Coal and Sustainability

Regional Phase Out and Policies

Sanne Akerboom

Contents

1 Introduction 2
2 Global Progress on Pledges and Commitments for Phase Out of Unabated Coal-Fired Power Plants 3
3 Potential Policy Instruments 5
3.1 Reduction Targets and Emission Standards 5
3.2 Financial Incentives 5
3.3 Just Transition Mechanisms 6
4 Coal Phase Out in the European Union and Selected Countries 6
4.1 Coal Phase Out in the European Union 7
4.2 Existing Policies and Regulations 8
4.3 Financial Incentives and the Just Transition 8
4.4 Specific European Countries: Poland, Germany, the UK, and the Netherlands 9
5 Coal Phase Out in American Countries 9
5.1 Chile 10
5.2 Canada 11
6 Coal Phase in African Countries 12
6.1 Morocco 12
6.2 South Africa 13
7 Coal Phase Out in Asia Pacific Countries 14
7.1 China 14
7.2 India 15
7.3 Australia 16
8 Summary 16
9 Cross-References 18
References 18

Abstract

Mitigating global climate change and the aim to achieve the Paris Agreement target of limiting global warming to 2, although preferably to 1.5 °C, puts

S. Akerboom (✉)
Faculty of Geosciences, Utrecht University, Utrecht, Netherlands
e-mail: s.akerboom@uu.nl

C. Constance (ed.), *The Palgrave Handbook of Global Sustainability*,
https://doi.org/10.1007/978-3-030-38948-2_14-1

pressure on coal-fired power generation. Coal-fired power has (had) a large contribution to global climate change. Phasing out unabated coal-fired power is therefore an important part of global climate action. According the International Energy Agency all emissions from coal-fired power must be reduced by 2040 globally, and developed countries should reach this target before 2030. This therefore poses significant challenges, especially since coal-fired power is linked to economic development, which is essential for various countries across the globe. This chapter describes firstly the necessary targets for unabated coal-fired power, and global pledges following from alliances and international conferences. Furthermore, this chapter describes the different types of legal and policy instruments countries can employ to achieve coal-phase out strategies. Lastly, this chapter offers descriptions of regional (if applicable) and country commitments and the use of instruments to achieve a coal-phase out across Europe, the Americas, Africa, and Asia Pacific and progress thus far.

Keywords

Sustainability · Electricity production · Unabated coal-fired power plants · Policy instruments

1 Introduction

Mitigating global climate change and the aim to achieve the Paris Agreement target of limiting global warming to 2, although preferably to 1.5 °C, puts pressure on coal-fired power generation. Coal-fired power has (had) a large contribution to global climate change. The International Energy Agency reports annually on analysis and forecasts of coal. In 2019, they reported that coal-fired power generation accounted for 37% of global electricity output, but accounted for 72% of CO_2 emissions from the power sector and 30% of global energy-related CO_2 emissions (IEA 2021c). Unabated coal-fired power plants are thus the largest source of electricity generation and the largest single source of energy-related CO_2 emissions (IEA 2021d). The term *unabated* coal-fired power plant refers to the use of coal power that is not mitigated with technologies to reduce carbon dioxide emissions, such as Carbon Capture Utilization and Storage (CCUS) (IEA 2021a).

Phasing out unabated coal-fired power plants (UCFPP), which is targeted in different countries, such as several member states of the European Union (EU), will thus make a large contribution to meeting the Paris Agreement target and the mitigation of global climate change. The special IPCC report on 1.5 °C (2018) shows that a near complete coal phase out by 2050 is necessary to limit global climate change. To remain consistent with a 1.5 °C scenario, coal must be reduced to 1–7%, with a large share of this combined with carbon capture and storage (CCS), thus reducing the greenhouse gas emissions (GHG) stemming from coal-fired power to nearly 0% in 2050. In the Net Zero by 2050 Roadmap (NZE scenario) of the International Energy Agency (IEA), it is predicted that the construction of new

UCFPP will slow down while solar photovoltaics (PV) and wind energy take off (IEA 2021a). This Roadmap together with the IEA (IEA 2021b) furthermore clarifies that all UCFPP should be phased out in advanced economies and the least efficient plants globally by 2030, and in emerging markets and developing economies by 2040 (IEA 2021a, 2021b) to keep consistent with the 1.5 °C target. There is therefore a significant pressure on countries to develop pathways and policies to plan this phase out.

In this chapter, such coal phase out strategies are discussed. Starting with an overview of global progress on pledges and commitments for phase out of unabated coal-fired power plants (Sect. 2) and an overview of possible policy instruments that can be employed to meet this target (Sect. 3), Sects. 4, 5, 6, and 7 offer descriptions of regional (if applicable) and country commitments to a coal-phase out across Europe, the Americas, Africa, and Asia Pacific. Section 8 offers a conclusion.

2 Global Progress on Pledges and Commitments for Phase Out of Unabated Coal-Fired Power Plants

Since the Paris Agreement, 21 countries have pledged to fully phase out coal use in the power sector within a fixed timeframe (IEA 2021c). Most of the 21 countries are EU member states, and the EU has been instrumental in facilitating the transition away from coal. Most EU member states commit to phase out coal by or before 2030 (Austria, Belgium, Denmark, Finland, Greece, Ireland, Italy, the Netherlands, Portugal, Slovak Republic, Spain, and Sweden). Of these countries, Austria, Belgium, and Sweden have completed their phase outs, with some minor exceptions. Together, these countries represent 4.1% of global electricity generation in 2020 (IEA 2021c). Only Romania and Germany set later deadline, 2032 and 2038. Germany, therefore, has set a deadline beyond the NZE scenario. In total, the EU aims at phasing out 95 GW. Other countries have set pledges in line with the NZE scenario: Canada (2030), Chile (2040), Israel (2030), New Zealand (2030), and the UK (2024). The USA aims at retiring 140 GW of its aging fleet of coal plants. Japan has a similar target, to phase out less efficient plants by 2030. In total, existing policies are expected to contribute to over 430 GW of coal-fired capacity retirements by 2030, which represents 20% of the 2020 global capacity (IEA STEPS).

Despite the level of ambitions, these pledges fall short of achieving the NZE scenario. Moreover, new UCFPPs with a planned capacity of 200 GW will become operational through to 2025, mostly in People's Republic of China, India, and Southeast Asia. This will offset the phase out pledges to a large extent (IEA 2021c).

