SWP Research Paper

Kirsten Westphal, Maria Pastukhova and Jacopo Maria Pepe

Geopolitics of Electricity: Grids, Space and (political) Power

Stiftung Wissenschaft und Politik
German Institute for International and Security Affairs

SWP Research Paper 6
March 2022, Berlin

- Although electricity grids shape and define both political and economic spaces, the geopolitical significance of electricity remains underestimated. In political communities and beyond, such grids establish new channels for projecting geopolitical influence and new spheres of influence.
- In the Europe-Asia continental area, integrated electricity grids meet *interconnectors* — that is, cross-border transmission lines linking different electric grids. Interconnectors define new, partly competing vectors of integration that extend beyond already integrated electricity grids.
- In this context, it is attractive for non-EU states to belong to the electricity system of continental Europe. This is because interconnected synchronous systems form "grid communities" that share a "common destiny" — not only in terms of electricity supply but also in terms of security and welfare.
- Germany and the EU must develop an electricity foreign policy in order to optimise, modernise, strengthen and expand the European electricity grid. Above all, however, Germany and the EU should help shape interconnectivity beyond the EU's common integrated electricity grid.
- China is gaining considerable influence in the electricity sector, setting standards and norms as well as expanding its strategic outreach — to the benefit of its own economy. Its efforts are part of Beijing's larger Belt and Road Initiative (BRI), an attempt to reorient global infrastructure and commercial flows.
- In the EU's eastern neighbourhood, geopolitical issues have dominated the configuration of electricity grids since the end of the Cold War. There is unmistakable competition over integration between the EU and Russia.
- The eastern Mediterranean region, the Black Sea and Caspian Sea regions, and Central Asia are, each in their own way, changing from peripheral zones into interconnecting spaces. The EU, China, Russia and — across the Black Sea — Iran and Turkey are competing in these zones to influence the reconfiguration of electricity grids. And in South and Southeast Asia, India's influence is on the rise.

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ISSN (Print) 2747-5123
ISSN (Online) 1863-1053
doi: 10.18449/2022RP06

(Revised and updated
English version of
SWP-Studie 14/2021)

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The manuscript was finished on 20 December 2021.

Geopolitics of Electricity: Grids, Space and (political) Power

The geopolitical relevance of electricity has traditionally been underestimated But with the global transformation to greener energy and the expansion of renewables (the “energy transition”), electricity grids are gaining importance and momentum. Beijing in particular is driving global electricity interconnectivity with its Belt and Road Initiative (BRI). Today, the impact of electricity interconnection on international relations and geopolitics deserves the closest possible scrutiny.

The Europe-Asia continental area studied here exhibits particular dynamics. New configurations of electricity infrastructure — in the form of interconnectors (i.e., cross-border transmission lines linking grids) and integrated electricity grids — are remapping spaces by redefining the relationship of centre to periphery. In addition to the old centres of gravity, Russia and the EU, new ones are emerging. They include not only China but also Turkey, Iran and India. Their networks are not yet as densely interconnected as those of Europe and parts of the former Soviet Union, but interconnectors are nevertheless now being directed towards them. As a result, areas that were once considered peripheral such as the eastern Mediterranean, the Black Sea and Caspian Sea regions, and Central Asia are quickly becoming sites of competition.

Electricity is grid-bound. Electricity moves almost at the speed of light and connects distant points and spans vast spaces in an interconnected grid. Electricity grids (“infrastructurise”) shape regions over the long term, creating their own topographies that reflect the organisation of economic and social life within a geographical area. The electricity system is the backbone of any economy, and electricity grids constitute critical infrastructure.

The interplay of three factors — the electricity grid, space and geopolitical power — deserves close scrutiny. Infrastructure networks create techno-political and techno-economic spheres of influence. Because electricity spaces extend beyond state borders and across legal jurisdictions, they enable a diffusion of geopolitical power. The vulnerability of states to strength projection and external influence also depends on how robust and resilient the electricity grids are.

The European Community and the European Union have never been identical with the more general entity of "Electrified Europe". The network expansion and synchronization still primarily follow economic and geographical conditions. Despite sharing a political and legal framework, technical and market integration within the EU has proceeded very unevenly and with a time lag. With the creation of the internal market, the EU also pushed for integration and harmonisation at the political, technical and economic levels. But the respective physical nodes and control centres of technical-operational, economic and political power overlap neither in location nor in their organizational structure. Moreover, the synchronous integrated electricity grids of continental Europe spans countries to the east and south of the EU proper. The importance of Europe's neighbourhood is likely to increase, as there are favourable locations on Europe's periphery for generating solar and wind electricity. International interconnectivity of electricity is on the rise outside the EU as well. China is the driving force behind this development, fostering the expansion of electricity lines to keep pace with logistics and transport routes as well as information and communication technologies that tie Europe more tightly to the People's Republic. Beijing's policy reveals the permeability of spaces and of spheres of influence as well as the extent to which political power can be projected through "interconnectors". Power projection exercised via electricity lines expansion and grid development results in reordering greater economic spaces. The electricity communities emerging from this process may still be rudimentarily regulated and harmonised. But they are certainly characterised by geopolitical ambition. Within such fluid regulatory and legal frameworks, the discrepancy between levels of interconnection and approaches to regulation raises a whole series of geopolitical questions.

Continental Europe is highly regulated and integrated at the technical-operational level as well as in terms of trade and data. Such coordination, however, thins out on Europe's southern, southeastern and eastern periphery. The synchronous integrated electricity grids in Europe could be said to share a "common electricity destiny" — that is, the parties involved share opportunities and risks equally. Beyond the European continental grid, however, a number of competing regional or even continental connectivity initiatives can be observed, all aiming at creating large energy and economic areas.

Electricity interconnections and grids can serve geopolitical interests in three general ways. Political entities can take advantage of them to establish asymmetrical dependencies; they can use them to establish market dominance, legal-regulatory dominance and technical and economic dominance; and, finally, they can exploit them to pursue mercantilist goals. In such situations, we seem to find a classic example of what Carl Schmitt outlined in his 1939 work *Völkerrechtliche Großraumordnung* (The Großraum Order of International Law) — namely, that there is a connection at the level of the technical-organizational development between large areas, economic relations, and energy and electricity networks.

In the case of electricity, space and network follow competing systems of logic depending on location. Within the EU, for example, the legal-regulatory principle of order applies and extends to the territorially contiguous "electricity space" of Europe. In contrast, in spaces that are permeable to outside influence in political and legal terms, great powers seek to control electricity flows as a way of projecting political power and establishing centralised or hierarchically structured spaces. We are currently observing processes of reintegration and resynchronisation in regions such as Central Asia and the South Caucasus, North Africa, and South and Southeast Asia — regions that historically had been only marginally interconnected and infrastructurally fragmented. Today this is being done either through electricity interconnectors — such as the Central Asian Power System (CAPS) and the BRI — or through the creation of electricity markets like the Eurasian Economic Union (EAEU). The degree of socioeconomic, technical-regulatory as well as infrastructural concentration and integration of these regions is generally still low. This increases their permeability to external political power and transforms them into areas of interconnection and competition. Competition for normative, technical, economic — and thus geopolitical — spheres of influence is intensifying. In the strategically important Europe-Asia continental area, China, Russia, Turkey and Iran are vying with the EU and the United States for influence.

The situation poses new challenges for Germany and the EU, since the European sphere of influence is becoming permeable to the sway of other powers. To prepare the way for a smooth and low-conflict energy transformation and compete effectively with other integrated electricity grids, the EU must actively shape interconnectivity in its neighbourhood and develop its own foreign policy for electricity.

Geopolitics and Electricity Grids

The geopolitical implications of the energy transformation[*] are considerable.[1] Because analysis has traditionally focussed on oil and gas, however, the importance of electricity is still underestimated.[2] There are at least three reasons why the German and European foreign policy community should devote more attention to electricity issues. First, the share of electricity in the energy mix will increase as the trend towards greater electrification continues worldwide. The research firm BloombergNEF estimates that demand for electricity will increase by 60 percent by 2050.[3] Second, international interconnections are on the rise, transporting electricity more and more efficiently over greater and greater distances. In this context, electricity interconnections are emerging primarily as a result of political decisions — unlike with oil and gas, where trading links are dictated by the geographical location and geology of oil and gas fields. The third reason is that electricity grids and interconnections are responding to new dynamics in the energy sector — namely the fact that fossil-fuel power plants are being shut down and renewable sources of energy are expanding.

Grids, Space and (Political) Power

This study focuses on the interplay of infrastructure, space and political power in the continental Europe-Asia region.[4] Our analysis is based on the following four theoretical and conceptual assumptions:

First, grid infrastructures can expand techno-political spheres of influence and be used as a means of projecting political power and authority beyond territorial space.[5] This is particularly evident in the example of digital networks, but it is increasingly true of electricity grids as well. With the digitalisation of electricity grids, moreover, the two forms of infrastructure are becoming increasingly intertwined so that a data level now tends to supplement the power line on the physical level.

It is essential to distinguish here between two terms: an “infrastructurised space” (Netzraum) and a “legal space” (*Rechtsraum* — i.e., the space of jurisdiction). This is because different principles of power

* We are very grateful to Dr Susanne Nies for her detailed comments and valuable advice, and to Michael Paul for his expert opinion. As the authors, we are responsible for any errors in this paper. We thank Patricia Wild, Friedemann Schmidt and Julian Grinschgl for their help preparing the manuscript. We gratefully acknowledge the work of Paul Bochtler, Rebecca Majewski, Maximiliane Schneider, Corinna Templin (SWP Data and Statistics Team), and Daniel Kettner (Communications Department) for their detailed research as well as for creating and designing the maps. Our thanks also go to Michael Alfs for editing the original German draft and to Miranda Robbins for editing the English manuscript.

1 International Renewable Energy Agency (IRENA), ed., *A New World: The Geopolitics of the Energy Transformation* (Abu Dhabi, 2019), https://www.irena.org/publications/2019/Jan/A-New-World-The-Geopolitics-of-the-Energy-Transformation.

2 Susanne Nies, “Security of Supply and Risk Preparedness: A New Focus on Electricity”, in *The European Energy Transition: An Agenda for the Twenties*, ed. Susanne Nies, 2nd ed. (Deventer: Claeys & Casteels, 2020), 53–78.

3 BloombergNEF, *New Energy Outlook 2020, Executive Summary* (October 2020), 9.

4 Margarita M. Balmaceda, *Russian Energy Chains: The Remaking of Technopolitics from Siberia to Ukraine to the European Union* (New York: Columbia University Press, 2021); Per Högselius, *Energy and Geopolitics* (London and New York: Routledge, 2019); Per Högselius, *Red Gas: Russia and the Origins of European Energy Dependence* (Basingstoke and New York: Palgrave Macmillan, 2013).

