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Renewables and the future of geopolitics: Revisiting main concepts of international relations from the lens of renewables

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Abstract

The development of renewable energy is often treated as a purely positive outcome for the world, without consideration of the challenges that come with implementation at scale, which will inevitably follow with the process of a global energy transition. Studies on the political process of the transition to a world of renewables are scarce. This article provides a review on the geopolitical, institutional, and technological aspects of the development of renewable energy sources, including transportation and delivery of energy across national borders. At scale internationally, renewable energy will present many of the same issues as other mature sources of energy. Security, export interdependence, and the availability of source materials will all become increasingly important concerns.

Keywords: renewables, geopolitics, energy security.
JEL classification: F50, Q48.

1. Introduction

While the current discourse on energy and geopolitics often focuses on the role that oil and gas play in interstate relations (e.g., Carroll, 2015; Gupta, 2008), the generation of renewable energy, and the trade of materials required to produce renewable energy, are becoming increasingly salient around the world. The rise of renewables impacts interstate relations through two mechanisms: (i) instantaneous transfer of energy, i.e. electricity, and (ii) technology and raw material transfer needed for renewable energy. Both processes bring about challenges to the existing global governance schemes on energy and trade, and perturbate existing power relations between states. Moreover, the quest to secure supply of electricity, transfer of renewable technology, and related raw materials gives leverage to new

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players in the international arena. Therefore, the energy transition has notable implications for international security, international political economy and global governance, all main pillars of the study of international relations.

For example, Great Britain and France wheel electricity to each other, with the former's imports from the latter constituting slightly more than 5% of its annual electricity consumption. In 2016, hydro-electric exports constituted 20% of Bhutan's domestic revenue and 33% of its export earnings (IRENA, 2019, pp. xi, 5). Northeastern United States has increasingly been eyeing Quebecois hydroelectricity imports, which already supplies about 6000 MWh of renewable energy to the region (Morgan 2019).

Differences exhibited by the trade of renewable energy force players to move from spot-market interactions to long-term contracts. Being locked over such contractual commitments is a breeding ground for various types of conflict. In the absence of a strong governance regime, these conflicts can escalate into geopolitical tensions. These long-term contracts for capital-intensive investments can also give financiers more leverage, and arguably constitute a source of soft power for these financier countries, possibly blurring the borders between a "Marshall Plan" and a "trojan horse."

The range of players that the advent of renewable energy also places the global spotlight on an increasing range of players. As the global energy market grows more intertwined with politics, policymakers face increasingly complex challenges. The influence of individuals, governments, and international organizations, as well as the roles played by local, national, and interstate politics, become increasingly blurry with the rise of renewables. A local government can block a multinational electricity trade deal. A social media campaign can change a country's energy investment priorities. Shifts in policy and consumer preferences in one state can quickly cascade through global linkages.

The changing importance of electricity generation by renewables could also trigger conflicts over territory between neighboring states. Compared to traditional thermal power, solar and wind power installations tend to require close to 100 times more area (Zalk and Behrens, 2018). Dormant conflicts over border areas may reignite as states lay claim to these lands to generate renewable electricity. Offshore wind farms could likewise spark maritime disputes over rights to exclusive economic zones and other ocean areas. The increasing demand for rare earth minerals is another novel area where the actions of exporter and importer countries have implications for global trade and security.

This article provides a review of the implications of renewable energy from a political science perspective. This review is conducted over the course of six sections. The next section contextualizes renewable energy's role in global politics. In doing so, we treat state relations emanating from the trade of renewable energy as a special case of economic interdependence, and identify specific mechanisms through which this interdependence occurs. Our discussion here highlights various ways through which trading of renewable energy can lead to conflict and/or cooperation between two states. Section Three points to a mismatch between current governance challenges that renewables bring to world politics and the ability of existing global governance institutions to address these challenges. In doing so, we especially note the rising role local actors play. Two new dimensions of security central to renewables are discussed in Section Four.

At the state level, the integration of renewable energy to the central grid can lead to two specific national security risks with a notable potential to internationalize: the risk of civil strife, and increasing vulnerability to cyberattacks. The latter is of special note as many security doctrines remain silent against security threats by "faceless" attacks, possibly instigated by individuals or small groups. Section Five shifts the focus from the trade of renewable energy to its generation, more specifically the international political economy of rare earth elements (REE) that are critical in the manufacturing of renewable energy generators. Here, we argue that increasing reliance on REE has already created tensions in global production chains, and can further create a new form of natural resource curse for states with prospects to mine these resources. The conclusion highlights the main points of this paper and suggests further avenues of the research agenda on renewables and international relations to mature in a fecund manner.

2. Renewables and energy trade: A new form of interdependence?

International relations scholars have since long debated whether economic interdependence leads to cooperation or conflict (see, inter alia, Liberman, 1996; Mansfield and Pollins, 2009; Li and Reuveny, 2011). Those identifying themselves with the realist camp have argued that increasing economic relations render states vulnerable to each other, especially when the relationship becomes asymmetric (Mastanduno, 1988; Barbieri, 2002). The realist position builds on the presence of a "security dilemma," an essential feature of geopolitics for many IR scholars. The security dilemma posits that states are concerned with relative, rather than absolute, gains from any interaction, including trade. International trade often tends to favor one party more than the other, thereby making one party relatively stronger even though both are better off in absolute terms. In an anarchical environment, where no higher authority exists to police and sanction a belligerent state, every state must fend for itself and will strive to maximize its power relative to others. This will also make opportunistic attacks against weaker targets more likely.

In contrast, liberal democratic peace theorists assert that "peace dividends" enlarge and strengthen the dovish camp in trading countries, leading to more cordial relations between states. This pacifying effect becomes especially potent when beneficiaries of international trade have more influence over the foreign policymaking apparatus of their respective states. Indeed, those in the liberal camp have provided ample empirical evidence showing the pacifying effects of strong trade and economic ties between states (Hegre et al., 2010; Bussman, 2010). Since then, the debate moved from whether economic relations pacify states or not to what specific types of economic relations result in more peaceful or conflictual relations. Dorussen (2006), for instance, showed that the exchange of goods and resources that can otherwise be easily appropriable by force builds tensions between trading states. Trading goods that rely on high levels of technology, as well as human and organizational capital, on the other hand, brings countries closer into partnership.