Three relevant IEA reports on UCFPP – IEA (2021b), NZE Roadmap (2021a), and phasing out IEA (2021c) – were published ahead of the Conference of Parties 26 (COP26) in Glasgow in November 2021, with the explicit aim to inform decision-makers on the global situation, and to highlight potential avenues of climate action. A global coal phase out is one of the most explicit options highlighted by the IEA. Considering this, a new pledge "Global Coal to Clean Power Transition Statement" was signed at COP26 by more than 40 countries. This pledge states that signatories

are aware that "coal power generation is the single biggest cause of global temperature increases" and that a transition toward clean energy is key for global climate change mitigation. Signatories, therefore, envision to accelerate the "transition away from unabated coal power generation, in a way that benefits workers and communities and ensures access to affordable, reliable, sustainable and modern energy for all by 2030." To this end, signatories commit to the following actions:

1. Rapidly scale up deployment of clean power generation energy efficiency measures
2. Rapidly scale up technologies and policies in this decade to achieve a transition away from unabated coal power generation in the 2030s for major economies and in the 2040s globally
3. To cease issuance permits and construction of new (New UCFPP is defined as coal-fired power generation projects that have not yet reached financial close.) UCFPP and to end new government support for international coal-fired power generation and
4. Strengthen our domestic and international efforts to provide a robust framework of financial, technical, and social support to affected workers, sectors, and communities to make a just and inclusive transition. Furthermore, signatories are called upon their leadership positions making ambitious commitments, including through the No New Coal Power Compact.

This pledge has been signed by most European countries, including the European Union, Azerbaijan, Botswana, Brunei, Canada, Chile, Cote d'Ivoire, Ecuador, Egypt, Indonesia, Israel, Kazakhstan, Maldives, Mauritania, Mauritius, Morocco, Nepal, New Zealand, Philippines, Senegal, Singapore, Somalia, Republic of Korea, Sri Lanka, Viet Nam, and Zambia. The No New Coal Power Compact was launched by a group of governments including Sri Lanka, Chile, Denmark, France, Germany, Montenegro, and the UK ahead of COP26 to encourage all countries to commit to a coal phase out. It must be noted that a transition away from coal within major economic in the 2030s and 2040s globally is not consistent with the NZE scenario depicted by the IEA (2021a), which requires 2030 and 2040 as deadlines.

Sparked by the COP26, many countries have announced new national pledges and are joining the Powering Past Coal Alliance (PPCA), a "coalition of national and subnational governments, businesses and organizations working to advance the transition from unabated coal power generation to clean energy." PPCA membership counts 165 countries, cities, regions, and businesses. For instance, Ukraine, the third largest coal country in Europe after Germany and Poland, commits to end coal power by 2035. Other countries such as Mauritius also commit to a coal phase out by 2030.

3 Potential Policy Instruments

The coal phase out can be achieved in several different ways; the first obvious option is to end investments in new UCFPP to halt new capacity. Secondly there are options to retrofit or repurpose existing plants, including with CCUS capacity. Lastly, retirement of existing plants can be a good option for older ones.

Achieving the coal-phase out must be facilitated and supported by the implementation of policy instruments. These policy instruments can stem from the global level, such as the COP26 pledge, regional level such as the EU, or national level. There are different types of instruments that countries and institutions can employ: regulations including emission standards, targets, deadlines and timelines, financial incentives, including funds to transition away from fossil fuels, carbon prices and emission trading schemes, restrictions on funding of new fossil fuel facilities, air pollution regulation, support for renewable energy and low-carbon pathways, and just transition mechanisms. Most often, countries and institutions opt for mixes of policy instruments.

3.1 Reduction Targets and Emission Standards

First it is important to lay down clear emission standards and targets. Important targets include deadlines and timelines for the phase out of certain fossil fuels, such as the coal-phase out targets of many EU member states by 2030. Other important targets include levels of renewable energy or energy efficiency, to enable the path toward low-carbon options. In many regions these types of targets have been implemented. At the global level the Paris Agreements lays down the most important goal: to limit global climate change to 2, although preferably to 1.5 °C. Different regions interpret this goal in various ways. This can be translated into targets at the regional or national level, depending on the institutional governance, containing for instance GHG emission reduction targets, which are often accompanied by targets to increase the share of renewable energy sources, or energy savings.

Specific activities can also be targeted by targets or emission standards. Often these regulations are connected to air pollution regulation. That way, new units must be able to maintain a balance between electricity production and a specific emission level per MWh. Surpassing that may be subject to closing down or financial repercussions. This can also be accompanied by the obligation to build new units according to the Best Available Techniques, for which elaborate technical standards are drawn up. This ensures that new units produce electricity in the cleanest way possible.

3.2 Financial Incentives

There are different types of financial incentives, aimed at different goals. First, it is important to make GHG emissions expensive. This can for instance be achieved by

implementing carbon prices or taxes. This way, producing GHG emissions becomes less attractive and investments into clean(er) technologies become more attractive. Other mechanisms are emission trading schemes, if allowances have a cost. Otherwise, emission trading schemes can contribute to emission reduction targets by lowering the number of allowances at given intervals.

Other financial incentives can restrict new investments in fossil fuels, and UCFPP specifically, especially where it concerns public funding. A global example of this concerns the CoP26 pledge to longer fund new UCFPP. Target regulation combined with deadlines will ensure the restriction of private funding of fossil fuels. At the same time, investments in clean technologies can be stimulated by providing access to subsidies for instance. This way, countries or regions can implement a two-fold financial strategy.

3.3 Just Transition Mechanisms

The coal-phase out strategy, albeit necessary to reach the NZE scenario, poses different challenges for different regions. For some regions, coal use is explicitly mentioned as a strategy for economic growth and development. It is argued that a coal phase out may have negative implications to continue to strive toward development at the national or regional level. At a local level, the coal phase out may bring about negative implications for local communities and workers. Workers are at risk of losing their job, and the loss of structural employment within a community may have impact on the community at large. Therefore, regions and countries aim to implement coal-phase out strategies combined with just transition mechanisms; e.g., the reduction or prevention of negative outcomes associated with the coal phase out. On the global level this may bring about support schemes from developed to developing countries, as is also supported under the Paris Agreement, but may be agreed upon bilaterally as well. At the local level, funds for workers may be introduced, for retraining or responsible retirement for instance. Governments may also opt to stimulate development of new (clean) economic activities within these regions with public funds. Depending on the specific characteristics of the negative implications associated with the coal phase out, different policy instruments can be introduced to mitigate these as much as possible.