5 Matthias Schulze and Daniel Voelsen, “Digital Spheres of Influence”, in *Strategic Rivalry between United States and China*, SWP Research Paper 1/2020, ed. Barbara Lippert and Volker Perthes (Berlin: Stiftung Wissenschaft und Politik, April 2020), 32–36, https://www.swp-berlin.org/publikation/strategic-rivalry-between-united-states-and-china#hd-d18124e1781.

and order underlie the two concepts. The "networked space" is based on a fluid principle of order according to which network components and electricity flows are controlled within a techno-political grid space that penetrates and spans different territories and jurisdictions. Here, the most important actors are those controlling flows, regulating access to electricity and thereby influencing other actors. Nevertheless, techno-political spheres of influence are not exclusive.[6] A "legal space", on the other hand, follows the classical exclusive principle of order, with jurisdiction exercised within a territory. While a legal space strives to create a transparent "level playing field" — that is, equal opportunities for participation following generally applicable norms, standards and rules — the projection of strength in infrastructurised spaces is much more diffuse. For example, the rules for participation are more likely to follow particular interests. In this context, control over nodes or important network components is of great significance.[7] On the technical-operational level, *the legal space* corresponds to the *synchronous integrated electricity grids*, while *the infrastructurised space* is created by *interconnectors* and electricity highways (see the next section). The result is a fluid interplay of infrastructure, spaces and power that has the effect of undermining territoriality as an international principle of order.

The second assumption underlying the analysis is that any grid infrastructure still entails a literal geographical dimension. Electricity grids ("infrastructure") shape energy spaces and entail spatial reorganisation. Cross-border electricity interconnections and integrated electricity grids should be considered as an infrastructure which durably shapes geographies. Electricity lines establish vectors of connection or even integration that constitute new power spaces over time. Drawing on concepts of political geography, the analysed interconnection can be understood as a process of organising social and political power across space.[8] Accordingly, electricity infrastructures have a constitutive effect on network and legal spaces: they reconfigure them, thus exerting inclusive and exclusive effects on socioeconomic transactions, promoting divergent and convergent institutions, norms and narratives. They align spaces with (new) centres.

The third assumption is that electricity grids are critical infrastructure — vitally important to every economy and society. They shape their own "topography". The welfare, security and stability of a state — as well as the participation of individuals in political, social and economic life — are co-determined by the degree of interconnectivity between urban and rural areas, by the relationship of economic centres to electricity generation and by the resilience, robustness and competitiveness of the electricity supply itself. The rulership factor within a country cannot be overlooked, because infrastructures offer channels of action for establishing control over national territory all the way to the periphery. This also makes infrastructure a politically contested subject. Questions of social acceptance are also important, especially with regard to electricity. In terms of foreign policy, infrastructure also plays a significant role in how power is projected, how hybrid threats are handled or mounted and even in how warfare is conducted.[9]

Interdependence, the control of electricity flows and interconnections are increasingly understood as political currency.

The fourth and final theoretical assumption is that infrastructure overcomes spatial and temporal distances and enables circular exchange. Infrastructures both open channels for transactions and create their own techno-political ecosystems.[10] Since political power is understood here as being polymorphic, the focus is not only on the material control over access, availability and use of electricity sources and the flows of electricity; equally significant are the norms, rules and notions of space. Who has the political authority to plan and regulate electricity networks? Who controls their technical operation, and who has the technology and components to develop the electricity grid? In this context, integrated electricity grids overlap with jurisdictional spaces, but they are not necessarily congruent. Electricity grids are a prerequisite for the exchange of electricity. Against the back-

6 Ibid., 32.

7 Paul Joscha Kohlenberg and Nadine Godehardt, *China's Global Connectivity Politics: On Confidently Dealing with Chinese Initiatives*, SWP Comment 18/2018 (Berlin: Stiftung Wissenschaft und Politik, April 2018), https://www.swp-berlin.org/publications/products/comments/2018C17_khb_gdh.pdf.

8 Gavin Bridge, Stefan Bouzarovski, Michael Bradshaw and Nick Eyre, "Geographies of Energy Transition: Space, Place and the Low-Carbon Economy", *Energy Policy* 53 (2013): 331—40 (336).

9 Selina Ho, "Infrastructure and Chinese Power", *International Affairs* 96, no. 6 (2020): 1461—85 (1468).

10 Ibid., 1466, 1469.

ground of both systemic and geo-economic competition, transactional relationships and interdependencies are increasingly understood as political currency. So is control over electricity flows and interconnections. At the heart of the current debate on geo-economic rivalry lies the ability of foreign powers to use economic and technical influence to shape international relations to their own benefit. A newly competitive environment involving relations of asymmetrical dependence has also brought into focus the resilience of production and value chains as well as a foreign power's sovereignty and strategic capacity to act. But there are other factors to consider as well, namely perceptions, the projection of norms, and concepts of space. Asymmetry within a network of relationships can determine decisions or merely influence them, but at the very least it is a factor for all actors involved to consider.[11]

Electricity grids are a valuable subject of analysis; not only are they a basic prerequisite for prosperity and growth but they also affect strategic capacity to act in a modern economy. This study examines the commercial, strategic and geopolitical dimensions of electricity projects. Scholten and Bosman's concept of "grid communities"[12] underpins the idea that any electricity interconnection is based on a conscious political choice and that, at least in theory, there is geopolitical freedom of choice. The extent to which transnational infrastructures reinforce asymmetric relations between states should not be neglected, however. Building infrastructure gives *outside* powers the opportunity to open up and reconfigure spaces *inside* the borders of third states. In doing so, they can transform and reconfigure the economies and societies within.[13]

Interconnectivity and integrated electricity grids: A Conceptual Framework

Interconnectivity in the electricity system is defined here as *a cross-border transmission lines* (interconnector) *via a node* (cross-border interconnection point). At transmission-grid level, grids predominantly have a voltage of 220 or 380 kilovolts (kV) or more; rarely is the voltage only 110 kV.[14] Unlike oil or gas, electricity interconnections are not characterised by asymmetric interstate import-export relationships; instead, electricity flows almost at the speed of light in both directions.[15] Despite these physical characteristics, very different vulnerabilities can arise. These depend on whether (and to what extent) the electricity supply within the respective electricity grid can remain robust and resilient in the absence of the interconnector (N-1 principle, see Glossary, p. 55). An interconnector linking two electricity grids can thus entail geopolitical risks; it be abused as a kind of political blackmail.

Interconnectors link national or even supraregional electricity grids. Differences in infrastructure, voltage and frequency must be taken into account. For example, electricity grids can be connected "back to back" (B2B) — that is, via high-voltage direct-current short-circuit coupling. High-voltage direct-current transmission lines (HVDC lines) can also connect points within a country and its electricity grid.

Integrated electricity grids used to be built nationally, are operated synchronously and are meshed according to settlement and economic activities — i.e., linked with more and more transmission and distribution grid lines and with ring connections. To put it simply: the more closely meshed the network is, the better the supply situation and the stability within the network.

When voltage and frequency match, the grid is said to be synchronous. Synchronised electricity grids create a community marked by "electricity solidarity" — a "common electricity destiny", if you will. This is because the states share the same opportunities and risks as well as the same rights and obligations in the synchronised grid. Scholten and Bosman speak of "grid communities".[16] The balance of power — a classic element of geopolitics — is distributed much

11 Also raised by Ho, ibid., 1461.

12 Daniel Scholten and Rick Bosman, "The Geopolitics of Renewables: Exploring the Political Implications of Renewable Energy Systems", *Technological Forecasting & Social Change* 103 (2016): 273–83.

13 Ho, "Infrastructure and Chinese Power" (see note 9), 1471.

14 Although there are different standards worldwide and no uniform definition of transmission grid connections, interconnectors of over 220 kV are common both within the EU and in the rest of the Euro-Asian area, with a few exceptions.

15 Susanne Nies, *At the Speed of Light? Electricity Interconnections for Europe*, Gouvernance Européenne et Géopolitique de l'Énergie, vol. 8 (Paris: Institut Français des Relations Internationales [IFRI], 2010).

16 Scholten and Bosman, "The Geopolitics of Renewables" (see note 12), 279.

more homogeneously within the synchronised network. Synchronisation (see Glossary, p. 56) of electricity grids thus goes much further than simple interconnection via point-to-point HVDC lines.

The Drivers of Electricity Interconnection

The driving factors for interconnectivity and synchronisation of integrated electricity grids can be characterized as follows: 1) technical-operational, 2) socioeconomic, 3) climate and environmental and 4) geopolitical.

1. From a *technical-operational* point of view, electricity grid interconnection improves the security of the grid. A larger network and stronger interconnectors generally offer more flexibility and thus increase the resilience of the network to both traditional and new risks. Known risks include power outages,[17] which usually affect only the local distribution level and may be caused by short circuits, digging activities, weather events and the like. Far more serious are electricity outages that also affect interregional transmission networks. Possible triggers include cyberattacks, extreme weather events, earthquakes, technical failures, terrorist attacks, and system overloads, among others. Here, grid communities need to study risks, prevent electricity outages and take emergency measures. On 8 January 2021, for example, a fault in a substation in Croatia led to a drop in frequency. This resulted in a split through the synchronised continental grid that lasted about an hour. As a result, southeast Europe fell out of interconnection during that time, while large consumers in France and Italy were taken off the grid to compensate for the drop in frequency.[18] Then, on 24 July, 2021 there was a system disconnection, this time lasting around half an hour, in which the Iberian peninsula was cut off from the rest of the continental grid. This was triggered by forest fires and the associated fire-fighting operations.[19] As this event makes all too clear, the effects of climate change must also be counted among the new challenges.[20]

2. Socioeconomic factors are also prominent drivers of grid expansion, as it is well known that the electricity grid is critical infrastructure. A breakdown in the electricity grid has far-reaching, cascading effects for everything from the internet, telecommunications and logistics to drinking water supply, healthcare and a range of other critical systems. This in turn demonstrates the extent of the aforementioned “common destiny of a grid community” — the fact that countries with synchronous interconnected electricity grids are “in it together”. A synchronised electricity grid can therefore help establish and maintain political order and promote socioeconomic welfare.[21]

The grid topography will change fundamentally – also spatially.

