Low-Carbon Energy Transformation in China, India, Pakistan, and Afghanistan: An Overview

Abdullah Fahimi and Kai Stepputat

Abstract

Approximately 40% of the world's population lived in China, India, Pakistan, and Afghanistan in 2021. These countries were responsible for about 36% of the world's CO_2 emissions in 2018. Economically, in the same year they represented 20% of the global Gross Domestic Product (GDP). Considering the population, the CO_2 emissions, and the share of their GDP in world economy, actions in these countries regarding fighting climate change and promoting low-carbon energy transformations have global consequences and are key to realization of 2015 Paris Agreement and Sustainable Development Goals (SDGs) (e.g., SDG7 and SDG13). In this article, we review the current energy situation, low-carbon energy targets and challenges to low-carbon energy transformation in each country and provide an overview of general trends and key factors in this transformation. The assessment shows that the above countries are not on the path to achieve the Paris Agreement target. CO_2 emissions and the use of fossil fuels are still high in these countries. However, general trends such as decreasing costs of renewables, a decreasing dependency on

A. Fahimi (✉)
Institute of Sustainability Governance (INSUGO), Leuphana University, Lüneburg, Germany
e-mail: abdullah.fahimi@stud.leuphana.de

K. Stepputat
Technical University of Berlin, Berlin, Germany
e-mail: stepputat@campus.tu-berlin.de

S. Groh et al. (eds.), *Electricity Access, Decarbonization, and Integration of Renewables*, Energiepolitik und Klimaschutz. Energy Policy and Climate Protection, https://doi.org/10.1007/978-3-658-38215-5_5

fossil fuels imports, additional liquidity for energy infrastructure due to fuel costs savings, and remuneration schemes for renewables are all promising for decarbonisation efforts and low-carbon energy transformation.

Keywords

Low-carbon energy transformation · Global South · China · India · Pakistan · Afghanistan

1 Introduction

The four countries China, India, Pakistan, and Afghanistan play a crucial role regarding climate change. Representing approximately 40% of the world's population in 2021, around 20% of the world's GDP in 2019 and around 36%[1] of the world's CO_2 emissions in 2018 (World Bank, 2016b, 2020, 2021c; IEA, 2018d, 2020a, d, e), their energy development pathways have significant impacts on the world's climate.

On the one hand, due to their economic and social characteristics, including economic catch-up processes and ongoing inner demographic processes and trends such as urbanization, a growing middle class and changing consumer patterns, they contribute significantly to the rise of CO_2 emissions. Efforts to increase access to energy, especially in the latter three countries, could further contribute to emissions rise if relied on fossil fuels instead of low-carbon energy sources.

On the other hand, these countries, in particular China and India, are strongly promoting the development of renewable energies, for example through the expansion of wind and solar capacities. Between 2015–2017, additions of coal capacity in developing countries have decreased significantly, most of it due to reductions in China and India, which have simultaneously promoted the development of renewable energies (Nicholas & Buckley, 2018). Total installed renewable capacities in 2020 were 2,799 GW, of which China had a percentage of 31.97%, India 4.79%, Pakistan 0.44% and Afghanistan around 0.013%, so in total the installed renewable capacities of these countries combined was more than 37.2% of the world's share (IRENA, 2021a).

[1] This is an estimated number as the latest available CO_2 emission figures from Afghanistan are from 2016.

In the following, an overview of the current energy situation will be given for the countries People's Republic of China (hereafter China), Republic of India (hereafter India), Islamic Republic of Pakistan (hereafter Pakistan), and Islamic Republic of Afghanistan (hereafter Afghanistan). For each country, a brief context will be followed by a short overview of energy production, consumption, and renewable energy potential. As electricity is becoming increasingly important as an energy carrier to meet increasing energy demands and to decarbonise sectors such as transport and heating, the focus in these sections is on electricity. Data from the International Energy Agency (IEA) and World Bank, our two main data sources, is complemented by information from national authorities. Each country section will conclude by identifying challenges to the low-carbon energy transformation. The country sections will be followed by a section on general trends and key factors. The paper concludes with discussing the developments in the four countries regarding the low-carbon energy transformation.

2 China

2.1 Introduction

With a total CO_2 emission of 9.528 Gt in 2018, China is by far the largest emitter of CO_2 (IEA, 2020a). With a population of 1.412 billion in 2021, China is also the world's most populous country (World Bank, 2021c). Despite the enormous economic growth of the country in recent decades, both total CO_2 emissions and CO_2 emission per capita remained relatively constant in the period from 2013 to 2018 (IEA, 2020a, c).

2.2 Production and Supply

Total primary production of energy in China was 3,970,000,000 tce (i.e., equivalent to around 2,779,037 ktoe) in 2019. Raw coal had a percentage of 68.6% of the total energy production, crude oil 6.9% and natural gas 5.7%. Primary electricity and other energy accounted for 18.8% of the total energy production (National Bureau of Statistics of China, 2021a).

According to the IEA, total energy supply to China was 3,197,631 ktoe in 2018, of which coal had a share of 61.9%, oil 19.1% and natural gas 7.2% (IEA, 2020a).

As depicted in Fig. 1, total generation capacity for electricity in China was around 2,010 GW, of which thermal had a share of around 59%. Renewables

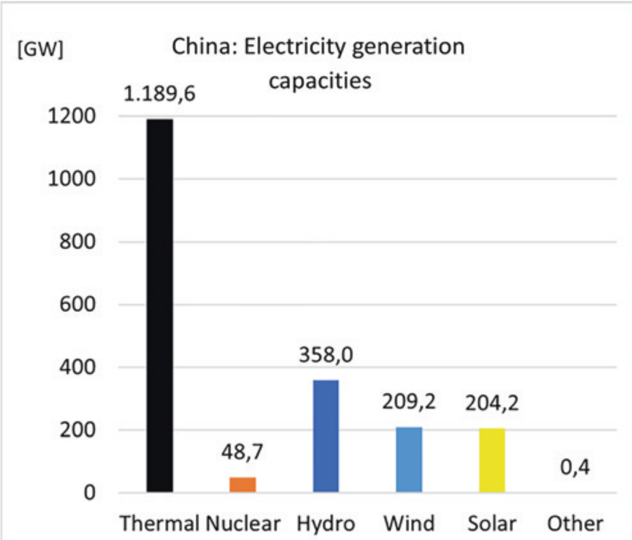

Fig. 1 Electricity generation capacities in China in 2020. (Source: National Bureau of Statistics of China, 2021c)

(including hydro) accounted for around 38.4% (National Bureau of Statistics of China, 2021c).

According to the International Renewable Energy Agency (IRENA), with a total capacity of renewables of about 894.9 GW in 2020, China owns the largest installed renewable capacity in the world with a world's share of 31.97%. This proportion increased from 20.14% in 2011. While hydro has the highest percentage of installed renewable capacity, wind and solar energy show the highest growth rates. The increase in solar capacity from 2019 to 2020 in China was around 49.4 GW, almost five times as high as the total installed solar capacity in whole of Africa in 2020 (10.6 GW) (IRENA, 2021a).

