ADBI Working Paper Series

NAVIGATING THE ENERGY TRILEMMA DURING GEOPOLITICAL AND ENVIRONMENTAL CRISES

Richard Tol

No. 1372
April 2023

Asian Development Bank Institute

Richard Tol is a Professor at the Department of Economics, University of Sussex, United Kingdom, and a Professor of the Economics of Climate Change at the Institute for Environmental Studies and Department of Spatial Economics, Vrije Universiteit, Amsterdam, The Netherlands.

Suggested citation:

Tol, R. 2023. Navigating the Energy Trilemma during Geopolitical and Environmental Crises. ADBI Working Paper 1372. Tokyo: Asian Development Bank Institute. Available: https://doi.org/10.56506/EBHD4081

Please contact the authors for information about this paper.

Emails: r.tol@sussex.ac.uk

Dina Azhgaliyeva and Zhanna Kapsalyamova had constructive comments on a previous version. The Asian Development Bank provided welcome financial support.

Asian Development Bank Institute
Kasumigaseki Building, 8th Floor
3-2-5 Kasumigaseki, Chiyoda-ku
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500
Fax: +81-3-3593-5571
URL: www.adbi.org
E-mail: info@adbi.org

Abstract

There are many indicators of energy security. Few measure what really matters—an affordable and reliable energy supply—and the trade-offs between the affordability and reliability. Reliability is physical, affordability is economic. The latest Russian invasion of Ukraine highlights some of the problems with energy security, from long-term contracts being broken to supposedly secure supplies being diverted to retired power plants being recommissioned to spillovers to other markets. Energy security requires government intervention. Policies on energy access and poverty should shift from price support, widespread in Asia, to income support. The transition to carbon-free energy poses new challenges for energy security, from a shift in dependence from some resources (coal, oil, gas) to others (rare earths, wind, sunshine) to substantial redundancies in the energy capital stock to undercapitalized energy companies, while regulatory uncertainty deters investment. Renewables improve energy security in one dimension, but worsen it in others, particularly due to long spells of little wind. Security problems with rare earths and borrowed capital are less pronounced. The potential for asset stranding by climate policy is particularly large in Asia.

Keywords: affordability, reliability, violent conflict, climate policy

JEL Classification: Q34, Q37, Q48, Q5

1. Introduction

We want energy to be cheap, reliable, and clean. It is typically easy to meet one of these three criteria, but meeting all three at the same time is difficult. This is known as the *energy trilemma*: You can't have your cake, eat it, and consume it. Trade-offs are real.

The energy trilemma and its components are not new. As the price of fuel wood rose in London, people switched to sea coal, bituminous coal mined on the northeast coast of England. Burning this coal made the air intolerable to breathe, and in 1307 King Edward I of England banned the use of sea coal in lime kilns. The ban was no success and later kings and parliaments issued their own regulations (te Brake 1975). Nonetheless, in December 1952, some 4,000 people were killed by air pollution and maybe 8,000 more in the following months (Bell and Davis 2001). The Clean Air Act of 1956 marks the beginning of the transition away from coal as the prime fuel for heating in the cities of the UK. Elsewhere, indoor and outdoor air pollution, primarily due to energy use, continue to kill millions of people each year.[1]

Energy security focuses on two aspects of the energy trilemma: reliability and affordability (Lefèvre 2010). The two concepts are often mixed together,[2] but they are really separate. Energy reliability is a physical concept. Electric power is unreliable if transmission lines frequently fail, or generation plants suffer many outages. Reliable electric power is available when it is needed, unreliable electricity may or may not be there.

Affordability is an economic concept. Electricity may be available but sold at such a high price that its use is forgone or rationed. From the perspective of the final user, it does not matter whether energy is not there or not affordable. In either case, energy is not used. From an analytical perspective, however, it is important to distinguish the two concepts because technical solutions differ and the two objectives may clash. The reliability of an electricity grid can be improved with more transmission lines that are redundant except in emergencies. The electricity supply can be made more reliable by adding more power plants, used only in times of exceptional outages or very high demand. Such an increase in reliability would come at a cost, and so make electricity less affordable.

Jansen and Seebregts (2010) argue that environmental externalities pose security risks, so that energy security encompasses the whole of the energy trilemma. Bohi and Toman (1993, 1996) agree but restrict attention to those externalities that can be meaningfully influenced by policy, as indicators that are impervious to policy intervention should not be used to advise policy. I disagree, not because clean energy is not important, but because indicators should support policy by clarifying choices and consequences. A single indicator

[1] See WHO.

[2] Some analysts define the energy trilemma to be a three-way trade-off between cleanliness, security, and equity. Besides combining reliability and affordability, equitable access to energy is a matter of the distribution of income—unless there is strong price discrimination. Others replace clean energy with sustainable energy, but why use a long word where a short one will do? Besides, sustainability no longer refers just to the environment but also includes notions of social justice and economic development (Purvis et al. 2019).

that obscures the reality of the energy trilemma is not helpful. Free after Tinbergen (1952), we should have as many indicators as we have problems.

This paper continues as follows. Section 2 discusses the various indicators of energy security that have been used in the literature and that provide the conceptual framework for the rest of the paper. Section 3 treats policy instruments to increase energy security. Section 4 is about the effects of geopolitics on energy reliability and affordability. Section 5 treats the impact of climate policy in the short- and long-run. Section 6 concludes.

2. Indicators of energy security

If we want to assess the impacts of geopolitics and climate policy on energy security, we need to be able to measure energy security. Much thought has gone into this, but this has not brought much clarity.

Böhringer and Bortolamedi (2015) critically reviews energy security indicators and their use in policy. Energy security indicators tend to suffer from the following limitations. First, indicators are supply-oriented, disregarding the demand side (Jansen and Seebregts 2010; Sovacool 2013; Gracceva and Zeniewski 2014). Second, indicators are proxies only; they do not assess the energy system's responses to shocks (Cherp and Jewell 2011; Gracceva and Zeniewski 2014). Third, energy security indicators have no information on the costs and benefits of different levels of energy security (Gracceva and Zeniewski 2014). Fourth, different energy security indicators cannot meaningfully be added or compared (Böhringer and Jochem 2007; Kruyt et al. 2009; Frondel and Schmidt 2014).

According to Böhringer and Bortolamedi (2015, see also Kruyt et al. (2009); Löschel et al. (2010)), four indicators of energy security are in widespread use:

- **Primary energy intensity** is defined as total primary energy use over Gross Domestic Product (GDP). Primary energy use is a physical measure, so this indicator only proxies reliability, not affordability. However, this indicator makes no distinction between more reliable and less reliable energy supplies. No account is taken of international trade in energy; offshoring energy-intensive industry would seem to increase energy security, even if goods are now imported from countries with a higher energy intensity (Gnansounou 2008). GDP too is problematic. It can be a poor measure of economic output in small open economies. Comparison of prices across international borders is difficult too; economies vary greatly in size between market exchange rates and purchasing power rates (Samuelson 2014; Suehiro 2008).
- **Dependence on foreign primary energy supply** is defined as the sum (over all fuels) of net imports (or zero for net exporters) divided by total primary energy use (Bhattacharyya 2011; Le Coq and Paltseva 2009). As with the previous indicator, there is no distinction between more and less reliable energy supplies. All foreign suppliers are deemed to be equally risky, and all domestic suppliers are supposed to be without risk.

- **Concentration of primary energy supply** is defined as the Herfindahl-Hirschman index—the sum of squared market shares—for fuels (Bhattacharyya 2011). This indicator again ignores the actual reliability of the energy supply. It also ignores that different fuels serve different purposes—liquid fuels for transport, solid and gaseous fuels for power generation—so that differences in demand naturally lead to more or less reliance on particular fuels (Stirling 2010).
- **Concentration of foreign primary energy supply** is defined as the Herfindahl-Hirschman index for net energy imports, where concentration is measured either over the number of foreign suppliers (Kleindorfer and Saad 2005) or over the number of foreign suppliers and fuels (Frondel and Schmidt 2014). Once more, the reliability of imports is omitted from the indicator—oil purchases from Norway are treated the same as oil purchases from Libya—although this can be accommodated by introducing a riskiness parameter per supplier. Fungibility is another critique (Le Coq and Paltseva 2009). A country may depend on a single supplier of coal. An idiosyncratic shock to that supplier would not be a problem if other suppliers can take over. A country may buy oil from many suppliers, but this would not protect it from a system-wide shock. Transport is ignored too. Crossing the territory of a third party may be risky—recall piracy off the Horn of Africa and hijackings in the Strait of Hormuz—and some modes of transport are more flexible than others—contrast gas pipelines and liquified natural gas.

Ang et al. (2015) also review the literature on energy security, finding no fewer than 83 different definitions and a great many indicators. For instance, Sovacool and Mukherjee (2011) use 320 simple indicators and 52 complex ones. None of this makes much sense. Energy security is security from a human perspective, and it should therefore be measured as a reduction of human welfare (Bohi and Toman 1996). There are two reasons why energy might not be secure: An energy source is temporarily or permanently (*i*) unavailable or (*ii*) unaffordable, and cannot be replaced at short notice.

Ex post, energy security is easy to observe: a power plant tripped, an oil tanker ran aground, energy bills were unpaid, or energy offers were not bought. *Ex ante*, energy reliability is hard to measure because it necessarily involves an assessment of the probability of things not going as expected. Energy affordability is predictable to the extent that incomes and energy prices are.

As argued above, energy reliability is a physical concept: Is the primary energy available, can it be transformed into a useful energy carrier, and can it be transported to the final user? Energy affordability is an economic concept: Is the price acceptable to the final user?

2.1. Ex post indicators

The World Bank has a number of indicators that measure the reliability of the electricity supply, including:

- fraction of value lost due to electrical outages;

- percentage of firms experiencing electrical outages; and
- monthly number of power outages in firms.