3. New developments in *climate and environmental policy*, above all the energy transition, constitute another main driver of grid expansion. With the energy transformation, the expansion of renewable energies, the gradual phase-out of nuclear and coal energy, and the shutdown of thermal power plants, the load flows are changing in the grid that connects generation centres with demand centres (load centres). The grid topography will change fundamentally in spatial terms as well. Not only is interconnection a prerequisite for the optimally situated expansion of renewable energies. It can also lead to greater economic efficiency if electricity flows transnationally within and beyond a network and if it is traded transnationally. The International Energy Agency’s (IEA)[22] modelling for a net-zero energy system by 2050 also highlights the crucial role of the electricity system. To reach this goal, installed generation capacity must increase drastically: to 37,300 terawatt hours (TWh) by 2030 (from 26,800 TWh in 2020) and to 71,200 TWh by 2050. For this to occur, investment in the electricity grid will have to triple by 2030.[23] And the share of renewable

17 See Nies, “Security of Supply” (see note 2).

18 Günter Drewnitzky, “Europa am Rande eines Black Friday”, *Energy & Management/Powernews.org* (online ed.), 11 January 2021, https://www.energie-und-management.de/nachrichten/networks/detail/europa-am-rande-eines-black-friday-140715.

19 Peter Koller, “Wieder Systemtrennung im europäischen Stromnetz”, *Energy & Management/Powernews.org* (online ed.), 26 July 2021, https://www.energie-und-management.de/nachrichten/netze/detail/wieder-systemtrennung-im-europaeischen-stromnetz-144002.

20 International Energy Agency (IEA), *Power Systems in Transition: Challenges and Opportunities ahead for Electricity Security* (Vienna, 2020).

21 Bridge et al., “Geographies of Energy Transition” (see note 8).

22 IEA, *Net Zero by 2050: A Roadmap for the Global Energy Sector* (Vienna, 2021), 117.

23 Ibid., 118.

energies will have to increase from today's 29 percent to 88 percent in 2050.[24] With the growing expansion of renewable energies, both the demands on the grids and the functioning of the market are constantly changing. Electrification and sector coupling (i.e., the increased use of electricity in the heating, transport and industrial sectors as well) pose further challenges for the electricity grid and system stability. Certainly digitalisation is becoming an increasingly important way of reliably and efficiently managing both the electricity grid and electricity trading. At the same time, this creates new vulnerabilities. Constant review not only of the resilience of the electricity grid but also of so-called system adequacy (see Glossary, p. 56) is needed.

4. Finally, *geopolitics* itself is a central driver. At least two geopolitical directions of action can be discerned in relation to electricity grid interconnections. First, a network interconnection can be expanded for security policy considerations in order to underpin the community between two or more states in the electricity sector. Here the model of the "grid community" and the demarcation from the outside world play a role. A second, more geo-economically driven direction, in contrast, is the expansion of grids and electricity interconnections to project economic power as well as to strengthen the influence and position of states. China, for example, is not only exporting equipment and components as part of its BRI. It explicitly wants to set Chinese norms and standards at the international level.[25] Moreover, China appoints the president of the International Electrotechnical Commission.[26] China's position in AC-DC converters and substations is strong, partly because manufacturing and processing capacity for key large-scale components at the generation and transmission level has migrated to China.[27]

Centres and Peripheries in the Europe-Asia Continental Area

Electricity grid infrastructures, especially in the form of integrated electricity grids, shape political and socioeconomic relationships between two or more centres as well as between centres on the one hand and peripheries on the other.

Centres[28] are defined here as infrastructurally and industrially dense spaces (including beyond the sphere of a single country's influence) characterised by a high density of economic and social transactions, normative-political homogeneity and a low degree of permeability to outside geopolitical power. Peripheries, in contrast, are characterised by poor infrastructure, weak industrialization, variable socioeconomic conditions, a weak or absent centre of political gravity, a high degree of permeability to outside geopolitical power and strong centrifugal forces.

Following socioeconomic network theory, centres and peripheries can be connected in several ways. A centre can be linked to several areas on its periphery. At the same time, two or more centres can be linked to each other through a common peripheral space. It is also conceivable for several centres, each with its own periphery, to exist side by side with only a weak link to each other.[29] Different centre-periphery con-

24 Ibid., 117.

25 See Gerhard Steiger, *Neue Normungsstrategie "China Standards 2035"* (Frankfurt: Verband Deutscher Maschinen und Anlagenbau e.V. [VDMA], Abteilung Normung, 30 July 2020), http://normung.vdma.org/viewer/-/v2article/render/50001829; see also Sibylle Gabler, *Internationale Normung und Standardisierung im Bereich neuer Technologien als Teil des geopolitischen Wettbewerbs* (Berlin: Deutsches Institut für Normung, 7 June 2021), https://www.bundestag.de/resource/blob/846438/5165a1089417d56629aef3d539844d12/Praesentation-Sibylle-Gabler-data.pdf.

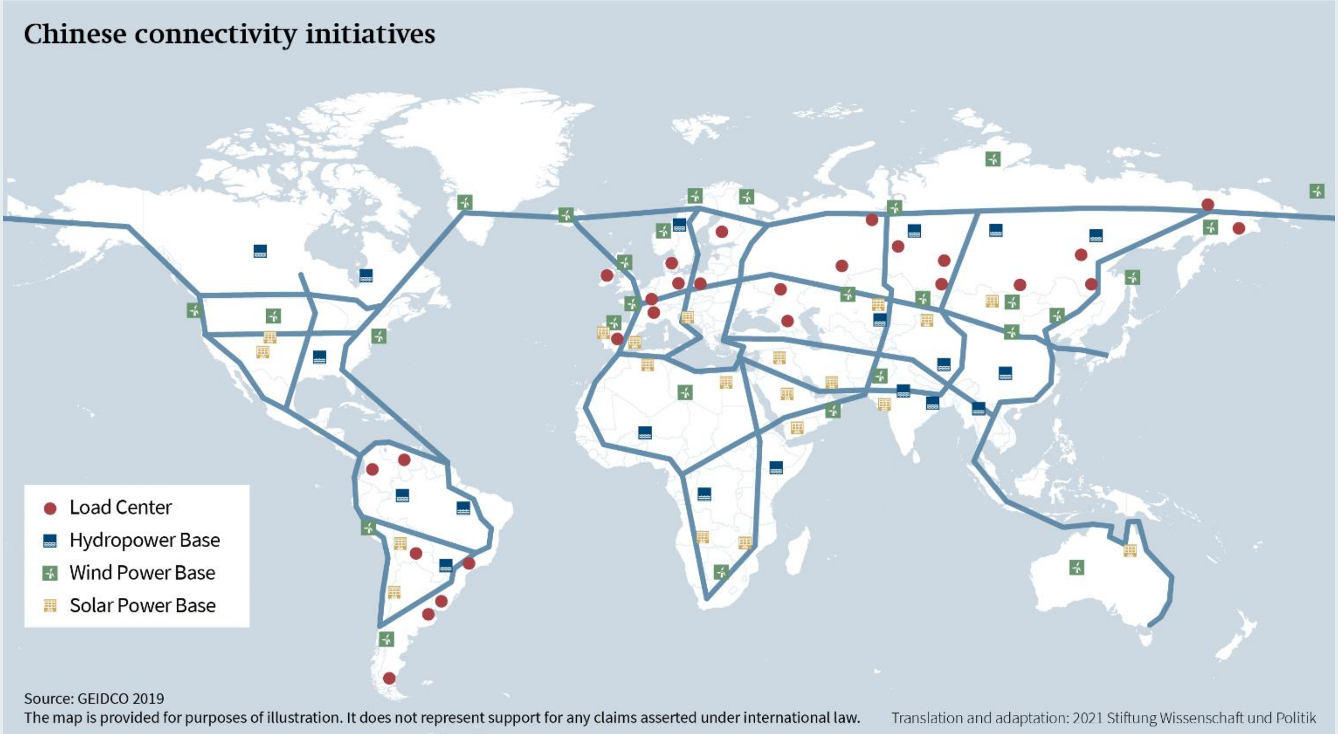
26 Tim Nicholas Rühlig, *Chinas Geopolitik technischer Standards*, background paper (Berlin: Auswärtiger Ausschuss des Deutschen Bundestages, 7 June 2021), https://www.bundestag.de/resource/blob/845192/722efed99b71b971bc62cdd43579dd5b/Stellungnahme-Dr-Tim-Nicholas-Ruehlig-data.pdf. The International Electrotechnical Commission sets international standards in electrics and electrical engineering, partly in cooperation with the International Organization for Standardization (ISO).

27 This challenge was discussed in detail at a roundtable on the "New US-EU Energy Security Agenda" on June 3, 2021. The roundtable was organised by the Global Center on Energy Policy, SIPA, Columbia University and Stiftung Wissenschaft und Politik.

28 Of course, centres and peripheries also exist at the national level. However, the focus of this study is on international relations.

29 Bowen Yan and Jianxi Luo, "Multicores-Periphery Structure in Networks", *Network Science* 7, no. 1 (2019): 70—87, https://arxiv.org/ftp/arxiv/papers/1605/1605.03286.pdf; Stephen P. Borgatti and Martin G. Everett, "Models of Core/Periphery Structures", *Social Networks* 21 (1999): 375—95; Paul Krugman, "Increasing Returns and Economic Geography", *Journal of Political Economy* 99, no. 3 (1991): 483—99.

Map 1



stellations reflect diverging geo-economic power relations and geopolitical projections.

Interconnectors as well as electricity grids and synchronous electricity systems not only affect power relations; they also shape centre-periphery relations as vectors of connection and integration. With its BRI, China is propagating the global vision of a Global Energy Interconnection (GEI; see Map 1). This study focuses on three macro-regions within the Europe-Asian continental area: Europe (consisting of the EU and its eastern, southern and southeastern neighbourhoods as well as the Middle East and North Africa); two Eurasian subregions (the South Caucasus and Central Asia); and Asia (with its subregions South Asia, Southeast Asia, and Northeast Asia).

New centres of gravity are emerging, and peripheries are changing from border spaces into connecting spaces.

The continental area spanning from Europe to Asia is characterised by a special dynamic. On the one hand, three international electricity alliances and electricity centres already exist, namely those of the EU, Russia and China. On the other hand, new interconnectors and electricity grids are being developed, and new centres such as Iran, Turkey and India are becoming increasingly active in constructing cross-border electricity infrastructure. Although they exist at different depths, the electricity integration trends in the three macro-regions show similar characteristics: as new centres of gravity emerge, peripheries are being transformed from border spaces into interconnecting spaces. As a result, the boundaries of old spaces are blurring while new large spaces are being created. The old geopolitical opposition of continental centre and maritime periphery is thus visibly fading.

