and batteries, many governments have still invested in traditional fossil-fuel projects (such as coal power plants) rather than in renewables. But these new fossil-fuel projects produce longer-term lock-in effects of 'stranded assets'**. Thus, the cheaper fossil-fuel projects of today may prove much more expensive in the mid- and long-term future. This already existing problem and dilemma is further increasing with the global COVID-19 pandemic.

(5) The multifaceted pandemic crisis is threatening core development goals (like SDG7 and SDG13), multilateralism and international cooperation. Although the global pandemic has affected all countries, they are not impacted in the same way. Moreover, their ability to resist and recover from the multiple shocks is not equally distributed either due to the various resilience of their healthcare, energy, and other sectors. The resilience depends on how much attention the countries have spent on potential crisis as well as disruption of services and supplies in the past. Too often governments have overlooked or marginalized potential supply crisis and have either no or at least insufficient emergency plans and built-in resilience capacities. Investing in much needed redundancies for cybersecurity or global pandemics is of course a cost factor. **Thus, insufficient investment in redundancies as part of resilience concepts may serve short-term interests but is contradicting long-term interests as those crises may turn out as much more costly than any preventive policies and investments.**

Figure 66

Future emissions development by different IEA-scenarios, 2019-2040



Source: Financial Times, 2020, based on data from IEA's WEO.

Hence the present pandemic crisis should be used for reviewing and re-evaluating existing emergency plans and concepts for enhancing their resilience by lessons learned. In the light of previous epidemics and pandemics (like SARS and MERS), an even more global severe and more deadly pandemic cannot be excluded. This scenario should be included in future emergency concepts, which also need to be simulated and trained. If a more severe pandemic will increase the number of dead workers and specialists in CIs, the energy sector and other CIs may face major challenges of functioning as a stable supply of electricity for CIs. A shortage of specialists and skilled workforce could have been of the most underestimated impacts of a severe pandemic and important security challenges of the energy sector and other CIs. Even a longer-lasting rule of social distance may complicate the internal functioning of the energy sector in crisis by reducing a minimal emergency workforce for CIs.

Maintaining the functioning of reliable national electricity supply and grid stability for CIs with sufficient resources - including a redundant professional workforce and other Backup capacities as well as disaster recovery operations as part of the process for restoring delivery mechanisms - will become an ever more important strategic tasks for governments and energy companies – particularly when rising cyber risks and vulnerabilities are taken into account alongside of the energy transition, the electrification of the transport, heating and 'industry 4.0' as well as the introduction of numerous new digitalization technologies and billions of unsafe IoTs applications.[226] Under those rapidly changing circumstances, the traditional supply services for CIs cannot be granted during a lasting global pandemic and with a rapidly rising electricity demand for the functioning of state functions and economic operations. But without stable electricity supplies throughout the day and night, no other CI will function. All modern societies rely more than ever on a stable electricity supply. A collapse of the energy sector could have cascading impacts on the functioning of the other CIs.[227]

The existing emergency plans for the functioning of CIs in major crisis need to be reviewed and re-evaluated in the light of the present pandemic challenges and its impacts on supply chains. The worldwide crisis in the healthcare sector during the months after the outbreak of the COVID-19 pandemic has revealed a heavy dependence on masks and healthcare protection material as well as on basic medicines on just two major suppliers (China and India). The failing diversification of suppliers has indicated a lack of preparedness and emergency planning to pandemics or other reasons of supply disruption. The increasing reliance on 'just-in-time' global supply value chains has highlighted a lack of resilience in the healthcare sector, which also offers lessons to be learned in other critical sectors.

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226 See chapter 2 again.

227 ibid.

These specific 'just-in-time' global supply chains are defined by supply efficiency and cost effectiveness as well as operation in normal times. But they are inherently unable to deal with immediate regional and global supply disruptions in a major worldwide supply crisis due to a severe global pandemic or other cases.[228]

In contrast to the global healthcare sector, the worldwide energy sector has traditionally been conceptualized by thinking through supply disruptions (due to political instabilities in fossil fuel exporting countries or due to the use of energy dependencies for geopolitical objectives) and developing responding strategies for enhancing energy resilience.

Figure 67

Energy security instruments and approaches for Strengthening Supply Security, Redundancy and Resilience

- Building-up and expansion of oil and gas storage sites, which gives IEA member states a stable supply in times of import shortages and disruption (in the case of oil up to some 90 days of national demand).
- Diversification of the energy mix by expanding renewables: the broader the mix, the less dependent is a country on a single energy resource.
- Diversification of oil and particularly gas imports (to reduce the dependence on a single supplier) by:
    - expanding LNG imports and import terminals;
    - the creation of regional energy markets (like in the EU) with common regulations to guarantee competition and political sovereignty on the regional markets;
    - the building of transnational gas and electricity interconnectors to neighbouring countries for ending national isolation or 'energy islands'.[229]
- New holistic strategies for coping with rising cybersecurity challenges for increasing resilience of energy and electricity supplies for the stability of the countries' CIs (including redundancy capacities and backup systems).