Electricity is important but there are other energy sources as well. It would be useful to systematically collect information on shortages of transport, heating, and cooking fuels.

The negative impact of power outages is well-documented for both firms[3] and households,[4] as well as for the economy as a whole.[5] The evidence is for all parts of the world, and all levels of development. The negative impact comes in two parts. Unreliable electricity leads to interruption of production and daily life. In addition, firms invest in expensive backup equipment, locking scarce capital into unproductive means.

These studies make it clear that an unreliable energy supply is bad for the economy in the short-run and for economic development in the long-run. Capital diverted to backup power generation could have been used more productively. Learning and human capital accumulation are interrupted too. Although the actual outages happen by chance, the probability of outages can be reduced through better management of power plants and transmission lines, and better regulation of utilities.

The World Bank also publishes data on access to energy:

- Fraction of people (total, rural, urban) that have access to electricity; and
- Fraction of people (total, rural, urban) that have access to clean energy.

It would be good to extend this to access to modern energy. Furthermore, while energy access is an important issue in poorer countries, energy poverty is important in richer countries—but there is no systematic data collection on this. Energy poverty is variously defined as energy expenditures above a certain fraction of income or an inability to provide a basic level of energy services. The latter, better definition is difficult to measure consistently over time and space.[6]

The impact of energy access is well-documented too, with mostly positive effects on a range of economic, social, and environmental aspects across the world, for all levels of development,

[3] Pasha et al. (1989); Beenstock (1991); Tishler (1993); Beenstock et al. (1997); Serra and Fierro (1997); Steinbuks and Foster (2010); Alby et al. (2013); Allcott et al. (2016); Cole et al. (2018); Elliott et al. (2021); Chen et al. (2022)

[4] Carlsson and Martinsson (2007, 2008); Carlsson et al. (2011); Amador et al. (2013); Chakravorty et al. (2014); Ozbafli and Jenkins (2016); Poczter (2017); Kennedy et al. (2019); Meles (2020); Bajo-Buenestado (2021); Carlsson et al. (2021); Deutschmann et al. (2021); Meles et al. (2021); Motz (2021); Sedai et al. (2021b); Alberini et al. (2022); Aweke and Navrud (2022); Lawson (2022); Toto (2022)

[5] Sanghvi (1982); de Nooij et al. (2007, 2009); Andersen and Dalgaard (2013); Reichl et al. (2013); Carranza and Meeks (2021); Woo et al. (2021)

[6] Energy poverty is reported in poorer countries as well (Barnes et al. 2011; Khandker et al. 2012; Andadari et al. 2014; Sadath and Acharya 2017; Crentsil et al. 2019; Feeny et al. 2021; Gafa and Egbendewe 2021) but difficult to separate from energy access.

and in the short- and long-term.[7]

These papers show that improving access to energy, by expanding the physical supply and reducing prices, has a direct effect on the economy by reducing costs, freeing up time, and facilitating more production. In addition, it improves health care and education which, in the long term, further accelerate economic development.

Energy poverty too has negative impacts on well-being,[8] physical health,[9] mental health,[10] education,[11] crime,[12] agriculture,[13] and development in general.[14]

3. Improving energy security

Policymakers have a number of instruments at their disposal to improve energy security in its many guises. This is not the place for an exhaustive discussion.[15]

The reliability of the energy supply is threatened in two ways: There may not be enough energy, or the energy may not reach its destination.

Insufficient capacity is a particular problem in power generation. The technical answer is more capacity. As electricity cannot (yet) be stored at scale and demand varies considerably

[7] Dinkelman (2011); Grogan and Sadanand (2013); Lipscomb et al. (2013); Rao (2013); Khandker et al. (2014); Dasso and Fernandez (2015); Grimm et al. (2015); Kitchens and Fishback (2015); Grogan (2016); Peters and Sievert (2016); Salmon and Tanguy (2016); Abeberese (2017); Akpandjar and Kitchens (2017); Barron and Torero (2017); Da Silveira Bezerra et al. (2017); Grimm et al. (2017); van de Walle et al. (2017); Aklin et al. (2018); Burke et al. (2018); Ding et al. (2018); Fujii et al. (2018); Grogan (2018); Kumar and Rauniyar (2018); Lewis (2018); Rathi and Vermaak (2018); Saing (2018); Thomas and Urpelainen (2018); Dang and La (2019); He (2019); Jahangir Alam and Kaneko (2019); Litzow et al. (2019); Richmond and Urpelainen (2019); Zhang et al. (2019); Burgess et al. (2020); Cravioto et al. (2020); Diallo and Moussa (2020); Emmanuel and Japhet (2020); Fujii and Shonchoy (2020); Irwin et al. (2020); Lee et al. (2020b,a); Lewis and Severnini (2020); Sievert and Steinbuks (2020); Tagliapietra et al. (2020); Thomas et al. (2020); Acheampong et al. (2021b,a); Chhay and Yamazaki (2021); Fried and Lagakos (2021); Gaggl et al. (2021); Gupta and Pelli (2021); Jeuland et al. (2021); Sedai et al. (2021a); Wagner et al. (2021); Wirawan and Gultom (2021); Wu et al. (2021); Acharya and Sadath (2022); Adom and Nsabimana (2022); Ayana and Degaga (2022); Bo et al. (2022); Chaurey and Le (2022); Dendup (2022); Hong et al. (2022); Koirala and Acharya (2022); Ogunro and Afolabi (2022); Sedai et al. (2022); Guo et al. (2023)

[8] Sambodo and Novandra (2019); Awaworyi Churchill et al. (2020); Nie et al. (2021)

[9] Teller-Elsberg et al. (2016); Ortiz et al. (2019); Bukari et al. (2021); Awaworyi Churchill and Smyth (2021); Nawaz (2021); Prakash and Munyanyi (2021)

[10] Zhang et al. (2021)

[11] Oum (2019); Rafi et al. (2021); Apergis et al. (2022)

[12] Hailemariam et al. (2021); Awaworyi Churchill and Smyth (2022a)

[13] Shi et al. (2022)

[14] Singh and Inglesi-Lotz (2020); Acheampong et al. (2021b)

[15] See, for instance, Anderson (2019); Baumol and Oates (1988); Berck and Helfand (2011); Endres and Radke (2012); Field and Field (2009); Goodstein (2005); Hanley et al. (2007, 2013); Harris and Roach (2018); Hodge (1995); Kahn (2020); Keohane and Olmstead (2016); Kolstad (2011); Lewis and Tietenberg (2019); Pearce and Turner (1990); Perman et al. (2011); Phaneuf and Requate (2017); Tietenberg and Lewis (2018); Turner et al. (1994); Wills (1997)

during the day, week, and year, there is typically a mismatch between peak demand and maximum supply. Peak demand lasts only a few hours, a short period to earn back the investment in peak supply. The best solution is a mixture of setting a level of acceptable blackouts, preparing for blackouts, and a reverse auction to buy spare generating capacity, financed by a levy on electricity use (Creti and Fabra 2007).

Inadequate transport or transmission is the other cause of an unreliable energy supply. The technical solution is to build redundancy in transport and transmission systems. If the market is competitive—e.g., tanker transport of oil—the costs of redundancy will be weighed against the costs of non-delivery, a breach of contract, and loss of reputation. If the market is not competitive—power cables, pipelines—direct regulation is the way forward. Natural monopolies tend to be state-owned and strictly regulated anyway, so additional regulation is straightforward whereas price signals—taxes or subsidies—are less effective without competition (Jamasb and Marantes 2012; Schmidthaler et al. 2015).

Energy affordability is about energy access in poorer countries and about energy poverty in richer ones. In both cases, poverty is the core problem. Rich people in poor countries have access to modern fuels. Energy companies happily hook up neighbourhoods once enough people can pay for their products. Similarly, energy poverty in rich countries is tightly correlated with income poverty. Stimulating economic growth, and particularly economic growth that disproportionally favours the less well-off, is, therefore, a key strategy to improve energy affordability.

More targeted interventions are also possible. Many countries subsidize energy use. Data are hard to get. The International Monetary Fund (IMF) has probably the best data but does not share, while their aggregate statistics are hard to read as explicit and implicit subsidies are added (Parry et al. 2021). The International Energy Agency (IEA) does share data,[16] but only split by fuel. In 2021 in Azerbaijan, Uzbekistan, Turkmenistan, and Kazakhstan, the retail energy price was less than the wholesale price. These countries, as well as Bangladesh, spent more than 5% of their GDP on fuel subsidies.

Price subsidies are not advised. Price subsidies help those who would otherwise not be able to afford energy, but also and primarily help those who would have bought energy at the unsubsidized price anyway. Price subsidies also encourage waste when energy is, in fact, short. Price vouchers allow targeted price support (Podesta et al. 2021). Income support is another, better alternative to price support—if it is well targeted (Best et al. 2021; García Alvarez and Tol 2021; Bagnoli and Bertoméu-Sánchez 2022).

Furthermore, as lack of energy access and energy poverty hold back development (see above), alleviating this should be part of an overall economic development strategy (Bouzarovski et al. 2012; Karpinska and Śmiech 2021). Unaffordable energy is often caused by a lack of investment, which in turn is caused by a lack of access to capital markets. Investment subsidies are thus justified, in home insulation and efficient heating in richer countries, and

[16] See here.

in microgeneration, -grids, and -storage in poorer countries. However, energy poverty is not just about financials.[17] Any campaign against energy poverty needs to pay careful attention to age and family structure, as well as to ethnic, racial, and religious discrimination.

4. Geopolitics and energy security

The exploitation of fossil fuels, and particularly of oil and gas, is heavily concentrated in a small number of places. Although there are oil and gas fields in many countries, most are relatively small. A few large producers dominate production. This has been the case since the start of the large-scale use of oil and gas.