More recently, the role third parties play in shaping the relations of two states has been of interest to scholars. Chatagnier and Kavaklı (2017) show that two states exporting to similar customers are more likely to have militarized disputes

with each other. Kleinberg et al. (2012) demonstrate that the more alternatives an exporter and an importer have should their trading relations cease, the more likely that these two countries remain as a peaceful pair. Peterson (2011) illustrates how relative gains between two trading parties become a security concern when a potential third party ally for one of the states can destabilize the balance of power between the two trading parties.

Interestingly, systematic examinations of energy interdependence as a distinct phenomenon in prevailing political science literature has been scarce. As energy is the most important traded commodity in global markets, this omission is noteworthy. New technologies such as fracking and renewable energy constantly disrupt global energy trade and transform interstate relations. Specific case studies examining how states shape their foreign policy to ensure energy security (Kalicki and Goldwyn, 2005; Daojiong, 2006; Krickovic, 2015), have led to further studies that systematically correlate energy attributes of a single state to its foreign policy actions (Colgan, 2011; Ross and Voeten, 2015). More recently, scholars have started looking at how energy shapes relations between two states. Of particular note is the release of the Global Energy Relations Dataset, the first systematic dataset to offer comprehensive global data on trade relations between two specific states in a given year. Using this dataset, we found that trade of energy resources, and natural gas in particular, leads to more cordial relations between two states. In a similar vein, Lee and Mitchell (2019) showed that when producing notable hydroelectric power from a river themselves, downstream states prefer more cordial relations with upstream states.

How does renewable energy fit into what we already know about how economic interdependence, and energy relations in particular shape relations between two states? The current rise of renewables highlights two distinct ways in which states relate to each other: (i) instantaneous transfer of energy, i.e. electricity, and (ii) a reliance on technology and raw material transfer. Both processes bring about challenges to the existing global governance schemes on energy and trade, and perturbate existing power relations between states. Trade in electricity, and what renewables produce, is fundamentally different from trade in other forms of energy sources. Due to limited storage technology, the trade of electricity should be immediate; electricity that is not consumed on the spot is instantly "spoiled." In this respect, renewable energy differs from conventional hydrocarbon resources that can be stored. Inventories of hydrocarbons, such as the Strategic Petroleum Reserve of the US, have been used to smooth out disturbances to the market (Considine, 2006; Leiby et al., 2019). Unexpected events can also be addressed by redirecting oil and LNG tankers. For instance, facing low demand due to a warmer than expected winter in the region, Korea Gas Corporation diverted three LNG tankers en route to Korea to northwest Europe (Kravtsova and Chung, 2019). Without gargantuan leaps in battery storage technology, such smoothing out of disruptions to the trade of renewable energy is simply not possible in the short term. Lead times required to bring energy projects online point to another challenge trading of renewable energy posits in the medium term. The advent of shale gas and oil have substantially decreased the time needed to bring wells online, often as low as 90 to 180 days (Hiller, 2019). Major photovoltaics (PV) and wind power installations on the other hand, mainly due to "not in my back yard" (NIMBY) attitudes, require longer lead times to start producing electricity

(World Energy Council, 2016). Furthermore, renewable investments are more capital intensive (Best, 2017), requiring more sophisticated financing schemes with often the need to establish partnerships beyond borders.

3. Trade in renewable energy and challenges to global governance

Not surprisingly, the abovementioned properties of renewable energy create challenges for its global governance. A global regime, defined as a "[set] of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area" (Krasner 1982, 185), for energy has hardly been established (Florini and Sovacool, 2009; Goldthau and Witte, 2010). While one can argue about the existence of an "oil regime" along the IEA-OPEC axis, the tools and concepts of this regime do not easily translate into the governance of interstate relations instigated by the trade of renewable energy. As mentioned above, interstate trade of renewable energy raises challenges for which no off-the-shelf solution exists. Pricing (immediate, next-hour and next-day) remains a salient issue. Even now, national and subnational grids, operating under a national legal system and its coercive mechanisms still have a difficult time interpreting and meeting contractual obligations in electricity trading (Bower and Fuentes, 2014; Siosansi, 2011). Contracts of larger magnitudes under the auspices of international law may create conflicts between states that are more intractable in nature. For example, how to price base-load, variable-load and peak-load supply may lead to various conflicts amongst contracting parties.

Another potential challenge relates to secondary mechanisms contingent on sustained flow of energy from an exporter to an importer. Global carbon caps and emissions trading is one such mechanism. If carbon caps and pricing become meaningfully adhered to in the global economy, many countries will rely on low or zero-carbon electricity imports. Unexpected constraints in the supply of this low-carbon electricity by the exporter may lead to considerable geopolitical tensions. Being targeted with economic sanctions, unplanned growth in energy consumption crowding out exports, or geographical trends cutting into renewable production may lead to such constraints. An exporter country may, due to such unforeseen circumstances, choose not to meet its contractual obligations and reduce the amount of electricity available to its client countries. Such trade conflicts borne out of unexpected lapses in the supply of low-carbon electricity can reverberate into other aspects of the importing country's industry (such as additional carbon costs reflecting on manufactured products), and hence carry the potential to escalate into geopolitical conflicts.

The presence of intermediary countries poses a physical risk against ensuring the continuous transmission of renewable energy across borders. Since electricity must physically travel continuously from its start to its end point, any intermediary state can easily break the connection, and gain significant geopolitical leverage over both the originator and end-consumer states, with notable security and economic implications. Without effective dispute resolution mechanisms, these conflicts can escalate into military hostilities in a bid to secure energy flow, income or both. The role intermediary states have played in recent conflicts regarding the transport of gas can be illuminating for such risks beholding

the trade of renewable energy. Being dependent on the Soviet legacy pipeline to relay its gas to world markets, Turkmenistan consistently complained that Russia restricted Turkmen access to global gas markets. Ukraine, in turn, occasionally threatened to cut off supplies of Russian gas to Europe and Turkey to extract political concessions. It is important to note that these gas conflicts remain salient in the world agenda despite increasing dominance of LNG, which is turning gas into an increasingly fungible good and weakening the political leverage intermediary countries for gas transit can impose.