Source: Umbach, F.

The worldwide economic fallout of the pandemic and the priority to shift all political attention and resources to its challenges has put the topic of climate change mitigation policies to the side-lines. Even after the end of the worldwide

228 Umbach, F., 'Supply Chain Security: The Energy Sector's Lessons for Healthcare'.

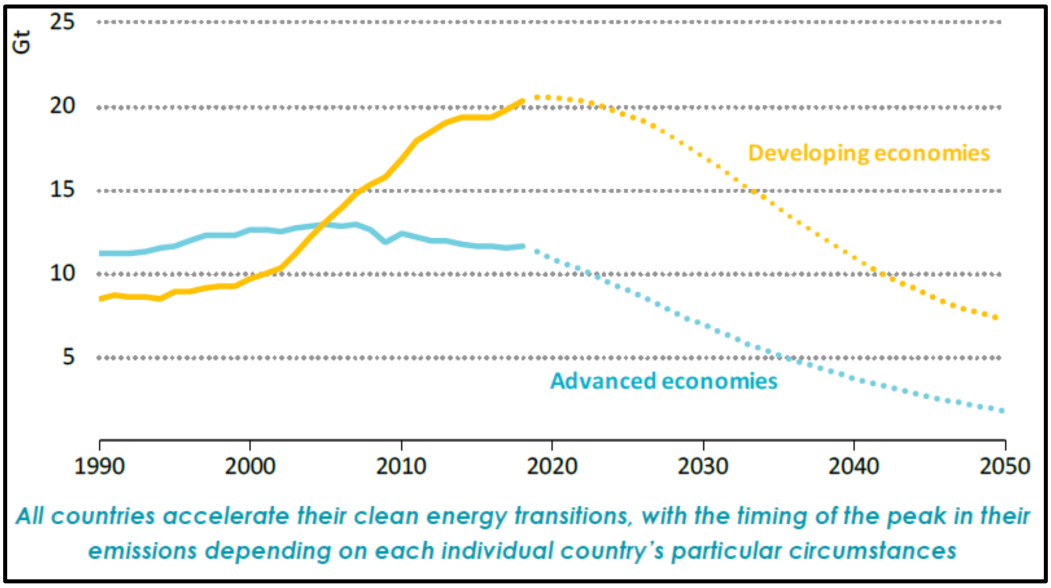
229 For Asia see also ESCAP, 2019, 'Electricity Connectivity Roadmap for Asia and the Pacific. Strategies towards interconnecting the region's grids'.

pandemic, many governments may return to coal as a domestic, cheap, and worldwide available energy resources internationally at the expense of a rapidly expansion of renewables as it fits into their short-term interests. The political priority might focus on the economic revival with limited financial resources being left for the next decade.

Ahead of the COP26 global climate change summit in 2021, the discrepancy between much more ambitious energy policies for the green energy transition and the realities on the global energy markets may further grow. China, Japan, and the Republic of Korea have adopted a carbon neutral target by 2060 or 2050, but to date no new ambitious goals by 2030 for achieving the long-term target of 1.5°C of climate change. While advanced economies (including China) need to go ahead and to set examples to follow by developing countries, also the latter ones need to adopt more ambitious green energy policies – particularly in the most ambitious SDS and NZE2050-scenario. This has already proved difficult in the light of their population growth and rising living standards. It might be even more challenging in the next years, which calls for more international support and collaboration.

Figure 68

CO_2-emissions in advanced and developing economies in the 'Sustainable Development Scenario (SDS)'



Source: IEA, 'WEO 2019'.

Balancing between shorter- and longer-term energy security interests of countries is also different between the individual scenarios offered by the IEA. At a first glance, the 'Delayed Recovery Scenario (DRS)', appears rather as a relatively low risk one for energy security: the global energy demand is lower, creating a longer period of worldwide overcapacities on the supply side and easing potential concerns about sufficient timely investments. Energy prices are likewise lower than in STEPS, so that the affordability of energy could also be seen as less of short-term concern.

