Energy Research & Social Science 49 (2019) 36–40

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Perspective

The geopolitics of renewable energy: Debunking four emerging myths

Indra Overland

Norwegian Institute of International Affairs (NUPI), Oslo, Norway

A B S T R A C T

This article seeks to nip in the bud four emerging myths about the geopolitics of the rise of renewable energy and the concomitant increase in electricity usage. The article presents alternative perspectives, arguing that (1) the risk of geopolitical competition over critical materials for renewable energy is limited; (2) the resource curse as we know it from the petroleum sector will not necessarily reappear in many countries in connection with renewable energy; (3) transboundary electricity cut-offs will mostly be unsuitable as a geopolitical weapon; and (4) it is not clear that growing use of renewable energy will exacerbate cyber-security risks. In all four areas, the evolving literature could place more emphasis on uncertainty and risks and less on one-sided scenarios and maximization of threats.

1. Introduction

The founding fathers of the study of geopolitics conceived of it as a deterministic causal relationship between geography and international affairs, focused on the permanent rivalry, territorial expansion and military strategies of imperial powers [1]. With time, "geopolitics" came to denote the influence of geography on the power of states and international affairs more broadly, with less emphasis on determinism and more on the strategic importance of natural resources, their location, transportation routes, and chokepoints.

During World War I, warfare became mechanized and Winston Churchill made his famous decision to shift the British navy from coal to oil. From then on, access to oil was a key component of much geopolitical analysis [2]. As car ownership grew, Western countries came to depend on oil imports from the Middle East and were caught off guard by the oil crises of 1973 and 1979. These events transformed oil security from a military issue into one of economic stability [3,4]. Often the focus of geopolitical analysis was on great power rivalry over specific oil-rich parts of the world such as the Persian Gulf, the Caspian, or the Arctic, or on chokepoints such as the Strait of Hormuz or the Suez Canal (e.g. [5,6]). Sometimes the analysis took on a neo-Malthusian, peak-oil hue (e.g. [7]). Later on, the gas crises between Russia and Ukraine in 2006 and 2009 raised concerns about natural gas, with particular emphasis on the use of monopsony, gas transportation infrastructure, pricing power, and supply disruption as foreign energy policy tools (e.g. [8,9]).

The current rapid growth of renewable energy is giving the impetus to a yet another phase in geopolitical thinking, this time focusing on changes in the positions of states in the international system that may follow from the rise of renewables (e.g. [10–15]).

Although the geopolitics of renewables represents a new direction for geopolitical analysis, some arguments are already being repeated with such frequency that they may come to be seen as common knowledge. They tend to involve the transposition of the geopolitical logic of oil and gas onto renewables, despite the considerable differences between the energy types and their associated technologies and infrastructure. While shifting focus from fossil fuels to reneables, geopolitical analysis remains centered on resource-rich locations, key infrastructure, transportation routes, control over energy supplies, and the potential for supply disruptions. The continuing underlying assumption is that control over resources and their distribution endows states with power in the international system. In this article, I therefore seek to nuance and challenge four specific arguments concerning the geopolitics of renewable energy.

Traditional geopolitical thinking found its counterpart in critical geopolitics, a constructivist approach to the maps and texts produced by actors involved geopolitical theory- and policymaking [16], but so far there have not been any critical geopolitics contributions on the geopolitics of renewables. This article could be thought of as a first step in that direction.

The article is a response both to the emerging academic literature on the geopolitics of renewables and to the discussions at seminars and conferences convened between 2016 and 2018 by the International Renewable Energy Agency (IRENA); the ministries of foreign affairs of Germany, the Netherlands, Norway, and the United Emirates; the Clingendael Institute, Columbia University, Harvard University, the Norwegian Institute of International Affairs, and Stiftung Wissenschaft und Politik.