4 Coal Phase Out in the European Union and Selected Countries

Coal production has been an important part of the European electricity production mix, but has steadily declined since 1990. In 1990, the share of coal in Europe's electricity production was 38%, but has declined to 18% in 2019 (IEA Data and Statistics). Below four European countries will be discussed, because they rely or have relied on a large share of coal in the electricity production mix (Poland and Germany) or have implemented coal-phase out strategies (the UK and The

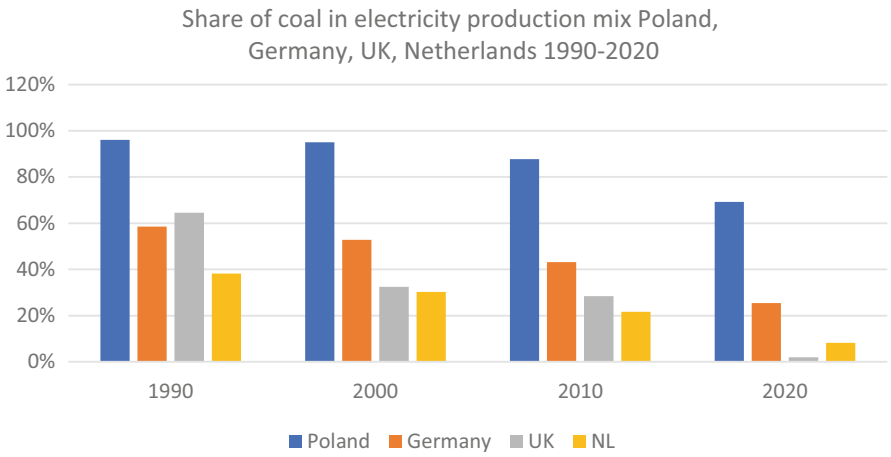

Fig. 1 European countries share of coal in the electricity production mix 1990–2020

Netherlands). In 2019, the share of coal in the total coal production in Europe amounted to: Poland, 17%, Germany, 25%, the UK, 1%, and the Netherlands, 3%.

Within EU member states, coal has been an important part of the electricity production mix. The UK, Germany, and Poland have had large shares of coal in their electricity production mix, and have decreased this significantly. Germany's share of coal decreased from 58% in 1990 to 25% in 2020 and Poland's share decreased from 96% in 1990 to 69%. The UK has nearly phased out all coal and decreased the share of coal in its mix from 65% in 1990 to 2% in 2020. The Netherlands' share was lower but has also decreased from 38% in 1990 to 8% in 2020 (Fig. 1).

4.1 Coal Phase Out in the European Union

As is also recognized by the IEA, the EU is a frontrunner within the transition away from coal. The EU Green Deal sets the tone for an ambitious policy and regulatory package to become the first net-zero continent by 2050 (EU Green Deal 2019; EU Climate Act). The energy sector is important to achieve this target: "the production and use of energy across economic sectors account for more than 75% of the EU's greenhouse gas emissions." The future power sectors must therefore rely on renewable sources, complemented by a rapid phase out of coal. In 2019, the EU Commission noted that at least no new coal plants should be constructed.

4.2 Existing Policies and Regulations

The transition away from fossil fuels toward renewable energy sources has long been facilitated by different policies and regulation at the EU level. Aiming at the reduction of GHG, the EU introduced the Effort Sharing and Emission Trade (EU ETS) mechanisms. The EU ETS covers about 45% of all GHG (2009/29/EC). Through emission allowances, GHG emissions were limited to allowances per company. Annually, the ceiling of available allowances reduces, thus restricting GHG emissions in the region. It has a twofold strategy: by restricting GHG emissions and by putting a price on emissions it will become less attractive (if not impossible) over time to emit GHG and to transition toward low-carbon options. The transition toward low-carbon options is simultaneously supported by directives on renewable energy (EU 2018/2001) and energy efficiency (EU 2018/2002).

Ensuring that any type of GHG-producing facility within the European Union is as efficient as possible, the industrial emissions directive (EU 2010/75) ensures that all new facilities adhere to Best Available Techniques.

4.3 Financial Incentives and the Just Transition

Essential to support the ambitious net-zero target at the EU level is the focus on a "just transition." As mentioned in the EU Green Deal: "The transition can only succeed if it is conducted in a fair and inclusive way. The most vulnerable are the most exposed to the harmful effects of climate change and environmental degradation. At the same time, managing the transition will lead to significant structural changes in business models, skill requirements and relative prices. Citizens, depending on their social and geographic circumstances, will be affected in different ways. Not all Member States, regions and cities start the transition from the same point or have the same capacity to respond. These challenges require a strong policy response at all levels."

Several financial instruments are introduced by the EU to support this just transition. First, a Sustainable Europe Investment Plan, combined with an InvestEU Fund. Secondly, the EU Commission introduces a Just Transition Mechanism (JTM) which will focus on the regions and sectors that are most affected by the transition because they depend on fossil fuels or carbon-intensive processes (EU Green Deal 2019). For these financial incentives over € 150 billion has been allocated. From this, A Just Transition Fund (JTF) containing € 40 billion will be channeled to relevant projects and regions. A Just Transition Platform (JTP) will help EU member states draw up Just Transition Plans, to access both funds (EU Just Transition Fund Regulation 2021). The distribution of financial means will focus most on those territories most affected by the climate transition. On the other hand, carbon taxes will be introduced to further incentive the transition away from fossil fuels.

4.4 Specific European Countries: Poland, Germany, the UK, and the Netherlands

Beyond the policies of the European Union, several (former) Member States have formulated national policies to stimulate the coal phase out. Poland is well-known for relying on UCFPP and domestic coal production. Following EU pledges to a net-zero target by 2050 and stimulated through EU funds supporting a coal-phase out in Poland, in September 2020 the Polish government agreed with trade union to gradually cease coal mining by 2049 (IEA 2021e). From Sect. 2 it becomes apparent that most countries committed to targets fitting within the NZE scenario, and the equitable distribution amongst advanced and developing economies, with the stand-out exception of Germany, which targets to phase out UCFPP by 2038. This is not aligned to the NZE scenario.

Although no longer part of the European Union, the UK has put forward an ambitious pledge to phase out coal by 2024, whereas current EU member state the Netherlands has opted to phase out coal by 2030. The UK is one of the two founding countries, together with Canada, of the Powering Past Coal Alliance. The transition away from coal has been pivotal to the UK's successful decarbonization and climate action. Starting with 65% share of coal in its electricity production in 1990, the phase out of coal is expected to be completed by October 2024, even though this explicit target has only been introduced in 2015 (IEA 2021c).

Since 1990, electricity production by means of UCFPP has been relatively steady in the Netherlands up until 2015. With a production of 25 billion kWh in 1990, and 38.9 billion kWh in 2015 (CBS 2016), this even increased over time. In 2015 and 2016 three new coal-fired plants became operational. It was not long after this that the Dutch government opted for a complete phase out of coal by 2030. First, two older plants were shut down as a reaction to the landmark Urgenda judgment, a court case against the Dutch State by NGO Urgenda to undertake more climate action – which the Dutch state lost. In 2017, the new coalition Rutte III opted to close the remaining five UCFPP by 2030. Two older plants will close by 2025. The newer plants from 2015 and 2016 would be closed by 2030. This timeline was laid down in the Prohibition to Coal Act, and to incentive this closure, a minimum carbon price for electricity production has been introduced (Akerboom et al. 2020).