However, these factors do not remove worrying strategic concerns to the security of energy supply in the DRS. But the price declines, the sharp investment decline of around 18 per cent in 2020 and near-term excess capacity in many markets also create uncertainties for the mid- and longer-term energy security. Whether they will be proportional to the demand shock is uncertain and difficult to estimate and project, which may create risks of market volatility as markets need to rebalance. While the vulnerabilities are different between countries, the revenue declines would make the task of maintaining key public services and economic growth even more challenging, added by the need to create jobs for large, youthful populations, and to create adequate investment conditions for the private sector. Under DRS and a longer economic recovery, maintaining commitments to reform and diversify their economies becomes even more difficult.[230]

Furthermore, any perceived peak in fossil fuels could result in increased competition among producing and exporting countries of fossil fuels as it may force them to produce as much as of their remaining fossil fuel resources to avoid stranded resources. It could lead to a more dramatic fall of oil prices and lower extraction costs, which could further slowdown the decarbonization processes.[231] Even significant amounts of recoverable oil and gas resources might never be extracted.

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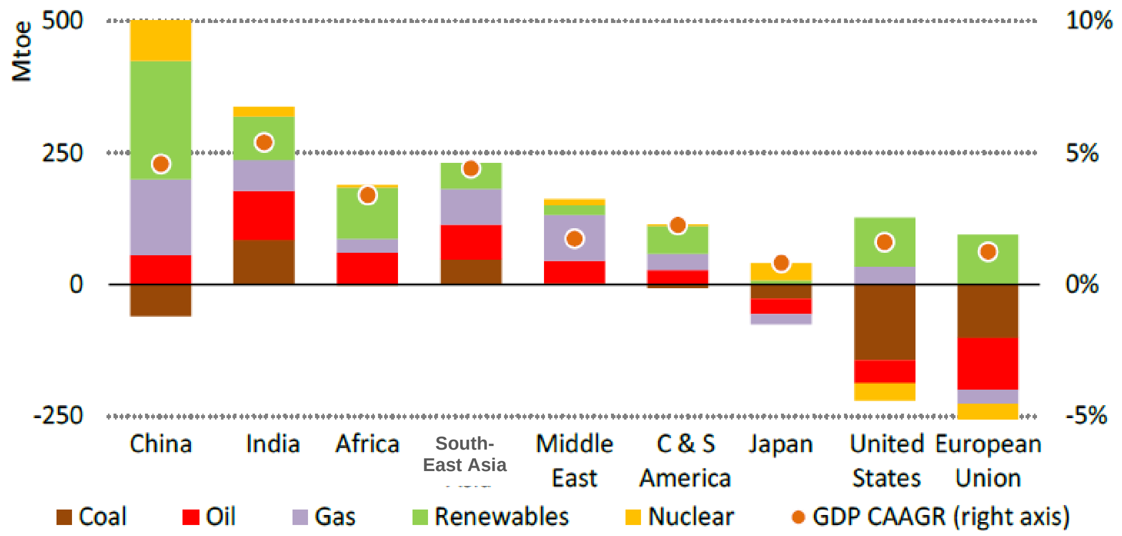
[230] IEA, 'WEO 2020', pp. 318 ff.

[231] Raval, A., 'Fixation on Timing of Peak Oil Is 'Misguided', Financial Times, 18 January 2018.

Figure 69

Changes in primary energy demand by fuel and region in the STEP-Scenario, 2019 and 2030



Renewables see the most growth in all regions, followed by gas, while coal use declines. Demand growth is highest in China and India

Note: GDP CAAGR = gross domestic product compound average annual growth rate; C & S America = Central and South America.

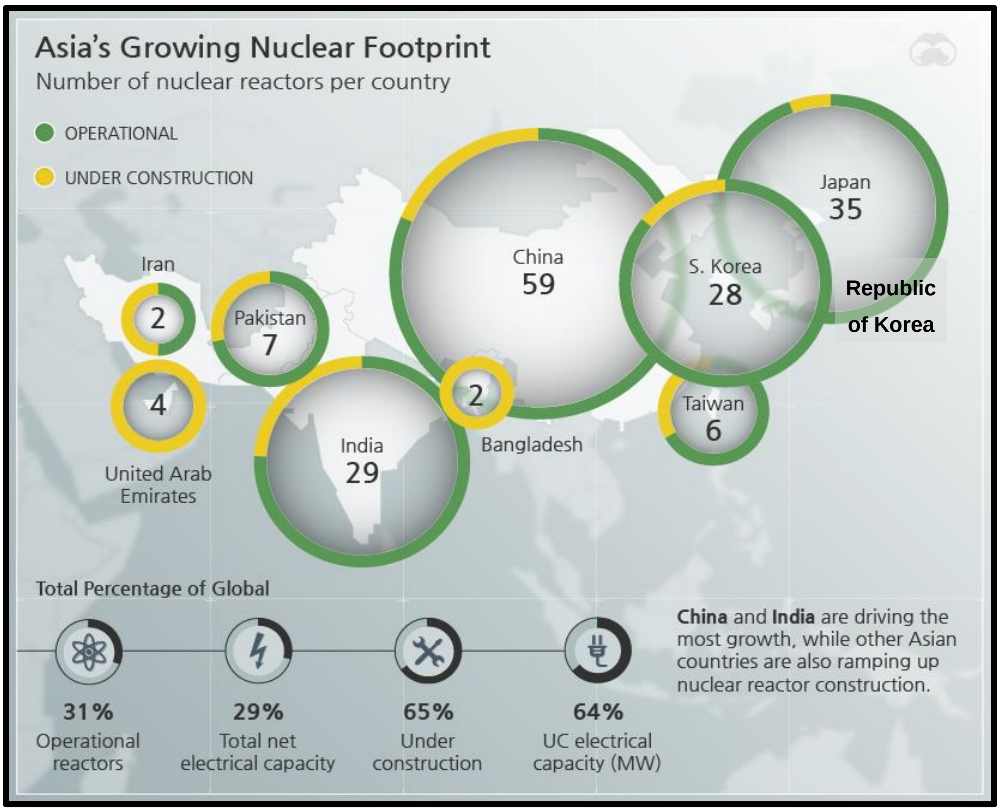
Source: IEA, 'WEO 2020'.