2. Competition over critical materials

One frequent claim about the consequences of the energy transition is that there will be increasing geopolitical competition over critical materials for renewable energy technologies [17–20]. "Critical

E-mail address: ino@nupi.no.

https://doi.org/10.1016/j.erss.2018.10.018
Received 9 August 2018; Received in revised form 12 October 2018; Accepted 18 October 2018
Available online 13 November 2018

materials" is a broad term that refers to raw materials for which there are no viable substitutes with current technologies, which most consumer countries are dependent on importing, and whose supply is dominated by one or a few producers.

Much of the concern over critical materials for renewables is focused on the 17 rare earth elements and was sparked by an episode in 2010 when China imposed a rare earths embargo on Japan over a territorial dispute [20–24]. China dominated global production, Japan depended on Chinese supplies, and it was feared that China would be able to use its increasingly dominant position in global rare earths markets as a foreign policy tool.

However, most of the rare earth elements are in fact geologically abundant in the earth's crust. For example, cerium is more common than lead [25]. The heavier rare earth elements are less common than the lighter ones, but most of them are still not among the most scarce basic elements [26]. Only promethium is truly scarce, but is not used in renewable energy technologies. What is true about rare earth elements is that they are mostly found in dilute concentrations—making it expensive to mine them—and that there has not been much demand until recently and production is therefore limited [22,27]. The Chinese—-with low costs, lax environmental standards, and an eye for profit—-have cornered most of the market.

One of the most relevant rare earth elements for renewable energy is neodymium, followed by praseodymium and dysprosium, all of which are used in permanent magnets for direct-drive wind turbines [21,22]. However, the vast majority of wind turbines are constructed with geared-turbine technology that does not require permanent magnets [28]. In the United States, for example, less than 2% of wind turbines use permanent magnets [29].

Sometimes "rare earth elements" is used as shorthand for all critical materials for renewable energy. However, some of the most important materials for renewable energy technologies do not belong to the rare earth elements group. For example, lithium and cobalt are essential for lithium ion battery technology, and copper is used for electric turbines and electricity distribution, but none of these belong to the group of rare earth elements. The term "rare earth elements" could be used with greater caution.

Whether and which critical materials might be rare and sought-after is a complex question. The energy transition is above all about technology and innovation. It is impossible to predict with certainty which renewable energy technologies will be developed in the future; but it is highly probable that there will be technological improvements and cost reductions in some or other areas [30]. One of the main aims of research on renewable energy is to develop new technologies that use cheaper materials, and the prospects for success in this endeavor are good [31,32]. Just in recent years, the materials intensity of neodymium, dysprosium, germanium, tellurium, europium and terbium in clean energy technologies has been reduced [33]. The 2010 China-–Japan rare-earth-elements spat triggered technological innovation in the following years, weakening China's grip on the market [23]. This does not mean that a technological fix can necessarily be found for any critical material, but it does mean that it is important to consider at least the possibility of technological change. If not, one risks falling into the same static technology assumption trap as peak oil proponents who were caught off guard by improvements in fracking technology and the rise of shale oil.

Another problem with the discourse on critical materials is that it tends to confuse the economics of commodity cycles with geological scarcity. Commodity markets are typically cyclical, repeating patterns of boom and bust. Mining projects have long lead-times, in some cases decades from an investment in exploration until a processed product reaches the market. This time lag—combined with neo-Malthusian discourses of peak extraction—leads companies to overinvest. When the output of many different new mining projects finally reaches the market, prices collapse, initiating a new cycle of boom and bust. Again, the 2010 China supply disruption is a case in point, as it triggered more investment in rare earths extraction and processing in other countries, changing the supply picture to a degree [23,24].

Current discourses also tend to overlook the fact that—unlike fossil fuels—most critical materials for renewable energy technologies can be recycled [33–36]. For some materials, the cost of recycling is currently high, but this is conditional upon volumes and recycling technologies—both of which are dynamic. If demand increases for a critical material, recycling will likely increase too [19,32,37]. As recycling increases, scale economies will reduce the cost of recycling.