The prospects for the construction of ultra-high-voltage (UHV) infrastructure is worth mentioning here. Having the proof-of-concept been demonstrated in various parts of China, the long-distance UHV infrastructure technology aims to transfer very high amounts of electricity over very large distances, even across continents (Huang et al., 2009). Such a "global grid" can make use of day-time (East-West) and seasonal (North-South) differences on earth to carry renewable energy from points of origin to points of demand. The establishmest of such a grid can allow flows of energy to circumvent certain choke points, partially offsetting the geopolitical advantage intermediary countries derive from having the power to cut off connections. The global adoption of the UHV infrastructure would raise, in turn, various questions regarding its governance. What international body would oversee the maintenance and governance of the grid? How would the technical specifications be decided upon? How would conflicts in the field (e.g. expropriation of land) with the locals be carried out? And more questions in the same vein.

Local politics: A new force to reckon with in global governance of renewable energy. In democratic societies, especially in those that have considerably devolved authority to local governments, local politics have also become a dimension to reckon with in understanding how renewable energy is governed.[1] That the continuous supply of energy and the interdependence it creates between states may be subject to the veto/approval of local sources is a phenomenon that conventional geopolitical analysis has yet to grapple with. Following the Fukushima incident, certain local players, such as the mayors of Mihama and Takahama and power companies such as the Kansai Electric Power Company (KEPCO) and Yonden, played important roles in shaping the national debate on whether to restart Japan's nuclear plants (Efird et al., 2018).

The contrast between how the Northern Pass and Empire Wind projects concluded in Northeastern United States further point out to the role local politics may play in the governance of renewable energy between states. The Northern Pass project was an infrastructure project that aimed to carry Quebecois hydroelectric power to New England states and the state of New York. A critical part of the project consisted of carrying Canadian power from the border through New Hampshire forests to be distributed to recipient states. Various townships and civil society organizations in New Hampshire opposed the project on the grounds

[1] The idea of local players conducting foreign policy is not new. See Guay (2000), for instance, in how the state of Massachusetts sanctioned apartheid South Africa in defiance of the federal government; Van der Heiden (2010) on how Swiss cantons conduct their own foreign policy and Jain (2004) on how individual cities in Japan and China conclude trade agreements with each other. The debate on how local interests shape foreign policy formulation in the context of energy has mostly been confined to hydrocarbon exporters such as Russia (Kaczmarski, 2014; Ivanenko, 2008) and Turkmenistan (Anceschi, 2010).

of the negative effects the project could have on New Hampshire ecology, its tourism potential and future issues regarding land expropriation. Responding to the requests of these local players, the New Hampshire State Site Evaluation Committee rejected Eversource's application for a permit. When Eversource carried this issue to court, the New Hampshire State Supreme Court upheld the Committee's decision, forcing Eversource to shelve this multibillion-dollar project. In sum, local actors hardly visible in the international arena with arguably miniscule power were able to prevent the implementation of an interstate renewable energy investment. This was mainly since decisions on energy investments, regardless whether they have international dimensions or not, remain in the purview of local governments in this case.

The Norwegian company Equinor's pro-active engagement with local stakeholders led to a contrasting result in its bid for the Empire Wind Project. Equinor's project aimed to install an 820 MWh offshore wind farm in southern Long Island. The project created similar issues with local stakeholders; local fishermen expressed concern about accessing fisheries and certain towns mentioned their views being broken into. Although the area for which the project has been planned falls under federal jurisdiction, Equinor addressed such concerns proactively, engaging various stakeholders in the field, in the city municipality of New York as well as the state capital Albany. As a result, the final permits were issued in July 2019 with 2024 set as the target for the delivery of first electricity.

4. Renewables and security: New dimensions

Renewable energy systems challenge traditional interstate notions regarding security, and bring new aspects at different levels. The decentralized nature of renewables brings many benefits to rural and remote areas, but also presents risks when dealing with sub-state actors. The interconnected technological systems that renewables rely on also pose a cybersecurity threat to nations, as witnessed in the near past with national grids coming under cyber-attacks. This section introduces the new dimensions that renewables present regarding security beyond conventional state-to-state conflict.

4.1. Civil conflict

In the decades following the end of the Cold War and the 9/11 attacks, the evolving geopolitical landscape has brought about a resurgence of interest in sub-state actors, autonomous political entities and insurgent groups, and the roles they play in international relations. Dubbing this trend a "new" kind of international relations, scholars have adapted various canonical IR theories to further the understanding of intrastate relations, with a particular focus on civil conflict. As a result, the lines between domestic and international phenomena have blurred, and many have called for the abolishment of the formal distinction between the studies of intrastate and international relations.

The different ways the advent of renewable energy shuffles political power amongst players in a country suggests we revisit this debate. Much of renewable energy technology favors decentralized, distributed networks (e.g., many

solar panels on buildings, integrated to neighborhood storage batteries, together with municipality run windmills meeting a major portion of a city's electricity demand) over a centralized, national energy grid (such as a group of coal and gas terminals meeting electricity demand of multiple cities in a country). Requiring substantially less capital investment, such decentralized, and even off-the-major-grid, networks can play an important role in developing rural areas. This idea can even apply to nuclear power, where recent developments in modular nuclear technology allows small-reactors with capacity as small as 15 MWe to be transferred, by train, road or barge (Mignacca and Locatelli, 2020). One group of scholars argues that a more equitable access to energy within a country will help alleviate income inequality and help achieve sustainable development (see, inter alia, Kanagawa and Nakata, 2008; Onyeji et al., 2012; Khandker et al., 2012), two of the more potent antidotes against civil strife (Collier and Hoeffler, 2004; Hegre and Sambanis, 2006; Gubler and Selway, 2012). Others, on the other hand, argue that the ability to meet energy needs without support from the central government (i.e., being better off on their own) can fuel centrifugal tendencies of certain groups (Brancati, 2006; Groll et al., 2015)