In STEPS, the changes of the energy mix would be rather marginal in the mid-term perspective compared with the much more ambitious SDS and NZE2050-scenario.

In contrast to DRS and STEPS, the 'Sustainable Development Scenario (SDS)' envisages that also nuclear energy would play an important role in decarbonising the power sector in countries that seek to support its future deployment. But despite the cost-effectiveness of operational lifetime extensions, building new nuclear power plants is presently with the declining costs of renewables and natural gas (including LNG) not cost-competitive - especially if the unresolved long-term storage costs of nuclear material are included. Nonetheless, nuclear power plays in China and Asia a larger role as they have not sufficient indigenous energy resources and thus have become dependent on nuclear energy for their own energy security.

Figure 70

Asia's growing number of nuclear power plants



Source: Eurasia Group, 2020.

Despite the net-zero emissions target for 2050 and 2060 and the expansion of renewables as well as many other green technologies, the world is still on the pathway to warm more than 3°C by the end of the century.[232] In this light, the SDS also projects that CCUS needs to be more widely deployed in order to capture an annual average of 1.5 Gt CO2 between 2019-2050 to put the world on track to meet the objectives of the Paris Agreement. The volume of CO_2 captured would have to increase to 2.8 Gt in 2050 – equivalent to 28 per cent of total CO2 emissions in that year. In the view of the IEA and its SDS, CCUS would be almost equally split in 2050 between the power and other industry sectors (including cement, iron and steel, upstream oil and gas, and refineries). In the power sector, CCUS is concentrated in a handful of countries, especially China and the United States of America.

[232] Bernard, S., 'Paris Climate Agreement Anniversary: Energy Trends since 2015', Financial Times, 12 December 2020; Leslie Hook, 'China Lays out Steps towards Climate Targets at UN Summit', Financial Times, 12 December 2020; Hook, L., 'Climate Change: ,the Paris goals are within Reach', Financial Times, 12 December 2020; and Hausfather, Z., 'Net-Zero Pledges from China, the United States of America, EU and Others can Meet our Climate Goals, Says UNEP. But…', Energypost.eu, 8 January 2021.

A net-zero carbon power system - whether SDS or NZE2050 - needs an ever more careful long-term and integrated planning covering all parts of the energy system and industry sector as a whole. As also the IEA has noted, the entire system capacities need from today to deploy all kind of low-emissions technologies to achieve net-zero emissions by mid-century. Existing fossil fuel assets will have to be repurposed, retrofitted with CCUS or retired. For the future electricity security and demand, a sufficient investment in electricity networks and flexibility to accommodate the high levels of electricity generation coming from variable renewables need to be guaranteed.[233] However, in these technocratic and technological assessments, neither costs and affordability nor public acceptance, other competing political objectives (such as numerous short-term interests) or the need of a worldwide change of human behaviour do play any major role or concern. Any projected investment assessment should be read with great caution as the German Energiewende and experiences in other countries teach because they have always and repeatedly until today greatly underestimated the huge investments needs.[234]

The other big question for the Asia-Pacific region is how climate change will determine government and industry policies over the next years and decades as the region is at the front line of the global climate warming and is expected to experience much more socio-economic impacts than global averages and other world regions. Also McKinsey has forecasted in its climate risks analysis for Asia (see also figure 67) that system thresholds will be breached and knock-on effects on infrastructures and other costly damages will materialize, forcing countries and the region to adopt costly mitigation measures for enhancing resilience across all economic sectors.[235]