The concentration of production implies that political unrest or violent conflict at the locale of oil and gas fields has a disproportionate impact on the world market for oil and gas. The concentration of production increases the importance of long-distance transport and the bottlenecks of international trade, such as the Panama and Suez Canals, and the Straits of Hormuz and Malacca. Furthermore, aware of the strategic importance of the centres of oil and gas production, outside forces have long sought to control these centres, or to control the strongmen who control them, competing with indigenous people and with other outsiders. In return, the strongmen have sought to influence the politics of other countries, both near their borders and far away. The result is a vicious cycle of political instability, interspersed with periods of stable but brutal and brittle regimes.

The second invasion of Ukraine by the Russian Federation illustrates the short-term issues. The violence has affected key energy infrastructure—damage to substations and thermal generators, threats to nuclear plants and hydropower dams—some accidental, and some apparently deliberate. The violence is concentrated in Ukraine, but occasionally spills into the Russian Federation and there are seemingly related acts of sabotage in Germany and the Baltic Sea. The rulers of the Russian Federation may have hoped that its position as the main supplier of energy to Europe would prevent other countries from coming to Ukraine's aid, but that was a miscalculation. The flow of oil and gas from the Russian Federation to Europe fell sharply. This forced the countries of Europe to seek imports from elsewhere, driving up the price of oil and liquefied natural gas (LNG). This in turn made energy unaffordable elsewhere. Pakistan, for instance, could no longer afford to import LNG and suffered power blackouts as a result. At the same time, Russian oil and gas traded at a discount, benefiting those countries that had the infrastructure to import (e.g., gas pipelines) and even re-export. The details are different for other conflicts, but violent conflict involving large energy exporters causes a lot of misery.

For the effects in the long-run, the literature on the natural resource curse offers some empirical support for the hypothesis that economies with weak institutions and an abundance

[17] Xu and Chen (2019); Awaworyi Churchill and Smyth (2020); Karpinska and Śmiech (2020); Ampofo and Mabefam (2021); Paudel (2021); Awaworyi Churchill and Smyth (2022b); Dogan et al. (2022); Koomson and Awaworyi Churchill (2022); Koomson et al. (2022); Moniche-Bermejo (2022); Barkat et al. (2023); Crago et al. (2023); Elder and Payne (2023); Li et al. (2023b,a); Lin and Okyere (2023); Luan et al. (2023)

of oil and gas, grow more slowly, as they are susceptible to political corruption[18] and violent conflict[19]—although there are also papers highlighting flaws in the research.[20]

Unlike outages caused by the technical failure of energy production and transport, or power generation and transmission, unrest, and conflict are hard to predict. Instead of objective probabilities based on observed frequencies, we have subjective degrees of belief that, as autocratic regimes are rarely transparent, are based on incomplete knowledge and understanding (García-Verdugo and Munoz 2012). Yet, as once again demonstrated by the second Russian invasion of Ukraine in February 2022, geopolitical risks can, when realized, cause great havoc in energy markets as the impacts are system-wide rather than location-specific.

Although some have argued that a shift away from fossil fuels would lead to a reduction in geopolitical energy risks (Kemfert 2019), others point out that geopolitical risks would change rather than disappear (Hache 2018) as discussed below.

5. Climate policy and transition risk

The energy trilemma has that we want energy that is reliable, affordable, and clean. Reliability and affordability together constitute energy security. The drive for cleaner energy affects its reliability and affordability. In the current discourse, "clean" energy is seen as carbon-free energy. There are other, perhaps larger environmental problems due to energy use—such as indoor air pollution, outdoor air pollution, and acidification—but these primarily affect poorer countries and are not seen as global priorities.

The replacement of fossil fuels by renewable energy will, in the long run, lead to a more reliable energy supply. Whereas thermal power plants are large and therefore few, wind turbines and solar panels are small and therefore many. By the law of large numbers, a large number of small power sources is less vulnerable to outages—be it due to mechanical faults, natural disasters, or terrorist attacks—than a small number of large power sources. Maintenance too is less disruptive.

On the other hand, solar and wind power are not dispatchable; power generation happens when it does, rather than when it needs to happen. This is particularly a problem for wind power. There is no solar power at night, but this is no surprise and can be solved with short-term electricity storage, as demand drops rapidly mid-evening. Lulls in wind can last for weeks, well beyond storage capacity, and may coincide with high demand—in Western Europe, for instance, winter cold and low winds go hand in hand.

[18] Ross (1999); Sachs and Warner (2001); Jensen and Wantchekon (2004); Papyrakis and Gerlagh (2004); Bulte et al. (2005); Hodler (2006); Mehlum et al. (2006b,a); Robinson et al. (2006); Boschini et al. (2007); Brunnschweiler (2008); Kolstad and Søreide (2009); van der Ploeg and Poelhekke (2009); Torvik (2009); Aslaksen (2010); Vicente (2010); Cavalcanti et al. (2011); Van Der Ploeg (2011); Williams (2011); Boschini et al. (2013); Brollo et al. (2013); Betz et al. (2015); Havranek et al. (2016); Badeeb et al. (2017)

[19] Grossman (1999); Collier and Hoeffler (2005); Dunning (2005); Basedau and Lay (2009); Brunnschweiler and Bulte (2009)

[20] Brunnschweiler and Bulte (2008); Alexeev and Conrad (2009); van der Ploeg and Poelhekke (2010); Haber and Menaldo (2011); Smith (2015)

Some argue that renewable energy is more secure because it is mostly generated in the home country rather than imported.[21] This argument is false. Foreign suppliers are not necessarily less reliable than domestic ones. The argument rests on either xenophobia or the false belief of being in control of what is happening in your own country.

Others argue that renewable energy is not secure because it relies on rare earths[22] and depends on foreign capital (Nakatani 2010). These arguments affect the speed of expansion of renewables rather than their functioning once installed. Rare earths are essential for both generation and storage. Their spatial concentration is a reason for concern. However, existing solar panels will continue to operate if the supply of rare earths is interrupted—unlike thermal plants which cease to operate if their fuel runs out.

The same argument holds for capital. Renewable energy uses more capital per kilowatt-hour than fossil energy and is, therefore, more exposed to movements of the interest rate and to sanctions in the capital market. This argument holds for the financing of new renewables, and for the refinancing of existing renewables. It does not hold for their operation. Operators run their wind turbines and solar panels regardless of the interest rate. The same cannot be said of thermal plants, which cease operation if the wholesale electricity price does not cover the cost of fuel.

Hache (2018) argues that patents are another bottleneck—a country or company may deny another country or company a license for the use of advanced technology. But, as with rare earths and investment, withholding patents would decelerate the expansion of renewables but would not stop existing renewables. And, anyway, legal niceties such as respect for intellectual property rights rapidly go out of the window in case of conflict.

An expansion of nuclear power would also help to reduce climate change, but probably at the expense of affordability and reliability. Taking the costs of accident prevention and waste disposal into account, nuclear fission is not among the cheaper sources of electricity (Ahearne 2011). Nuclear power plants are large;[23] unscheduled outages therefore threaten a reliable power supply. The situation in France in 2022 is a reminder. While small modular reactors are all the rage at the moment, these are in fact only somewhat smaller than a typical gas-fired power plant. Nuclear power poses two unique challenges. An expansion of the nuclear power supply large enough to have a notable effect on greenhouse gas emissions and so climate change would require the building of nuclear power plants in currently unstable countries. The first challenge is that the people who run a nuclear power plant, know how to and have the material to build a dirty bomb. Second, as illustrated by the second Russian invasion of Ukraine, it is a really bad idea to situate a nuclear power plant in a war zone.

However, while climate policy may make energy more reliable in the long run, this is not necessarily the case in the short and medium term. Instability in the fossil-fuel producing

[21] See Wikipedia, UK Government, US Government.

[22] See UK Government, US Government

[23] Nuclear fusion plants would be larger still.

regions is one concern, as the old regimes lose their power of patronage—and the restraint to seek conflict with the buyers of their energy.

Another concern is the scale of investment needed, particularly if the ambitious goals set out in the 2015 Paris Agreement and reaffirmed at 27th Conference of the Parties to the United Nations Framework Convention on Climate Change at Sharm el-Sheikh in 2022 are to be met.[24] A rapid expansion of renewable energy by investors with a limited budget may well lead to a lack of redundancy. Reliability would fall as a consequence.

A rapid transition to renewables risks stranding fossil fuel assets Davis et al. (2010); Tong et al. (2019); Ansari and Holz (2020); Semieniuk et al. (2022); Ferentinos et al. (2023). These studies estimate the global size and value of stranded assets, but only Tong et al. (2019) provide substantial regional detail: 41% of the world's committed emissions are in the People's Republic of China, 9% in India, and another 12% in other members of the Asian Development Bank. Coleman et al. (2021) find that few asset managers in India are aware of the possibility that their fossil fuel assets may be stranded and lose their value.

Asset stranding can be seen as an increase in redundancy, as delays between deactivation and demolition can be long. The current energy crisis in Europe due to the Russian Federation's second invasion of Ukraine is indeed alleviated by previously mothballed power stations being turned back on. However, the greater risk to energy security is the higher probability of bankruptcy as companies have to retire assets before the end of their economic lifetime. This leaves less money to invest within the energy sector and deters money from outside the sector from flowing in. If governments bail out energy companies, the budget for energy support falls—including investment in such things as peak capacity, transmission, interconnection, and storage.