At the same time, centres and peripheries are defined less by geography than by the degree of infrastructural density and by political and socioeconomic factors. A country’s permeability to outside geopolitical power is also a factor, as is its own effective power. The more important the Euro-Asian continental becomes as a maritime and continental connecting bridge, the more tension there will be in existing spaces; there will also be more competition for ordering principles and projections of strength; and as peripheries pull away from old centres, centrifugal forces will intensify.

Synchronisation and Interconnectivity in Europe and Its Neighbourhood

Historical Review: Grid Expansion in Europe

The European integrated electricity grids has evolved over time and has never been identical with the political borders of Europe (i.e., the European Communities or the European Union). Thus, the European electricity grid has grown together successively, first from sub-national electricity grids and bilateral high-voltage connections, then from multilateral electricity rings with an ever closer meshing into a common system. Today's electricity grid and electricity system is shaped by geography, by the connection of electricity sources with consumption centres and by the linking of urban and rural areas. Last but not least, it is shaped by the history of the political idea of Europe.[30]

The continental European grid originated in an electricity line that ran from Nancy via Switzerland to Milan and began transmitting electricity in 1921.[31] A Europe-wide electricity grid was being considered as early as 1929. However, the technical possibilities were still very limited.[32]

The Second World War and its aftermath made tangible the importance of the electricity system for social and economic life. The electricity system was thus given priority in the reconstruction of the continent. Due to technical and political circumstances, the focus was on regional networking.[33]

In 1951, the European Coal and Steel Community was founded, establishing joint control over two sectors of strategic and military importance: coal and steel.[34] Electricity cooperation was institutionalised with the Union for the Coordination of Production and Transmission of Electricity (UCPTE). On the other side of the Iron Curtain, electricity grids were also established and expanded, here within the framework of the Council for Mutual Economic Assistance (Comecon). From the mid-1950s onwards, cross-border electricity exchange even functioned across system boundaries, namely between the Federal Republic of Germany (West Berlin) and the German Democratic Republic as well as between Yugoslavia and Austria.[35]

Between 1945 and 1996, until the First EU Internal Electricity Market Directive came into force,[36] grids were developed by geographical region, mainly following the paradigm of security of supply.[37] The increasingly close-knit and deep-meshed nature of the grid was not only a consequence of demography and economic development but also of the diversification of electricity sources. Electricity grids thus followed the script for economic development in Europe; updating them, however, increasingly took place under political auspices.

30 Vincent Lagendijk, *Electrifying Europe: The Power of Europe in the Construction of Electricity Networks* (Amsterdam, 2008) and Nies, "Security of Supply" (see note 2).

31 Union for the Coordination of Production and Transmission of Electricity (UCPTE)/Union for the Co-ordination of Transmission of Electricity (UCTE), *The 50 Year Success Story: Evolution of a European Interconnected Grid* (Brussels, 2009), 8.

32 Lagendijk, *Electrifying Europe* (see note 30), 106–07.

33 Ibid., 158.

34 UCPTE/UCTE, *The 50 Year Success Story* (see note 31), 9.

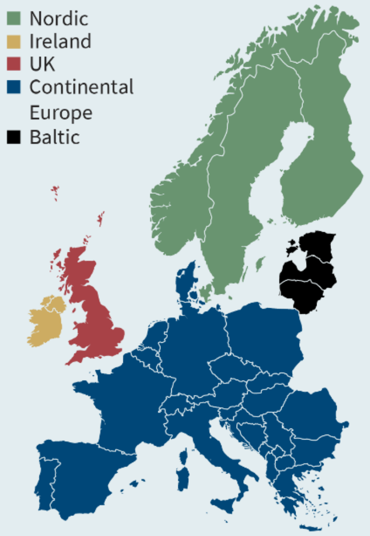
35 Ibid., 15.

36 *Directive 96/92/EC of the European Parliament and of the Council of 19 December 1996 Concerning Common Rules for the Internal Market in Electricity*, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:31996L0092&from=DE.

37 Nies, "Security of Supply" (see note 2).

Map 2

Five Synchronous Areas in Europe



Source: entsoe.eu
Translation and adaptation: 2021 Stiftung Wissenschaft und Politik

The European Union: From Cooperation to Electricity Market Integration

The European Continental Grid (Continental Europe Synchronous Area, CESA — formerly the Union for the Co-ordination of Transmission of Electricity, UCTE) forms the "centre" within the EU and the rest of Europe. The other regionally synchronised interconnected grids are connected to it via direct current (DC) lines. Chief among these is the Nordic Grid (NORDEL) — consisting of Norway, Sweden, Finland, eastern Denmark, and Iceland (operating autonomously in island mode) — which is interconnected with the continental grid via HVDC lines. The continental grid is also interconnected with the electricity grids of the United Kingdom and Ireland (see Map 2). The Baltic electricity grid is still part of the post-Soviet electricity grid (Integrated Power System/Unified Power System of Russia, IPS/UPS) and functions as a ring grid for Belarus, Russia, Estonia, Latvia and Lithuania (collectively: BRELL). Finland, part of NORDEL, also has a back-to-back connection, i.e., a DC short circuit (see Glossary, p. 54), with this post-Soviet grid.

In 1958, Switzerland, Austria, France, the Benelux countries and Germany had an installed capacity of 32 gigawatts (GW) in the common grid. Portugal, Spain and Italy were subsequently added in waves until the mid-1970s; in the 1990s and the first decade after 2000, the new member states of the Central European CENTREL network followed successively. More recently, the countries of the Western Balkans and the "Burshtyn electricity island" (an area in western Ukraine around the Burshtyn power plant and its substations) were also added. By 2013 the network already spanned 26 countries with 430 GW.[38] The peculiar topography of the European continental grid results from the tension between efficient supranational networking on the one hand and an electricity supply oriented towards national security of supply and sovereignty on the other.

The completion of the internal market for electricity in the EU[39] has been a guiding principle for the last two decades, including for its Energy Union Strategy, which was launched in 2015.[40] The EU's Acquis Communautaire determines energy policy. Energy policy competencies are shared between the EU and its member states under Article 194 of the Treaty on the Functioning of the European Union (TFEU), while the latter retain national sovereignty over the energy mix. Supranational and intergovernmental institutions coexist. They shape the vertical power relations between Brussels and the member states as well as its horizontal counterpart. EU energy policy is characterised, among other things, by the coexistence of national regulatory authorities and network operators, most of which were only established as a result of the internal market regulations.

The EU's Third Internal Market Package of 2009 created new institutions: the umbrella organisation of the European Network of Transmission System Operators for Electricity (ENTSO-E) and the Agency for the Cooperation of Energy Regulators (ACER), which organizes the national regulatory authorities. This also involves the gradual convergence and harmonisation of the regulatory framework in the EU. In addition, the national regulatory authorities established the Council of European Energy Regulators (CEER). It deals with all issues that lie outside ACER's remit, for example consumer protection aspects, regulatory

38 Ibid.
39 For the different phases and steps of electricity market integration, see Leonardo Meeus, *The Evolution of Electricity* Markets in *Europe* (Cheltenham and Northampton, MA: Edward Elgar, 2020).
40 On the Energy Union, which was also established in 2015 in response to the annexation of Crimea, see European Union, *Energy Union* (website), https://ec.europa.eu/info/energy-climate-change-environment/overall-targets/2030-targets/energy-union_de.

aspects of end-customer markets, the promotion of renewable energies and international cooperation. This clearly shows that electricity grids constitute techno-political spaces in which cooperation must be organised and institutionalised to ensure the safe operation of the grid.[41]

The EU's political structure enables close and synchronous electricity interconnection and extensive market integration.

It is true that the EU member states are moving at different speeds with regard to energy transformation and the liberalisation of the wholesale and end-consumer markets for electricity. Nevertheless, the EU's political structure enables close and synchronous electricity interconnection and extensive market integration.

The EU comprises a regulatory area whose energy market rules are being adopted step by step in the European Energy Community but also largely in the European Economic Area. However, regulation has always had a profound impact on structures in the electricity sector. This sector underwent several paradigm shifts within the EU: from national security of supply to collective security; from the state to the market; and from the efficient system to clean, secure and affordable electricity for private end consumers. This has not left electricity grids untouched. Their position as natural monopolies has been subjected to regulation. Since electricity is carried by transmission lines, competition had to be made possible at this point; independent system operators were created, thus unbundling the transport sector from the sectors of generation, distribution and sales. In addition, the Third Internal Market Package of 2009 established non-discriminatory access to the grid. Since then, network operation has been a regulated business. Depending on the member state, ownership is partly in state hands and partly in private hands.

Interconnectivity has been an issue since the end of the Cold War and became part of network planning at the latest with the Trans-European Networks for Energy (TEN-E). Initially, the aim was to connect peripheral European regions or even existing "energy islands" more closely to the EU's central regions.[42] Later, the so-called Projects of Common Interest (PCI) and the Connecting Europe Facility were added. Improving interconnectivity also helps the internal market function more effectively. For this reason, the exchange capacity at cross-border interconnection points with neighbouring countries was to be increased to 10 percent of installed national generation capacity by 2020.[43] The Clean Energy Package of 2019 then set the target of increasing physical interchange capacity to 15 percent by 2030.[44] In addition, 70 percent of cross-border (or, more precisely, cross-price zone) pipeline capacity is to be gradually released for European electricity trading by the end of 2025. This shows that interconnectivity within the EU has operational and security aspects as well as a trading component.[45]

Synchronised grid operation in an interconnected grid requires high standards that can be generally applied and implemented. Since 2009, the umbrella organisation ENTSO-E has been the successor to all regional electricity associations, including UCTE. A common operating manual and set of rules applies to all grid operators. The System Operation Regulation (Commission Regulation 2017/1485)[46] sets out the rules for transmission and distribution system opera-

41 German Federal Network Agency, "*Rat der europäischen Energieregulierungsbehörden*" (webpage), https://www.bundesnetzagentur.de/DE/Allgemeines/DieBundesnetzagentur/Internationales/Energie/CEER/start.html.

42 European Parliament, ed., "*Briefing No 43: Energy Policy and the Enlargement of the European Union*" (Brussels, 10 June 1999), https://www.europarl.europa.eu/enlargement/briefings/43a2_en.htm.

43 Lidia Puka and Kacper Szulecki, "The Politics and Economics of Cross-border Electricity Infrastructure: A Framework for Analysis", *Energy Research & Social Science* 4 (2014): 124–34.

44 The Commission's legislative proposal "Clean Energy for All Europeans" covered energy efficiency, renewable electricity generation, electricity market development, security of supply and governance for the Energy Union. For more information and an overview of the adopted directives and legislation, see European Commission, *Clean Energy for All Europeans Package* (webpage), https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans (accessed 3 June 2021).