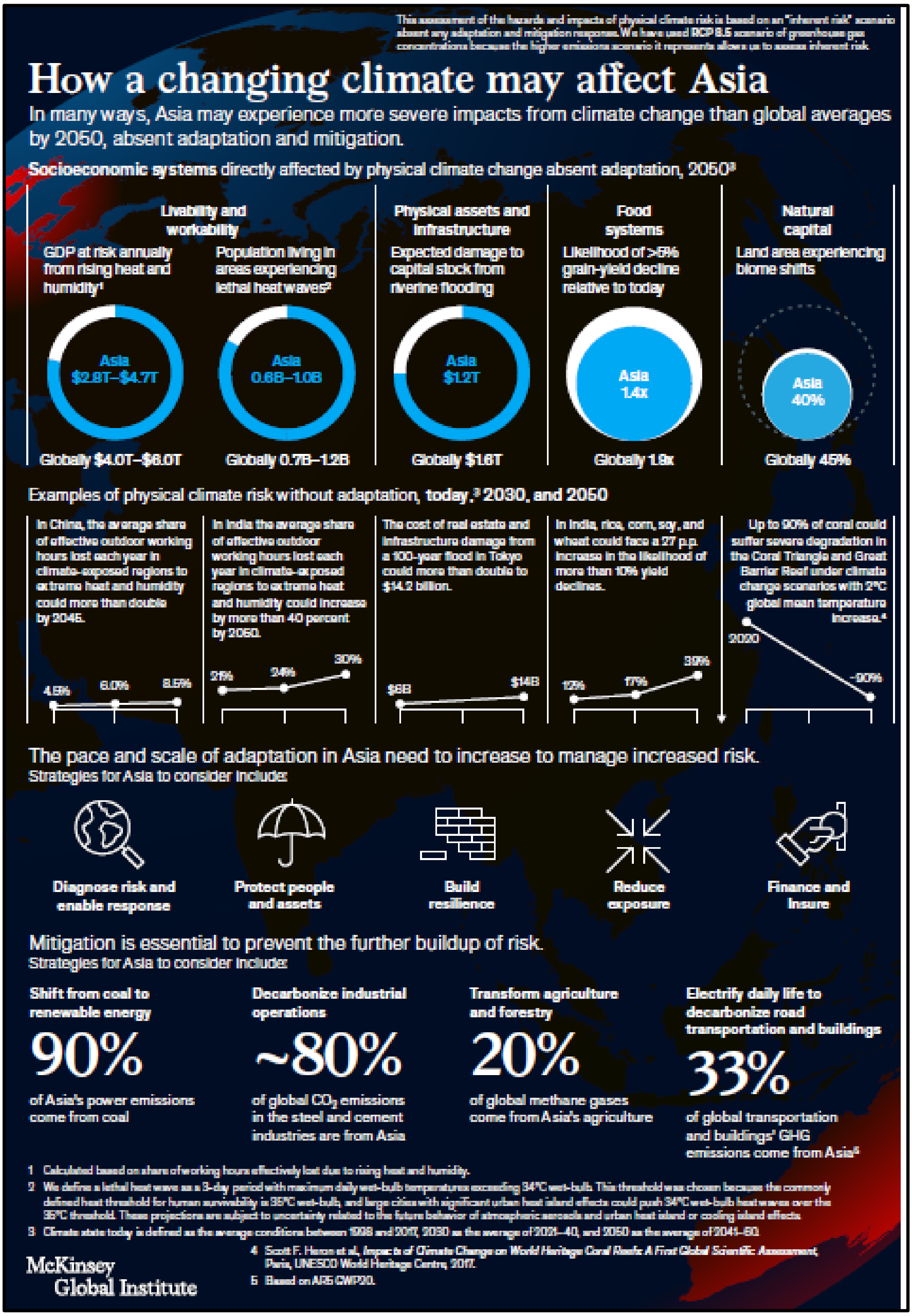
233 IEA, 'WEO 2020', p. 159.

234 The Energy Transition Commission, 'Making Mission possible'. The report calculated the incremental investments for the next 30.-40 years to achieve a zero-emissions economy at only about 1-2% of global GDP per year.