2.3 Consumption and Demand

Currently, China is the world's biggest energy consumer. The country's total primary energy demand was about 3,314 Mtoe in 2019, which is about 23.0% of the world's share (IEA, 2020g). China's total energy consumption in 2019 was around 4,870,000,000 tSCE (i.e., equivalent to around 3,409 Mtoe), of which coal had a percentage of 57.7%, petroleum 18.9%, natural gas 8.1%, primary electricity and other sources accounted for 15.3% (National Bureau of Statistics of China, 2021b).

According to the World Energy Outlook 2020, China's coal demand was 2,864 Mtce in 2019, oil demand 13.2 mb/d and natural gas demand 307 bcm. According to the *Stated Policies Scenario* for 2040, coal demand is estimated to be 2,524 Mtce, oil demand 14.1 mb/d and natural gas demand 637 bcm. For the *Sustainable Development Scenario*, coal demand is estimated to be 1,045 Mtce, oil demand 8.9 mb/d and natural gas demand 511 bcm in 2040 (IEA, 2020g).

2.4 Renewable Energy Potential

According to the IEA, additional 489 GW of installed renewable capacity is expected to become operational between 2019–2024 in China, which is the largest increase in renewable capacity of a single country in this period in the world. 84% of this capacity increase is expected to come from wind and solar PV (IEA, 2019b).

China's photovoltaic power potential varies greatly from around 1,000–1,300 kWh/kWp yearly along the populous East Coast to around 1,650 kWh/kWp in the Inner Mongolia and around 1,850 kWh/kWp in Tibet Autonomous Region. For comparison: the specific photovoltaic power output in Berlin is around 1,059 kWh/kWp per year (Global Solar Atlas 2.0 2019a, 2021).

China's wind energy potential is very diverse, the highest mean wind speeds can be measured in the Inner Mongolia and Tibet Autonomous Region. The 10% windiest areas of China have an average wind speed of 8.93 m/s (Global Wind Atlas 3.0, 2021a).

2.5 Low-Carbon Energy Targets

Five-years plans, published by the Communist Party, play a significant role in the economic development of China. In the 14th five-year plan for the period from 2021 to 2025, China states to "formulate an action plan to reach peak carbon emissions by 2030". Moreover, "carbon neutrality by 2060" and "more forceful policies and measures" are planned (Xinhua News Agency, translated on behalf of Center for Security and Emerging Technology (CESET), 2021, 94).

The World Energy Outlook 2020, published by the International Energy Agency (IEA), describes several energy consumption scenarios for the world and various large economies, such as China and India. In the *Stated Policies Scenario*, defined by the IEA as "based on today's policy settings and an assumption that the pandemic is brought under control in 2021", total CO_2 emissions of 9.111 Gt are forecasted by 2040 for China (IEA, 2020g, 27, 396). This is almost three times as much as forecasted for China in the *Sustainable Development Scenario*, defined as a scenario with "a near-term surge of investment in clean energy technologies in the next ten years". In this scenario, CO_2 emissions of 3.078 Gt for China in 2040 are projected (IEA, 2020g, 28, 397).

2.6 Challenges to Low-Carbon Energy Transformation

The potential increase in China's renewable energy capacity between 2019–2024, according to the IEA's calculations, will be a significant 489 GW mainly due to enhanced cost competitiveness of solar and wind and more onshore wind because of a reduced curtailment in northern China. However, the ongoing policy transition from feed-in tariffs (FITs) to competitive auctions remains a key uncertainty factor (IEA, 2019b).

Despite the enormous economic development China has undergone in the last decades, there are millions still living in poverty in several regions, especially in the less-developed western and rural areas of the country showing a contrast to the coastal metropolises in the east and industrialized centres. Social inequality is also a major problem. Moreover, the current dominant social imaginary in the country is assessed to be against the reduction of emissions and compliance with climate change agreements and environmental limits as they are often interpreted as abstention of consumption and restriction of development. A public information campaign emphasizing the importance of a combination of sustainable growth with the required reduction of emissions might be a possible solution (Burandt et al., 2019).

3 India

3.1 Introduction

With a population of 1.393 billion in 2021, India is the second most populated country in the world (World Bank, 2021c). Total CO_2 emission from India accounted for about 2.308 Gt in 2018 (IEA, 2020d). From 2000 to 2018, CO_2 emissions per capita more than doubled from 0.8 tonnes per capita in 2000 to 1.7 tonnes per capita in 2018 (IEA, 2018a).

From 2000–2019, about 750 million people in India obtained access to electricity (i.e., SDG 7) (IEA, 2020f; United Nations, 2020). With a growing middle-class, increased urbanization and social mobility, one of the biggest consumer markets could emerge in India (Ramakrishnan et al., 2020). According to the current policies, energy demand in India could double by 2040. Electricity demand could, according to the IEA, potentially triple by 2040 due to increased ownership of appliances and cooling devices (IEA, 2020f).

3.2 Production and Supply

Total energy supply in India was 919,771 ktoe in 2018, dominated by coal with a share of 45.0%. Oil had a share of around 25.6% and biofuels and waste made up about 20.1% of the total energy supplied to the population (IEA, 2020d).

As depicted in Fig. 2, total electricity generation capacity in India on 31.08.2020 was around 373 GW, dominated by thermal with a share of 62.1%, followed by

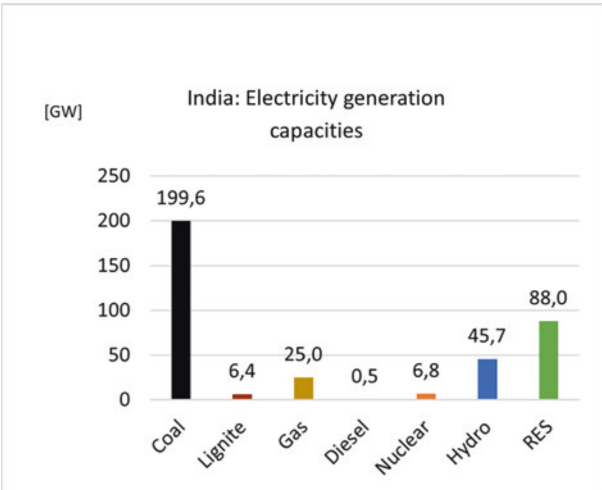

Fig. 2 Electricity generation capacities in India in 2020. (Source: Central Electricity Authority, Ministry of Power, 2020)

solar and wind, with a combined share of 23.8%. Hydro had a share of 12.3% in the electricity mix (Central Electricity Authority, Ministry of Power 2020).

Total installed renewable capacity was about 134.2 GW in 2020. Especially solar capacity strongly increased in the last years, with growth rates of 50.7% in 2018, 28.3% in 2019 and 11.7% in 2020. India's global share of renewable capacity is about 4.79% (IRENA, 2021a).