5 Coal Phase Out in American Countries

In this section selected countries from the Americas (encompassing Northern, Central, and Southern American countries) will be discussed. In Northern America, the share of coal in the total electricity production mix amounts to 21% in 2019, which is a significant decrease in relation to 1990, when the share of coal amounted to 47%. Of this share, the USA is the largest producer, with a share of 95% in 1990 and 94% in 2019. Canada for instance only makes up for 4% in 2019 (5% in 1990). In Central and Southern America, the share of coal in the total electricity mix amounts to 5% in 2019, whereas this was 3% in 1990. Of this total share of coal,

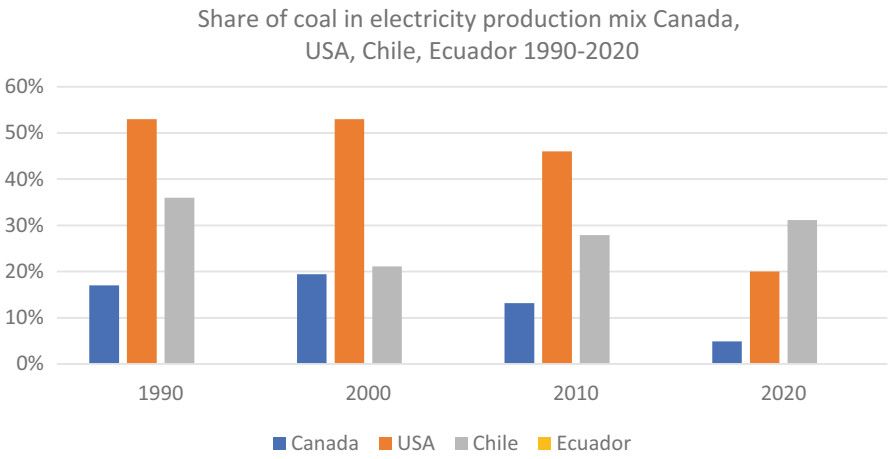

Fig. 2 Countries in the Americas share of coal in the electricity production mix 1990–2020

Chile is the largest producer with 41% in 1990 and 42% in 2019. Ecuador on the other hand has never relied on coal in its electricity production share.

Both the USA and Canada have decreased the share of coal in their electricity generation mix between 1990 and 2020. Canada has relied less on coal for their electricity production, and the share amounted to 17% in 1990 and 8% in 2020. The USA on the other hand relied significantly on coal with a share of 53% of its electricity production but has significantly decreased this to 20% in 2020. Chile has also decreased the share of coal, from 36% in 1990 to 31% in 2020 but has shown larger drops in 2000 (21%) and 2010 (28%) before increasing again (Fig. 2).

The COP26 pledge has been signed by a small number of northern and southern American countries, namely Canada, Chile, and Ecuador. Chile and Canada already formulated coal-phase out targets, 2040 resp. 2030, both in line with the NZE Roadmap (2021a). Ecuador has never had coal power generation, despite having domestic coal reserves. The USA had not signed the COP26 pledge, but being part of the G7, has issued a new pledge in March 2022 to have "predominantly decarbonized electricity sectors by 2035." The policies of the USA will not be discussed in this chapter as the coal-phase out strategies largely depend on the states.

5.1 Chile

Chile is one of the South American countries to opt for a total coal phase out by 2040. This is combined with targets for the share of renewable electricity generation: 60% by 2035 and 70% by 2050 (Nasirov et al. 2021). Today, there are 18 UNCFFP in operation, which account for 41% of the whole electricity mix (Gaete-Morales et al. 2018). The electricity sector is responsible for 45.3% of all CO_2 emissions in Chile (Amigo et al. 2021). Chile has introduced two important instruments to

achieve to phase out of UNCFPP by 2040: carbon tax and emission standards. Two other instruments can influence the accelerated phase out of UNCFFP in Chile: Social costs of carbon dioxide tax and non-conventional renewable energy law.

Chile was the first South American country to establish a carbon tax in 2018, equivalent to \$5 per tCO_2 (Amigo et al. 2021). Several studies however show that a higher carbon tax between \$13 and \$50 per tCO_2 would present more effective incentive for the reduction of emission (Diaz et al. 2020; Vera and Sauma 2015). Secondly, emission standards, introduced in 2011 establish caps on UNCFFP emissions such as mercury, particulates, sulfur dioxide, and nitrogen oxide (Agora 2021). These standards will become more stringent over time.

Moreover, Chile introduced a non-conventional renewable energy (NCRE) obligation in 2013, as part of the existing Electricity Act which was introduced in 1982 (Serra 2022). This obligation determines that 20% of energy sales must be provided by NCRE by 2025 (Benavides et al. 2015). A Social costs carbon dioxide tax, introduced in 2017, requires 40 USD per tonne to be used as a basis for assessing the "social cost" of emissions. This signals to business that the Chilean government aims to increase costs of doing business (Agora 2021).

5.2 Canada

Canada is one of the two founding countries, together with the UK, of the Powering Past Coal Alliance and has announced new regulations in December 2018 to phase out all coal-fired electricity by 2030 and GHG regulation for natural gas-fired electricity. The most important instrument for this coal phase out is the Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations, which originates from 2012 and was last amended in November 2018. In article 1 the most important goals are laid down: (1) performance standards for the intensity of CO_2 emissions of regulated units integrated with carbon capture and storage systems; (2) requirements for reporting, recording, sending, and retention of information; (3) quantification rules for determining the intensity of CO_2 emissions from regulated units; and (4) dates for entry into force. A regulated unit means physically connected equipment located in a power plant – including boilers and other combustion devices, gasifiers, reactors, turbines, generators, and emission control devices – that operate together to produce electricity by means of thermal energy using coal as a fuel, whether in conjunction with other fuels or not (article 2). In this Regulation it is determined that the "useful life" of a unit is the period between the commissioning and end date. For units whose commissioning date is before 1975, the end date is 50 years after the commissioning date, or on 31 December 2019. For units whose commissioning date is after 1974, the end date is 50 years after the commissioning date, or on 31 December 2029 (article 2).

The Regulation moreover contains emission-intensity limits of units from the combustion of fossil fuel, namely 420 tonnes CO_2 for each GWh of electricity produced by the unit during a calendar year (article 3). A temporary exemption may be granted if a new unit can be constructed with a CCS system, of if an old unit

may be retrofitted with the integration of a CCS system (article 9). During the period until the CCS system becomes operational, the emissions may exceed the limitation under article 3. Other options to comply with the emission-intensity limit are repowering or use of natural gas (Butler et al. 2017).