Besides the impact on the reliability of the energy supply, climate policy also affects the affordability of energy.[25] Climate policy necessarily makes energy more expensive, by a little for lenient emission reduction targets and smart policy design, and perhaps by a lot when targets are stringent and policies suboptimal. Energy is a necessary good; the burden of higher energy prices, therefore, falls disproportionally on the poor. However, the substitution away from fossil fuels reduces the return on capital and increases the demand for labour and wages. Climate policy may thus be a relative benefit to the working poor.[26]

Estimates of the costs of climate policy vary widely between studies—predicting the future is hard—but all agree that a uniform carbon tax leading to the complete decarbonization of

[24]See IEA.

[25]Chakravarty and Tavoni (2013) note that lifting 3.5 billion people out of energy poverty would raise the global mean surface air temperature by 0.13℃ only.

[26]Rausch et al. (2011); Cullenward et al. (2016); Rausch and Schwarz (2016); Melnikov et al. (2017); Rosas-Flores et al. (2017); Tovar Reaños and Wölfing (2018); Goulder et al. (2019); Metcalf (2019); Pizer and Sexton (2019); Saelim (2019); Böhringer et al. (2021); Chepeliev et al. (2021); hn and Yonezawa (2021); Garaffa et al. (2021); Landis et al. (2021); Mayer et al. (2021); Vandyck et al. (2021); García-Muros et al. (2022); Wu et al. (2022)

the economy by 2100 would be cheap, perhaps even too cheap to meter (Clarke et al. 2014; Riahi et al. 2022). The costs can be reduced by the clever use of the revenues from carbon taxes and emission permit auctions (Goulder 1995)—if those policy instruments are indeed used. However, costs rapidly increase if a policy is suboptimal—multiple emission permit markets, overlapping regulations such as a tax on top of tradable permits, unpredictably fluctuating subsidies, or inappropriate technical standards (Boehringer et al. 2009). Costs also increase rapidly if decarbonization needs to be completed well before 2100.

Climate policy affects energy access as well. Under pressure from donor countries and climate activists, development banks and, increasingly, investment banks have stopped the financing of fossil fuel projects in developing countries.[27] In many parts of the world, coal-fired power is the cheapest source of electricity. Restricting investment and driving up the price of electricity reduces access, excluding more people and companies from using electricity and the appliances that use electricity.

6. Discussion and conclusion

Measuring energy security is difficult, mostly because it consists of two conflicting parts—energy reliability and energy affordability—both of which are easy to measure *ex post* but harder to predict *ex ante*.

Providing energy security requires state intervention. Peak capacity is a public good, best purchased in a reverse auction. Redundancy in transport and transmission network monopolies is best achieved by direct regulation. Across Asia and the Pacific, energy price subsidies are large and widespread. Instead, policies on energy access and poverty should focus on well-targeted income support and investment subsidies.

Because the supply of fossil fuels is spatially concentrated, political unrest in the areas of production can have worldwide effects. Outside interference and the resource rents from oil and gas exploitation may increase instability.

In the long run, climate policy and the replacement of fossil fuels with renewable energy should reduce the geopolitical risks to the energy supply. In the medium term, however, climate policy reduces energy affordability and, through asset stranding and bankruptcy, may negatively affect reliability too. Asia holds the majority of potentially stranded assets.

As illustrated by the many references above, there is a vast amount of research on energy security. Further research would be welcome in some areas. Indicators of the reliability of the electricity supply are readily available, but lacking for other energy sources and carriers. Internationally comparable indicators of energy access can be found, but not of energy poverty. Research on policy interventions to increase energy access and reduce energy poverty would proceed most fruitfully via field experiments, in which energy companies, regulators, and academics collaborate to test which policies work well and which not so

[27] See World Bank, Asian Development Bank, and HSBC.

well. Improved quantification of the probability of the outbreak of violent conflict would be a great boon. We do not understand enough about the impact of asset stranding and second-best climate policies.

Policy implications are implied in the above discussion. The key policy recommendation, however, follows from the reality of the energy trilemma—the impossibility of energy that is clean, reliable, and cheap. If policymakers push too hard on one dimension of the energy trilemma, the other two will suffer. Energy policy, therefore, requires a careful and balanced consideration of all options.

References

Abeberese, A., 2017. Electricity cost and firm performance: Evidence from India. Review of Economics and Statistics 99 (5), 839–852.

Acharya, R., Sadath, A., 2022. Achievements and challenges of energy poverty alleviation policies: Evidence from the select states in India. Journal of Public Affairs 23 (1), e2839.

Acheampong, A., Dzator, J., Shahbaz, M., 2021a. Empowering the powerless: Does access to energy improve income inequality? Energy Economics 99.

Acheampong, A., Erdiaw-Kwasie, M., Abunyewah, M., 2021b. Does energy accessibility improve human development? Evidence from energy-poor regions. Energy Economics 96.

Adom, P., Nsabimana, A., 2022. Rural access to electricity and welfare outcomes in Rwanda: Addressing issues of transitional heterogeneities and between and within gender disparities. Resource and Energy Economics 70.

Ahearne, J., 2011. Prospects for nuclear energy. Energy Economics 33 (4), 572–580.

Aklin, M., Bayer, P., Harish, S., Urpelainen, J., 2018. Economics of household technology adoption in developing countries: Evidence from solar technology adoption in rural India. Energy Economics 72, 35–46.

Akpandjar, G., Kitchens, C., 2017. From darkness to light: The effect of electrification in Ghana, 2000-2010. Economic Development and Cultural Change 66 (1), 31–54.

Alberini, A., Steinbuks, J., Timilsina, G., 2022. How valuable is the reliability of residential electricity supply in low-income countries? evidence from Nepal. Energy Journal 43 (4), 1–26.

Alby, P., Dethier, J., Straub, S., 2013. Firms operating under electricity constraints in developing countries. World Bank Economic Review 27 (1), 109–132.

Alexeev, M., Conrad, R., 2009. The elusive curse of oil. Review of Economics and Statistics 91 (3), 586–598.

Allcott, H., Collard-Wexler, A., O'Connell, S. D., 2016. How do electricity shortages affect industry? Evidence from India. American Economic Review 106 (3), 587–624.

Amador, F. J., González, R. M., Ramos-Real, F. J., 2013. Supplier choice and WTP for electricity attributes in an emerging market: The role of perceived past experience, environmental concern and energy saving behavior. Energy Economics 40, 953–966.

Ampofo, A., Mabefam, M., 2021. Religiosity and energy poverty: Empirical evidence across countries. Energy Economics 102.

Andadari, R., Mulder, P., Rietveld, P., 2014. Energy poverty reduction by fuel switching. impact evaluation of the LPG conversion program in Indonesia. Energy Policy 66, 436–449.

Andersen, T., Dalgaard, C.-J., 2013. Power outages and economic growth in Africa. Energy Economics 38, 19–23.

Anderson, D., 2019. Environmental Economics and Natural Resource Management (5th edition). Routledge.

Ang, B. W., Choong, W. L., Ng, T. S., 2015. Energy security: Definitions, dimensions and indexes. Renewable and Sustainable Energy Reviews 42, 1077–1093.

Ansari, D., Holz, F., 2020. Between stranded assets and green transformation: Fossil-fuel-producing devel-

oping countries towards 2055. World Development 130, 104947.
URL https://www.sciencedirect.com/science/article/pii/S0305750X20300735
Apergis, N., Polemis, M., Soursou, S.-E., 2022. Energy poverty and education: Fresh evidence from a panel of developing countries. Energy Economics 106.
Aslaksen, S., 2010. Oil and democracy: More than a cross-country correlation? Journal of Peace Research 47 (4), 421–431.
Awaworyi Churchill, S., Smyth, R., 2020. Ethnic diversity, energy poverty and the mediating role of trust: Evidence from household panel data for Australia. Energy Economics 86.
Awaworyi Churchill, S., Smyth, R., 2021. Energy poverty and health: Panel data evidence from Australia. Energy Economics 97.
Awaworyi Churchill, S., Smyth, R., 2022a. Local area crime and energy poverty. Energy Economics 114.
Awaworyi Churchill, S., Smyth, R., 2022b. Protestantism and energy poverty. Energy Economics 111.
Awaworyi Churchill, S., Smyth, R., Farrell, L., 2020. Fuel poverty and subjective wellbeing. Energy Economics 86.
Aweke, A. T., Navrud, S., 2022. Valuing energy poverty costs: Household welfare loss from electricity blackouts in developing countries. Energy Economics 109.
Ayana, O., Degaga, J., 2022. Effects of rural electrification on household welfare: A meta-regression analysis. International Review of Economics 69 (2), 209–261.
Badeeb, R., Lean, H., Clark, J., 2017. The evolution of the natural resource curse thesis: A critical literature survey. Resources Policy 51, 123–134.
Bagnoli, L., Bertoméu-Sánchez, S., 2022. How effective has the electricity social rate been in reducing energy poverty in spain? Energy Economics 106.
Bajo-Buenestado, R., 2021. The effect of blackouts on household electrification status: Evidence from Kenya. Energy Economics 94.
Barkat, K., Alsamara, M., Mimouni, K., 2023. Can remittances alleviate energy poverty in developing countries? New evidence from panel data. Energy Economics 119.
Barnes, D., Khandker, S., Samad, H., 2011. Energy poverty in rural Bangladesh. Energy Policy 39 (2), 894–904.
Barron, M., Torero, M., 2017. Household electrification and indoor air pollution. Journal of Environmental Economics and Management 86, 81–92.
Basedau, M., Lay, J., 2009. Resource curse or rentier peace? The ambiguous effects of oil wealth and oil dependence on violent conflict. Journal of Peace Research 46 (6), 757–776.
Baumol, W., Oates, W., 1988. The Theory of Environmental Policy (2nd edition). Cambridge University Press.
Beenstock, M., 1991. Generators and the cost of electricity outages. Energy Economics 13 (4), 283–289.
Beenstock, M., Goldin, E., Haitovsky, Y., 1997. The cost of power outages in the business and public sectors in Israel: Revealed preference vs. subjective valuation. Energy Journal 18 (2), 39–61.
Bell, M., Davis, D., 2001. Reassessment of the lethal London fog of 1952: Novel indicators of acute and chronic consequences of acute exposure to air pollution. Environmental Health Perspectives 109 (SUPPL. 3), 389–394.
Berck, P., Helfand, G., 2011. The Economics of the Environment. Addison Wesley.
Best, R., Hammerle, M., Mukhopadhaya, P., Silber, J., 2021. Targeting household energy assistance. Energy Economics 99.
Betz, M., Partridge, M., Farren, M., Lobao, L., 2015. Coal mining, economic development, and the natural resources curse. Energy Economics 50, 105–116.
Bhattacharyya, S. C., 2011. Energy Economics: Concepts, Issues, Markets and Governance.
Bo, S., Chen, T., Liu, C., 2022. Trade shocks, industrial growth, and electrification in early 20th-century China. Journal of Comparative Economics 50 (3), 732–749.
Boehringer, C., Rutherford, T. F., Tol, R. S. J., 2009. The EU 20/20/2020 targets: An overview of the EMF22 assessment. Energy Economics 31 (SUPPL. 2), S268–S273.
Bohi, D., Toman, M., 1993. Energy security: Externalities and policies. Energy Policy 21 (11), 1093–1109.