3.3 Consumption and Demand

India's total primary energy demand in 2019 was around 929 Mtoe. Coal demand was 590 Mtce, oil demand 5.0 mb/d and natural gas demand 63 bcm. According to the IEA's *Stated Policies Scenario*, for 2040, coal demand is estimated to be 772 Mtce, oil demand 8.7 mb/d and natural gas demand 201 bcm. For the *Sustainable Development Scenario*, coal demand is estimated to be 298 Mtce, oil demand 5.8 mb/d and natural gas demand 210 bcm in 2040 (IEA, 2020g).

3.4 Renewable Energy Potential

India's photovoltaic power potential is relatively evenly distributed ranging from around 1,400 kWh/kWp in the Gangetic Plains to around 1,700 kWh/kWp in the westernmost parts of the country (Global Solar Atlas 2.0, 2019b).

Compared to China, India's wind energy potential is smaller, with a relatively low mean wind speed especially in the northern and eastern areas of the country. The 10% windiest areas have an average wind speed of 6.58 m/s (Global Wind Atlas 3.0, 2021b).

According to the IEA, renewable installed capacity in the country is expected to almost double in the period from 2019–2024 due to competitive auctions for PV and wind to 235 GW in 2024–an increase of 112 GW compared to 123 GW installed capacity in 2018 (IEA, 2019b).

3.5 Low-Carbon Energy Targets

The total CO_2 emission of India in 2018 was 2.31 Gt (IEA, 2019a). According to the World Energy Outlook 2020, CO_2 emissions of India in 2040 are projected to be 3.359 Gt in the *Stated Policies Scenario* and 1.46 Gt in the *Sustainable Development Scenario* (IEA, 2020g, 400, 401).

In its Nationally Determined Contributions (NDC), India declared to decrease its emissions level by 20–25% in 2020 compared to 2005, and stated concrete programmes for renewable capacity expansion by 2022 (Government of India, 2016).

3.6 Challenges to Low-Carbon Energy Transformation

According to the IEA, the future growth of renewables in India depends on the financial and operational capability of its distribution companies (DISCOMs), the development of Green Energy Corridors, a project aiming to synchronize renewable electricity with conventionally generated electricity by implementing transmission lines (Ministry of New and Renewable Energy, Government of India, 2020), and programmes to enhance access to affordable funding. A further challenge is the acquisition of required land (IEA, 2019b).

4 Pakistan

4.1 Introduction

While a total CO_2 emissions of 183 Mt and per capita CO_2 emissions of about 0.9 tonnes in 2017, Pakistan was still considered a relatively small emitter compared to other countries globally or in the region. These figures are rising with the country having a lot to develop, currently ranking 152nd in the Human Development Index (HDI) with a score of 0.560 in 2019 (IEA, 2018b, 2018c; United Nations Development Programme, 2019). In the electricity sector, there are many reports of frequent and substantial blackouts; however, up-to-date empirical data is rare. A power deficit (difference between generation capacity and demand) of 22.11 GW in 2016 and 17.67 GW in 2015 has been calculated and estimated to increase to 45.5 GW in 2025 due to an increase in population and therefore demand (Baloch et al., 2019).

4.2 Production and Supply

Total primary energy supply for Pakistan was around 111,232 ktoe in 2018. Biofuels and waste accounted for the largest share (32.7%), oil 26%, natural gas 25.4% and coal 10.2% (IEA, 2020e).

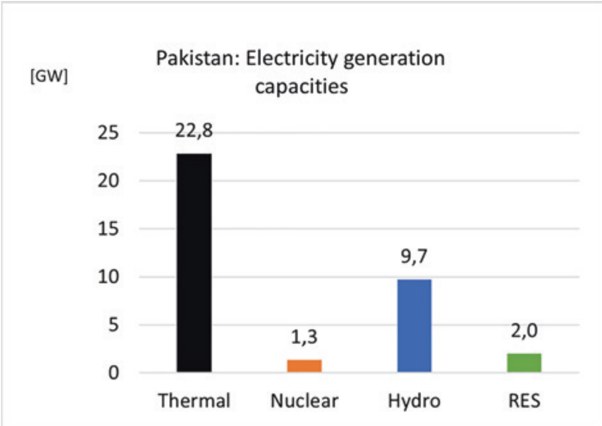

Fig. 3 Electricity generation capacities in Pakistan in 2019. (Source: National Electric Power Regulatory Authority, 2019)

As depicted in Fig. 3, total generation capacity for electricity in Pakistan was around 36 GW in 2019. Thermal capacities had a share of around 63.6%, followed by hydro with a share of 27.1% and other renewables with a share of 5.6% (National Electric Power Regulatory Authority, 2019).

Renewable capacities are historically dominated by hydro in Pakistan. In the recent years, also wind and solar capacities grew, but from a very low initial level, reaching around 1.2 GW wind capacity and around 0.7 GW solar capacity in 2020 (IRENA, 2021a).

4.3 Consumption and Demand

Pakistan's total final consumption of energy was 95,594 ktoe in 2018. Total final consumption of coal was 7,933 ktoe in 2018, and a further 21,937 ktoe of oil products and 20,071 ktoe of natural gas was consumed in this year (IEA, 2020b).

4.4 Renewable Energy Potential

According to the IEA, renewable electricity capacity in Pakistan is expected to increase from 13 GW in 2018 to 22 GW in 2024 (IEA, 2019b). Pakistan's photovoltaic power potential ranges from around 1,200 kWh/kWp in the mountainous north, about 1,600 kWh/kWp in the densely populated eastern lowlands to up to 2,000 kWh/kWp in the mountainous Balochistan province in south-western of Pakistan (Global Solar Atlas 2.0, 2019c). The country's wind energy potential varies widely, with the south-western and southern parts of the country being the most promising. The 10% windiest areas have an average wind speed of 7.87 m/s (Global Wind Atlas 3.0, 2021c).

4.5 Low-Carbon Energy Targets

Pakistan highlights its potential emission reduction regarding projected (future) emissions in its Intended Nationally Determined Contribution, submitted in November 2016. According to the document, 20% of the projected emissions in 2030 could be reduced with an investment of around \$ 40 billion. A diminishing marginal utility is stated: A 10% reduction could be achieved with an investment of around \$ 5.5 billion, and a 15% reduction with an investment of \$ 15.6 billion. However, to realize those emission reductions, Pakistan's NDC is requesting international financial and technical support (Government of Pakistan, 2016).

Presumably since Pakistan is neither a member country nor an associated country of the International Energy Agency, the World Energy Report does not provide dedicated data for Pakistan. Instead, Pakistan is included in the Asia Pacific Region (IEA, 2020g).

Pakistan's energy structure is also highly impacted by the China Pakistan Economic Corridor (CPEC), which is part of the Belt and Road Initiative. The CPEC, a \$ 60 billion project according to reports in July 2018, provides more than \$ 35 billion of Chinese loans for new power stations in Pakistan, most of them coal-fired (Stacey, 2018). These developments are not in line with climate change agreements.

4.6 Challenges to Low-Carbon Energy Transformation

Barriers to achieve 100% renewables in Pakistan are manifold. These include a lacking political will in the country for a sustainable energy transition (shown by examples such as subsidies for fuel-based electricity or plans to integrate only 5% renewables in 2030) and a limited public awareness regarding renewable energy which has led to the general perception that renewables are expensive and unreliable. Moreover, a weak infrastructure undermines developments in the sector.