Renewable energy may also play an important role in post-conflict reconstruction. Strategic and random shelling by government and rebel forces during civil conflict often gives significant damage to infrastructure including generators, transmission lines and transformers (Tülüş et al., 2014). For instance, the civil war in Libya, which erupted in 2014, divided the country's national grid into four separate "island regions" (Daloub, 2017). This deterioration of energy infrastructure makes the resumption of economic activity significantly more difficult. A quick and healthy resumption of economic activity is, in turn, key to successful security service reform and the prevention of relapse into hostilities (Collier et al., 2008). Similarly, the provision of energy may be a key issue for the central government to reestablish its legitimacy, as the recent demonstrations in Iraq against power shortages have shown (Powers, 2019). Investments in distributed energy generation, before and after civil conflict, can render resilience to countries recovering from conflict (Zerrifi et al., 2002). Renewable energy could provide regions that are "off-line" from the national grid enough energy for basic functions such as lighting of public areas, telecommunications and powering of hospitals and other public services. This resilience would especially be beneficial for regions which do not necessarily experience acute conflict themselves, but whose access to the national grid is severed due to conflict.

4.2. Cybersecurity

Cyber warfare and cyber management have increasingly become a global concern, and with the upcoming adoption of 5G wireless technologies systems allowing the Internet of Things (IoT) to unleash its full potential, this concern is due to only grow further in the future. Cyber warfare also poses a major risk for electricity grids, of which we have already witnessed numerous cases in the past, leading to large scale power outages. According to the European Commission's Smart Grids Task Force, a modern digital society's energy infrastructure is among the most critical and complex, and it "serves as the backbone for its economic activities and for its security" (European Commission, 2018).

Amongst the most notable cyber-attacks on electricity infrastructure in the recent past was the December 2016 malware attack on regional power stations in Ukraine, leading to a loss of electricity for over 225,000 people for many hours (Kshetri and Voas, 2017). The most notable of such malware targeting electricity infrastructure is Stuxnet, first discovered in July 2010, considered to be the first cyber warfare weapon with the ability to target control systems used in power plants. Black and Veatch, an infrastructure engineering and construction consultancy firm, ranked cybersecurity as the third most pressing issue facing electricity utilities, behind only aging infrastructure and an aging workforce. According to Henry Harji, the firm's Director of Business in Asia, smart grids and IoT technologies are "introducing new interdependencies and vulnerabilities across utilities' entire asset and distribution portfolio" (Black and Veatch, 2017).

Further amplifying the issue is that utilities' communication protocols are generally standardized across the industry, where "malware used against one type of industrial control system can simply be 'tweaked' to attack a power grid" (Kshetri and Voas, 2017). Utilities' existing equipment is generally expensive to replace, however the increasing implementation of renewables will likely offer enough of an incentive for them to justify the upgrade to new and more secure equipment. However, the increasing implementation of renewables will likely also lead to, and require, increased digitalization, thus increasing the risk of a cyber-attack once again despite the more secure upgraded equipment.

The U.S. Department of Commerce's NIST (National Institute of Standards and Technology) report for Smart Grid Cybersecurity guidelines states that while increased digitalization is essential, it will introduce "new interdependencies and vulnerabilities to potential attackers and unintentional errors" (NIST, 2014) Amongst the essential functions at risk are: electricity supply and transmission, electricity transmission and distribution stability, communication between systems/equipment, and backup systems (Dagoumas, 2019). Additionally, cyber-attacks could not only affect utilities, but market participants as well. This becomes increasingly important with the deployment of distributed generators to utilize renewables, such as the use of residential solar panels, as well as the risk of personal data breaches.

The integration of renewable energy into electricity grids poses a very serious question regarding a nation's energy infrastructure and its vulnerability to cyber-attacks. Future technologies create a catch-22 situation as digitalization and inter-connectivity will likely lead to an upgrade in equipment that is more secure, yet inter-connectivity may also lead to increased inter-dependence and thus pose a higher cyber-risk. Furthermore, cyber-attacks also raise the issue of non-state actors conducting what may be interpreted as acts of war against nation states, similar to large scale terrorist attacks, with numerous powerful hacktivist groups operating worldwide. Further research is needed to adequately assess not only the technological impacts of renewable integration into electricity grids, but the geopolitical risks that such an integration poses as well.

5. Energy transition and the politics of natural resources

As the debate on climate change occupies an increasingly salient place on the global agenda, transitioning to clean, carbon neutral energy has become

a focal point for most states. Such transition requires a secure and steady supply of REE necessary for the production and implementation of key renewable technologies. Materials such as lithium, cobalt, graphite and vanadium are critical to manufacturing and maintaining renewable energy products and installations; defense, space and other advanced technologies are also highly reliant on rare earth metals and minerals. Lithium and cobalt are key to the production of battery cells; gallium is an essential component of LED cells; neodymium and dysprosium are used in wind turbines and hybrid cars, to name only a few important uses of REE.

Current projections point to a sizeable increase in global demand for REE in the coming decades. Alonso et al. (2012, p. 3406) argue that, "following a path consistent with stabilization of atmospheric CO_2 at 450 ppm [parts per million]," the global demand for neodymium and dysprosium over the next 25 years may increase by seven and 26-fold, respectively. Similarly, the demand for lithium, compared to 2017 levels, could increase by 117% to 674% by 2030, depending on the speed of the energy transition.

World REE markets have so far experienced only small supply shocks, which have not yet reached crisis levels. For example, in response to a maritime clash with Japan in 2010, China stopped exporting rare earth minerals to its eastern neighbor for two months. Cobalt production in the Democratic Republic of Congo (DRC), the world's leading exporter of the mineral, has often been a stop-and-go process because the government has had numerous political, economic and human-rights related issues with its neighbors as well as the world community. The resulting deterrence to investment has created bottlenecks throughout the global supply chain.