45 See Agency for the Cooperation of Energy Regulators (ACER), ed., *ACER Report on the Result of Monitoring the Margin Available for Cross-Zonal Electricity Trade in the EU in the First Semester of 2020* (Ljubljana, 18 December 2020).

46 European Commission, *Commission Regulation (EU) 2017/1485 of 2 August 2017 Establishing a Guideline on Electricity Transmission System Operation* (Brussels, 2 August 2017), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R1485.

Map 3

Regional coordination of the transmission system operators
Five regional security coordinators

Source: entsoe.eu
Translation and adaptation: 2021 Stiftung Wissenschaft und Politik

tors, as well as for large electricity customers, to harmonise operations and ensure security of supply.

Coordination at the regional and pan-European level is becoming increasingly important.[47] To this end, five Regional Security Coordinators will be established (see Map 3). The five synchronised European network associations — the Nordic, the Baltic, Ireland, Great Britain and Continental Europe — are supported by five regional security centres in order to prepare outage plans, network modelling, adequacy forecasts, capacity calculations and security analyses in regional cooperation.

The grid is operated according to network codes (network codes, a set of rules and guidelines, see Glossary, p. 55) developed by the European transmission system operators for electricity. A smoothly functioning European electricity market requires the close, intertwined interaction of an integrated network and clear market mechanisms. The construction of a common European electricity market was started in 1996 with the First Internal Market Directive, followed by the Second and Third Internal Market Packages in 2003 and 2009, respectively. The directives placed a technical-operational, a regulatory and a "virtual" trading layer on top of the physical network layer. The development of an integrated functioning internal market followed the paradigm of efficiency and competition shaped by the neoliberalism of the 1980s and 1990s. On the basis of the existing, well-developed network infrastructure, new rules could be established in the EU. Generation and distribution were separated from the grid; the grids became accessible to third parties without discrimination; and territorial and concession monopolies were dissolved. In many cases, electricity companies were gradually privatised, and the shares of municipalities and the state were sold. The paradigm of the market gained weight over the paradigm of security of supply.

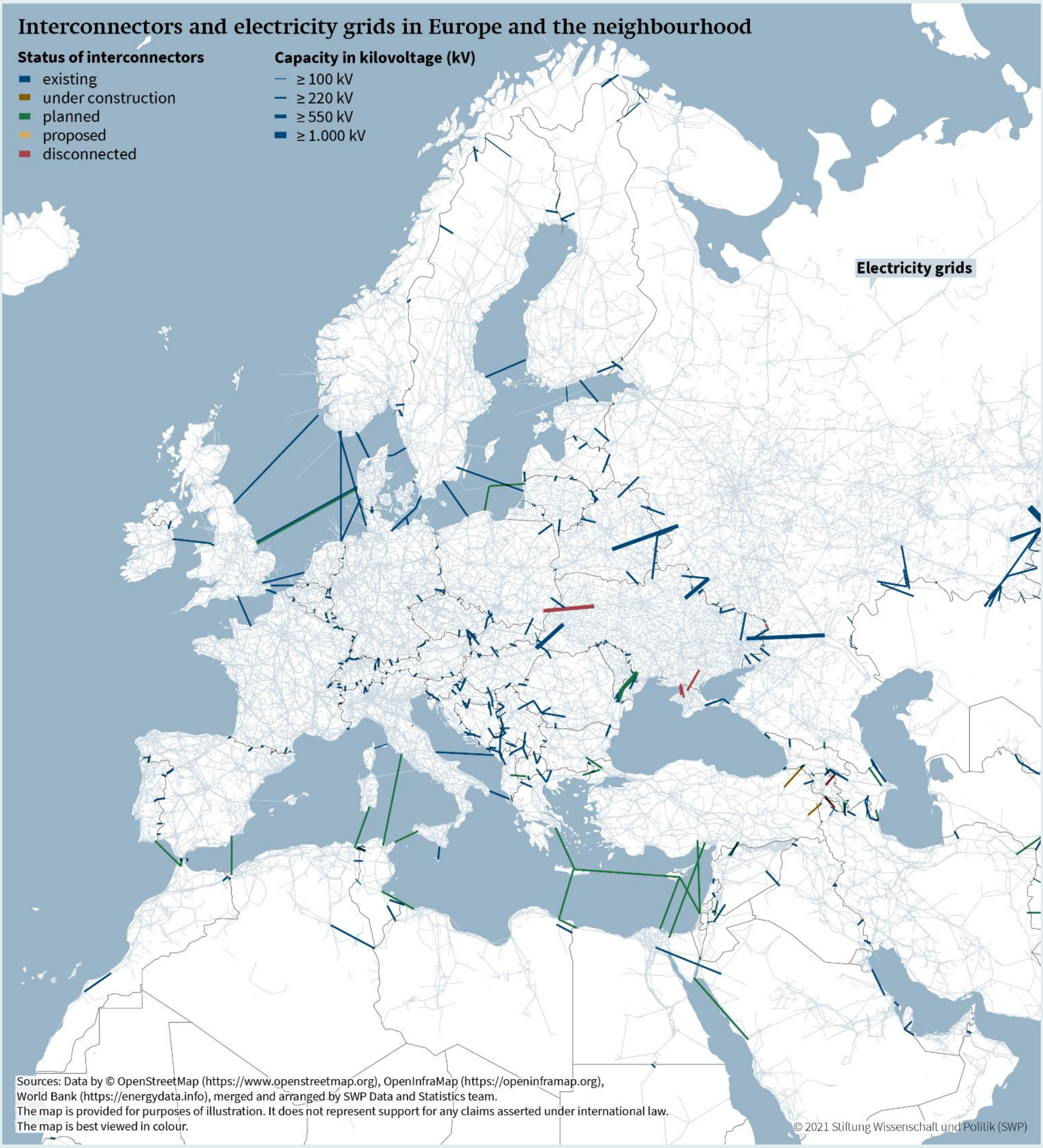
In order to develop the internal market, a new organisational level has been introduced. The aim is for the grid and the market to increasingly converge and for the market to signal transmission congestion and generation bottlenecks. Even in the synchronous integrated electricity grids of continental Europe, however, there is still a long way to go. Within the area encompassed by the continental grid, there are different market areas — i.e., electricity bidding zones — in which electricity is traded at a uniform price at the wholesale level. A market area zone is akin to the idea of a "copper plate" where electricity can be traded without the physical specifics of the grid. In technical regulatory terms, this means that no transmission capacity needs to be booked. These market area zones coincide often but not always with the national borders of EU member states. There are 26 market zones in continental Europe (excluding Ireland, Great Britain, Sweden, Finland and Norway).

The Clean Energy Package of 2019, however, envisages the creation of ten Capacity Calculation Regions to advance market integration.[48] The aim is to expand internal trading from day-ahead to intraday trading and eventually to successively link or merge the market areas. Price formation zones and mechanisms are still under discussion, as the existing zones

47 ENTSO-E, ed., *Enhanced TSO Regional Coordination for Europe: Act Locally, Coordinate Regionally, Think European* (Brussels, November 2019), https://eepublicdownloads.entsoe.eu/clean-documents/Publications/Position%20papers%20and%20reports/entsoe_regional%20coordination_Europe_191031.pdf.

48 "Day-ahead" includes electricity trading for the following day; "intraday trading" means short-term trading of electricity in minute or hourly blocks on the same day.

Map 4



do not provide clear price signals where physical transmission bottlenecks exist and where the infrastructure needs to be expanded. This could be remedied by a nodal pricing system. Critics, however, have expressed political reservations about nodal pricing because it could endanger national sovereignty and social cohesion. Politically, it matters to governments whether there is a level playing field for grid access, electricity generation and procurement. For example,[49] at the end of 2017, the German government passed a legislative amendment to this effect,[50] establishing a uniform electricity bidding zone in Germany.[51]

The EU's Green Deal has brought about a clear paradigm shift favouring climate protection and energy transition. It is already having an impact on the grid today and will have an even more serious impact in the future. The expansion of renewable energies and the shutdown of conventional, flexibly redispatchable thermal power plants are fundamentally changing the electricity flows in the grid and require new load management in order to link generation and demand over long distances. Parts of the fleet of power plants must remain redispatchable in order to react to changes in demand. The spatial dimension of the grid thus increasingly follows the logic of linking ideal locations for renewable energies with the load centres in an efficient, integrated manner. The expansion of fluctuating renewable generation requires greater emphasis on crisis preparedness, efficient security mechanisms, and the regional cooperation of long-distance grid operators. This is also where system change comes in. With increased solar and wind generation comes increased production volatility — and with it, multiplying interventions in grid operations.[52] Moreover, 50 GW of installed capacity will be phased out in the EU in the next few years.[53] In addition, rotating masses (i.e., large alternators and synchronous machines of thermal power plants), which are important for maintaining frequency and thus the stability of the grid, will be removed from the grid.[54] Overall, the technical challenges for the security of system operation will grow; this in turn will increase the requirements for monitoring, prospective grid development planning and adequacy of power plant capacities. The institutional, regulatory and market framework for joint system operation will need to be further adapted. In this respect, expansion and deepening also remain critical topics for the electricity grid.[55]

The Shift from Constructing a "Common European House" to Promoting "Rules before Joules"

Outside the EU, geopolitical considerations proved to be both a driver for and an obstacle to interconnectivity and network expansion (see Map 4, p. 17). After the dissolution of the Soviet Union, the idea of a "common European house" briefly flourished, inspiring large-scale plans for interconnections stretching from Lisbon to Vladivostok. Attention shifted with the EU's enlargement, however. The energy networks and the energy market became a key instrument for bringing accession candidates closer to the EU as well as for stabilising the neighbourhood and promoting the development of renewable energies.

South Europe: The Mediterranean as a connecting space

The Mediterranean Sea — bordered to the north by the EU and Turkey, by the Maghreb to the south and by the Mashreq to the southeast — provides a prime example of changing and fluid energy spaces. Electricity interconnections contribute to the re-mapping of the region. While the interconnection vectors in the western Mediterranean run from North Africa to the EU, the eastern Mediterranean region is proving to be much more geopolitically fluid. Turkey, Greece,

49 Alexander Kaiser, Christian Todem, Valentin Wiedner and Hannes Wornig, *Europäische Netzwerkcodes – Bidding Zone Review: Auswirkungen von Änderungen der Marktgebiete in Europa am Beispiel Österreich-Deutschland*, 14. Symposium Energieinnovation, Graz, 10—12 February 2016, https://www.tugraz.at/fileadmin/user_upload/Events/Eninnov2016/files/lf/Session_D3/LF_Kaiser.pdf.