Collapses of the electricity system are common, especially during peak-demand hours. The current electricity transmission and distribution systems can only just transport half of the total demand for electricity. Large investments in the national grid are therefore urgently needed, but a large proportion of them are going into fossil-based solutions (Shah & Solangi, 2019).

5 Afghanistan

5.1 Introduction

One of the least developed countries, Afghanistan is a mountainous landlocked country located at the crossroads of Central Asia and South Asia. Since no official census has been conducted for decades, figures on the population of the country are conflicting. The World Bank estimates the country's population to be 39.835 million in 2021 (World Bank, 2021c). Afghanistan shares borders with Pakistan in the south and east, Iran in the west, China in the northeast, and Turkmenistan, Uzbekistan, and Tajikistan in the north.

The country has one of the lowest rates of access to and usage of electricity in the world with an annual per capita consumption of 186 kWh (World Bank, 2016a; Korkovelos et al., 2017a). Since 2001, when the Taliban regime was ousted, the country has made progress in terms of access to electricity. This has risen fivefold from 6% to around 30% in 2015. However, there are substantial disparities between rural and urban population in terms of access to and usage of electricity. In rural areas, where around 67% of the country's GDP comes from and more than 77% of the population lives, less than 11% of them have access to grid power, while in large urban areas up to 90% have access to grid power (World Bank, 2016a).

Since 2001, billions of US dollars and dozens of development aid organizations have been supporting the development of the energy sector in Afghanistan. The major aid agencies in the sector are Gesellschaft für Internationale Zusammenarbeit (GIZ), the United States Agency for International Development (USAID), the Asian Development Bank (ADB), the World Bank, and the United Nations Development Programme (UNDP) (Fahimi & Upham, 2018). These and several other aid agencies have also supported the national power utility, Da Afghanistan Breshna Sherkat (DABS), and the energy sector in general in areas such as system loss minimization, revenue collection, distribution, capacity building, and policy design. With the financial and technical support of these aid organizations, most of the necessary institutions, laws, and policies in the sector's regulatory landscape have been developed or are being developed.

5.2 Production and Supply

The total installed power generation capacity in Afghanistan is roughly around 500 MW which comes mainly from large hydropower plants, thermal sources, and distributed diesel generators and renewables (Fahimi & Upham, 2018). Because it does not produce enough electricity to meet the growing demand, the country imports around 80% of its electricity needs from neighbouring Central Asian countries including Uzbekistan (37% of total imports), Tajikistan (29% of total imports), and Turkmenistan (10% of total imports) and its western neighbour Iran (23% of total imports) (Gencer et al., 2018).

A unified national electricity grid is lacking in the country. There are several regional supply systems, such as the North East Power System (NEPS) and the South East Power System (SEPS) which feed customers in the north, south, east, west and capital Kabul. These systems rely mostly on imported power from neighbouring countries. These regional supply systems and islands are not interconnected or synchronized. This problem stems from the fact that power systems of the neighbouring exporting countries are asynchronous (except for Turkmenistan and Iran which are synchronized). This makes it difficult for Afghanistan to synchronize them which then in turn negatively impacts trading and energy transfer (Gencer et al., 2018). Over the past two decades several development aid agencies including the USAID and the ADB have worked on transmission lines from neighbouring countries and within Afghanistan. The national power utility, DABS, which is also responsible for operation and management of electric power generation and imports is also in charge of transmission and distribution activities in the country.

5.3 Consumption and Demand

Peak demand in 2015, the latest reliable data available, was 1,500 MW and the total consumption was roughly 5,000 GWh (World Bank, 2016a). Demand in Afghanistan peaks in the winter while energy supply is at its lowest in this season due to the exporting countries' reduction of export to meet their own domestic needs. As we alluded to the low access rate and the disparity in access to electricity between rural areas and urban centres earlier, the unmet needs of most of the population, especially those in rural remote areas, are met by solid fuels such as fuelwood, charcoal, agricultural waste, and animal dung, particularly for heating and cooking purposes. In terms of urban and rural gap, 90.7% of the rural population use the mentioned fuels for cooking and 97.7% for heating, while 27.2% in urban areas use solid fuels for cooking and 90.0% for heating (Central Statistics Organization, 2016). For lighting, a large percentage of the population use kerosene, candles, and gas.

5.4 Renewable Energy Potential

Afghanistan has significant renewable energy resources. The estimated hydropower potential in the country is 23,000 MW, mainly from large dams. Being a "sunbelt" country with 300 sunny days in a year, Afghanistan has the potential to produce up to 220,000 MW solar energy according to a study by the National Renewable Energy Laboratory (NREL) of the United States (Asian Development Bank, 2014). In terms of wind potential, there are large areas in the country, mainly in the western provinces of Nimroz, Farah, Herat, and the north-eastern provinces of Balkh and Takhar, that can produce significant amounts of energy (Fahimi & Upham, 2018). The official estimate for wind potential is 67,000 MW, although there are other sources which quote higher figures (Chaurey et al., 2017; Elliott, 2011). Biomass is another source of energy that is used widely in the country, although in its solid traditional form. However, as per Afghanistan's Energy Policy of 2015, 4,000 MW of energy can be produced from this source including 3,090 MW from agricultural waste, 840 MW from animal waste, and 91 MW from Municipal Solid Waste (MSW) (Islamic Republic of Afghanistan, Ministry of Energy and Water, 2015a, b). Lastly, the country can also produce energy from its active geothermal systems. These systems are located in the main axis areas of the Hindu Kush Mountains with the surface manifestation in the form of hot springs (Saba et al., 2004). According to the country's Inter-Ministerial Commission for Energy (ICE), a total of 3,500 MW of energy can be produced from 70 spots that are identified in the Afghanistan Renewable Energy Policy (Inter-ministerial Commission for Energy, 2016). So far, the Ministry of Energy and Water (MEW) with the support of international aid agencies and other governmental agencies have implemented around 5,000 small-scale renewable energy projects (Gencer et al., 2018).

5.5 Low-Carbon Energy Targets

The government of Afghanistan in its Renewable Energy Policy of 2015 sets a target for deploying about 4,500 MW of Renewable Energy by 2032. The country's Power Sector Master Plan (PSMP) of 2013 projects the total energy mix in 2032 to be 6,000 MW (FICHTNER GmbH & Co. KG, 2013). The country's Renewable Energy Policy estimates that around 95% of the energy supply in 2032 will rely on renewables (Islamic Republic of Afghanistan, Ministry of Energy and Water, 2015a, b). According to calculations by the PSMP, the electrification rate will increase from 30 to 83% in 2032 and the share of locally generated electricity will rise from 20 to 67% (FICHTNER GmbH & Co. KG, 2013).