It is important to note that the current reliance on a limited number of producers is not due to scarcity of resources. Deposits of many rare earth minerals are widespread on Earth. For example, a 2014 parliamentary report argued that "half of the rare earths that are available for exploitation outside of China are available in Canada" (Standing Committee on Natural Resources, 2014, p. 11). Instead, the geographical concentration of rare earth minerals production today has been a result of supply-demand equilibrium. Chinese dominance in REE markets has mostly been due to its "operational cost competitiveness" (Mancheri et al., 2019, p. 102). Excavating such minerals can be costly and heavily polluting. Many advanced countries have been reluctant to invest in rare earth mineral extraction, preferring to externalize this process to poorer countries.

Such supply gaps are risky for world trade and may produce tensions in global relations. Advanced manufacturing chains are increasingly more sensitive to interruptions in the flow of materials. Factoring in the cost of supply risks may render renewable energy projects unprofitable or commercially unfeasible. Disruptions in the transition to "cleaner" energy at the country level may also reverberate on a global scale, potentially preventing countries from meeting their nationally determined CO_2 reduction contributions and undermining the global carbon trading scheme.

Freeman and Bazilian (2018) also point out three distinct ways the increasing reliance on REE can trigger tensions that may escalate to military conflict. First, at the intrastate level, producer countries with weak institutions are vulnerable to insurgents capturing their resources. Recalling the DRC-cobalt example, research

has shown that not only the government, but also various warring factions have used cobalt mines to finance their insurgency (Kisangani, 2003). Second, at the international level, states may compete to establish hegemony over global "resource commons." Despite decades-long debates, the international community is still struggling in reaching a global consensus on how to demarcate continental shelves and exclusive economic zones into the deep sea (Nelson, 2009; Charney, 1996), resulting in frequent ship seizures even amongst close allies (Gibler and Little, 2017). The current standoff between Turkey and other littoral states in the Eastern Mediterranean over potential off-shore natural gas reserves illustrates the most recent geopolitical tension relating to such issues of demarcation (Stocker, 2012).

The increasing demand on REE can result in such tension over territory, onshore and offshore. Similar to current tensions regarding the demarcation of sea shelves that are believed to possess natural gas reserves, we may see tensions over arid, non-habited areas or off-shore sectors due to wind and solar (and possibly wave) energy potential between claimant states. For instance, the increasing demand for lithium has rekindled the historical debate regarding the territorial and water access rights of Bolivia, Chile and Argentina over the Atacama Desert, which holds the world's largest reserve of lithium (Rossi, 2019; López Steinmetz and Fong, 2019). Local conflicts on such "off-shore borders," such as the recent series of rows the U.S. federal government has had with various individual littoral states in the Atlantic about off-shore wind farm permits, may also be foreshadowing how securing territorial rights to areas with renewable potential could lead to conflict.

Finally, supplier states may use dependency on these minerals as leverage to extract concessions from importer countries. As previously mentioned, REEs play a critical role in the manufacturing of wind turbines, solar panels and high-capacity lithium-ion batteries. The availability of these products is critical towards the establishment of a renewable energy infrastructure. The last couple of decades have witnessed certain countries leverage their oligopolistic positions as producers of REE to improve their stature in the international arena. This type of behavior has been quite reminiscent of OPEC members using global dependence on their oil reserves as leverage in foreign policy. For instance, with the new millennium, China has adopted the policy of internalizing the value chain in the renewable technology production as much as possible. Instead of selling REE in bulk as raw materials to world markets, China has increasingly sought to move downstream, hence export more value-added products (e.g. exporting high-tech magnets instead of raw neodymium). This change in policy reverberated throughout global value chains and led to small to medium-size crises between advanced industrial countries such as Japan, the US and Germany (Ting and Seaman, 2013; Humphries, 2012).

REE and the natural resource curse. The natural resource curse has been a well-established danger for certain countries to miss opportunities for export-led growth and fall into a development trap due to the abundance of natural resources that keep prices high (see, inter alia, Sachs and Warner, 2001; Robinson et al., 2006). Since relying on non-taxed revenue for government spending, these states often are also unable to develop institutions to foster such healthy and sustainable growth. States that have experienced such resource inflow before the consolidation of their political regimes have especially been susceptible to natural resource curse (Bayulgen, 2010). Increasing reliance on REE export revenue may cre-

ate such pitfalls for exporting states, especially for those who may experience a considerable surge in REE production should they tentatively conclude their domestic political problems, such as a post-conflict DRC or Bolivia.[2] The failure to strengthen the state institutions due to this resource curse may possibly lead to a relapse of civil conflict. A security-related implication of the resource-curse at the international level also deserves mention. States deriving most of their budgetary income from non-tax resources tend to follow more aggressive foreign policy, especially those led by "revolutionary" leaders geared towards changing the institutional structure of their states (Colgan, 2011). Similarly, the budgetary freedom REE revenue bestows may motivate certain states to pursue a more aggressive foreign policy.

6. Conclusion

Energy transitions have been one of the (if not the) most important drivers of energy policy in the last couple of decades. Innovations in renewable energy technology, coming at an ever-increasing pace, have redefined how various political, business and social actors relate to each other at the local and national level. Interstate relations are no exception to this. However, interest has only been recently picking up regarding how energy relations generally, and renewable energy in particular, shape global relations. From their generation to their consumption, renewable energy shapes global relations at various capacities. This review article highlights certain topics in international relations literature which, we believe, will benefit immensely from factoring renewable energy in as an explanatory variable in geopolitical phenomena of interest.

Renewable energy creates new forms of interdependency between states that may either foster cordial or conflictual relations. On the one hand, the trade of electricity requires high levels of coordination between two states, often leading to regulatory and trading regimes that perpetuate peace among its adherents. On the other hand, electricity is the least fungible type of energy good, where disruptions to its supply are very difficult to smooth out. Territory, the most important issue that causes conflict between states, is a central focus in renewable energy. Solar and wind power requires much more area per unit of energy produced. Some of the most suitable areas for renewable energy production and mines for the rare earth elements to produce renewable technology are placed at borders or otherwise contested sectors. Furthermore, "transit" states can hold the flow of electricity hostage and exert leverage on both the originator and the consumer state. Therefore, the quest for renewable energy can reawaken territorial issues that have so far remained dormant between states.