Depending on how technologies for renewable energy develop, it is plausible that prices for some critical materials will be high, that they will generate significant revenues for exporting countries and expenses for importing countries, and that some materials will be securitized. However, this does not mean that a geopolitical race to take control over critical materials is inevitable. In the words of Lovins [22], they "are simply another commodity—unusual, significant, but unable to transcend the realities of economics, innovation, and trade" (see also [33]).

3. New resource curses

The vast existing resource curse literature is oriented towards countries with oil, gas and valuable minerals and metals. Some actors now argue that the transition to renewable energy will lead to the reappearance of the resource curse among countries rich in critical materials and/or with large, exportable surpluses of renewable energy [12,38–40]. Like some oil producers in the past, their apparent wealth will lead to a weakening rather than a strengthening of their position in the world, it is thought.

This view requires nuancing. Renewable energy for export could potentially require more long-term maintenance of infrastructure, generate more local jobs, and produce more stable revenues than oil and gas have done [41–43], especially compared to an oil exporter such as Angola, for example, with oil and gas production located offshore and dominated by international oil companies and workers [44].

Oil is also often sold one tanker load at a time in international markets, and subsequently traded and re-traded around the world. By contrast, exported electricity from renewables will more likely be sold to nearby countries on long-term contracts needed to finance the upfront capital expenditure required to build renewable-energy infrastructure. In this regard, renewable energy may have more in common with piped natural gas than with oil.

The assumption of a new resource curse also ignores learning processes among countries handling resource revenues. While much of the literature on the resource curse is based on long timeseries of panel data and assumes that the curse is a stable phenomenon (e.g. [37,38]), the relationship between society and natural resource revenues may actually have changed over time. One major learning process has been improved design and management of sovereign wealth funds [47–49]. Exemplifying this trend, both Russia and Saudi Arabia managed to first save petroleum revenues and later disburse them to keep their economies afloat during the dip in oil prices from 2014 to 2018 [50]. Back in the 1980s, neither country had set up its petroleum revenue management to handle this kind of situation. There is little reason why countries rich in renewable-energy resources or critical materials should be at least as well equipped as the Russians and Saudis to manage future revenues.

The energy transition is likely to generate resource revenue windfalls for some countries, and for some of them this could lead to challenges. But a repetition of the resource curse on a large scale is not inevitable.

4. Electricity disruption as a geopolitical weapon

Increased use of renewable energy will lead to higher levels of electrification and increased trade in electricity across borders [51–53].

Another worry is therefore that interstate electricity cut-offs could become an important foreign policy tool [12,54,55]. This worry is often supported by references to historical cases of the use of energy as a foreign policy tool.

A comprehensive study by Fischhendler et al. identifies 38 cases of energy sanctions between 1938 and 2017 [56]. These cases include a broad range of measures, and only a minority of them involve supply disruptions. There are so few past cases of use of electricity as a foreign policy tool that Fischhendler et al. excluded them and limited their study to oil, gas, and coal [56].

The most high-profile past cases of energy sanctions are the oil crises of 1973 and 1979, but the relevance of these to the future use of electricity as a "weapon" is limited because they involved oil transported by tanker over long distances. Compared to solar and wind power distributed by cable, oil on tankers is easier to redirect or hold back and save for later.

The cases most often referred back to at seminars and conferences on the geopolitics of renewable energy are the Russia–Ukraine natural gas conflicts of 2006 and 2009, in which Russia halted the flow of piped gas across its border. However, much of the future international solar and wind power trade will likely involve more symmetrical relationships between different prosumer (producer-consumer) countries than does the unidirectional gas trade (and much past electricity trade). Many countries will produce domestically much of the renewable energy they consume, but trade with neighboring countries to balance their grids against the intermittency of solar and wind power [57]. Thus, prosumer countries will be mutually dependent upon each other [58]. Also gas-exporting and importing countries are mutually dependent, as the exporting countries need security of transit and demand, while the importing countries need security of supply and transit [59]. However, this dependence is more asymmetrical and therefore less stable than prosumer relationships [60].