Bohi, D., Toman, M., 1996. The Economics of Energy Security. Kluwer, Norwell, cited By 143.

Böhringer, C., Bortolamedi, M., 2015. Sense and no(n)-sense of energy security indicators. Ecological Economics 119, 359–371.

Böhringer, C., Jochem, P. E. P., 2007. Measuring the immeasurable—A survey of sustainability indices. Ecological Economics 63 (1), 1–8.

Böhringer, C., Rutherford, T. F., Schneider, J., 2021. The incidence of CO_2 emissions pricing under alternative international market responses: A computable general equilibrium analysis for Germany. Energy Economics 101, 105404.
URL https://www.sciencedirect.com/science/article/pii/S0140988321003017

Boschini, A., Pettersson, J., Roine, J., 2007. Resource curse or not: A question of appropriability. Scandinavian Journal of Economics 109 (3), 593–617.

Boschini, A., Pettersson, J., Roine, J., 2013. The resource curse and its potential reversal. World Development 43, 19–41.

Bouzarovski, S., Petrova, S., Sarlamanov, R., 2012. Energy poverty policies in the EU: A critical perspective. Energy Policy 49, 76–82.

Brollo, F., Nannicini, T., Perotti, R., Tabellini, G., 2013. The political resource curse. American Economic Review 103 (5), 1759–1796.

Brunnschweiler, C., 2008. Cursing the blessings? natural resource abundance, institutions, and economic growth. World Development 36 (3), 399–419.

Brunnschweiler, C., Bulte, E., 2008. The resource curse revisited and revised: A tale of paradoxes and red herrings. Journal of Environmental Economics and Management 55 (3), 248–264.

Brunnschweiler, C., Bulte, E., 2009. Natural resources and violent conflict: Resource abundance, dependence, and the onset of civil wars. Oxford Economic Papers 61 (4), 651–674.

Bukari, C., Broermann, S., Okai, D., 2021. Energy poverty and health expenditure: Evidence from Ghana. Energy Economics 103.

Bulte, E., Damania, R., Deacon, R., 2005. Resource intensity, institutions, and development. World Development 33 (7), 1029–1044.

Burgess, M. G., Ritchie, J., Shapland, J., Pielke Jr, R. A., 2020. IPCC baseline scenarios have over-projected CO_2 emissions and economic growth. Environmental Research Letters 16 (1), 024027.

Burke, P., Stern, D., Bruns, S., 2018. The impact of electricity on economic development: A macroeconomic perspective. International Review of Environmental and Resource Economics 12 (1), 85–127.

Carlsson, F., Kataria, M., Lampi, E., Martinsson, P., 2021. Past and present outage costs—A follow-up study of households' willingness to pay to avoid power outages. Resource and Energy Economics 64.

Carlsson, F., Martinsson, P., 2007. Willingness to pay among Swedish households to avoid power outages: A random parameter Tobit model approach. Energy Journal 28 (1), 75–89.

Carlsson, F., Martinsson, P., 2008. Does it matter when a power outage occurs?—A choice experiment study on the willingness to pay to avoid power outages. Energy Economics 30 (3), 1232–1245.

Carlsson, F., Martinsson, P., Akay, A., 2011. The effect of power outages and cheap talk on willingness to pay to reduce outages. Energy Economics 33 (5), 790–798.

Carranza, E., Meeks, R., 2021. Energy efficiency and electricity reliability. Review of Economics and Statistics 103 (3), 461–475.

Cavalcanti, T., Mohaddes, K., Raissi, M., 2011. Growth, development and natural resources: New evidence using a heterogeneous panel analysis. Quarterly Review of Economics and Finance 51 (4), 305–318.

Chakravarty, S., Tavoni, M., 2013. Energy poverty alleviation and climate change mitigation: Is there a trade off? Energy Economics 40, S67–S73.

Chakravorty, U., Pelli, M., Ural Marchand, B., 2014. Does the quality of electricity matter? Evidence from rural India. Journal of Economic Behavior and Organization 107 (PA), 228–247.

Chaurey, R., Le, D., 2022. Infrastructure maintenance and rural economic activity: Evidence from India. Journal of Public Economics 214.

Chen, H., Yan, H., Gong, K., Geng, H., Yuan, X.-C., 2022. Assessing the business interruption costs from power outages in China. Energy Economics 105.

Chepeliev, M., Osorio-Rodarte, I., van der Mensbrugghe, D., 2021. Distributional impacts of carbon pricing policies under the Paris Agreement: Inter and intra-regional perspectives. Energy Economics 102, 105530. URL https://www.sciencedirect.com/science/article/pii/S0140988321004084

Cherp, A., Jewell, J., 2011. Measuring energy security: from universal indicators to contextualized frameworks. The Routledge Handbook of Energy Security, 330–355.

Chhay, P., Yamazaki, K., 2021. Rural electrification and changes in employment structure in Cambodia. World Development 137.

Clarke, L., Jiang, K., Akimoto, K., Babiker, M. H., Blanford, G. J., Fisher-Vanden, K. A., Hourcade, J. C., Krey, V., Kriegler, E., Loeschel, A., McCollum, D. W., Paltsev, S., Rose, S., Shukla, P. R., Tavoni, M., van Vuuren, D., Van Der Zwaan, B., 2014. Assessing transformation pathways. In: Edenhofer, O., Pichs-Madruga, R., Sokona, Y. (Eds.), Climate Change 2014: Mitigation of Climate Change—Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Cole, M. A., Elliott, R. J. R., Occhiali, G., Strobl, E., 2018. Power outages and firm performance in Sub-Saharan Africa. Journal of Development Economics 134, 150–159.

Coleman, T. F., Dumont, N. S., Li, W., Liu, W., Rubtsov, A., 2021. Optimal pricing of climate risk. Computational Economics.

Collier, P., Hoeffler, A., 2005. Resource rents, governance, and conflict. Journal of Conflict Resolution 49 (4), 625–633.

Crago, C., Grazier, E., Breger, D., 2023. Income and racial disparities in financial returns from solar PV deployment. Energy Economics 117.

Cravioto, J., Ohgaki, H., Che, H., Tan, C., Kobayashi, S., Toe, H., Long, B., Oudaya, E., Rahim, N., Farzeneh, H., 2020. The effects of rural electrification on quality of life: A Southeast Asian perspective. Energies 13 (10).

Crentsil, A., Asuman, D., Fenny, A., 2019. Assessing the determinants and drivers of multidimensional energy poverty in Ghana. Energy Policy 133.

Creti, A., Fabra, N., 2007. Supply security and short-run capacity markets for electricity. Energy Economics 29 (2), 259–276.

Cullenward, D., Wilkerson, J., Wara, M., Weyant, J., 2016. Dynamically estimating the distributional impacts of U.S. climate policy with NEMS: A case study of the Climate Protection Act of 2013. Energy Economics 55, 303–318.

Da Silveira Bezerra, P., Callegari, C., Ribas, A., Lucena, A., Portugal-Pereira, J., Koberle, A., Szklo, A., Schaeffer, R., 2017. The power of light: Socio-economic and environmental implications of a rural electrification program in Brazil. Environmental Research Letters 12 (9).

Dang, D., La, H., 2019. Does electricity reliability matter? Evidence from rural Viet Nam. Energy Policy 131, 399–409.

Dasso, R., Fernandez, F., 2015. The effects of electrification on employment in rural Peru. IZA Journal of Labor and Development 4 (1).

Davis, S. J., Caldeira, K., Matthews, H. D., 2010. Future CO_2 emissions and climate change from existing energy infrastructure. Science 329 (5997), 1330–1333.

de Nooij, M., Koopmans, C., Bijvoet, C., 2007. The value of supply security. The costs of power interruptions: Economic input for damage reduction and investment in networks. Energy Economics 29 (2), 277–295.

de Nooij, M., Lieshout, R., Koopmans, C., 2009. Optimal blackouts: Empirical results on reducing the social cost of electricity outages through efficient regional rationing. Energy Economics 31 (3), 342–347.

Dendup, N., 2022. Returns to grid electricity on firewood and kerosene: Mechanism. Journal of Environmental Economics and Management 111.

Deutschmann, J., Postepska, A., Sarr, L., 2021. Measuring willingness to pay for reliable electricity: Evidence from Senegal. World Development 138.

Diallo, A., Moussa, R., 2020. The effects of solar home system on welfare in off-grid areas: Evidence from Côte d'Ivoire. Energy 194.