Sub-state actors have become increasingly important in the analysis of interstate relations. The analysis of the role renewables play in global relations is no exception. Current events continue to put the spotlight on the way local actors shape global energy relations, especially with respect to renewable energy. These actors can veto or promote energy relations; conduct "faceless" attacks or mobilize public opinion to force states to take action. Increasing renewable investments can foster centrifugal or centripetal forces within a state, with the possibility of fueling civil

[2] A similar risk exists for states whose electricity exports significantly increase over a short time.

conflict. International relations literature, in turn, often draws attention to the risk of civil wars internationalizing and becoming regional wars. Consequently, future analyses of energy markets and geopolitics can no longer enjoy the luxury of remaining within the confines of conventional interstate relations.

Likewise, future analysis of energy markets and geopolitics should incorporate the evolving importance of REE. Real time monitoring, data collection and analyses of REE data can be employed to build canonical datasets for use in international relations and international political economy. This will improve forecasting capabilities with respect to how geopolitical events affect the dynamics of REE markets, and vice versa.

Increased global trade in electricity and other aspects of renewable technology are poised to raise a plethora of governance questions for which the current international institutions may not be able to provide answers. Renewables carry the potential to connect countries and regions in ways that international politics has not seen before. How sovereignty should be divided amongst players, which conflict resolution mechanisms should be employed in acute conflicts, which stakeholders are relevant and legitimate are some of the questions that need to be answered towards designing an effective and equitable global governance mechanism for the new types of global relations renewable energy will bring about.

Finally, this review has focused on how developments in renewable energy are affecting interstate relations. It is important to note that geopolitical events, in turn, can also affect infrastructure decisions for renewables. Brexit was one of the factors for Ireland and France to conclude the "Celtic-interconnector" agreement, which aims to build a new electricity cable between the two countries, bypassing Britain (Stone, 2019). Similarly, China's financing of renewable projects in the developing world, Africa in particular, is often seen as a tool to project Chinese power in these geographies (Shen and Power, 2016).

References

Alonso, E., Sherman, A. M., Wallington, T. J., Everson, M. P., Field, F. R., Roth, R., Kirchain, R. E. (2012). Evaluating rare earth element availability: A case with revolutionary demand from clean technologies. *Environmental Science and Technology, 46*(6), 3406–3414. https://doi.org/10.1021/es203518d

Anceschi, L. (2010). Integrating domestic politics and foreign policy making: The cases of Turkmenistan and Uzbekistan. *Central Asian Survey, 29*(2), 143–158. https://doi.org/10.1080/02634937.2010.498231

Barbieri, K. (2002). *The liberal illusion: Does trade promote peace?*. Ann Arbor: University of Michigan Press.

Bayulgen, O. (2010). *Foreign investment and political regimes: The oil sector in Azerbaijan, Russia, and Norway*. New York: Cambridge University Press.

Best, R. (2017). Switching towards coal or renewable energy, the effects of financial capital on energy transitions. *Energy Economics* 63(1), 75–83. https://doi.org/10.1016/j.eneco.2017.01.019

Bower, J., & Fuentes, R. (2014). *In search of the Mexican way: How to kick start competition in the electricity sector and achieve lower tariffs*. Oxford: Oxford Institute for Energy Studies.

Brancati, D. (2006). Decentralization: Fueling the fire or dampening the flames of ethnic conflict and secessionism? *International Organization, 60*(3), 651–685. https://doi.org/10.1017/S002081830606019X

Bussmann, M. (2010). Foreign direct investment and militarized international conflict. *Journal of Peace Research, 47*(2), 143–153. https://doi.org/10.1177/0022343309354143