In some cases, renewable energy trade relationships may be more asymmetric and similar to natural gas trade relationships, with one country always being the importer and another country always being the exporter [56]. However, even in such cases, the nature of the asymmetry may be different, as most net-importer countries will still have the option of developing their own renewables potential and thus face long-term make-or-buy choices [14]. If the political risk premium on imported renewable energy becomes too great, it will lose its competitive edge over domestic alternatives. In other words, renewable energy exporters will often be competing against their own customers and will have to treat them with care.

5. Cybersecurity as a geopolitical risk

The growth of renewable energy is occurring simultaneously with another major development: digitalization. Digitalization can help keep grids balanced, even as large numbers of renewable energy producers raise and lower production depending on the weather [61]. This causes academics, security think tanks, intelligence and security organizations, parliamentary committees, and consultancies to fear that terrorists or the intelligence services of hostile countries may hack the computers that control utilities and grids [39,62].

Clearly, there is cause for these concerns as society becomes dependent on new technologies and the growing complexity of digital systems for grid management can give rise to new cybersecurity challenges. However, sometimes such concerns are overstated, as in when the potential large-scale hacking of smart meters was likened to "the modern day equivalent of a nuclear strike" [63] cited in [62].

Those who raise concerns about the cyber-security of electricity grids at seminars and conferences often invoke the case of a cyber-attack against three energy distribution companies in Ukraine in 2015 [64]. As a result of this attack, substations in 30 locations in Western Ukraine were shut down, cutting off the electricity supply to 230 000 people for a period of between 1 and 6 hours [65]. While utilities and electricity distribution networks in many countries are subject to frequent hacking attempts, this is considered to have been the first successful attack on this scale and with such geopolitical significance, foreshadowing the role of cyber-attacks in the future energy system. However, it is worth noting that Ukraine was a special case, comprising unusually dilapidated infrastructure, a high level of corruption, a military conflict with Russia, and exceptional possibilities for Russian infiltration due to the historical linkages between the two countries [66]. Despite all these issues, only 0.015% of Ukraine's daily electricity consumption was affected, and only for a few hours [67].

The use and associated risks of electricity are not new per se, as all homes, companies, and institutions in developed countries already depend on electricity grids, and grids have been controlled digitally for decades. It is also probable that increased use of renewable energy will lead to greater decentralization, with millions of prosumer households supplying electricity. This may actually make the system more resilient, as many different units will have to be hacked to destabilize the system as a whole.

Like many pessimistic, policy-oriented forecasts, those concerning digitalization and cybersecurity have merit, but are also potentially self-destructing predictions: the more such predictions are made, the greater the likelihood that incumbents will be encouraged to implement counter-measures. In other words, the predictors are part of the social context about which they are trying to make a prediction and may influence that context in the process.

As a source of policy recommendations, discourse on cybersecurity is therefore clearly useful; as a prediction about the future energy system it is trickier. As one of the rare critical contributions in the cybersecurity field put it, "Moderate and measured takes on cyber security threats are swamped by the recent flood of research and policy positions in the cyber research field offering hyperbolic perspectives based on limited observations" [68] (see also [69]).

6. Conclusions

In three of the four areas discussed above, there is a risk of transposing patterns of behavior from the fossil-fuels dominated energy system of the past onto the renewables-based energy system of the future: great powers have competed to control oil, in the future they will compete over critical materials; there has been a resource curse related to oil, and this will be replicated as a resource curse related to critical materials and renewable-energy exports; countries have used disruptions of oil and gas supplies as geopolitical weapons, now they will start disrupting electricity supplies instead. While some of these phenomena could indeed be reproduced, one cannot assume that they automatically will be.

The underlying challenge is that renewables change the premises for international energy affairs. Because renewable energy resources tend to be more evenly distributed geographically than are fossil and nuclear fuels, the economic and security advantages of access to energy will be more evenly spread among countries, there should be fewer risks related to transportation chokepoints and less reason for great powers to compete over valuable locations. In sum: international energy affairs will become less about locations and resources, and thus less geopolitical in nature. As renewable energy resources are abundant but diffuse, technologies for capturing, storing and transporting them will instead become more important. International energy competition may therefore shift from control over physical resources and their locations and transportation routes to technology and intellectual property rights. This may evolve into something along the lines of the competition in mobile telephony between China (Huawei), South Korea (Samsung), and the United States (Apple). It is not a war, nor is it geopolitics in any strict sense, but there are winners and losers–for example the Finns who used to work for Nokia.