Ding, H., Qin, C., Shi, K., 2018. Development through electrification: Evidence from rural China. China

Economic Review 50, 313–328.
Dinkelman, T., 2011. The effects of rural electrification on employment: New evidence from South Africa. American Economic Review 101 (7), 3078–3108.
Dogan, E., Madaleno, M., Inglesi-Lotz, R., Taskin, D., 2022. Race and energy poverty: Evidence from African-American households. Energy Economics 108.
Dunning, T., 2005. Resource dependence, economic performance, and political stability. Journal of Conflict Resolution 49 (4), 451–482.
Elder, J., Payne, J., 2023. Racial and ethnic disparities in unemployment and oil price uncertainty. Energy Economics 119.
Elliott, R. J. R., Nguyen-Tien, V., Strobl, E. A., 2021. Power outages and firm performance: A hydro-IV approach for a single electricity grid. Energy Economics 103.
Emmanuel, N., Japhet, K., 2020. Impact of rural electrification on Ugandan women's empowerment: Evidence from micro-data. Journal of Energy and Development 46 (1), 63–80.
Endres, A., Radke, V., 2012. Economics for Environmental Studies. Heidelberg.
Feeny, S., Trinh, T.-A., Zhu, A., 2021. Temperature shocks and energy poverty: Findings from Vietnam. Energy Economics 99.
Ferentinos, K., Gibberd, A., Guin, B., 2023. Stranded houses? The price effect of a minimum energy efficiency standard. Energy Economics 120.
Field, B., Field, M., 2009. Environmental Economics—An Introduction (5th edition). New York.
Fried, S., Lagakos, D., 2021. Rural electrification, migration and structural transformation: Evidence from Ethiopia. Regional Science and Urban Economics 91.
Frondel, M., Schmidt, C. M., 2014. A measure of a nation's physical energy supply risk. Quarterly Review of Economics and Finance 54 (2), 208–215.
Fujii, T., Shonchoy, A., 2020. Fertility and rural electrification in Bangladesh. Journal of Development Economics 143.
Fujii, T., Shonchoy, A., Xu, S., 2018. Impact of electrification on children's nutritional status in rural Bangladesh. World Development 102, 315–330.
Gafa, D., Egbendewe, A., 2021. Energy poverty in rural West Africa and its determinants: Evidence from Senegal and Togo. Energy Policy 156.
Gaggl, P., Gray, R., Marinescu, I., Morin, M., 2021. Does electricity drive structural transformation? Evidence from the United States. Labour Economics 68.
Garaffa, R., Cunha, B. S. L., Cruz, T., Bezerra, P., Lucena, A. F. P., Gurgel, A. C., 2021. Distributional effects of carbon pricing in Brazil under the Paris Agreement. Energy Economics 101, 105396.
URL https://www.sciencedirect.com/science/article/pii/S0140988321002954
García Alvarez, G., Tol, R. S. J., 2021. The impact of the Bono Social de Electricidad on energy poverty in Spain. Energy Economics 103.
García-Muros, X., Morris, J., Paltsev, S., 2022. Toward a just energy transition: A distributional analysis of low-carbon policies in the USA. Energy Economics 105, 105769.
URL https://www.sciencedirect.com/science/article/pii/S0140988321006113
García-Verdugo, J., Munoz, B., 2012. Energy dependence, vulnerability and the geopolitical context: A quantitative approach to energy security. pp. 37–53.
Gnansounou, E., 2008. Assessing the energy vulnerability: Case of industrialised countries. Energy Policy 36 (10), 3734–3744.
Goodstein, E., 2005. Economics and the Environment (4th edition). Hoboken.
Goulder, L., 1995. Environmental taxation and the double dividend: A reader's guide. International Tax and Public Finance 2 (2), 157–183.
Goulder, L. H., Hafstead, M. A. C., Kim, G., Long, X., 2019. Impacts of a carbon tax across US household income groups: What are the equity-efficiency trade-offs? Journal of Public Economics 175, 44–64.
Gracceva, F., Zeniewski, P., 2014. A systemic approach to assessing energy security in a low-carbon EU energy system. Applied Energy 123, 335?348.
Grimm, M., Munyehirwe, A., Peters, J., Sievert, M., 2017. A first step up the energy ladder? Low-cost solar

kits and household's welfare in rural Rwanda. World Bank Economic Review 31 (3), 631–649.
Grimm, M., Sparrow, R., Tasciotti, L., 2015. Does electrification spur the fertility transition? Evidence from Indonesia. Demography 52 (5), 1773–1796.
Grogan, L., 2016. Household electrification, fertility, and employment: Evidence from hydroelectric dam construction in Colombia. Journal of Human Capital 10 (1), 109–158.
Grogan, L., 2018. Time use impacts of rural electrification: Longitudinal evidence from Guatemala. Journal of Development Economics 135, 304–317.
Grogan, L., Sadanand, A., 2013. Rural electrification and employment in poor countries: Evidence from Nicaragua. World Development 43, 252–265.
Grossman, H., 1999. Kleptocracy and revolutions. Oxford Economic Papers 51 (2), 267–283.
Guo, D., Li, Q., Liu, P., Shi, X., Yu, J., 2023. Power shortage and firm performance: Evidence from a Chinese city power shortage index. Energy Economics 119.
Gupta, R., Pelli, M., 2021. Electrification and cooking fuel choice in rural India. World Development 146.
Haber, S., Menaldo, V., 2011. Do natural resources fuel authoritarianism? A reappraisal of the resource curse. American Political Science Review 105 (1), 1–26.
Hache, E., 2018. Do renewable energies improve energy security in the long run? International Economics 156, 127–135.
Hailemariam, A., Sakutukwa, T., Yew, S., 2021. The impact of energy poverty on physical violence. Energy Economics 100.
Hanley, N., Shogren, J., White, B., 2007. Environmental Economics in Theory and Practice (2nd edition). Palgrave MacMillan.
Hanley, N., Shogren, J., White, B., 2013. Introduction to Environmental Economics (2nd edition). Oxford University Press.
Harris, J., Roach, B., 2018. Environmental and Natural Resource Economics—A Contemporary Approach (4th edition). Routledge.
Havranek, T., Horvath, R., Zeynalov, A., 2016. Natural resources and economic growth: A meta-analysis. World Development 88, 134–151.
He, X., 2019. China's electrification and rural labor: Analysis with fuzzy regression discontinuity. Energy Economics 81, 650–660.
hn, T. F., Yonezawa, H., 2021. Emission targets and coalition options for a small, ambitious country: An analysis of welfare costs and distributional impacts for Norway. Energy Economics 103, 105607.
URL https://www.sciencedirect.com/science/article/pii/S0140988321004746
Hodge, I., 1995. Environmental Economics. Basingstoke.
Hodler, R., 2006. The curse of natural resources in fractionalized countries. European Economic Review 50 (6), 1367–1386.
Hong, X., Wu, S., Zhang, X., 2022. Clean energy powers energy poverty alleviation: Evidence from Chinese micro-survey data. Technological Forecasting and Social Change 182.
Irwin, B., Hoxha, K., Grépin, K., 2020. Conceptualising the effect of access to electricity on health in low- and middle-income countries: A systematic review. Global Public Health 15 (3), 452–473.
Jahangir Alam, M., Kaneko, S., 2019. The effects of electrification on school enrollment in Bangladesh: Short- and long-run perspectives. Energies 12 (4).
Jamasb, T., Marantes, C., 2012. Electricity distribution networks: Investment and regulation, and uncertain demand. In: Jamasb, T., Pollitt, M. G. (Eds.), The Future of Electricity Demand: Customers, Citizens and Loads. Cambridge University Press, Cambridge, pp. 379–400.
Jansen, J. C., Seebregts, A. J., 2010. Long-term energy services security: What is it and how can it be measured and valued? Energy Policy 38 (4), 1654–1664.
Jensen, N., Wantchekon, L., 2004. Resource wealth and political regimes in Africa. Comparative Political Studies 37 (7), 816–841.
Jeuland, M., Fetter, T., Li, Y., Pattanayak, S., Usmani, F., Bluffstone, R., Chávez, C., Girardeau, H., Hassen, S., Jagger, P., Jaime, M., Karumba, M., Köhlin, G., Lenz, L., Litzow, E., Masatsugu, L., Naranjo, M., Peters, J., Qin, P., Ruhinduka, R., Serrano-Medrano, M., Sievert, M., Sills, E., Toman, M.,

2021. Is energy the golden thread? A systematic review of the impacts of modern and traditional energy use in low- and middle-income countries. Renewable and Sustainable Energy Reviews 135.

Kahn, M., 2020. Fundamentals of Environmental and Urban Economics. M.E. Kahn.

Karpinska, L., Śmiech, S., 2020. Conceptualising housing costs: The hidden face of energy poverty in Poland. Energy Policy 147.

Karpinska, L., Śmiech, S., 2021. Breaking the cycle of energy poverty. Will Poland make it? Energy Economics 94.

Kemfert, C., 2019. Green deal for Europe: More climate protection and fewer fossil fuel wars. Intereconomics 54 (6), 353–358.

Kennedy, R., Mahajan, A., Urpelainen, J., 2019. Quality of service predicts willingness to pay for household electricity connections in rural India. Energy Policy 129, 319–326.

Keohane, N., Olmstead, S., 2016. Markets and the Environment (2nd edition). Washington.

Khandker, S., Barnes, D., Samad, H., 2012. Are the energy poor also income poor? Evidence from India. Energy Policy 47, 1–12.

Khandker, S., Samad, H., Ali, R., Barnes, D., 2014. Who benefits most from rural electrification? Evidence in India. Energy Journal 35 (2), 75–96.

Kitchens, C., Fishback, P., 2015. Flip the switch: The impact of the Rural Electrification Administration 1935-1940. Journal of Economic History 75 (4), 1161–1195.