Carroll, A. R. (2015). *Geofuels: Energy and the Earth*. New York: Cambridge University Press.
Charney, J. I. (1996). The implications of expanding international dispute settlement systems: The 1982 Convention on the Law of the Sea. *American Journal of International Law, 90*(1), 69–75. https://doi.org/10.2307/2203752
Chatagnier, J. T., & Kavaklı, K. C. (2017). From economic competition to military combat: Export similarity and international conflict. *Journal of Conflict Resolution, 61*(7), 1510–1536. https://doi.org/10.1177/0022002715613565
Colgan, J. (2011). Oil and resource-backed aggression. *Energy Policy,* 39(3), 1669–1676. https://doi.org/10.1016/j.enpol.2010.12.042
Collier, P., & Hoeffler, A. (2004). Greed and grievance in Civil War. *Oxford Economic Papers, 56*(4), 563–595. https://doi.org/10.1093/oep/gpf064
Collier, P., Hoeffler, A., & Söderbom, M. (2008). Post-conflict risks. *Journal of Peace Research, 45*(4), 461–478. https://doi.org/10.1177/0022343308091356
Considine, T. J. (2006). Is the strategic petroleum reserve our ace in the hole? *The Energy Journal, 27*(3), 91–112. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol27-No3-6
Black and Veatch (2017). Cybersecurity Act in Singapore set to improve security culture across Asian utilities, says Black & Veatch. *Black and Veatch*, June 8. https://www.bv.com/news/cybersecurity-act-singapore-set-improve-security-culture-across-asian-utilities-says-black
Dagoumas, A. (2019). Assessing the impact of cybersecurity attacks on power systems. *Energies, 12*(4), 725. https://doi.org/10.3390/en12040725
Daloub, L. (2017). Conflict damage and reconstruction. *TandD World*, May 1. https://www.tdworld.com/overhead-transmission/article/20969595/conflict-damage-and-reconstruction
Daojiong, Z. (2006). Energy interdependence. *China Security, 2*(2), 2–16.
Dorussen, H. (2006). Heterogeneous trade interests and conflict: What you trade matters. *Journal of Conflict Resolution, 50*(1), 87–107. https://doi.org/10.1177/0022002705283013
Efird, B., Al Muhanna, S., Al-Mubarak, I., Turkistani, S., & Al-Ghamdi, F. (2018). The policy-making process to restart Japanese nuclear power plants. *KAPSARC Discussion Paper*, No. 47.
European Commission (2018). *Recommendations for the European Commission on Implementation of a Network Code on Cybersecurity: 2nd Interim Report*. European Commission Smart Grids Task Force – Expert Group 2 – Cybersecurity.
Florini, A., & Sovacool B. K. (2009). Who governs energy? The challenges facing global energy governance. *Energy Policy, 37*(12), 5239–5248. https://doi.org/10.1016/j.enpol.2009.07.039
Freeman, M., Bazilian, M. (2018). How renewable energy could fuel future conflicts. *Georgetown Journal of International Affairs*, [online edition], October 8. https://www.georgetownjournalofinternationalaffairs.org/online-edition/2018/10/8/how-renewable-energy-could-fuel-future-conflicts
Gibler, D. M., & Little, E. K. (2017). Heterogeneity in the Militarized Interstate Disputes (MIDs), 1816–2001: What fatal MIDs cannot fix. *Political Science Research and Methods, 5*(1), 189–199. https://doi.org/10.1017/psrm.2016.11
Goldthau, A., & Witte, J. M. (Eds.) (2010). *Global energy governance: The new rules of the game*. Washington, DC: Brookings Institution Press.
Groll, M., Opp, C., Kulmatov, R., Ikramova, M., & Normatov, I. (2015). Water quality, potential conflicts and solutions — an upstream–downstream analysis of the transnational Zarafshan River (Tajikistan, Uzbekistan). *Environmental Earth Sciences, 73*(2), 743–763. https://doi.org/10.1007/s12665-013-2988-5
Guay, T. (2000). Local government and global politics: The implications of Massachusetts' Burma Law. *Political Science Quarterly, 115*(3), 353–376. https://doi.org/10.2307/2658123
Gubler, J. R., & Selway, J. S. (2012). Horizontal inequality, crosscutting cleavages, and Civil War. *Journal of Conflict Resolution, 56*(2), 206–232. https://doi.org/10.1177/0022002711431416
Gupta, E. (2008). Oil vulnerability index of oil-importing countries. *Energy policy, 36*(3), 1195–1211. https://doi.org/10.1016/j.enpol.2007.11.011
Hiller, J. (2019). U.S. shale seen unlikely to quickly replace barrels lost in attack on Saudi facilities. *Reuters*, September 15. https://www.reuters.com/article/us-saudi-aramco-attacks-shale-idUSKBN1W00TE
Huang, D., Shu, Y., Ruan, J., & Hu, Y. (2009). Ultra high voltage transmission in China: Developments, current status and future prospects. *Proceedings of the IEEE, 97*(3), 555–583. https://doi.org/10.1109/JPROC.2009.2013613

Hegre, H., Oneal, J. R., & Russett, B. (2010). Trade does promote peace: New simultaneous estimates of the reciprocal effects of trade and conflict. *Journal of Peace Research, 47*(6), 763–774. https://doi.org/10.1177/0022343310385995

Hegre, H., & Sambanis, N. (2006). Sensitivity analysis of empirical results on civil war onset. *Journal of Conflict Resolution, 50*(4), 508–535. https://doi.org/10.1177/0022002706289303

Humphries, M. (2012). *Rare earth elements: The global supply chain.* Washington, DC: Congressional Research Service

Ivanenko, V. (2008). Russian energy policy and its domestic and foreign implications. *International Journal, 63*(2), 263–274. https://doi.org/10.1177/002070200806300203

IRENA (2019). *Renewables readiness assessment: Kingdom of Bhutan.* Abu Dhabi: International Renewable Energy Agency.

Jain, P. (2004). Japan's subnational governments in China: Emerging bilateral relations. *Global Change, Peace and Security, 16*(1), 19–30. https://doi.org/10.1080/1478115042000176157

Kaczmarski, M. (2014). Domestic power relations and Russia's foreign policy. *Demokratizatsiya, 22*(3), pp. 383–409.

Kalicki, J., & Goldwyn, D. L. (2005). Energy and security: Toward a new foreign policy strategy. Washington, DC: Woodrow Wilson Center Press.

Kanagawa, M., & Nakata, T. (2008). Assessment of access to electricity and the socio-economic impacts in rural areas of developing countries. *Energy Policy, 36*(6), 2016–2029. https://doi.org/10.1016/j.enpol.2008.01.041

Khandker, S. R., Barnes, D. F. , & Samad, H. A. (2012). Are the energy poor also income poor? Evidence from India. *Energy Policy, 47*, 1–12. https://doi.org/10.1016/j.enpol.2012.02.028

Kisangani, E. (2003). Conflict in The Democratic Republic of Congo: A mosaic of insurgent groups, *International Journal on World Peace, 20*(3), 51–80.

Kleinberg, K. B., Robinson, G., & French, S. L. (2012). French, trade concentration and interstate conflict. *Journal of Politics, 74*(2), 529–540. https://doi.org/10.1017/S0022381611001745

Krasner, S. D. (1982). Structural causes and regime consequences: Regimes as intervening variables. *International Organization, 36*(2), 185–205. https://doi.org/10.1017/S0020818300018920

Kravtsova, E., & Chung, J. (2019) South Korea's KOGAS sends U.S. LNG cargoes to Europe. *Reuters*, February 22. https://jp.reuters.com/article/lng-kogas-idAFL5N20H3BF

Krickovic, A. (2015). When interdependence produces conflict: EU–Russia energy relations as a security dilemma. *Contemporary Security Policy, 36*(1), 3–26. https://doi.org/10.1080/13523260.2015.1012350

Kshetri, N., & Voas, J. (2017). Hacking power grids: A current problem. *Computer, 50*(12), 91–95. https://doi.org/10.1109/MC.2017.4451203

Lee, S., & Mitchell, S. M. (2019). Energy resources and the risk of conflict in shared river basins. *Journal of Peace Research, 56*(3), 336–351. https://doi.org/10.1177/0022343318808347

Leiby, P. N., Oladosu, G., Martinez, R. U., Johnson, M., & Bowman, D. (2019). *Final CRADA report: 2018 benefits study of emergency IEA oil stocks*. Oak Ridge, TN: Oak Ridge National Laboratory.