References

[1] G.Ó. Tuathail, Introduction, The Geopolitics Reader, Routledge, London, 1998, pp. 15–26.
[2] D. Yergin, The Prize: The Epic Quest for Oil, Money & Power, Free Press, New York, 2008.
[3] B. Russett, Security and the resources scramble: will 1984 be like 1914? Int. Affairs (R. Inst. Int. Affairs 1944-) 58 (1981) 42–58, https://doi.org/10.2307/2618274.
[4] R.A. Kelanic, The petroleum paradox: oil, coercive vulnerability, and great power behavior, Security Stud. 25 (2016) 181–213, https://doi.org/10.1080/09636412.2016.1171966.
[5] J. Barnes, A.M. Jaffe, The Persian gulf and the geopolitics of oil, Survival 48 (2006) 143–162, https://doi.org/10.1080/00396330600594348.
[6] I. Overland, Russia's Arctic energy policy, Int. J. LXV (2010) 865–878.
[7] M.T. Klare, The Race for What's Left: The Global Scramble for the World's Last Resources, Picador, New York, 2013.
[8] J.D. Sharples, The shifting geopolitics of Russia's natural gas exports and their impact on EU-Russia gas relations, Geopolitics 21 (2016) 880–912, https://doi.org/10.1080/14650045.2016.1148690.
[9] R. Orttung, I. Overland, A limited toolbox: explaining the constraints on Russia's foreign energy policy, J. Eurasian Stud. (2011) 74–85.
[10] M. Bazilian, B. Sovacool, T. Moss, Rethinking energy statecraft: United States foreign policy and the changing geopolitics of energy, Global Policy 8 (2017) 422–425, https://doi.org/10.1111/1758-5899.12461.
[11] E. Hache, Do renewable energies improve energy security in the long run? Int. Econ. (2018), https://doi.org/10.1016/j.inteco.2018.01.005 In press.
[12] M. O'Sullivan, I. Overland, D. Sandalow, R. Vakulchuk, N. Lemphers, H. Begg, A. Behrens, N. Bhatiya, A. Clark, T. Cremer, J. Elkind, M. Fessler, M. Nakagawa, M. Seol, C. Soylu, The Geopolitics of Renewable Energy (2017) https://www.researchgate.net/publication/317954274 (accessed November 22, 2017).
[13] S. Paltsev, The complicated geopolitics of renewable energy, Bull. Atomic Sci. 72 (2016) 390–395.
[14] D. Scholten (Ed.), The Geopolitics of Renewables, Springer, Cham, 2018.
[15] D. Scholten, R. Bosman, The geopolitics of renewables: exploring the political implications of renewable energy systems, Technol. Forecasting Social Change 103 (2016) 273–283.
[16] G.Ó. Tuathail, Thinking critically about geopolitics, The Geopolitics Reader, Routledge, London, 1998, pp. 1–15.
[17] E. Barteková, R. Kemp, National strategies for securing a stable supply of rare earths in different world regions, Resources Policy 49 (2016) 153–164, https://doi.org/10.1016/j.resourpol.2016.05.003.
[18] J.H. Brown, J.R. Burger, W.R. Burnside, M. Chang, A.D. Davidson, T.S. Fristoe, M.J. Hamilton, S.T. Hammond, A. Kodric-Brown, N. Mercado-Silva, J.C. Nekola, J.G. Okie, Macroecology meets macroeconomics: resource scarcity and global sustainability, Ecol. Eng. 65 (2014) 24–32, https://doi.org/10.1016/j.ecoleng.2013.07.071.
[19] K. Habib, L. Hamelin, H. Wenzel, A dynamic perspective of the geopolitical supply risk of metals, J. Cleaner Prod. 133 (2016) 850–858, https://doi.org/10.1016/j.jclepro.2016.05.118.
[20] K. Smith Stegen, Heavy rare earths, permanent magnets, and renewable energies: an imminent crisis, Energy Policy 79 (2015) 1–8, https://doi.org/10.1016/j.enpol.2014.12.015.
[21] M. De Ridder, The geopolitics of mineral resources for renewable energy technologies. https://www.hcss.nl/sites/default/files/files/reports/The_Geopolitics_of_Mineral_Resources_for_Renewable_Energy_Technologies.pdf (accessed July 24, 2018).
[22] A. Lovins, Clean energy and rare earths: Why not to worry, Bulletin of the Atomic Scientists. (2017). https://www.thebulletin.org/clean-energy-and-rare-earths-why-not-worry10785 (accessed July 17, 2018).