Kleindorfer, P. R., Saad, G. H., 2005. Managing disruption risks in supply chains. Production and Operations Management 14 (1), 53–68.

Koirala, D., Acharya, B., 2022. Households' fuel choices in the context of a decade-long load-shedding problem in Nepal. Energy Policy 162.

Kolstad, C., 2011. Intermediate Environmental Economics (2nd international edition). Oxford University Press.

Kolstad, I., Søreide, T., 2009. Corruption in natural resource management: Implications for policy makers. Resources Policy 34 (4), 214–226.

Koomson, I., Afoakwah, C., Ampofo, A., 2022. How does ethnic diversity affect energy poverty? Insights from South Africa. Energy Economics 111.

Koomson, I., Awaworyi Churchill, S., 2022. Employment precarity and energy poverty in post-apartheid South Africa: Exploring the racial and ethnic dimensions. Energy Economics 110.

Kruyt, B., van Vuuren, D. P., de Vries, H. J. M., Groenenberg, H., 2009. Indicators for energy security. Energy Policy 37 (6), 2166–2181.

Kumar, S., Rauniyar, G., 2018. The impact of rural electrification on income and education: Evidence from Bhutan. Review of Development Economics 22 (3), 1146–1165.

Landis, F., Fredriksson, G., Rausch, S., 2021. Between- and within-country distributional impacts from harmonizing carbon prices in the EU. Energy Economics 103, 105585.
URL https://www.sciencedirect.com/science/article/pii/S0140988321004540

Lawson, K., 2022. Electricity outages and residential fires: Evidence from Cape Town, South Africa. South African Journal of Economics.

Le Coq, C., Paltseva, E., 2009. Measuring the security of external energy supply in the European Union. Energy Policy 37 (11), 4474–4481.

Lee, K., Miguel, E., Wolfram, C., 2020a. Does household electrification supercharge economic development? Journal of Economic Perspectives 34 (1), 122–144.

Lee, K., Miguel, E., Wolfram, C., 2020b. Experimental evidence on the economics of rural electrification. Journal of Political Economy 128 (4), 1523–1565.

Lefèvre, N., 2010. Measuring the energy security implications of fossil fuel resource concentration. Energy Policy 38 (4), 1635–1644.

Lewis, J., 2018. Infant health, women's fertility, and rural electrification in the United States, 1930-1960. Journal of Economic History 78 (1), 118–154.

Lewis, J., Severnini, E., 2020. Short- and long-run impacts of rural electrification: Evidence from the historical rollout of the U.S. power grid. Journal of Development Economics 143.

Lewis, L., Tietenberg, T., 2019. Environmental Economics and Policy (7th edition). New York.
Li, X., Smyth, R., Xin, G., Yao, Y., 2023a. Warmer temperatures and energy poverty: Evidence from Chinese households. Energy Economics 120.
Li, Y., Chen, K., Ding, R., Zhang, J., Hao, Y., 2023b. How do photovoltaic poverty alleviation projects relieve household energy poverty? Evidence from China. Energy Economics 118.
Lin, B., Okyere, M. A., 2023. Race and energy poverty: The moderating role of subsidies in South Africa. Energy Economics 117.
Lipscomb, M., Mushfiq Mobarak, A., Barham, T., 2013. Development effects of electrification: Evidence from the topographic placement of hydropower plants in Brazil. American Economic Journal: Applied Economics 5 (2), 200–231.
Litzow, E., Pattanayak, S., Thinley, T., 2019. Returns to rural electrification: Evidence from Bhutan. World Development 121, 75–96.
Löschel, A., Moslener, U., Rübbelke, D. T. G., 2010. Indicators of energy security in industrialised countries. Energy Policy 38 (4), 1665–1671.
Luan, B., Zou, H., Huang, J., 2023. Digital divide and household energy poverty in China. Energy Economics 119.
Mayer, J., Dugan, A., Bachner, G., Steininger, K. W., 2021. Is carbon pricing regressive? Insights from a recursive-dynamic CGE analysis with heterogeneous households for Austria. Energy Economics 104, 105661.
URL https://www.sciencedirect.com/science/article/pii/S0140988321005181
Mehlum, H., Moene, K., Torvik, R., 2006a. Cursed by resources or institutions? World Economy 29 (8), 1117–1131.
Mehlum, H., Moene, K., Torvik, R., 2006b. Institutions and the resource curse. Economic Journal 116 (508), 1–20.
Meles, T., 2020. Impact of power outages on households in developing countries: Evidence from Ethiopia. Energy Economics 91.
Meles, T., Mekonnen, A., Beyene, A., Hassen, S., Pattanayak, S., Sebsibie, S., Klug, T., Jeuland, M., 2021. Households' valuation of power outages in major cities of Ethiopia: An application of stated preference methods. Energy Economics 102.
Melnikov, N., O'Neill, B., Dalton, M., van Ruijven, B., 2017. Downscaling heterogeneous household outcomes in dynamic CGE models for energy-economic analysis. Energy Economics 65, 87–97.
Metcalf, G. E., 2019. The distributional impacts of U.S. energy policy. Energy Policy 129, 926–929.
Moniche-Bermejo, A., 2022. Do collective energy switching campaigns engage vulnerable households? Evidence from the big switch. Energy Policy 167.
Motz, A., 2021. Security of supply and the energy transition: The households' perspective investigated through a discrete choice model with latent classes. Energy Economics 97.
Nakatani, K., 2010. Restrictions on Foreign Investment in the Energy Sector for National Security Reasons: The Case of Japan. In: McHarg, A. (Ed.), Property and the Law in Energy and Natural Resources. Oxford University Press.
Nawaz, S., 2021. Energy poverty, climate shocks, and health deprivations. Energy Economics 100.
Nie, P., Li, Q., Sousa-Poza, A., 2021. Energy poverty and subjective well-being in China: New evidence from the China Family Panel Studies. Energy Economics 103.
Ogunro, T., Afolabi, L., 2022. Evaluation of access to electricity and the socioeconomic effects in rural and urban expanses of Nigeria. International Journal of Social Economics 49 (1), 124–137.
Ortiz, J., Casquero-Modrego, N., Salom, J., 2019. Health and related economic effects of residential energy retrofitting in Spain. Energy Policy 130, 375–388.
Oum, S., 2019. Energy poverty in the Lao PDR and its impacts on education and health. Energy Policy 132, 247–253.
Ozbafli, A., Jenkins, G. P., 2016. Estimating the willingness to pay for reliable electricity supply: A choice experiment study. Energy Economics 56, 443–452.
Papyrakis, E., Gerlagh, R., 2004. The resource curse hypothesis and its transmission channels. Journal of

Comparative Economics 32 (1), 181–193.
Parry, I., Black, S., Vernon, N., 2021. Still not getting energy prices right: A global and country update of fossil fuel subsidies. Working Paper WP/21/36, International Monetary Fund.
Pasha, H. A., Ghaus, A., Malik, S., 1989. The economic cost of power outages in the industrial sector of Pakistan. Energy Economics 11 (4), 301–318.
Paudel, J., 2021. Why are people energy poor? Evidence from ethnic fractionalization. Energy Economics 102.
Pearce, D., Turner, R., 1990. Environmental and Natural Resource Economics. New York.
Perman, R., Ma, Y., Common, M., Maddison, D., McGilvray, J., 2011. Natural Resource and Environmental Economics (4th edition). Addison Wesley.
Peters, J., Sievert, M., 2016. Impacts of rural electrification revisited: The African context. Revue d'Economie du Developpement 23 (HS), 77–98.
Phaneuf, D., Requate, T., 2017. A Course in Environmental Economics—Theory, Policy, and Practice. Cambridge University Press.
Pizer, W., Sexton, S., 2019. The distributional impacts of energy taxes. Review of Environmental Economics and Policy 13 (1), 104–123.
Poczter, S., 2017. You can't count on me: The impact of electricity unreliability on productivity. Agricultural and Resource Economics Review 46 (3), 579–602.
Podesta, M., Poudou, J.-C., Roland, M., 2021. The price impact of energy vouchers. Energy Journal 42 (3), 27–54.
Prakash, K., Munyanyi, M., 2021. Energy poverty and obesity. Energy Economics 101.
Purvis, B., Mao, Y., Robinson, D., 2019. Three pillars of sustainability: In search of conceptual origins. Sustainability Science 14 (3), 681–695.
URL https://link.springer.com/article/10.1007/s11625-018-0627-5
Rafi, M., Naseef, M., Prasad, S., 2021. Multidimensional energy poverty and human capital development: Empirical evidence from India. Energy Economics 101.
Rao, N., 2013. Does (better) electricity supply increase household enterprise income in India? Energy Policy 57, 532–541.
Rathi, S., Vermaak, C., 2018. Rural electrification, gender and the labor market: A cross-country study of India and South Africa. World Development 109, 346–359.
Rausch, S., Metcalf, G. E., Reilly, J. M., 2011. Distributional impacts of carbon pricing: A general equilibrium approach with micro-data for households. Energy Economics 33 (SUPPL. 1), S20–S33.
Rausch, S., Schwarz, G., 2016. Household heterogeneity, aggregation, and the distributional impacts of environmental taxes. Journal of Public Economics 138, 43–57.
Reichl, J., Schmidthaler, M., Schneider, F., 2013. The value of supply security: The costs of power outages to Austrian households, firms and the public sector. Energy Economics 36, 256–261.
Riahi, K., Schaeffer, R., Arango, J., Calvin, K., Guivarch, C., Hasegawa, T., Jiang, K., Kriegler, E., Matthews, R., Peters, G., Rao, A., Robertson, S., Sebbit, A. M., Steinberger, J., Tavoni, M., van Vuuren, D., 2022. Mitigation pathways compatible with long-term goals. In: Shukla, P. R., Skea, J., Slade, R., Khourdajie, A. A., van Diemen, R., McCollum, D., Pathak, M., Some, S., Vyas, P., Fradera, R., Belkacemi, M., Hasija, A., Lisboa, G., Luz, S., Malley, J. (Eds.), Climate Change 2022: Mitigation of Climate Change—Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.
Richmond, J., Urpelainen, J., 2019. Electrification and appliance ownership over time: Evidence from rural India. Energy Policy 133.
Robinson, J., Torvik, R., Verdier, T., 2006. Political foundations of the resource curse. Journal of Development Economics 79 (2), 447–468.
Rosas-Flores, J., Bakhat, M., Rosas-Flores, D., Fernández Zayas, J., 2017. Distributional effects of subsidy removal and implementation of carbon taxes in Mexican households. Energy Economics 61, 21–28.
Ross, M., 1999. The political economy of the resource curse. World Politics 51 (2), 297–322.
Sachs, J., Warner, A., 2001. The curse of natural resources. European Economic Review 45 (4-6), 827–838.