235 McKinsey Global Institute, 'Climate Risk and Response in Asia', November 2020.

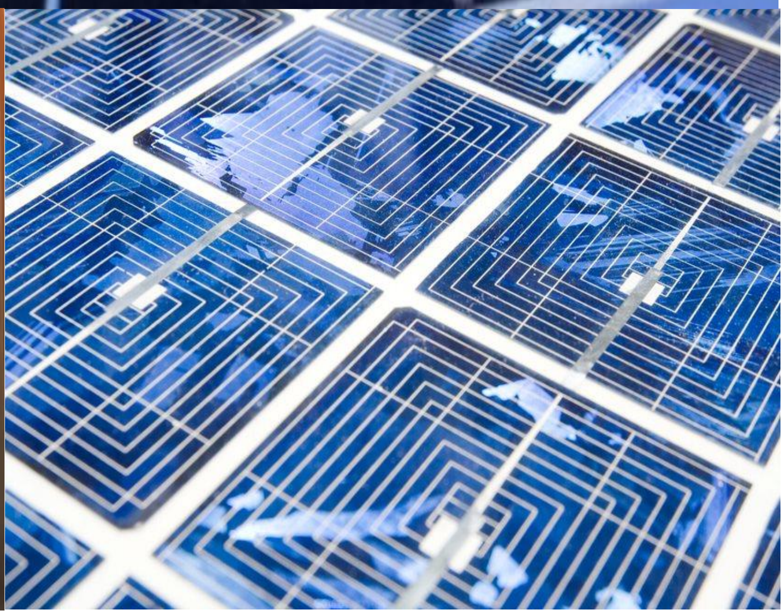
Figure 71

How climate change may affect Asia



Source: McKinsey Global Institute, 2020.





Chapter 7

Conclusions and Recommendations

The traditional energy security concepts were based primarily on the historic experiences with the oil supply crisis in 1973, which demanded new thinking and addressing the oil disruption to the Western consumer countries. These concepts and energy security strategies have been focused on the diversification of the energy mix and fossil fuel imports for reducing oil dependencies from one single country or region, particularly from politically unstable oil producing and exporting countries. These strategies need to balance the diversification of imports with the costs of oil supplies as those in Saudi Arabia and the Gulf region have always been cheaper than in other regions and countries. The diversification imperative has also played a role for importing nuclear material (especially uranium and plutonium), but had not been considered an energy security risk comparable with oil supplies as the remaining oil reserves have been concentrated in the Gulf- and Middle East and North Africa (MENA)-region. Another instrument for oil supply security has been the oil storage for about 90 days of national consumption.

With the expansion of renewables, the electrification of the transport sector and industries (‘industry 4.0’) as well as the widespread introduction of new digitalization technologies, the energy markets are undergoing fundamental shifts. They offer economic benefits (enhancing energy efficiency and conservation) and, together with decarbonization efforts contribute to the realisation of the long-term target for mitigating climate change to just 1.5°C, the prospect of reducing 'dirty' fossil fuel imports, therewith increasing energy (supply) security, and a green energy transition to a non-fossil-fuel age and sustainable developments in light of the UN goals (particularly SDG7 and SDG13). But like all new technologies, they do not just offer new benefits for private and industry consumers, but also create new supply security challenges, risks, and vulnerabilities (particularly regarding cybersecurity). With all new digital interconnections, the countries and their critical infrastructures (CIs) are becoming ever more dependent on (a) stable access to the internet, and (b) on a stable electricity supply. Hence a reliable electricity supply is a pre-condition that all other CIs are able to operate 24 hours a day, which is a national security interest for governments as otherwise all public and governmental functions cannot be provided and managed. These problems are added by the fact that many new technologies (such as smart metering, Internet of Things (IoTs) are designed and developed with often no digital safety requirements. As such, they are often little computers, which add billions of targets for cyberattacks with potential cascading impacts along entire supply chains and other sectors as well as CIs.

Furthermore, although renewables can be considered as a local energy source, which reduce fossil fuel imports from politically unstable exporting countries, their production, and rather short operational lifetimes (being replaced with newer versions of solar cells and windmills every 10-15 years or even less) create new import dependencies on politically unstable mining countries exporting CRMs. The concentration of some of those CRMs in mining producing and refining countries is often much more challenging. It therefore is more difficult to diversify those imports and avoiding an overdependence of imports from a single country or few exporters.

The argument has often been made that the problem of overdependence cannot be instrumentalized in short-term perspective as countries can diversify those imports from other countries. This argumentation has often been used in the case of rare earths supplies, whose reserves and resources are globally much more widespread available than the term "rare" and the present production and refining capacities suggest.

Furthermore, and often overlooked, efforts for diversifying rare earths are often hampered by strict environmental regulations particularly in many advanced economies and much higher prices elsewhere. Moreover, opening new mining sites internationally takes in average 7 years from the original planning until the first production. In developed countries, the average time is often even more than 10 years. Thus, the option of diversifying mining production and refining capacities worldwide has de facto often proved rather difficult, and in political-economic realities ultimately often impossible. In addition, the supply situation of the 17 different rare earths minerals existing varies by itself. The worldwide demand for heavy rare earths, for instance, is particularly troubling as resource availability is concentrated in very few countries.