[23] E. Gholz, Rare earth elements and national security, Council on Foreign Relations, New York, NY, 2014. http://www.jstor.org/stable/resrep00311 (accessed April 9, 2018).
[24] J.D. Wilson, Whatever happened to the rare earths weapon? Critical materials and international security in Asia, Asian Security 14 (3) (2017) 1–16, https://doi.org/10.1080/14799855.2017.1397977.
[25] N. Greenwood, A. Shaw, Chemistry of the Elements, Butterworth-Heinemann, New York, NY, 1997.
[26] U.S.G.S. Rare earth elements—critical resources for high technology, 2002. https://www.pubs.usgs.gov/fs/2002/fs087-02/ (accessed September 10, 2018).
[27] R. Phadke, Green energy futures: responsible mining on Minnesota's iron range, Energy Res. Social Sci. 35 (2018) 163–173, https://doi.org/10.1016/j.erss.2017.10.036.
[28] J. Drexhage, D. La Porta, K. Hund, M. McCormick, J. Ningthoujam, The Growing Role of Minerals and Metals for a Low Carbon Future, World Bank, Washington, DC, 2017.
[29] M. Goggin, Fact check: wind turbines built with the same materials used by conventional energy. 2016. http://www.aweablog.org/fact-check-wind-turbines-built-materials-used-conventional-energy/ (accessed July 17, 2018).
[30] J.A. Alic, D. Sarewitz, Rethinking innovation for decarbonizing energy systems, Energy Res. Social Sci. 21 (2016) 212–221, https://doi.org/10.1016/j.erss.2016.08.005.
[31] A. Månberger, B. Stenqvist, Global metal flows in the renewable energy transition: exploring the effects of substitutes, technological mix and development, Energy Policy 119 (2018) 226–241, https://doi.org/10.1016/j.enpol.2018.04.056.
[32] C.C. Pavel, R. Lacal-Arántegui, A. Marmier, D. Schüler, E. Tzimas, M. Buchert, W. Jenseit, D. Blagoeva, Substitution strategies for reducing the use of rare earths in wind turbines, Resources Policy 52 (2017) 349–357, https://doi.org/10.1016/j.resourpol.2017.04.010.
[33] R.L. Moss, E. Tzimas, P. Willis, L. Tercero Espinoza, Critical metals in the path towards the decarbonisation of the EU energy sector petten, 2013. https://setis.ec.europa.eu/sites/default/files/reports/JRC-report-Critical-Metals-Energy-Sector.pdf (accessed April 9, 2018).
[34] J. Busch, D. Dawson, K. Roelich, Closing the low-carbon material loop using a dynamic whole system approach, J. Cleaner Prod. 149 (2017) 751–761, https://doi.org/10.1016/j.jclepro.2017.02.166.
[35] S. Zhang, Y. Ding, B. Liu, C. Chang, Supply and demand of some critical metals and present status of their recycling in WEEE, Waste Manage. 65 (2017) 113–127, https://doi.org/10.1016/j.wasman.2017.04.003.
[36] S. Ziemann, D.B. Müller, L. Schebek, M. Weil, Modeling the potential impact of lithium recycling from EV batteries on lithium demand: a dynamic MFA approach, Resources Conserv. Recycl. 133 (2018) 76–85, https://doi.org/10.1016/j.resconrec.2018.01.031.
[37] S. Ali, Social and environmental impact of the rare earth industries, Resources 3 (2014) 123–134, https://doi.org/10.3390/resources3010123.
[38] L. Eisgruber, The resource curse: analysis of the applicability to the large-scale export of electricity from renewable resources, Energy Policy 57 (2013) 429–440, https://doi.org/10.1016/j.enpol.2013.02.013.
[39] A. Månsson, A resource curse for renewables? Conflict and cooperation in the renewable energy sector, Energy Res. Social Sci. 10 (2015) 1–9, https://doi.org/10.1016/j.erss.2015.06.008.
[40] B.K. Sovacool, G. Walter, Major hydropower states, sustainable development, and energy security: insights from a preliminary cross-comparative assessment, Energy 142 (2018) 1074–1082, https://doi.org/10.1016/j.energy.2017.09.085.
[41] H. Garrett-Peltier, Green versus brown: comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input–output model, Econ. Model. 61 (2017) 439–447, https://doi.org/10.1016/j.econmod.2016.11.012.