50 German Federal Ministry for Economic Affairs and Energy, "Die Einheitlichkeit der deutschen Stromgebotszone bleibt gewahrt: Bundeskabinett billigt Änderung der Stromnetzzugangsverordnung", press release, 22 November 2017, https://www.bmwi.de/Redaktion/DE/Pressemitteilungen/2017/20171122-einheitlichkeit-der-deutschen-stromgebotszone-bleibt-gewahrt.html.

51 Ibid.

52 Jesper Starn, Brian Parkin, and Irina Vilcu, "The Day Europe's Power Grid Came Close to a Massive Blackout", *Bloomberg* (online ed.), 27 January 2021, https://www.bloomberg.com/news/articles/2021-01-27/green-shift-brings-blackout-risk-to-world-s-biggest-power-grid.

53 Irene Mayer-Kilani, "Netzbetreiber warnen vor drohenden Stromausfällen", *energate messenger,* 12 January 2021, https://www.energate-messenger.de/news/208781.

54 Marc-Oliver Bettzüge, "Systemtrennung als Warnschuss? Aktuelle Aspekte der elektrischen Versorgungssicherheit", in *Redundanzen, Resilienzen und Nachhaltigkeit: Energie für die 20er Jahre*, Schriftenreihe des Kuratoriums, vol. 14 (Berlin: Forum für Zukunftsenergien, May 2021), 26—35 (28—29), http://zukunftsenergien.de/fileadmin/user_upload/zukunftsenergien/Dokumente/FfZ_Schriftenreihe2021_Bettzuege.pdf.

55 Ibid., 32—33.

Libya and Cyprus are competing with each other over maritime borders, sovereignty issues and zones of influence. At the same time, this region has become much more permeable to the influence of foreign powers.

A major push for grid expansion in the Mediterranean occurred after the EU formulated an integrated climate and energy policy in 2007. With limited solar and wind potential as well as limited land availability inside the EU, the import of renewable electricity from North Africa became more attractive. The Desertec Industrial Initiative (Dii) was founded in 2009 as the idea of producing green electricity in the desert and also exporting it to Europe[56] drew renewed political and economic attention. Dii got involved in feasibility studies for renewable energy production, its potential for use and export, and the construction of an electricity grid that would encompass Europe, the Middle East and North Africa (EU-MENA).[57] The desire to import renewable energy in order to decarbonise the EU’s electricity mix was the main driver behind plans to develop an electricity grid for EU-MENA.

The geopolitical and spatial dimension manifested itself organisationally and institutionally in the newly established Union for the Mediterranean, which developed the Mediterranean Solar Plan (MSP). Furthermore, between 2007 and 2012, the EU-Mediterranean Energy Market Integration Project (MED-EMIP) was established as a platform for dialogue and to share experiences.[58] In order to advance technical-operational issues as well as regulatory convergence, two institutions — Mediterranean Transmission System Operators (MED-TSO) and Mediterranean Energy Regulators (MED-REG) — were established at a bi-regional level as the legacies of this first wave of interconnectivity plans. Fault lines and discord on the North African side introduced high political hurdles to a bi-regional partnership, however, hindering plans for an energy ring around the Mediterranean from the outset. At the end of 2010, the Arab Spring began in Tunisia, introducing a period of serious political and social upheaval.

The grand idea of an EU-MENA integrated electricity grid also failed due to zero-sum considerations on the European side. In the EU, and especially between Spain, France and Germany, it was not possible to develop politically attractive business models or create optimal framework conditions.[59] The advantages of generating one’s own renewable electricity were valued far more highly than the benefits of imports.[60] As Gonzalo Escribano convincingly demonstrates, geopolitical and security concerns of individual countries such as Spain as well as conflicting Spanish and French commercial interests also blocked the necessary grid expansion.

The goal of importing renewable energy from the North African deserts to Europe was also hindered by another strong counter-trend: the rapidly increasing demand for energy in the North African countries themselves. This would have led to de facto electricity exports from Europe to North Africa in Desertec’s first phase, which could well have put more demand on coal-fired power plants in Italy. Overall, no viable short-term business model emerged for the companies involved, so many companies left the Dii.[61]

Further undermining the narrative of “electricity from the desert” were counter-narratives that placed the initiative politically and economically in a neo-colonialist context. Criticism focussed mainly on the export dimension (that is, the flow of energy to Europe)[62] while neglecting the reciprocal benefits of expanding the capacity to generate renewable electricity. The hype surrounding the project fizzled out. Pusillanimity and opportunism — in the form of mistrust and the search for short-term, individual gain — undermined long-term strategic plans. In fact Desertec was ahead of its time. At the project level, renewable electricity generation capacities have since been

56 Paul van Son and Thomas Isenburg, *Emission Free Energy from the Deserts: How a “Crazy Desertec Idea” Has Become Reality in North Africa and the Middle East* (The Hague: Smart Book Publishers, 2019).

57 Dii, *2050 Desert Power: Perspectives on a Sustainable Power System for EUMENA* (Munich, June 2012); Dii, *Desert Power: Getting Started; The Manual for Renewable Electricity in MENA. Full Report* (Munich, June 2013).

58 EU Neighbours, *MED-EMIP: Energy Cooperation*, https://www.euneighbours.eu/en/south/stay-informed/projects/med-emip-energy-cooperation.

59 Johan Lilliestam, Saskia Ellenbeck, Charikleia Karakosta and Natàlia Caldés, “Understanding the Absence of Renewable Electricity Imports to the European Union”, *International Journal of Energy Sector Management* 10, no. 3 (2016): 291–311.

60 Gonzalo Escribano, “The Geopolitics of Renewable and Electricity Cooperation between Morocco and Spain”, *Mediterranean Politics* 24, no. 5 (2019): 674–81.

61 Ibid., 677.

62 Isabelle Werenfels and Kirsten Westphal, *Solar Power from North Africa: Frameworks and Prospects*, SWP Research Paper 3/2010 (Berlin: Stiftung Wissenschaft und Politik, May 2010), https://www.swp-berlin.org/publikation/solar-power-from-north-africa.

expanded quite consistently, especially in Morocco, but not only there. Today, the idea of close cooperation in the field of green electrons and molecules is experiencing a renaissance.

Since 1997, two 700 megawatt (MW) submarine cables have connected Morocco and Spain. Morocco as well as Tunisia and Algeria have been synchronised with ENTSO-E since then. A third submarine cable is to be laid between Morocco and Spain by 2026.[63] Between the two countries, the rules for electricity trade as well as for the operation of electricity lines are negotiated by the Spanish National Markets and Competition Commission (Comisión Nacional de los Mercados y la Competencia, CNMC), which relies on bilateral agreements. This shows that synchronous operation via interconnectors is possible without also adopting the legal and market framework. Electricity trade is also still quite limited.[64]

Additional interconnectors between the Maghreb and Europe are being planned. Morocco signed an agreement with Portugal in 2015 for a 1,000 MW submarine cable, which is scheduled for completion in 2030.[65] A direct line between Gibraltar and Morocco is also being discussed.[66] In addition, the construction of the Elmed HVDC line with 600 MW capacity from Cap Bon in Tunisia to Sicily was agreed in 2019.[67] In addition, the TuNur HVDC line from Kebili in Tunisia to Montalto di Castro in Italy is in the approval process. It will have a capacity of more than 2 GW and could be extended to France and Malta.[68]

Meanwhile in the eastern Mediterranean, the geopolitical situation is considerably influencing the shape of interconnectivity and interdependency.[69] On the one hand, energy interconnections are an expression of regional alliances. On the other hand, they serve as an instrument to link the EU more closely to its peripheries. In the course of the gradual synchronisation of the countries of the Western Balkans and the establishment of an electricity bridge to Greece, Turkey also became more significant.[70]

Turkey provides an eloquent example of how the synchronisation process was part of a broader "geopolitical approach". The country has been a candidate for EU membership since 1999, with accession negotiations officially launched in 2005. The NATO member also occupies a key geographical position. When the European Energy Community was established in 2006, Turkey was granted observer status. Moreover, the synchronisation process began in 2005 with a study and was completed in 2015. Despite this, both sides today are in a situation where the grids are synchronised but governance is rudimentary. The observer status of the Turkish grid operator TEİAŞ within ENTSO-E is on hold. While Turkey has interconnectors with Greece (one 400 kV) and Bulgaria (two, both 400 kV), electricity trade with the EU remains limited. The country is also connected via DC short-circuit interconnectors with Syria, Iraq, Iran, Nakhichevan (an exclave of Azerbaijan), Armenia and Georgia.

The situation in the eastern Mediterranean is currently particularly delicate. The conflict involving Greece, Cyprus and Turkey — as well as other neighbouring states — over spheres of influence, border demarcations and resources could well escalate at any time. This repeatedly attracts the involvement of regional powers as well as of powers external to the region (namely the US and Russia) in an effort not

63 Ilias Tsagas, "Spain's Third Interconnection with Morocco Could Be Europe's Chance for African PV — or a Boost for Coal", *pv magazine* (online ed.), 20 February 2019, https://www.pv-magazine.com/2019/02/20/spains-third-interconnection-with-morocco-could-be-europes-chance-for-african-pv-or-a-boost-for-coal/.

64 Comisión Nacional de los Mercados y la Competencia (CNMC), *Informes y circulares*, https://www.cnmc.es/ambitos-de-actuacion/energia/informes-circulares.

65 Med-TSO, *Deliverable 2.1. 2: Detailed Project Description; 01-MAPT Morocco-Portugal* (EC DEVCO — Grant Contract: ENPI/2014/347-006, 2014), https://www.med-tso.com/publications/pub3/01_MAPT_Detailed_Project_Description.pdf; Ahmed Eljechtimi, "Portugal, Morocco to Invite Bids for Power Link after Studies in 2019", *Reuters* (online ed.), 19 November 2018, https://www.reuters.com/article/us-morocco-portugal-energy/portugal-morocco-to-invite-bids-for-power-link-after-studies-in-2019-idUSKCN1NO1SD?edition-redirect=uk.

66 "Gibraltar Considers Power Link with Morocco — Spanish Media", *The North Africa Post* (online ed.), 24 July 2020, https://northafricapost.com/42645-gibraltar-considers-power-link-with-morocco-spanish-media.html.

67 ENTSO-E, "*Project 29 – Italy-Tunisia*" (Brussels, 2018), https://tyndp.entsoe.eu/tyndp2018/projects/projects/29; Eljechtimi, "Portugal, Morocco to Invite Bids" (see note 65).