5.6 Challenges to Low-Carbon Energy Transformation

The barrier and factor that overshadows everything in the case of Afghanistan is the lack of security which deters investment in the sector. Regarding its hydro resources which the country relies heavily on it must be said that the use of these waters takes an international dimension since almost all the country's rivers are transboundary. Afghanistan, however, does not have an agreement with these countries except only with Iran. This makes it difficult to develop its hydro resources. Other barriers include "lack of policy clarity and consistency, poor coordination between the stakeholders, shortage of technical capacity, weak grid infrastructure, and climate change and variability" (Fahimi & Upham, 2018, 6).

6 General Trends and Key Factors in Low-Carbon Energy Transformations

In the following, trends in the energy sector and factors which either facilitate or hinder a successful transition towards carbon-neutrality will be discussed. These have been derived from the previous reviews analysing the energy sectors of China, India, Pakistan, and Afghanistan.

6.1 Decreasing Costs of Renewables

Due to economies of scale, technical improvements and accumulated experience, costs of technologies for renewable power generation have fallen sharply in the last decade worldwide. As depicted in Fig. 4, global weighted average levelized costs of electricity for newly commissioned solar photovoltaic (utility-scale) sank by 85.0% from 0.381 USD/kWh in 2010 to only 0.057 USD/kWh in 2020. Costs for newly commissioned onshore wind (utility-scale) dropped by 56.2% from 0.089 USD/kWh in 2010 to 0.039 USD/kWh in 2020, newly commissioned

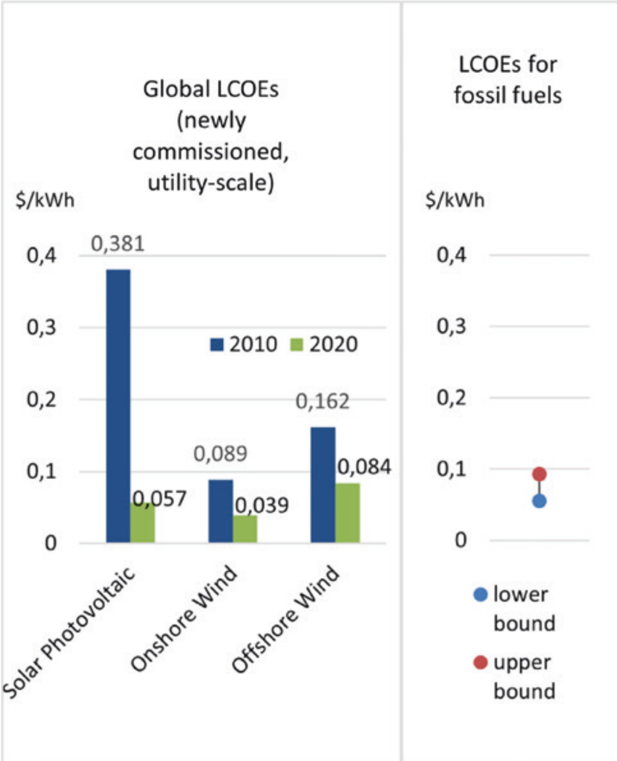

Fig. 4 Global LCOEs of different power generation technologies. LCOEs for fossil fuels are based to G20 countries. (Source: IRENA, 2021b)

offshore costs (utility-scale) fell by 48.1% from 0.162 USD/kWh in 2010 to 0.084 USD/kWh in 2020. By reaching these price levels, renewables became competitive with fossil fuel based electricity, whose price level is stated by the International Renewable Energy Agency as 0.055 USD/kWh to 0.148 USD/kWh for newly-built power plants (IRENA, 2021b).

For utility-scale solar PV in China, total costs of 795 2019-USD/kW are stated; for India, total costs of only 618 2019-USD/kW are calculated. For comparison, total costs for Germany are stated with 899 USD-2019/kW (IEA, 2019b). For Pakistan, the International Energy Agency unfortunately doesn't provide any data, but in a trade journal estimated cost for a planned 50 MW project of 900 USD-2019/kW have been reported (Willuhn, 2019).

This trend is also confirmed by the World Energy Outlook 2020, released on 13.10.2020 by the IEA: Estimates for solar electricity costs have decreased by 20–50% compared to the World Energy Outlook 2019. According to the document, LCOEs in the range of only 0.02–0.04 USD/kWh would apply in China and India, where revenue supporting mechanisms (e.g., price guarantees) are implemented. By achieving such low price levels, solar projects in utility-scale are able to beat new coal plants in terms of LCOEs, and are in a similar range with operating costs of present coal plants (Evans & Gabbatiss, 2020; quoted from IEA, 2020g).

6.2 Decreasing Dependency on the Import of Fossil Fuels

As shown above, renewables have not only become cheaper over time, but they also offer many other advantages as well. From a macroeconomic point of view, replacing fossil fuels with renewables capacities can help reduce the dependence on fossil imports. Those saved costs not only help to achieve a more equal balance of trade of a country, but to stop further macroeconomic follow-up effects, such as a possible devaluation of the country's currency which can lead to even increasing costs for imported fossil fuels. The saved costs also allow additional liquidity and therefore investments for renewable capacity and improvements into required infrastructure, for example grids and storage capacities.

6.3 Remuneration Schemes

By switching from administratively set feed-in tariffs (FITs) to competitive auctions, both government and developers can benefit: Provided remuneration schemes are smartly designed, governments can achieve price reductions for the deployment of renewable energy and subsidies. For developers, long-term power purchase agreements (PPAs) allow certainty regarding the remuneration of renewables.

China is transitioning from FITs to competitive auctions. In May 2019, over 20 GW wind and solar projects without subsidies have been permitted by the National Development and Reform Commission (NDRC). Grid operators have been encouraged to sign long-term (20-years) PPAs with developers (IEA, 2019b).

Similarly, in India, due to the introduction of reverse auctions and the resulting increase in competition, a reduction of prices for solar energy has been reached (Burke et al., 2019; Jaiswal et al., 2017).

6.4 The Impact of Fossil Fuel Subsidies

In a working paper by the International Monetary Fund, an assessment has been conducted to evaluate price gaps between the retail fossil fuel prices, which consumers are paying and efficient prices for fossil fuel where all externalities (e.g., environmental costs) from the consumption of fossil fuel would have been internalized (Baoping Shang et al., 2019). These effects include the costs resulting of the impact to global warming, the contribution to local air pollution (and resulting consequences like an increased mortality rate) and other negative effects such as congestion and accidents resulting from traffic powered by fossil fuels. According to their approach, (non-)existing fossil fuel price policies resulted in post-tax subsidies of $ 1,432 billion in China (12.8% of the GDP, or $ 1,025 per capita) in 2015. For India, post-tax subsidies of $ 209 billion (10.0% of the GDP, or $ 160 per capita) emerged in 2015, for Pakistan, post-tax subsidies of $ 18 billion (6.8% of the GDP, or $ 97 per capita) appeared in 2015.

These extensive values show the massive distortions due to non-pricing of external effects related to the consumption of fossil fuels and offer at the same time a substantial potential for cost-effective market-based, fiscal, or regulatory instruments to foster the exit from fossil fuels, the cutting of emissions and the support for (or at least not the discrimination against) renewables.