[42] H. Hondo, Y. Moriizumi, Employment creation potential of renewable power generation technologies: a life cycle approach, Renew. Sustain. Energy Rev. 79 (2017) 128–136, https://doi.org/10.1016/j.rser.2017.05.039.
[43] M. Wei, S. Patadia, D.M. Kammen, Putting renewables and energy efficiency to work: how many jobs can the clean energy industry generate in the US? Energy Policy 38 (2010) 919–931, https://doi.org/10.1016/j.enpol.2009.10.044.
[44] J. Ovadia, Angola: civil society actors and petroleum management, in: I. Overland (Ed.), Public Brainpower: Civil Society and Natural Resource Management, Palgrave Macmillan, Cham, 2018, pp. 41–54.
[47] B. Alhashel, Sovereign wealth funds: a literature review, J. Econ. Business 78 (2015) 1–13, https://doi.org/10.1016/j.jeconbus.2014.10.001.
[48] J.-F. Carpantier, W.N. Vermeulen, Emergence of sovereign wealth funds, J. Commodity Markets 11 (2018) 1–21, https://doi.org/10.1016/j.jcomm.2018.01.002.
[49] D. Park, G.E.B. Estrada, Chapter 17—the emergence of sovereign wealth funds in Asia, in: G.N. Gregoriou, D.L.K. Chuen (Eds.), Handbook of Asian Finance, Academic Press, San Diego, 2014, pp. 299–313, , https://doi.org/10.1016/B978-0-12-800982-6.00017-2.
[50] D. Fjaertoft, I. Overland, Financial sanctions impact Russian oil, equipment export ban's effects limited, Oil Gas J. 113 (2015) 66–72.
[51] G. Arcia-Garibaldi, P. Cruz-Romero, A. Gómez-Expósito, Future power transmission: visions, technologies and challenges, Renew. Sustain. Energy Rev. 94 (2018) 285–301, https://doi.org/10.1016/j.rser.2018.06.004.
[52] P. Fragkos, N. Tasios, L. Paroussos, P. Capros, S. Tsani, Energy system impacts and policy implications of the European Intended Nationally Determined Contribution and low-carbon pathway to 2050, Energy Policy 100 (2017) 216–226, https://doi.org/10.1016/j.enpol.2016.10.023.
[53] C. Kennedy, I.D. Stewart, M.I. Westphal, A. Facchini, R. Mele, Keeping global climate change within 1.5 °C through net negative electric cities, Curr. Opin. Environ. Sustain. 30 (2018) 18–25, https://doi.org/10.1016/j.cosust.2018.02.009.
[54] B. Johansson, Security aspects of future renewable energy systems—a short overview, Energy 61 (2013) 598–605, https://doi.org/10.1016/j.energy.2013.09.023.
[55] S. Moore, Evaluating the energy security of electricity interdependence: perspectives from Morocco, Energy Res. Soc. Sci. 24 (2017) 21–29, https://doi.org/10.1016/j.erss.2016.12.008.
[56] I. Fischhendler, L. Herman, N. Maoz, The political economy of energy sanctions: insights from a global outlook 1938–2017, Energy Res. Soc. Sci. 34 (2017) 62–71, https://doi.org/10.1016/j.erss.2017.05.008.
[57] D. Scholten, R. Bosman, The strategic realities of the emerging energy game: conclusion and reflection, in: D. Scholten (Ed.), The Geopolitics of Renewables, Springer, Cham, 2018, pp. 307–328.
[58] J. Lilliestam, S. Ellenbeck, Fostering interdependence to minimise political risks in a European-North African renewable electricity supergrid, Green 2 (2012) 105–109, https://doi.org/10.1515/green-2012-0003.
[59] I. Overland, The hunter becomes the hunted: Gazprom encounters EU regulation, in: N. Sitter, S. Andersen, G. Andreas (Eds.), Energy Union: Europe's New Liberal Mercantilism? Palgrave Macmillan, Basingstoke, 2017, pp. 115–130.
[60] Ø. Harsem, D. Harald Claes, The interdependence of European–Russian energy relations, Energy Policy 59 (2013) 784–791, https://doi.org/10.1016/j.enpol.2013.04.035.
[61] W. Canzler, F. Engels, J.-C. Rogge, D. Simon, A. Wentland, From “living lab” to strategic action field: bringing together energy, mobility, and information technology in Germany, Energy Res. Soc. Sci. 27 (2017) 25–35, https://doi.org/10.1016/j.erss.2017.02.003.