68 ENTSO-E, "*Project 283 – TuNur*" (Brussels, 2018), https://tyndp.entsoe.eu/tyndp2018/projects/projects/283; TuNur, "*Export Projects*" (webpage), https://www.tunur.tn/project/export-projects/.

69 Gabriel Mitchell, *Supercharged: The EuroAsia Interconnector and Israel's Pursuit of Energy Interdependence* (Ramat Gan: The Israeli Institute for Regional Foreign Policies [MITVIM], February 2021).

70 Energy Community, "*Who We Are*" (webpage), https://www.energy-community.org/aboutus/whoweare.html.

only to exert influence but also to define the vectors of connectivity. A significant project to connect the "energy island" of Cyprus to southeast Europe is the EuroAfrica Interconnector.[71] This submarine cable will connect Heraklion (Crete), Kofinou (Cyprus) and Damietta (Egypt) with a capacity of 2 GW and 500 kV. In addition, the EuroAsia Interconnector will link Heraklion in Crete and Kofinou in Cyprus with the Israeli city of Hadera.[72] The Memorandum of Understanding (MoU) between Israel, Greece, and Cyprus aims primarily at the expected synergies in the expansion of renewable forms of energy and the targets set by the Paris Climate Agreement.[73] For Israel, it is also an important building block for international integration.[74] The EuroAsia Interconnector is planned to go into operation in December 2023. In contrast, initial plans to connect Libya with Greece have been put on hold.

Electricity interconnections in the Mediterranean are like a hub-and-spoke system, with the ENTSO-E network at the centre.

For the maritime interconnection area of the Mediterranean, it should be emphasised that the electricity connections are like a hub-and-spoke system, with the ENTSO-E network at its centre. While the development of renewable energy generation has been a driver for the interconnection of the Maghreb states with the EU, conflicts in the region have impeded extending the electricity grid to include a ring around the Mediterranean. This is even more true of the eastern Mediterranean, where the competing actors Greece, Cyprus and Turkey are paradoxically part of a common electricity networked space. Here, the expansion of renewables and geopolitics interact. From the EU's perspective, connecting the Greek islands to the mainland is important for EU cohesion, but countering competing zones of influence and establishing access to good locations for renewables are equally significant.

However, interconnectivity in the Mediterranean is also increasingly shaped by actors from outside the region, including China. China's strategic interest in shaping EU interconnectivity is becoming clearer and clearer. In doing so, Beijing is relying on the techno-economic importance of norms and standards, the tendering process for hardware and software, and the provision of modern equipment and its components.[75] For example, China's State Grid holds shares in the Greek network operator Admie, among others. This is because network operators play a key role in the operation, expansion and modernisation of networks. China also wants to acquire shares in the Ariadne Interconnector, which will link Crete with Athens and the Attica region.[76] Looking ahead — especially with an eye towards cross-sectoral interconnectivity — future transport corridors and commodity chains from Africa to Europe are emerging, for which Morocco, Algeria and Egypt will act as gateways to Europe.[77] These corridors will combine ports, highways, railways and commodity and supply chains, and they will reach far into the African continent. Because of electrification, they will be flanked by electricity interconnectors. This will shape the Afro-Eur-Asian Ellipse — a more or less contiguous space that both includes and transcends the EU's immediate neighbourhood in the east and the south and is geo-economically and politically of great significance for the EU.[78]

71 *EuroAfrica Interconnector* (website), https://www.euroafrica-interconnector.com/.

72 *EuroAsia Interconnector* (website), https://euroasia-interconnector.com/; ENTSO-E, *Project 219 – EuroAsia Interconnector* (Brussels, 2018), https://tyndp.entsoe.eu/tyndp2018/projects/projects/219.

73 Republic of Cyprus, Ministry of Interior, Press and Information Office, "Joint Statement by the Ministers of Energy of Cyprus, Israel and Greece on the Signing of the MoU on Cooperation in Relation to the EuroAsia Interconnector Project", press release, 8 March 2021, https://www.pio.gov.cy/en/press-releases-article.html?id=18879#flat.

74 Mitchell, *Supercharged* (see note 69).

75 See chapter "The Drivers of Electricity Interconnection" (p. 10).

76 Igor Todorović, "EUR 400 Million Loan for Attica-Crete Interconnection Secured", *Balkan Green Energy News*, 10 July 2020, https://balkangreenenergynews.com/eur-400-million-loan-for-attica-crete-interconnection-secured/.

77 See Michaël Tanchum, *Europe-Africa Connectivity Outlook 2021: Post-Covid-19 Challenges and Strategic Opportunities*, IAI Papers 21/20 (Rome: Istituto Affari Internazionali [IAI], May 2021); Michaël Tanchum, *Europe-Mediterranean-Africa Commercial Connectivity: Geopolitical Opportunities and Challenges*, KAS Mediterranean Dialogue Series, no. 31 (Tunis: Konrad-Adenauer-Stiftung, November 2020), https://www.kas.de/documents/282499/282548/Europe-Mediterranean-Africa+MED+Dialogue+31.pdf.

78 Maria Pastukhova, Jacopo Pepe and Kirsten Westphal, *Beyond the Green Deal: Upgrading the EU's Energy Diplomacy for a New Era*, SWP Comment 65/2020 (Berlin: Stiftung Wissen-

Europe's East: From a "Common European House" to competition over integration

The history of interconnectivity in Eastern Europe furnishes an even clearer example of the importance of geopolitics for electricity grids.[79] Here, the central role of electricity grids as a critical infrastructure for security, welfare, and thus also power unfolded over time. Indeed, in historical retrospect, geopolitics was a driving force. The impetus for the largest interconnection project between the "old" European UCTE continental grid and the IPS/UPS network of the former USSR came with the EU-Russia Energy Dialogue launched in 2000.[80] It was driven by the idea of a common economic and energy space stretching from Lisbon to Vladivostok, which was in turn based on Mikhail Gorbachev's continental vision of a "common European house".

On the Russian side, economic interest was the main driver. The Russian electricity company RAO UES, led by Anatoly Chubais, was in the process of being privatised. Chubais promoted the interconnection project because he believed it would demonstrate that the Russian electricity system was reliable from a technological point of view and therefore attractive to investors. Following a feasibility study in 2002 and 2003,[81] a more detailed study later examined the technical details, costs and regulatory issues. While the Russian electricity company was behind the idea of a large grid interconnection, European electricity companies were concerned about strong price competition. These worries proved unfounded when it became clear that electricity would tend to be imported from Europe rather than vice versa. With the introduction of the capacity market and the gradual liberalisation[82] in the two Russian price zones of Europe and Siberia, the prices for Russian electricity rose so sharply that they were no longer competitive with NORDEL prices. According to a feasibility study primarily financed on the Russian side, synchronous interconnection could have been implemented but only at considerable cost; in a synchronous grid, the reliability and stability of Russian power plants would have had to be significantly improved. This in turn would have required the introduction of automated controls.[83] In the course of five years, the environment for mega-synchronisation from Lisbon to Vladivostok turned completely around; in 2007, with the successful launch of the privatisation of RAO UES, the idea of interconnection lost support in Russia. This is partly because Chubais, the protagonist, moved to the Rosnano Group in 2008.

On the EU side, energy relations with Russia came under close scrutiny after the EU's eastward enlargement in 2004. The narrative changed fundamentally, as the new Baltic member states viewed the Soviet legacy of synchronous interconnection with Russia and Belarus within the IPS/UPS as a challenge to their sovereignty but also as a risk to their electricity supply.[84] Estonia and Latvia had signed the BRELL agree-

schaft und Politik, June 2020), https://www.swp-berlin.org/publikation/beyond-the-green-deal-upgrading-the-eus-energy-diplomacy-for-a-new-era.

79 This section is based, among other things, on five interviews conducted by Kirsten Westphal between December 2020 and May 2021 with current and former representatives of the EU Commission, the EEAS and the U.S. Special thanks are due to Christian Cleutinx for his rich insight and to the other interviewees, who wished to remain anonymous.

80 European Commission, *EU-Russia Energy Dialogue* (webpage), https://ec.europa.eu/energy/topics/international-cooperation/key-partner-countries-and-regions/russia/eu-russia-energy-dialogue_en.

81 UCTE, "Feasibility Study: Synchronous Interconnection of the Power Systems of IPS/UPS with UCTE", *UCTE Annual Report 2004,* 18–21, https://eepublicdownloads.entsoe.eu/clean-documents/pre2015/publications/ce/report_2004_6.pdf.

82 M. Oksanen, R. Karjalainen, S. Viljainen and D. Kuleshov, "Electricity Markets in Russia, the US, and Europe", *Energy Market, 2009: Sixth International Conference on the European Energy Market,* 17 May 2009, https://simsee.org/simsee/biblioteca/ElectricityMarketsInRussiaUSandEU.pdf; Rinat Abdurafikov, *Russian Electricity Market: Current State and Perspectives*, VTT Research Working Paper 121 (Espoo et al., June 2009), https://www.vttresearch.com/sites/default/files/pdf/workingpapers/2009/W121.pdf.

83 Kirsten Westphal owes this information to long interviews with former EU officials. See also Matthias Luther, "The Feasibility of Synchronous Interconnection between IPS/UPS and UCTE", PowerPoint presentation, Regional Electricity System and Market towards the Internal Electricity Market (RESM) (Bucharest, 26 October 2007); UCTE/IPSUPS, *Feasibility Study: Synchronous Interconnection of the Power Systems of IPS/UPS with UCTE* (2008).

84 See Kai-Olaf Lang, *Auf dem Weg zu mehr Resilienz: Die baltischen Staaten zwischen Verwundbarkeit und Bündnissolidarität*, SWP-Studie 3/2020 (Berlin: Stiftung Wissenschaft und Politik, February 2020); Emmet Tuohy, Anna Bulakh and Yuri Tsarik, *Desynch or Sink. A Political Analysis of Baltic Electricity Desynchronisation* (Tallinn: International Centre for Defence and Security [ICDS], May 2017), https://icds.ee/wp-content/

ment with Belarus and Russia in 1999, with Lithuania joining in 2001; at the time they had no electricity connections to the continental or the NORDEL grids.[85] Their position as an "energy island" has been an issue ever since, as has their dependence on their Russian neighbour. They pushed ever more vehemently for decoupling and desynchronising from the BRELL interconnection and synchronising with the EU electricity grid instead. The vision of "connecting the energy island to the EU" gained momentum.