These examples and new energy security challenges call for new holistic concepts and strategies of energy security, which need systematically to address and conceptualise them not just individually and separately from energy security discussions as well as traditional concepts and in isolation to each other. Thus these new challenges of supply strategies for CRMs, disruptive technologies and their wide-ranging impacts, new cybersecurity risks and vulnerabilities, impacts of the decarbonization on traditional oil and gas producing countries, new geopolitical dependencies as the result of the expansion of renewables and batteries, a potential higher increase of the worldwide electricity consumption and lessons learned from the global COVID-19 pandemic need to be an integral part of those new holistic concepts for enhancing national, regional and global energy security as well as resilience.

Equally, energy security is being perceived, discussed and conceptualized on the side of producer countries differently from net-importing countries as they are particularly interested at 'demand security'. With the worldwide declining oil, gas and coal prices as the result of an era of energy abundance (instead of a previously expected 'energy scarcity') and worldwide efforts for decarbonizing the energy sector for climate change mitigation goals, their economic-political stability could be at larger stake if they do not diversify their economies away from their oil and gas export revenues for their state budgets. But any economic diversification of traditional 'rentier states' is a daunting task and challenge, which takes decades rather than years and need timely investments for the next decades.

This problem adds to the need for balancing short-term with longer-term interests of governments and the management of energy companies as new investments could prove unprofitable over time by becoming 'stranded assets' as the result of decarbonization policies or disruptive technological developments (such as the United States oil and gas revolution). Moreover, the unprecedented energy transition and energy transformation themselves are challenging as it demands to conceptualize them systematically for the entire energe systems. Thus, the expansion of renewables force governments to modernize all other kind of energy infrastructures (such as electricity grids) and to change the traditional pricing system of energy (especially electricity). The declining costs of renewables and batteries are a promising investment signal, but itself can also be misleading as many hidden and cascading systemic costs - directly linked with the expansion fo renewables and batteries – are often overlooked or underestimated.

Balancing those short- and longer-term interests has now become even more challenging and difficult with the economic impacts of the multi-faceted global pandemic. This is also due to the still too much overlooked fact that countries and populations are affected even within a region often in different and uneven ways that demands country-tailored strategies for economic recovery and coping with different mixes of short-term and longer-term strategies. Those differentiating strategies are needed for both developing countries and advanced economies but also among both groups themselves. The affordability of modern energies by including the hidden systemic costs of the concrete national energy transition need greater attention and better assessments for ensuring a realistic, fair and inclusive energy transition that leaves no one behind.

The understandable short-term interests for helping as well as supporting the poorer and most affected people by the pandemic also needs to be balanced with prudent and timely long-term investment strategies for expanding renewables and new digital technologies or even more disruptive Artificial Intelligence (AI) systems. The tendency or political temptation of a return to energy nationalism instead of regional and international multilateralism and cooperation can prove economically as well as politically as very costly for all countries and is no viable instrument to achieve the Sustainable Development Goals.

The developing countries also need material and financial support as otherwise the progess they made for a sustainable development might be reversed, which is threatening national and regional stability. The costs of doing nothing or even just delaying political-economic decisions by the international community, coping itself with economic recovery and financial liquidity, can prove as destabilizing for the regional cooperation and the international system – be it in the Asia-Pacific region or elsewhere. At present, around 1 billion people have currently to rely on healthcare facilities without electricity. The worldwide pandemic has made this situation often even more difficult to overcome.

Although for the worldwide and the Asia-Pacific energy sectors, electrification is central to emissions reduction efforts, low-carbon fuels are also needed in the view of the IEA. There are a number of other sectors that will require energy sources other than renewables and electricity to reduce emissions. This includes most of the world's shipping, aviation, heavy-duty trucking, and certain industrial processes. New technology options such as hydrogen, CCUS, biomethane and biofuels and other low-carbon fuels will become more important in the years ahead for a comprehensive decarbonization of the Asia-Pacific economies. Some liquid or gaseous fuels can be generated using electricity, even though they would require separate delivery infrastructures and supply chains.

Technology innovation remains a critical factor that also requires more regional and international collaboration as also the present global pandemic teaches. Developing new technologies and successfully deploying these at industrial scale can take a long time. It has historically taken 10-30 years for new energy technologies to go from first prototype to reaching the market. But the present challenge and risk is also that a rapid, uncoordinated, and badly managed introduction of new disruptive technologies may lead to unanticipated cascading impacts, which could prove as very costly or even as systemic failures blocking the further energy transition and economic developing of countries. Those risks might be even more challenging for developing countries, which do not have any financial capacities to re-start a failing energy transformation.