[62] S. Hielscher, B.K. Sovacool, Contested smart and low-carbon energy futures: media discourses of smart meters in the United Kingdom, J. Cleaner Prod. 195 (2018) 978–990, https://doi.org/10.1016/j.jclepro.2018.05.227.
[63] G. Peev, Government plans to install smart meters in our homes "will leave us open to cyber attack" (2012). http://www.dailymail.co.uk/news/article-2156648/Government-plans-install-smart-meters-homes-leave-open-cyber-attack.html (accessed July 18, 2018).
[64] E. Scholl, K. Westphal, K. Yafimava, I. Overland, Energy security and the OSCE: the case for energy risk mitigation and connectivity, SWP Berlin, 2016. https://www.swp-berlin.org/fileadmin/contents/products/comments/2016C26_wep_et_al.pdf, 2016.
[65] K. Zetter, Inside the cunning, unprecedented hack of Ukraine's Power Grid (2016). https://www.wired.com/2016/03/inside-cunning-unprecedented-hack-ukraines-power-grid/ (accessed July 19, 2018).
[66] T. Van de Graaf, J.D. Colgan, Russian gas games or well-oiled conflict? Energy security and the 2014 Ukraine crisis, Energy Res. Soc. Sci. 24 (2017) 59–64, https://doi.org/10.1016/j.erss.2016.12.018.
[67] Ministry of Energy and Coal, Minenergovugillya mae namir utvoriti grupu za uchastyu predstavnikiv usikh energetichnikh kompaniy, shcho vkhodyat do sferi upravlinnya Ministerstva, dlya vivchennya mozlivostey shchodo zapobigannya nesanktsionovanomu vtruchennyu v robotu energomerezh (2016). http://mpe.kmu.gov.ua/minugol/control/uk/publish/article?art_id=245086886&cat_id=35109 (accessed July 18, 2018).
[68] B. Valeriano, R.C. Maness, How we stopped worrying about cyber doom and started collecting data, Politics Governance 6 (2018) 49, https://doi.org/10.17645/pag.v6i2.1368.
[69] R.C. Maness, B. Valeriano, The impact of cyber conflict on international interactions, Armed Forces Soc. 42 (2016) 301–323, https://doi.org/10.1177/0095327X15572997.