Canada has formulated three subsequent goals for this transition: support Canada's transition to cleaner energy; create well-paying jobs in the electricity sector; and support the goal of 90% non-emitting electricity by 2030. Canada puts specific emphasis on realizing a just transition by focusing on coal workers and communities and support to developing countries. Support for coal workers and communities focuses on understanding how people will be impacted by this transition, and to support them during the transition. A Task Force on Just Transition for Canadian Coal Power Workers and Communities combined with Canada Coal Transition Initiative aims to assist workers and communities and to create green jobs. A first geothermal power facility near Estevan, Saskatchewan, will create 100 jobs for the local affected community, supply the community with clean, renewable energy, and create new business opportunities in the area (Gürtler et al. 2021). To support developing countries, for instance in Southeast Asia, Canada supported the World Bank with $275 million in 2018. This will help support countries to phase out coal while transitioning toward clean, renewable energy.

Certain Canadian regions are leading Canada's coal phase out, such as Ontario. The government of Ontario already pledged in 2003 to phase out all UNCFFP by 2007. Ultimately, the last unit closed in 2014 following replacement of capacity by gas-fired power plants and renewables and upgrading of the grid (IEA 2021d).

6 Coal Phase in African Countries

Africa has also decreased the share of coal in the total electricity production, from 52% in 1990 to 30% in 2019. Of this share, South Africa has the largest share of coal production, with 95% in 1990 and 85% in 2019. Of this share, Morocco has increased its share of coal, from 1% in 1990 to 10% in 2019.

South Africa relies heavily on coal for its electricity production, as it amounted to 93% in 1990, whereas this decreased to 88% in 2020, the share is still substantial. Morocco on the other hand has increased substantially the share of coal in its electricity production mix from 23% in 1990 to 68% in 2020 (Fig. 3).

6.1 Morocco

Morocco has signed the "Global Coal to Clean Power Transition Statement" at the COP26, whereas South Africa has not. Yet, Morocco started operating a new UNCFFP in 2018, and it set to realize another one by 2023–2034 of 1.3 GW. Morocco has also set ambitious climate targets; 45.5 GHG emission reduction and 52% renewable energy sources by 2030 (National Climate Plan). How Morocco will phase out UCFFP in line with the NZE scenario is yet to be determined.

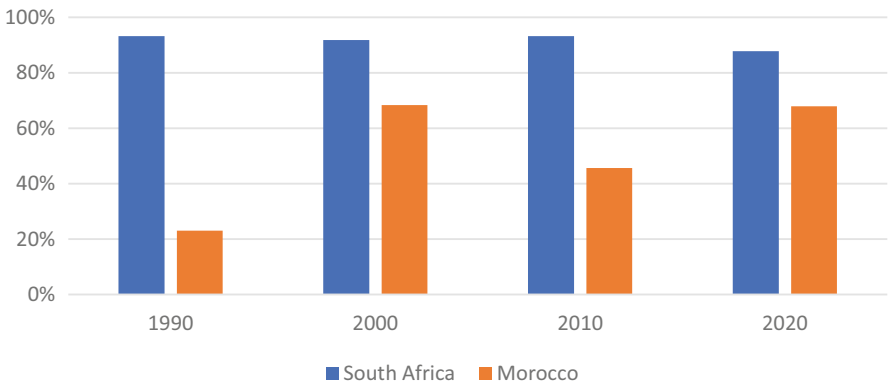

Fig. 3 Share of coal in electricity production mix South Africa and Morocco 1990–2020

6.2 South Africa

In the run-up to the COP26, South Africa increased its GHG reduction target under the Paris agreement to 350 mn to 420 mnt of CO_2 equivalent for 2030. In 2019, South Africa published an Integrated Resource Plan (IPR 2019) in which the target is to have an energy sector by 2030 that provides reliable and efficient energy service at competitive rates; that is socially equitable through expanded access to energy at affordable tariffs; and that is environmentally sustainable through reduced emissions and pollution, as was laid down in the National Development Plan. In 2019, the South African energy sector contributes to almost 80% of all total GHG emissions, of which 50% are from electricity generation and liquid fuel production (IPR 2019). In 2016, the share of coal in South Africa's primary energy consumption concerned 70% whereas the share of renewable energy was 2% (Adebayo et al. 2021b). The steady use of coal in South Africa is directly linked to economic growth, and it is feared that the reduction of CO_2 emissions will slow down development (Adebayo et al. 2021b; Joshua et al. 2020; Akinsola and Adebayo 2021; Shahbaz et al. 2013; Adebayo et al. 2021a).

The IRP (Integrated Resource Plan) of 2019 indicates that a total of 11,017 MW of coal power will phase out between 2020 and 2030. Moreover, between 2019 and 2023 5732 MW of coal power stations will be phased out (Semelane et al. 2021). Yet, an important goal of the IPR is not to limit new coal-fired power plants, but rather new projects must be based on high efficiency, low emission technologies and other cleaner coal technologies (IPR 2019). However, ahead of the COP26, South Africa announced the ambition to lower the share of coal in the energy mix to less than 60% by 2030. At the COP26, a partnership between Germany, the UK, the USA, France, and the EU was made to support South Africa in its energy transition by offering a coal phase out fund of $8.5 billion. This will include grants, loans from multilateral banks, guarantee schemes, and direct private investment for the next 5 years. Germany will contribute € 700 million to this fund, as well as expertise, for instance on how to improve the framework for private investment in renewable energy and to

mitigate the social impact of a coal-phase out. Workers are of particular importance, and around 90,000 South African coal miners will need to be retrained.

7 Coal Phase Out in Asia Pacific Countries

The share of coal in Asia Pacific countries (encompassing Asian countries and Australia and New Zealand) amounted to 41% in 1990 but has increased to 58% in 2019. Of this share, China has a large share, as it amounted to 45% in 1990 and increased to 65% in 2019. India's share of coal of the total Asia Pacific share of coal on the other hand decreased from 19% in 1990 to 16% in 2019, as well as Australia's share, which decreased from 12% in 1990 to 2% in 2019.

Whereas China's share of coal in the total share of coal in the Asia Pacific increased significantly, the share of coal in China's electricity production mix decreased, and amounted to 71% in 1990 and to 64% in 2020. India's share of coal in the electricity production mix increased from 65% in 1990 to 72% in 2020. Australia relied substantially on coal for its electricity generation, but has also decreased this share from 78% in 1990 to 55% in 2020 (Fig. 4).