6.5 Chinese Influence on Foreign Energy Policies in the Context of the Belt and Road Initiative

China's Belt and Road Initiative has consequences for at least 70 countries, influencing various sectors, such as trade, infrastructure and connectivity (European Bank for Reconstruction and Development, 2020). Coal power plants play a significant role in this context. While the global coal fleet outside of China shrank for the first time since the 1980s from January 2018 to June 2019 by 8.1 GW, China increased its coal capacities in the same period by 42.9 GW (Shearer et al., 2019a). China is not only expanding its national fleet of coal power plants, it is also exporting them in the context of the Belt and Road Initiative to other countries in Asia, Europe and Africa: According to the Institute for Energy Economics and Financial Analysis, based on a dataset from the Global Coal Plant Tracker, from 399 GW coal capacities under development in January 2019 outside of China, around a quarter (102 GW) have received funding or financial support commitment by financial institutions and corporations from China. For Pakistan, financial aid commitment from China was $ 2.32 billion for 1.98 GW of coal capacity, plus an additional $3.606 billion for 7.6 GW of coal capacity (Shearer et al., 2019b).

7 Discussion and Conclusion

This review set out to provide an overview of the current energy situation in China, India, Pakistan, and Afghanistan, the low-carbon energy targets in these countries, and challenges to and key factors in low-carbon energy transformation. Table 1 gives an overview of previous elaborations.

The crucial question is: Will those efforts be enough to be in line with the Paris climate protection goals?

Analysing the current (first submitted) NDCs of the countries reveals that it will not. No absolute emission reduction targets are provided, instead, for China and India, reduction targets for the emission intensity (decrease of the emissions per GDP unit) are given, which leaves open the possibility of increasing absolute emissions if the gross domestic product of a country increases faster than its emissions. According to the Climate Action Tracker, under the implemented policies of all countries at present, a temperature increase of 2.9 °C is projected until 2100 (Climate Action Tracker, 2020). Even if all countries would fully implement their NDCs, this would result in a temperature rise of 2.8 °C compared to a preindustrial level (Climate Action Tracker (Climate Analytics, NewClimate Institute, Ecofys), 2016).

The *Stated Policies Scenario* of the World Energy Outlook for China and India has significant higher emissions than allowed to achieve the 1.5/2 °C Paris target. According to the IPCC Special Report from 2018, the remaining Carbon Budget on 1st January 2018 was around 420 $GtCO_2$ for the ~ 1.5 °C target and around 1,170 $GtCO_2$ for the ~ 2 °C target (IPCC, 2018). China's CO_2 emissions of 9.111 Gt in the *Stated Policies Scenario* in 2040 are almost three times as high as allowed in the *Sustainable Development Scenario* (IEA, 2020g). Applying these findings to coal capacity, the Chinese global coal fleet must be reduced by more than 40% from 1,027 GW in July 2019 to around 600.9 GW in 2030 according to the Global Energy Monitor, to keep global warming well below 2 °C, which is in strong contrast to further expansion plans of the Chinese coal fleet proposed by state-owned enterprises and industry groups (Shearer et al., 2019a).

Table 1 An overview of low-carbon energy transformation in Afghanistan, China, India, and Pakistan. (Source: Own depiction)

Parameter	Afghanistan	China	India	Pakistan
Population [million] (2021) (World Bank, 2021c)	39.8	1,412.4	1,393.4	225.2
GDP [trillion current USD] (2020) (World Bank, 2020)	0.0198	14,723	2,623	0.264
Electricity consumption per capita [kWh]	186 (year not specified) (Korkovelos et al., 2017b)	5,119 (2019) (IEA, 2021)	987 (2019) (IEA, 2021)	538 (2019) (IEA, 2021)
CO_2 emissions per capita [t] (2018) (World Bank, 2021b)	0.2	7.4	1.8	1.0
Total CO_2 emissions [Mt] (2018) (World Bank, 2021a)	7.4	10,313.5	2,434.5	208.4
Prospects, based on 2016 NDCs	By 2030: • Reduce GHG emissions by 13.6% to a business as usual 2030 scenario, conditional on external support. (Islamic Republic of Afghanistan, 2015a, 2015b)	By 2030: • Achieve peak of carbon dioxide emissions • Reduce CO_2 emissions per GDP unit by 60–65% compared to 2005 • Raise share of non-fossil fuels in primary energy consumption to 20% • Increase forest stock volume increase by 4.5 billion m3 compared to 2005 (Government of People's Republic of China, 2015)	By 2022: • Achieve 60 GW wind energy capacity • Achieve 100 GW solar energy capacity • Achieve 10 GW biomass energy capacity By 2032: • Achieve 63 GW nuclear energy capacity From 2021 to 2030: • Reduce the emission intensity of its GDP by 33–35% by 2030 from 2005 level • Achieve a share of 40% electric power installed capacity from non-fossil fuels by 2030 • Create additional carbon sink of 2.5 - 3 billion tonnes of CO_2 equivalents through additional forest and tree cover by 2030. (Government of India, 2016)	By 2025: • Add 25 GW capacity to the national grid (Government of Pakistan, 2016)

Similarly, in India, projected emissions in the *Stated Policies Scenario* are about 2.3 times as high as permitted in the *Sustainable Development Scenario*.

For Pakistan and Afghanistan, ending the ongoing energy shortages and the energy supply–demand gap have priority. However, by making the choice now through investments into renewable instead of conventional fuel-based energy, the countries have the chance to make use of its abundant resources, avoiding lock-in effects into conventional energy and reducing its dependency from expensive energy imports.

All countries are equipped with abundant renewable energy resources. As renewables have become cheaper and cheaper, they nowadays not only provide massive ecological, but also economic advantages in comparison to coal, oil, and gas. Grid infrastructure often remains a bottleneck in these countries to transfer clean energy to its consumers. By setting the right course now, through the stop of building new coal power plants, the provision of both attractive and efficient remuneration schemes for renewables and an ongoing expansion of grid and storage infrastructure, these countries could reduce emissions and pollutants from the combustion of fuels significantly, decrease their costs for expensive energy imports, and provide a green, cost-efficient, and reliable power supply.

References

Asian Development Bank. (2014). *"Technical Assistance Report: Islamic Republic of Afghanistan: Renewable Energy Development, Project Number 47266-001."* Manila, Philippines. https://www.adb.org/sites/default/files/project-document/151922/47266-001-tar.pdf.

Baloch, M. H., Chauhdary, S. T., Ishak, D., Kaloi, G. S., Nadeem, M. H., Wattoo, W. A., Younas, T., & Hamid, H. T. (2019). Hybrid energy sources status of Pakistan: An optimal technical proposal to solve the power crises issues. *Energy Strategy Reviews, 24*(April), 132–153. https://doi.org/10.1016/j.esr.2019.02.001

Shang, B., Le, N. P., Parry, I., & Coady, M. D. (2019). *Global fossil fuel subsidies remain large: An update based on country-level estimates.* https://www.imf.org/~/media/Files/Publications/WP/2019/WPIEA2019089.ashx.