Li, Q., & Reuveny, R. (2011). Does Trade Prevent or Promote Interstate Conflict Initiation? *Journal of Peace Research, 48*(4), 437–453. https://doi.org/10.1177/0022343311406306

Liberman, P. (1996). Trading with the enemy: Security and relative economic gains. *International Security, 21*(1), 147–175. https://doi.org/10.1162/isec.21.1.147

Mancheri, N. A., Sprecher, B., Bailey, G., Ge J., & Tukker, A. (2019). Effect of Chinese policies on rare earth supply chain resilience. *Resources, Conservation and Recycling, 142*, 101–112. https://doi.org/10.1016/j.resconrec.2018.11.017

Mansfield, E. D., & Pollins, B. M. (Eds.) (2009). *Economic interdependence and international conflict: New perspectives on an enduring debate*. Ann Arbor: University of Michigan Press.

Mastanduno, M. (1988). Trade as a strategic weapon: American and alliance export control policy in the early postwar period. *International Organization, 42*(1), 121–150. https://doi.org/10.1017/S0020818300007153

Mignacca, B., & Locatelli, G. (2020). Economics and finance of small modular reactors: A systematic review and research agenda. *Renewable and Sustainable Energy Reviews, 118,* 109519. https://doi.org/10.1016/j.rser.2019.109519

Morgan, G. (2019). How Canada's other major energy export could light up New England states. *Financial Post*, April 16. https://financialpost.com/commodities/energy/how-canadas-other-major-energy-export-could-light-up-new-england-states

NIST (2014). *Guidelines for smart grid cybersecurity. Volume 1: Smart grid cybersecurity strategy, architecture and high-level requirements.* National Institute of Standards and Technology, U.S. Department of Commerce. https://doi.org/10.6028/NIST.IR.7628r1

Nelson, L. D. M. (2009). The settlement of disputes arising from conflicting outer continental shelf claims. *International Journal of Marine and Coastal Law, 24*(2), 409–422. https://doi.org/10.1163/157180809X421806

Onyeji, I., Bazilian, M., & Nussbaumer, P. (2012). Contextualizing electricity access in Sub-Saharan Africa. *Energy for Sustainable Development, 16*(4), 520–527. https://doi.org/10.1016/j.esd.2012.08.007

Peterson, T. M. (2011). Third-party trade, political similarity, and dyadic conflict. *Journal of Peace Research, 48*(2), 185–200. https://doi.org/10.1177/0022343310396266

Powers, L. (2019). Iraq protests: Everything we know so far as death toll rises. *Newsweek*, October 3. https://www.newsweek.com/iraq-protests-death-toll-rises-1463035

Robinson, J. A., Torvik, R., & Verdier, T. (2006). Political foundations of the resource curse. *Journal of Development Economics, 79*(2), 447–468. https://doi.org/10.1016/j.jdeveco.2006.01.008

Ross, M. L., & Voeten, E. (2015). Oil and international cooperation. *International Studies Quarterly, 60*(1), 85–97. https://doi.org/10.1093/isq/sqv003

Rossi, C. (2019). *Neoliberalism's contested encounter with international law in the lithium triangle.* Paper presented at the 2019 International Studies Association Annual Midwest Conference, St. Louis, Missouri, November 22–23.

Sachs, J. D., & Warner, A. M. (2001). The curse of natural resources. *European Economic Review, 45*(4–6), 827–838. https://doi.org/10.1016/S0014-2921(01)00125-8

Shen, W., & Power, M. (2016). Africa and the export of China's clean energy revolution. *Third World Quarterly, 38*(3), 678–697. https://doi.org/10.1080/01436597.2016.1199262

Standing Committee on Natural Resources (2014). *The rare earth elements industry in Canada — Summary of evidence*. RNNR (41-2), House of Commons of Canada. Available at: https://www.ourcommons.ca/Content/Committee/412/RNNR/WebDoc/WD6669744/412_RNNR_reldoc_PDF/RareEarthElements-Summary-e.pdf

López Steinmetz, R. L., & Fong, S. B. (2019). Water legislation in the context of lithium mining in Argentina. *Resources Policy, 64*, 101510. https://doi.org/10.1016/j.resourpol.2019.101510

Stocker, J. (2012). No EEZ solution: The politics of oil and gas in the Eastern Mediterranean. *The Middle East Journal, 66*(4), 579–597. https://doi.org/10.3751/66.4.11

Stone, J. (2019). Ireland and France to build new electricity cable bypassing Britain after Brexit. *Independent*, May 28. https://www.independent.co.uk/news/world/europe/ireland-france-electricity-cable-supply-uk-brexit-single-market-a8933116.html

Ting, M. H., & Seaman J. (2013). Rare earths: Future elements of conflict in Asia? *Asian Studies Review, 37*(2), 234–252. https://doi.org/10.1080/10357823.2013.767313

Tülüş, C., Tongal, Ç., & Hatipoğlu, E. (2014). *Afghanistan in transition: Institution and security nexus.* Istanbul Policy Center Report.

Van der Heiden, N. (2010). Urban foreign policy and domestic dilemmas: Insights from Swiss and EU city-regions. Colchester: ECPR Press.

World Energy Council (2016). *World Energy Resources, 2016*.

Zalk, J. van, & Behrens, P. (2018). The spatial extent of renewable and non-renewable power generation: A review and meta-analysis of power densities and their application in the U.S. *Energy Policy, 123*, 83–91. https://doi.org/10.1016/j.enpol.2018.08.023

Zerriffi, H., Dowlatabadi, H., & Strachan, N. (2002). Electricity and conflict: Advantages of a distributed system. *The Electricity Journal, 15*(1), 55–65. https://doi.org/10.1016/S1040-6190(01)00262-7