7.1 China

China's sustainability plans include to reach peak carbon emissions by 2030, and to become carbon neutral by 2060. At the COP26, China did not sign the coal pledge, but has committed to stop building coal-fired power plants abroad, even though this has been an important pillar of China's Belt & Road Initiative (Springer 2022; Lin and Bega 2021). Overall, the share of coal power generation has declined from 82% in 2009 to 66% in 2019, which accounts for 70% of all energy-related CO_2 emissions, while the share of renewable energy increased (Zhang et al. 2022; Jia and Lin 2021). According to Zhang et al. (2022) there are currently 4631 coal-fired

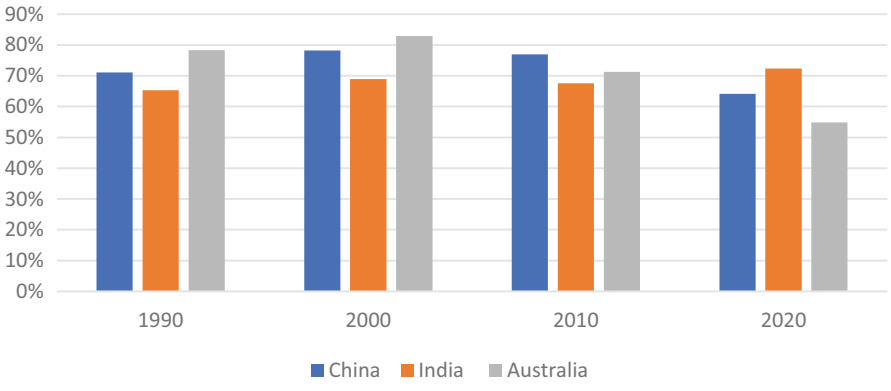

Fig. 4 Share of coal in electricity production mix China, India, and Australia 1990–2020

units in operation, 379 units under construction, 318 units being suspended or postponed, and 201 units that should have been approved by the end of 2019. The reason for the large share of coal in China concerns the fact that China has few oil and gas reserves, but large coal preserves (Jia and Lin 2021). Building new UCFFP has moreover been instrumental in local economic development (Yuan et al. 2017). A major concern for the further expansion of coal-fired units is the issue of stranded assets, if the 2060 target is to be met (Zhang et al. 2022).

One important instrument employed is the coal resource tax, introduced in 2014. This tax allows provincial governments to set their tax rates between 2% and 10%, depending on their local economic development (Liu et al. 2017). This tax has contributed to CO_2 emission reduction, while not increasing a tax burden (Jia and Lin 2021). Overall, China announced in its Energy Production and Consumption Revolution Strategy (2016–2030) to reduce carbon emission per unit of gross domestic product (GDP) by 60–65% in 2030 compared with 2005 levels (He et al. 2020).

To substitute the loss of coal-fired electricity, China invests heavily in renewable energy. More than half of the new renewable energy installation in the world is from China (Jia and Lin 2021), still there are improvements to be made in the policies (Chen et al. 2019). In China's Energy Production and Consumption Revolution Strategy (2016–2030) China plans to realize non-fossil primary energy shares of at least 15% (2020), 20% (2030), and 50% (2050) (He et al. 2020).

Another measure concerned the Action Plan on Prevention and Control of Air Pollution, which planned to constrain direct coal consumption to 65% of primary energy by 2017 through a combination of alternatives, renewables, and energy efficiency measures (He et al. 2020). Other measures include target to cap greenhouse gas emissions: new coal-fired power plants should limit PM, SO_2, and NOx emission concentrations to 10, 35, and 50 mg/m^3 by 2020, respectively, which is equivalent to the performance of gas turbines (He et al. 2020).

The coal mining industry employs a significant number of people in China: 5.3 million in 2013, but it dropped to 3.21 million in 2018. Thus far, coal-phase out strategies have already caused mass unemployment in the provinces of Shanxi, Shandong, and Inner Mongolia (Wang and Lo 2022; He et al. 2020). Although the central government has set up some worker support schemes, the finances available are limited (Wang and Lo 2022; He et al. 2020).

7.2 India

As the second largest coal consumer of Asia, it was noted that India did not sign the coal pledge at the COP26. However, ahead of the COP26, India formulated the target to become net-zero by 2070, and several sub-targets for 2030 are associated to this, such as the target to produce 55% of all electricity from renewable energy sources. Currently, India is the third largest emitter of GHG in the world, following the USA and China, and about half of these emissions are caused by coal-fired electricity. Coal provided 74.3% of Indian electricity generation in the financial year 2018–19

(1 April to 31 March) (Chakravarty and Somanatnhan 2021). The coal-fired capacity has substantially increased since 2000: from 50 GW to 209 in 2021 (Maamoun et al. 2022), which is largely explained by India's economic development.

Despite the expanse of renewable energy production, India is aiming at an increase of coal power capacity of 70–130% by 2040 as it is still seen as the cheapest energy source, even if research indicated that coal costs are higher than renewable energy (Chakravarty and Somanatnhan 2021).

Another vocal pillar is to focus on the increase of renewable energy sources. Besides the 2030 target, India wants to realize install 100 GW of solar pv and 60 GW of wind capacity by 2022, increasing the share of renewable energy to about 20% (Chakravarty and Somanatnhan 2021), while working toward 450 GW renewable energy by 2030 (Maamoun et al. 2022).

7.3 Australia

Australia currently has 18 UNCFPP with an average age of 30 years and a total capacity of over 23 GW. Although 10 UNCFPP have been retired since 2012, there has not been a fall in coal generation electricity (Webb et al. 2020). Australia has committed to a 28% GHG reduction between 2005 and 2030 and aimed to realize a share of renewable energy of 20% by 2020. Australia has no specific targets or policies to phase out coal-fired generation, nor has it committed to the COP26 coal-phase out pledge. In 2021, the Australian government presented "Australia's long-term emissions reduction plan," to achieve net zero emissions by 2050. In this plan it is explained that over $20 billions of government investment in low emissions technology will take place until 2030, yet, no shutdown of UCFPP is planned. In fact, Australia's coal and gas export industries will continue through to 2050 and beyond. As is explained in the plan, Australia is open to low emission technologies, including those that reduce the emissions from traditional fuels like gas or coal, for instance, CCS. No corresponding plan or targets have been elaborated upon.

8 Summary

Coal-fired power contributes to global climate change. Greenhouse gas emissions from coal-fired power plants should be abated; in developed countries by 2030 and in developing countries by 2040 as explained by NZE scenario. This chapter describes the current share of coal in power mixes across the world and countries' pledges toward meeting the phase out goal. There are several technological solutions to achieve this, which include, beyond the closure of power plants, mitigation techniques such as carbon capture and storage.