Burandt, T., Xiong, B., Löffler, K., & Oei, P.-Y. (2019). Decarbonizing China's energy system—modeling the transformation of the electricity, transportation, heat, and industrial sectors. *Applied Energy, 255*, 113820. https://doi.org/10.1016/j.apenergy.2019.113820

Burke, P. J., Widnyana, J., Anjum, Z., Aisbett, E., Resosudarmo, B., & Baldwin, K. G. H. (2019). Overcoming barriers to solar and wind energy adoption in two Asian giants: India and Indonesia. *Energy Policy, 132*, 1216–1228. https://doi.org/10.1016/j.enpol.2019.05.055

Central Electricity Authority, Ministry of Power. (2020). *"All India installed capacity (in MW) of power stations."* https://cea.nic.in/reports/monthly/installedcapacity/2020/installed_capacity-08.pdf.

Central Statistics Organization. (2016). *"Afghanistan at a glance: 2015–2016."* Kabul, Afghanistan.
Chaurey, A., Narasimhan, G., Chatterjee, A., Fazli, F., Musleh, A. J., Haseib, M., Shinwari, E. S. (2017). "Renewable energy roadmap 2032: TA-8808 AFG: Renewable energy development in Afghanistan." Asian Development Bank; IT Power Consulting Private Limited.
Climate Action Tracker. (2020). "Warming projections global update–September 2020." https://climateactiontracker.org/publications/global-update-pandemic-recovery-with-just-a-hint-of-green/.
Climate Action Tracker (Climate Analytics, NewClimate Institute, Ecofys). (2016). "Paris agreement in force, but no increase in climate action." https://climateactiontracker.org/documents/48/CAT_2016-11-10_TemperatureUpdateNov16_CATUpdate.pdf.
Elliott, D. (2011). "Wind resource assessment and mapping for Afghanistan and Pakistan." National Renewable Energy Laboratory (NREL). Golden, Colorado, USA. https://pdf.usaid.gov/pdf_docs/PNADO338.pdf.
European Bank for Reconstruction and Development. (2020). "Belt and road initiative (BRI)." https://www.ebrd.com/what-we-do/belt-and-road/overview.html. Accessed: 18 Oct 2020
Evans, S. & Gabbatiss, J. (2020). "Solar is now 'cheapest electricity in history', confirms IEA." CarbonBrief. https://www.carbonbrief.org/solar-is-now-cheapest-electricity-in-history-confirms-iea. Accessed: 13 Oct 2020
Fahimi, A., & Upham, P. (2018). The renewable energy sector in Afghanistan: Policy and potential. *Wiley Interdisciplinary Reviews: Energy and Environment, 7*(2), e280. https://doi.org/10.1002/wene.280
FICHTNER GmbH & Co. KG. (2013). "Islamic republic of Afghanistan: Power sector master plan, TA-7637 (AFG)." Asian Development Bank. Manila, Philippines. https://www.adb.org/sites/default/files/project-document/76570/43497-012-afg-tacr.pdf.
Gencer, Defne, John Irving, Peter Meier, Richard Spencer, and Chris Wnuk. (2018). "Energy security trade-offs under high uncertainty: Resolving Afghanistan's power sector development dilemma." International Bank for Reconstruction and Development/The World Bank. Washington, DC. https://www.esmap.org/sites/default/files/esmap-files/Uncertainty-OKR-R1.pdf.
Global Solar Atlas 2.0. (2019a). "Photovoltaic power potential–China." https://globalsolaratlas.info/download/china.
Global Solar Atlas 2.0. (2019b). "Photovoltaic Power Potential–India." https://globalsolaratlas.info/download/india.
Global Solar Atlas 2.0. 2019c. "Photovoltaic power potential–Pakistan." https://globalsolaratlas.info/download/pakistan.
Global Solar Atlas 2.0. 2021. "Global solar atlas 2.0." 2021. https://globalsolaratlas.info/map.
Global Wind Atlas 3.0. (2021a). "China." 2021a. https://globalwindatlas.info/area/China.
Global Solar Atlas 2.0. (2021b). "India." 2021b. https://globalwindatlas.info/area/India.
Global Solar Atlas 2.0. (2021c). "Pakistan." 2021c. https://globalwindatlas.info/area/Pakistan.
Government of India. (2016). "India First NDC." https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf.

Government of Pakistan. (2016). "Pakistan's intended nationally determined contribution (PAK-INDC)." https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Pakistan%20First/Pak-INDC.pdf.
Government of People's Republic of China. (2015). "China's first NDC submission." Bonn. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/China%20First/China's%20First%20NDC%20Submission.pdf.
IEA. (2018a). "Data & statistics. Energy topic: CO_2 emissions, indicator: CO_2 emissions per capita, Country: India." 2018a. https://www.iea.org/data-and-statistics?country=INDIA&fuel=CO2%20emissions&indicator=CO2PerCap.
IEA. (2018b). "Data & statistics. Energy topic: CO_2 emissions, indicator: CO_2 emissions per capita, Country: Pakistan." 2018b. https://www.iea.org/data-and-statistics?country=PAKISTAN&fuel=CO2%20emissions&indicator=TotCO2.
IEA. (2018c). "Data & statistics. Energy topic: CO_2 emissions, indicator: Total CO_2 emissions, country: Pakistan." 2018c. https://www.iea.org/data-and-statistics?country=PAKISTAN&fuel=CO2%20emissions&indicator=TotCO2.
IEA. (2018d). "Data & statistics. Energy topic: CO_2 emissions, indicator: Total CO_2 emissions, Country: World." 2018d. https://www.iea.org/data-and-statistics/data-browser/?country=WORLD&fuel=CO2%20emissions&indicator=TotCO2.
IEA. (2019a). "Data & statistics. Energy topic: CO_2 emissions, indicator: Total CO_2 emissions, Country: India." 2019a. https://www.iea.org/data-and-statistics?country=INDIA&fuel=CO2%20emissions&indicator=TotCO2.
IEA. (2019b). *Renewables 2019: Analysis and forecasts to 2024*. International Energy Agency. https://doi.org/10.1787/b3911209-en
IEA. (2020a). "China–key energy statistics." 2020a. https://www.iea.org/countries/china.
IEA. (2020b). "Data & statistics. Data tables. Energy category: Balances, Country: Pakistan, Year: 2018." 2020b. https://www.iea.org/data-and-statistics/data-tables?country=PAKISTAN&energy=Balances&year=2018.
IEA. (2020c). "Data & statistics. Energy topic: CO_2 emissions, indicator: CO_2 Emissions per capita, Country: China (People's Republic of China and Hong Kong China)." 2020c. https://www.iea.org/data-and-statistics?country=CHINAREG&fuel=CO2%20emissions&indicator=CO2PerCap.
IEA. (2020d). "India–Key Energy Statistics." 2020d. https://www.iea.org/countries/India.
IEA. (2020e). "Pakistan–key energy statistics." 2020e. https://www.iea.org/countries/pakistan.
IEA. (2020f). "India 2020f–Energy policy review." https://www.iea.org/reports/india-2020f.
IEA. (2020g). "World energy outlook 2020g." Paris. https://webstore.iea.org/world-energy-outlook-2020g.
IEA. (2021). "Key world energy statistics 2021." https://iea.blob.core.windows.net/assets/52f66a88-0b63-4ad2-94a5-29d36e864b82/KeyWorldEnergyStatistics2021.pdf.
Inter-ministerial Commission for Energy. (2016). "Afghanistan energy sector update." Ministry of Economy: Inter-ministerial Commission for Energy. Main Conference Hall. Retrieved from https://sites.google.com/site/iceafghanistan/.
IPCC. (2018). "IPCC, 2018: Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla,

A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (Eds.)]. In Press." https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf.