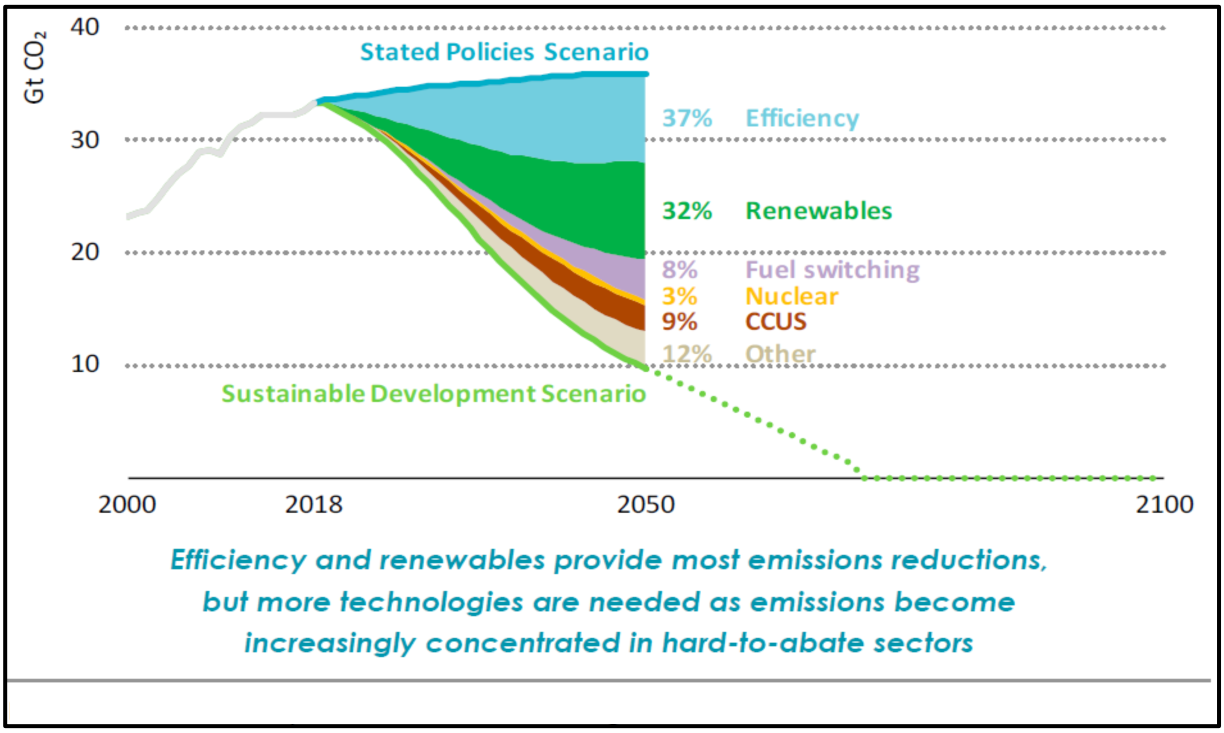
In the IEA's 'Sustainable Development Scenario (SDS)', development periods for emerging technologies are assumed to be at the lower end of this range, with new small or modular technologies taking less than 15 years from first prototype to reach the market, and larger or non-modular technologies taking less than 20 years. In the view of the IEA and international experts, the policy support remains needed to increase R&D as well as deployment spending and encourage risk sharing by private actors. Investing in decarbonized and green energy projects offer universal energy access, create new jobs, contributing to economic growth, accelerate innovation and support a more resilient and sustainable energy security future.

Given the already existing public acceptance problems, it is vitally important to engage by governments and industries more actively with citizens to help gain public acceptance for change, including of consuming behaviour. It is not possible to achieve large emissions reductions without a more open dialogue with citizen about the question how engage with or use energy. The change and education of consumer behaviour will become a more important task for more ambitious decarbonization efforts as they will inevitably have wide-ranging effects on large numbers of people demanding a careful handling and communication.

Despite international rivalries and increasing regional competition, regional and international collaboration can boost common projects and mutual interests and decrease the overall costs of the energy transformation and transition processes, making the target of mitigating climate change below 2°C more realistic. Achieving widespread net-zero emissions will require even more careful coordination to avoid possible conflicts of interest, maximise possible synergies and to help build consensus on the importance of regional and global emissions reductions. Cross-border and cross-sector collaboration would also help more countries to deploy particularly clean energy technologies as costs would decline more rapidly and allow project which many developing Asian-Pacific countries cannot afford nationally.

Figure 72

Emissions reductions by energy sources and technology options, 2000-2050



Source: IEA, 'WEO 2019'.

Finally, the Asia-Pacific region with a rather high population increase and dynamic economic development will play an ever more important role in global climate change and will have to take over more responsibilities for climate change mitigation policies. The Asia-Pacific region accounts for some 60 per cent of global CO_2-emissions – almost two-thirds resulting from the energy sector and its internationally high coal production and consumption – equivalent to 80 per cent of the worldwide coal consumption. The call of United Nations Secretary-General António Guterres that countries need to end their reliance on coal still needs to be heard in Asia-Pacific despite recent declarations of being carbon neutral in the long-term perspective by 2050 or 2060.

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