Overall, of the selected countries, coal-fired power has decreased between 1990 and 2019. At the same time, for certain countries, including Poland, Germany, South Africa, Morocco, China, India, and Australia, the share of coal in the total electricity production mix remains high in 2019 (69%, 25%, 88%, 64%, 72% resp.

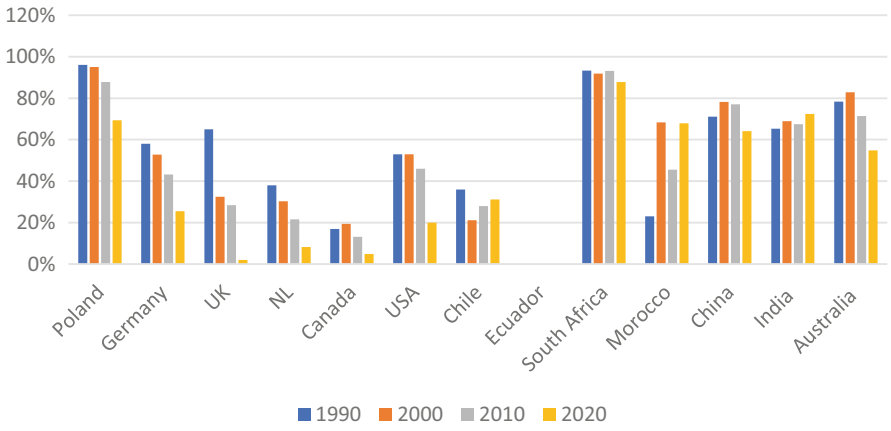

Fig. 5 Share of coal in selected countries 1990–2020

55%). This means that these countries face a substantial challenge to phase out unabated coal-fired power plants entirely by 2030 resp. 2040 (Fig. 5).

As mentioned in Sect. 2 of this chapter, the current pledges and commitments fall short of meeting the goal. The different country descriptions show that it is likely that coal-fired electricity production will persist until 2050, and perhaps beyond. Several countries rely on coal-fired power, for instance for economic development, and have not presented comprehensive plans to abate greenhouse gas emissions. This concerns South Africa, China, and India but also Australia. These countries however have formulated general climate change mitigation pledges, but lack specific plans for coal-fired power.

Other countries do have plans to phase out coal-fired power entirely, for instance by full closure of all remaining UCFPP, like the Netherlands, the UK, and Canada. Poland, which relies substantially on coal-fired electricity generation, lacks specific plans and Germany's trajectory, to phase out UCFPP by 2038, surpasses the NZE scenario deadline for developed countries.

This chapter thus shows that phasing out UCFPP will contribute substantially to global climate change mitigation, but efforts toward achieving this phase out should be stepped up significantly. For some countries this poses challenges toward their economic development, although many studies also show that investments in renewable energies will not only take off but also pose better investment strategies. Developed countries could support developing countries through global investment and financial support schemes, which currently exist, but not yet at the level required.

9 Cross-References

- Building More Sustainable and Resilient Urban Energy Infrastructures in Southern Africa: Gaps and Options
- Defining Sustainability
- Defining the Social Equity Issues in Sustainability
- Economic Development and Equity
- Environmental Law
- Environmental Regulation in Asia
- Environmental Regulation in the European Union
- Global Energy Use
- Greenhouse Gas Management
- Sustainability in Asia
- Sustainability in Latin America and the Caribbean
- The Evidence of Climate Change on Our Planet
- The Global South and Sustainability: Issues and Constraints
- The Science of Climate Change
- The State of Sustainability in Developing Countries
- The State of the World's Natural Resources

References

Adebayo TS, Kirikkaleli D, Adeshola I, Oluwajana D, Akinsola GD, Osemeahon OS (2021a) Coal consumption and environmental sustainability in South Africa: the role of financial development and globalization. Int J Renew Energy Dev 10(3):527–536. https://doi.org/10.14710/ijred.2021.34982

Adebayo TS, Awosusi AA, Bekun FV, Altuntaş M (2021b) Coal energy consumption beat renewable energy consumption in South Africa: developing policy framework for sustainable development. Renew Energy 175:1012–1024. https://doi.org/10.1016/j.renene.2021.05.032

Agora (2021) Phasing out coal in Chile and Germany. A comparative analysis, report available at https://www.energypartnership.cl/newsroom/coal-phase-out-in-chile/, [last accessed on . . .]

Akerboom S, Botzen W, Buijze A, Michels A, van Rijswick M (2020) Meeting goals of sustainability policy: CO_2 emission reduction, cost-effectiveness and societal acceptance. An analysis of the proposal to phase-out coal in the Netherlands. Energy Policy 138:111201 (OA). https://doi.org/10.1016/j.enpol.2019.111210

Akinsola GD, Adebayo TS (2021) Investigating the causal linkage among economic growth, energy consumption and CO_2 emissions in Thailand: an application of the wavelet coherence approach. Int J Ren Energ Dev 10(1):17–26

Amigo P, Cea-Echenique S, Feijoo F (2021) A two stage cap-and-trade model with allowance re-trading and capacity investment: the case of the Chilean NDC targets. Energy 224:120129. https://doi.org/10.1016/j.energy.2021.120129

Benavides C, Gonzales L, Diaz M, Fuentes R, García G, Palma-Behnke R, Ravizza C (2015) The impact of a carbon tax on the Chilean electricity generation sector. Energies 8:2674–2700. https://doi.org/10.3390/en8042674

Butler D, Hume S, Scott S, Lamprecht D (2017) Repowering options for complying with Canadian CO_2 emission intensity limits on existing coal plants. Energy Procedia 114:6386–6402. https://doi.org/10.1016/j.egypro.2017.03.1775