IRENA. (2021a). "Renewable capacity statistics 2021a." https://www.irena.org/publications/2021a/March/Renewable-Capacity-Statistics-2021.

IRENA. (2021b). "Renewable power generation costs in 2020." https://www.irena.org/publications/2021b/Jun/Renewable-Power-Costs-in-2020.

Islamic Republic of Afghanistan. (2015a). "Intended nationally determined contribution submission to the United Nations framework convention on climate change." https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Afghanistan%20First/INDC_AFG_2015a0927_FINAL.pdf.

Islamic Republic of Afghanistan, Ministry of Energy and Water. (2015b). "Renewable energy policy." https://policy.asiapacificenergy.org/sites/default/files/Afghanistan-Renewable-Energy-Policy-English-and-Dari.pdf.

Jaiswal, S., Jain, A., Orlandi, I., & Sethia, A. (2017). "Accelerating India's clean energy transition." Bloomberg New Energy Finance. https://data.bloomberglp.com/professional/sites/10/BNEF_Accelerating-Indias-Clean-Energy-Transition_Nov-2017.pdf.

Korkovelos, A., Bazilian, M., Mentis, D., & Howells, M. (2017a). "A GIS approach to planning electrification in Afghanistan. Live wire." World Bank. https://openknowledge.worldbank.org/handle/10986/29140.

Korkovelos, A., Bazilian, M., Mentis, D., & Howells, M. (2017b). "Afghanistan energy study - a GIS approach to planning electrification in Afghanistan." https://energypedia.info/images/d/d6/A_GIS_approach_to_electrification_planning_in_Afghanistan.pdf.

Ministry of New and Renewable Energy, Government of India. (2020). "Green Energy Corridor | Ministry of New and Renewable Energy, Government of India." https://mnre.gov.in/green-energy-corridor. Accessed: 16 Oct 2020

National Bureau of Statistics of China. (2021a). "China statistical yearbook 2020: 9–1 total primary energy production and its composition." 2021a. http://www.stats.gov.cn/tjsj/ndsj/2019/indexeh.htm.

National Bureau of Statistics of China. (2021b). "China statistical yearbook 2020: 9–2 total energy consumption and its composition." 2021b. http://www.stats.gov.cn/tjsj/ndsj/2020/indexeh.htm.

National Bureau of Statistics of China. (2021c). "China statistical yearbook 2020: 9–15 installed capacity of power generation." 2021c. http://www.stats.gov.cn/tjsj/ndsj/2020/indexeh.htm.

National Electric Power Regulatory Authority. (2019). "2018–2019 annual report." Islamabad. https://nepra.org.pk/publications/Annual%20Reports/Annual%20Report%202018-19.pdf.

Nicholas, S. & Buckley, T. (2018). "Pakistan's power future." Institute for energy economics and financial analysis. http://ieefa.org/wp-content/uploads/2018/11/Pakistans-Power-Future_December-2018.pdf.

Ramakrishnan, A., Kalkuhl, M., Ahmad, S., & Creutzig, F. (2020). Keeping up with the patels: Conspicuous consumption drives the adoption of cars and appliances in India. *Energy Research & Social Science, 70*, 101742. https://doi.org/10.1016/j.erss.2020.101742

Saba, D. S., Najaf, M. E., Musazai, A. M., & Taraki, S. A. (2004). "Geothermal energy in Afghanistan: Prospects and potential; prepared for center on international cooperation, New York University." Afghanistan Center for Policy and Development Studies.

Shah, S. A. A. & Solangi, Y. A. (2019). "A sustainable solution for electricity crisis in Pakistan: opportunities, barriers, and policy implications for 100% renewable energy." *Environmental Science and Pollution Research,* 26 (29), 29687–703. https://doi.org/10.1007/s11356-019-06102-0.

Shearer, C., Brown, M., & Buckley, T. (2019a). "China at a crossroads: Continued support for coal power erodes country's clean energy leadership." Institute for Energy Economics and Financial Analysis. https://ieefa.org/wp-content/uploads/2019a/01/China-at-a-Crossroads_January-2019a.pdf.

Shearer, C., Yu, A., & Nace, T. (2019b). "Out of step: China is driving the continued growth of the global coal fleet." Global Energy Monitor. https://endcoal.org/wp-content/uploads/2019b/11/Out-of-Step-English-final.pdf.

Stacey, K. (2018). "Pakistan's pivot to coal to boost energy gets critics fired up." *Financial Times*. https://www.ft.com/content/5cd07544-7960-11e8-af48-190d103e32a4. Accessed: 31 July 2018.

United Nations. (2020). "Goal 7 | Department of economic and social affairs." https://sdgs.un.org/goals/goal7. Accessed: 2020.

United Nations Development Programme. (2019). *Human Development Report 2019: Beyond Income, beyond Averages, beyond Today: Inequalities in Human Development in the 21st Century.*

Willuhn, M. (2019). "Pakistan's Nepra Mulls another 50 MW of solar – Pv magazine international." https://www.pv-magazine.com/2019/08/30/pakistans-nepra-mulls-another-50-mw-of-solar/. Accessed: 30 Aug 2019

World Bank. (2016a). "Afghanistan country snapshot." http://documents1.worldbank.org/curated/en/584381476781571691/pdf/109246-WP-AfghanistanCountrySnapshots-high-res-PUBLIC.pdf.

World Bank. (2016b). "CO_2 emissions (Kt) - Afghanistan | Data." 2016b. https://data.worldbank.org/indicator/EN.ATM.CO2E.KT?locations=AF.

World Bank. (2020). "GDP (Current US$) | Data." 2020. https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

World Bank. (2021a). "CO_2 emissions (Kt) | Data." 2021a. https://data.worldbank.org/indicator/EN.ATM.CO2E.KT.

World Bank. (2021b). "CO_2 emissions (Metric Tons per Capita) | Data." 2021b. https://data.worldbank.org/indicator/EN.ATM.CO2E.PC.

World Bank. (2021c). "Population 2021." https://databank.worldbank.org/data/download/POP.pdf.

Xinhua News Agency, translated on behalf of Center for Security and Emerging Technology (CESET). (2021). "Outline of the People's Republic of China 14th five-year plan for National Economic and Social Development and Long-Range Objectives for 2035." https://cset.georgetown.edu/wp-content/uploads/t0284_14th_Five_Year_Plan_EN.pdf.