Sadath, A., Acharya, R., 2017. Assessing the extent and intensity of energy poverty using Multidimensional Energy Poverty Index: Empirical evidence from households in India. Energy Policy 102, 540–550.

Saelim, S., 2019. Carbon tax incidence on household consumption: Heterogeneity across socio-economic factors in Thailand. Economic Analysis and Policy 62, 159–174.

Saing, C., 2018. Rural electrification in Cambodia: Does it improve the welfare of households? Oxford Development Studies 46 (2), 147–163.

Salmon, C., Tanguy, J., 2016. Rural electrification and household labor supply: Evidence from Nigeria. World Development 82, 48–68.

Sambodo, M., Novandra, R., 2019. The state of energy poverty in Indonesia and its impact on welfare. Energy Policy 132, 113–121.

Samuelson, R. D., 2014. The unexpected challenges of using energy intensity as a policy objective: Examining the debate over the APEC energy intensity goal. Energy Policy 64, 373–381.

Sanghvi, A., 1982. Economic costs of electricity supply interruptions. US and foreign experience. Energy Economics 4 (3), 180–198.

Schmidthaler, M., Cohen, J., Reichl, J., Schmidinger, S., 2015. The effects of network regulation on electricity supply security: A European analysis. Journal of Regulatory Economics 48 (3), 285–316.

Sedai, A., Jamasb, T., Nepal, R., Miller, R., 2021a. Electrification and welfare for the marginalized: Evidence from India. Energy Economics 102.

Sedai, A., Nepal, R., Jamasb, T., 2022. Electrification and socio-economic empowerment of women in India. Energy Journal 43 (2), 215–238.

Sedai, A., Vasudevan, R., Pena, A., Miller, R., 2021b. Does reliable electrification reduce gender differences? Evidence from India. Journal of Economic Behavior and Organization 185, 580–601.

Semieniuk, G., Holden, P., Mercure, J.-F., Salas, P., Pollitt, H., Jobson, K., Vercoulen, P., Chewpreecha, U., Edwards, N., Viñuales, J., 2022. Stranded fossil-fuel assets translate to major losses for investors in advanced economies. Nature Climate Change 12 (6), 532–538.

Serra, P., Fierro, G., 1997. Outage costs in Chilean industry. Energy Economics 19 (4), 417–434.

Shi, H., Xu, H., Gao, W., Zhang, J., Chang, M., 2022. The impact of energy poverty on agricultural productivity: The case of China. Energy Policy 167.

Sievert, M., Steinbuks, J., 2020. Willingness to pay for electricity access in extreme poverty: Evidence from sub-Saharan Africa. World Development 128.

Singh, K., Inglesi-Lotz, R., 2020. The role of energy poverty on economic growth in sub-Saharan African countries. Economics of Energy and Environmental Policy 10 (1).

Smith, B., 2015. The resource curse exorcised: Evidence from a panel of countries. Journal of Development Economics 116, 57–73.

Sovacool, B., Mukherjee, I., 2011. Conceptualizing and measuring energy security: A synthesized approach. Energy 36 (8), 5343–5355.

Sovacool, B. K., 2013. An international assessment of energy security performance. Ecological Economics 88, 148–158.

Steinbuks, J., Foster, V., 2010. When do firms generate? evidence on in-house electricity supply in Africa. Energy Economics 32 (3), 505–514.

Stirling, A., 2010. Multicriteria diversity analysis. A novel heuristic framework for appraising energy portfolios. Energy Policy 38 (4), 1622–1634.

Suehiro, S., 2008. Energy intensity as an index of energy conservation: Problems in international comparison of energy intensity of GDP and estimate using sector-based approach. IEEJ Energy Journal 7, 58–71.

Tagliapietra, S., Occhiali, G., Nano, E., Kalcik, R., 2020. The impact of electrification on labour market outcomes in Nigeria. Economia Politica 37 (3), 737–779.

te Brake, W. H., 1975. Air pollution and fuel crises in preindustrial London, 1250-1650. Technology and Culture 16 (3), 337–359.
URL http://www.jstor.org/stable/3103030

Teller-Elsberg, J., Sovacool, B., Smith, T., Laine, E., 2016. Fuel poverty, excess winter deaths, and energy costs in Vermont: Burdensome for whom? Energy Policy 90, 81–91.

Thomas, D., Harish, S., Kennedy, R., Urpelainen, J., 2020. The effects of rural electrification in India: An instrumental variable approach at the household level. Journal of Development Economics 146.

Thomas, D., Urpelainen, J., 2018. Early electrification and the quality of service: Evidence from rural India. Energy for Sustainable Development 44, 11–20.

Tietenberg, T., Lewis, L., 2018. Environmental and Natural Resource Economics (11th edition). New York.

Tinbergen, J., 1952. On the Theory of Economic Policy. North Holland, Amsterdam.

Tishler, A., 1993. Optimal production with uncertain interruptions in the supply of electricity. Estimation of electricity outage costs. European Economic Review 37 (6), 1259–1274.

Tong, D., Zhang, Q., Zheng, Y., Caldeira, K., Shearer, C., Hong, C., Qin, Y., Davis, S., 2019. Committed emissions from existing energy infrastructure jeopardize 1.5°C climate target. Nature 572 (7769), 373–377.

Torvik, R., 2009. Why do some resource-abundant countries succeed while others do not? Oxford Review of Economic Policy 25 (2), 241–256.

Toto, R. V., 2022. Residential welfare-loss from electricity supply interruptions in South Africa: Cost-benefit analysis of distributed energy resource subsidy programs. Economics of Energy and Environmental Policy 11 (1), 51–77.

Tovar Reaños, M., Wölfing, N., 2018. Household energy prices and inequality: Evidence from German microdata based on the EASI demand system. Energy Economics 70, 84–97.

Turner, R., Pearce, D., Bateman, I., 1994. Environmental Economics—An Elementary Introduction. Harlow.

van de Walle, D., Ravallion, M., Mendiratta, V., Koolwal, G., 2017. Long-term gains from electrification in rural India. World Bank Economic Review 31 (2), 385–411.

Van Der Ploeg, F., 2011. Natural resources: Curse or blessing? Journal of Economic Literature 49 (2), 366–420.

van der Ploeg, F., Poelhekke, S., 2009. Volatility and the natural resource curse. Oxford Economic Papers 61 (4), 727–760.

van der Ploeg, F., Poelhekke, S., 2010. The pungent smell of "red herrings": Subsoil assets, rents, volatility and the resource curse. Journal of Environmental Economics and Management 60 (1), 44–55.

Vandyck, T., Weitzel, M., Wojtowicz, K., Rey Los Santos, L., Maftei, A., Riscado, S., 2021. Climate policy design, competitiveness and income distribution: A macro-micro assessment for 11 EU countries. Energy Economics 103, 105538.
URL https://www.sciencedirect.com/science/article/pii/S0140988321004151

Vicente, P., 2010. Does oil corrupt? Evidence from a natural experiment in West Africa. Journal of Development Economics 92 (1), 28–38.

Wagner, N., Rieger, M., Bedi, A., Vermeulen, J., Demena, B., 2021. The impact of off-grid solar home systems in Kenya on energy consumption and expenditures. Energy Economics 99.

Williams, A., 2011. Shining a light on the resource curse: An empirical analysis of the relationship between natural resources, transparency, and economic growth. World Development 39 (4), 490–505.

Wills, I., 1997. Economics and the Environment—A Signalling and Incentives Approach. Allen & Unwin.

Wirawan, H., Gultom, Y., 2021. The effects of renewable energy-based village grid electrification on poverty reduction in remote areas: The case of Indonesia. Energy for Sustainable Development 62, 186–194.

Woo, C. K., Tishler, A., Zarnikau, J., Chen, Y., 2021. Average residential outage cost estimates for the lower 48 states in the US. Energy Economics 98.

Wu, L., Zhang, S., Qian, H., 2022. Distributional effects of China's national emissions trading scheme with an emphasis on sectoral coverage and revenue recycling. Energy Economics 105, 105770.
URL https://www.sciencedirect.com/science/article/pii/S0140988321006125

Wu, W.-P., Zeng, W.-K., Gong, S.-W., Chen, Z.-G., 2021. Does energy poverty reduce rural labor wages? Evidence from China's rural household survey. Frontiers in Energy Research 9.

Xu, X., Chen, C.-F., 2019. Energy efficiency and energy justice for U.S. low-income households: An analysis of multifaceted challenges and potential. Energy Policy 128, 763–774.

Zhang, T., Shi, X., Zhang, D., Xiao, J., 2019. Socio-economic development and electricity access in developing economies: A long-run model averaging approach. Energy Policy 132, 223–231.

Zhang, Z., Shu, H., Yi, H., Wang, X., 2021. Household multidimensional energy poverty and its impacts on physical and mental health. Energy Policy 156.