Chakravarty S, Somanatnhan E (2021) There is no economic case for new coal plants in India. World Dev Perspect 24:100373. https://doi.org/10.1016/j.wdp.2021.100373
Chen J, Gao M, Li D, Song M (2019) Analysis of the rebound effects of fossil and nonfossil energy in China based on sustainable development. Sustain Dev 28(1):235–246. https://doi.org/10.1002/sd.1991
Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, the European Green Deal, COM/2019/640 final (via https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN), [last accessed on . . .]
Diaz G, Muñoz FD, Moreno R (2020) Equilibrium analysis of a tax on carbon emissions with pass-through restrictions and side-payment rules. Energy J 41(2). https://doi.org/10.5547/01956574.41.2.gdia
Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community
Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)
Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources
Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency
Gaete-Morales C, Gallego-Schmid A, Stamford L, Azapagic A (2018) Assessing the environmental sustainability of electricity generation in Chile. Sci Total Environ 636:1155–1170. https://doi.org/10.1016/j.scitotenv.2018.04.346
Gürtler K, Löw Beer D, Herberg J (2021) Scaling just transitions: legitimation strategies in coal phase-out commissions in Canada and Germany. Polit Geogr 88:102406. https://doi.org/10.1016/j.polgeo.2021.102406
Lin B, Bega F (2021) China's Belt & Road Initiative coal power cooperation: transitioning toward low-carbon development. Energy Policy 156:112438. https://doi.org/10.1016/j.enpol.2021.112438
He G, Lin J, Zhang Y, Zhang W, Larangeira G, Zhang C, Peng W, Liu M, Yang F (2020) Enabling a rapid and just transition away from coal in China. One Earth 3(2):187–194. https://doi.org/10.1016/j.oneear.2020.07.012
International Energy Agency (2021a) Net Zero by 2050. A roadmap for the Global Energy Sector, May 2021 (via https://www.iea.org/reports/net-zero-by-2050), [last accessed on . . .]
International Energy Agency (2021b) World Energy Outlook, October 2021 (via https://www.iea.org/reports/world-energy-outlook-2021), [last accessed on . . .]
International Energy Agency (2021c) Phasing out unabated coal. Current status and three case-studies, October 2021 (via https://www.iea.org/reports/phasing-out-unabated-coal-current-status-and-three-case-studies), [last accessed on . . .]
International Energy Agency (2021d) Key lessons for phasing out CO2-emitting coal plants from electricity sectors, October 2021 (via https://www.iea.org/commentaries/key-lessons-for-phasing-out-co2-emitting-coal-plants-from-electricity-sectors), [last accessed on . . .]
International Energy Agency (2021e) Coal 2021. Analysis and forecast to 2024, December 2021 (via https://www.iea.org/reports/coal-2021), [last accessed on . . .]
IEA Data and Statistics., energy data by category, indicator, country or region, see for instance https://www.iea.org/data-and-statistics/data-tables?country=USA&energy=Electricity&year=2019
IEA., World Energy Model, Stated Policies Scenario (via https://www.iea.org/reports/world-energy-model/stated-policies-scenario-steps), [last accessed on . . .]
Interngovernmental Panel on Climate Change (2018) Special report on global warming of 1.5 °C, (via https://www.ipcc.ch/sr15/), [last accessed on . . .]

Integrated Resource Plan, South African government, 2019 (via http://www.energy.gov.za/files/irp_frame.html), [last accessed on . . .]

Jia Z, Lin B (2021) How to achieve the first step of the carbon-neutrality 2060 target in China: the coal substitution perspective. Energy 233:121179. https://doi.org/10.1016/j.energy.2021.121179

Joshua U, Bekun FV, Sarkodie SA (2020) New insight into the causal linkage between economic expansion, FDI, coal consumption, pollutant emissions and urbanization in South Africa. Environ Sci Pollut Res 27(15):1–12

Liu H, Chen Z, Wang J, Fan J (2017) The impact of resource tax reform on China's coal industry. Energy Econ 61:52–61. https://doi.org/10.1016/j.eneco.2016.11.002

Maamoun N, Chitkara P, Yang J, Shrimali G, Busby J, Shidore S, Jin Y, Urpelainen J (2022) Identifying coal plants for early retirement in India: a multidimensional analysis of technical, economic, and environmental factors. Appl Energy 312:118644. https://doi.org/10.1016/j.apenergy.2022.118644

Morocco, National Climate Plan., (via https://ndcpartnership.org/news/morocco-submits-enhanced-ndc-raising-ambition-455-percent-2030), [last accessed on . . .]

Nasirov S, Girard A, Peña C, Salazar F, Simon F (2021) Expansion of renewable energy in Chile: analysis of the effects on employment. Energy 226:120410. https://doi.org/10.1016/j.energy.2021.120410

Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations (SOR/2012-167), 11-30-2018 (via https://laws-lois.justice.gc.ca/eng/regulations/sor-2012-167/page-2.html#h-783511), [last accessed on . . .]

Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

Regulation (EU) 2021/1056 of the European Parliament and of the Council of 24 June 2021 establishing the Just Transition Fund (via https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R1056), [last accessed on . . .]

Shahbaz M, Tiwari AK, Nasir M (2013) The effects of financial development, economic growth, coal consumption and trade openness on CO_2 emissions in South Africa. Energy Policy 61:1452–1459

Semelane S, Nwulu N, Kambule N, Tazvinga H (2021) Evaluating available solar photovoltaic business opportunities in coal phase-out regions – an energy transition case of Steve Tshwete local municipality in South Africa. Energy Policy 155:112333. https://doi.org/10.1016/j.enpol.2021.112333

Serra P (2022) Chile's electricity markets: four decades on from their original design. Energ Strat Rev 39:100798. https://doi.org/10.1016/j.esr.2021.100798

Springer CH (2022) China's withdrawal from overseas coal in context. World Dev Perspect 25:100397. https://doi.org/10.1016/j.wdp.2022.100397

Statistics Netherlands, Elektriciteitsproductie uit steenkool opnieuw hoger, June 2016 (via: https://www.cbs.nl/nl-nl/nieuws/2016/26/elektriciteitsproductie-uit-steenkool-opnieuw-hoger#:~:text=De%20productie%20van%20elektriciteit%20uit%20steenkool%20bereikte%20vorig%20jaar%20het,onveranderd%20op%20118%20miljard%20kWh), [last accessed on . . .]

Letter to Ecoaction., https://en.ecoaction.org.ua/ua-govt-wobbles-on-the-coal.html, [last accessed on . . .]

Vera S, Sauma E (2015) Does a carbon tax make sense in countries with still a high potential for energy efficiency? Comparison between the reducing-emissions effects of carbon tax and energy efficiency measures in the Chilean case. Energy 88:478–488. https://doi.org/10.1016/j.energy.2015.05.067

Yuan J, Wang Y, Zhang W, Zhao C, Liu Q, Shen X, Zhang K, Dong L (2017) Will recent boom in coal power lead to a bust in China? A micro-economic analysis. Energy Policy 108:645–656. https://doi.org/10.1016/j.enpol.2017.06.035

Wang X, Lo K (2022) Political economy of just transition: disparate impact of coal mine closure on state-owned and private coal workers in Inner Mongolia, China. Energy Res Soc Sci 90:102585. https://doi.org/10.1016/j.erss.2022.102585

Webb J, Nadeeka de Silva H, Wilson C (2020) The future of coal and renewable power generation in Australia: a review of market trends. Econ Anal Policy 68:363–378. https://doi.org/10.1016/j.eap.2020.10.003

Zhang W, Ren M, Kan J, Zhou Y, Yuan J (2022) Estimating stranded coal assets in China's power sector. Util Policy 75:101352. https://doi.org/10.1016/j.jup.2022.101352