Geopolitics, but above all the EU's security of supply and electricity market integration were included in the Baltic Energy Market Interconnection Plan (BEMIP).[86] Within the framework of this plan, Projects of Common Interest (PCI) were developed to improve gas and electricity connections with the Baltic states. As part of this development, desynchronisation from IPS/UPS and synchronisation with ENTSO-E are now planned. This poses challenges for the electricity system, however, as Russia and Belarus currently still play an important role for frequency and voltage stabilisation as well as for electricity trading.[87] The geopolitical nature of the process is evident in the fact that both sides are making provisions in the event of a hasty decoupling, but there is no common agreement on the exact modalities. The geopolitical and security dimension is also particularly evident in the fact that the Baltic states will be connected to ENTSO-E's continental grid via land and via an AC link. This will fully integrate the three Baltic states into Europe's "grid community".

Estonia is already connected to Finland via two HVDC lines: Estlink I and II. NordBalt for its part has been connecting Lithuania with Sweden via an HVDC line since 2015. Politically, however, it subsequently became desirable for the actual synchronisation to take place via the LitPol Link interconnector, an AC line that has been in place since 2015 and whose capacity will be doubled from 500 MW to 1 GW.[88] Not only will the electricity grid in the Baltic countries be expanded, moreover, but a direct HVDC line called Harmony Link will also be built on the seabed from Poland to Lithuania. The three Baltic states will thus be connected to the EU through three electricity corridors.[89]

The estimated cost of the entire project is €1.6 billion.[90] Of this, the EU is providing €1.13 billion in funding. A political roadmap was drawn up in June 2018, and the "Interconnection Agreements" were signed in May 2019, when the parties involved agreed on the technical conditions.[91] This was followed in June 2019 by the political roadmap for the EU, Poland and the three Baltic states,[92] which envisages the expansion and modernisation of the electricity grids so that synchronisation with ENTSO-E can be completed by 2025.[93]

Geopolitical changes and the changing security situation were ultimately what tipped the scales in favour of connecting the Baltic countries to the continental grid. Beyond infrastructure development, however, major challenges remain in IT security and the capacity to generate electricity generation. The Baltic states lack their own generation capacities — particularly because Estonia for climate policy reasons has to phase out burning its own oil shale in

uploads/2017/ICDS_Analysis_Desynch_or_Sink_Tuohy-Bulakh-Tsarik_May_2017.PDF.

85 Joanna Hyndle-Hussein, *EU Support for Synchronising the Baltic States' Power Grids* (Warsaw: Centre for Eastern Studies [OSW], 30 January 2019), https://www.osw.waw.pl/en/publikacje/analyses/2019-01-30/eu-support-synchronising-baltic-states-power-grids.

86 European Commission, *Baltic Energy Market Interconnection Plan* (webpage, last update 9 October 2020), https://ec.europa.eu/energy/topics/infrastructure/high-level-groups/baltic-energy-market-interconnection-plan_en.

87 Janno Riispapp, "Russia Could Charge Millions for Maintaining Frequency", *Postimees*, 27 December 2018, https://news.postimees.ee/6488131/russia-could-charge-millions-for-maintaining-frequency.

88 ENTSO-E, *Project 123 – LitPol Link Stage 2* (Brussels, 2016), https://eepublicdownloads.entsoe.eu/clean-documents/tyndp-documents/TYNDP%202016/projects/P0123.pdf.

89 ENTSO-E, *Focus on the Nordic and Baltic Sea*, Insight Reports (Brussels, 2016), https://tyndp.entsoe.eu/2016/insight-reports/nordic-baltic-sea/.

90 Lithuanian Electricity Transmission System Operator (Litgrid), *"Synchronisation"* (webpage), https://www.litgrid.eu/index.php/synchronisation/synchronisation/31363.

91 European Commission, "Energy Security: The Synchronisation of the Baltic States' Electricity Networks; European Solidarity in Action", press release, Brussels, 20 June 2019, https://ec.europa.eu/commission/presscorner/detail/en/IP_19_3337.

92 European Commission, *Political Roadmap on Implementing the Synchronisation of the Baltic States' Electricity Networks with the Continental European Network via Poland* (Brussels, 20 June 2019), https://ec.europa.eu/energy/sites/default/files/20190620_signed_political_roadmap.pdf.

93 "Baltic Energy Systems: Synchronisation by 2025", *CORDIS EU Research Results*, 5 September 2018, https://cordis.europa.eu/article/id/123813-baltic-energy-systems-synchronisation-by-2025.

its power plants. With the decoupling of the Baltic states from BRELL, market transactions have to be reorganised and socioeconomic breaking points manifest themselves. Leaving BRELL entails high economic costs, not only for the EU but also for Russia and Belarus and especially the Russian enclave of Kaliningrad. The asynchronous transit of electricity from Russia through Lithuania to Kaliningrad is only secured by contract until 2025, so Kaliningrad will become an energy enclave. Moscow has since made arrangements to expand Kaliningrad's electricity supply and make the enclave self-sufficient with the help of three new gas and steam power plants and a coal-fired power plant.[94] An interesting side effect is that plans to build two nuclear power plants are now on hold. As a result, there is concern in the Baltics that Russia could terminate the BRELL contract prematurely with the six months' notice stipulated in the contract. There is probably a contingency synchronisation plan in place for the Baltic states should this occur. In December 2021, Lithuania and Poland conducted a successful emergency test on the Polish-Lithuanian interconnection.[95]

Stranded assets — and, in particular, drastically depreciating investments in nuclear power plants — have become an issue not only in Kaliningrad but also, and above all, in Belarus. There, the Ostrovets nuclear power plant has gone into operation. With the Baltic synchronisation, Minsk is on the cusp of losing important export markets for the electricity generated there.

A second synchronisation project in the east that is currently burying the 1990s-era vision of an electricity "house" stretching from Lisbon to Vladivostok is the planned synchronisation of the European continental network with Ukraine and Moldova.[96] Here, too, geopolitics is driving the process. By 2008, relations between Russia and Ukraine had deteriorated to the point where transit of Russian electricity through Ukraine was politically unsustainable.

The negotiations started in the framework of the first MoU between the EU and Ukraine on energy cooperation, signed on 1 December 2005 and reconfirmed in 2016.[97] The MoU aims for "full integration" of energy markets between the EU and Ukraine. As a result, the synchronisation of the electricity grids also came into focus. In this context, the "Burshtyn electricity island" in western Ukraine has been synchronously connected to Poland with the UCTE since 2003. Ukraine's grid connection to the EU[98] provides for eight interconnectors: two with Poland, one with Slovakia,[99] two with Romania and four with Hungary. Costs of €357 million have been estimated for this.[100] The synchronisation is to proceed in stages.[101] In June 2017, the network operators of Ukraine (Ukrenergo) and Moldova (Moldelectrica) signed an interconnection agreement with ENTSO-E. This sets out technical targets for interconnection to the continental grid planned by Ukrenergo for 2023 at the latest, to be implemented by 2023 or 2026 if necessary. However, there is no unanimity yet on this at ENTSO-E.

The timing of synchronisation will not only depend on the technical and operational status.[102] In

94 Anastasia Lyrchikova, "Russia Launches Plant to Reduce Kaliningrad's Reliance on EU Grid", *Reuters* (online ed.), 6 March 2019, https://www.reuters.com/article/us-russia-power-plants-idUSKCN1QN1KR.

95 "Lithuania and Poland Tests Emergency Support on Electricity Interconnection", 14 December 2021, https://www.tdworld.com/overhead-transmission/article/21183683/lithuania-and-poland-tests-emergency-support-on-electricity-interconnection.

96 See in more detail: Lukas Feldhaus, Kirsten Westphal and Georg Zachmann, *Connecting Ukraine to Europe's Electricity Grid,* SWP Comments 57 (Berlin: Stiftung Wissenschaft und Politik, November 2021).

97 European Union, European Atomic Energy Community and Government of Ukraine, *Memorandum of Understanding on a Strategic Energy Partnership between the European Union together with the European Atomic Energy Community and Ukraine* (Brussels, 24 November 2016), https://ec.europa.eu/energy/sites/ener/files/documents/mou_strategic_energy_partnership_en.pdf.

98 European Commission, ed., *Electricity Interconnections with Neighbouring Countries: Second Report of the Commission Expert Group on Electricity Interconnection Targets* (Brussels, 20 June 2019), 13, https://ec.europa.eu/energy/sites/ener/files/ documents/2nd_report_ic_with_neighbouring_countries b5.pdf.

99 "New Power Line to Be Built between Ukraine and Slovakia", *UNIAN*, 5 October 2018, https://www.unian.info/economics/10288323-new-power-line-to-be-built-between-ukraine-and-slovakia.html.

100 World Bank, ed., *Ukraine: Facilitating Power System Integration with Europe (P171980). Project Information Document (PID)* (Washington, D.C., 4 February 2020), https://ewsdata.rightsindevelopment.org/files/documents/80/WB-P171980_lDLAAYT.pdf.

101 *"Integration into ENTSO-E: Key Results over Two Years",* presentation of Ukrenergo, 30 May 2019, https://de.slideshare.net/Ukrenergo/integration-into-entsoe-key-results-over-two-years?from_action=save.

102 See in detail Georg Zachmann and Lukas Feldhaus, *Synchronising Ukraine's and Europe's Electricity Grids*, Low Carbon addition, a number of points must be clarified that are strongly determined by security and geopolitical considerations. Belarus in particular, but also Russia, provided significant volumes of electricity for voltage and frequency maintenance in the winter of 2020—21, when Ukrainian nuclear power plants were taken offline for technical overhauls. Actually, no electricity has been traded between Russia and Ukraine since 2015, except operationally necessary quantities. Due to the difficult situation in the Ukrainian grid, consideration is currently being given to limiting to as short a period as possible the "island mode" phase of the synchronisation process, during which the Ukrainian grid is operated on its own. This is due to concerns about not being able to return to the IPS/UPS grid before Ukraine is connected to the ENTSO-E grid. Politically, Kiev prefers synchronisation via an AC connection. Also, synchronisation via DC interconnection would technically mean that Ukraine would operate its grid in island mode. Critics argue that the country's electricity system is not designed for such a move — that a failure of one of its typical large, (i.e., nuclear or coal-fired) power plants would have fatal consequences. There is still a Soviet-era AC line (currently closed) running between Rzeszów in Poland and Zakhid Vinnytsia in Ukraine, and this 750-kV line could be used for synchronisation. However, this would require the modernization of the substations on both sides. Operating it for emergency synchronisation would probably involve dependence on Russian and possibly also Chinese technology. In any case, Poland objects Ukrainian plans, also for an energy bridge connecting the nuclear power plant Khmelnytskyi 2 with Rzeszów.

In eastern Ukraine and Crimea, the geopolitical implications are even clearer: separatist areas are temporarily disconnected from the Ukrainian grid and are supplied with electricity by Russia. Four 220-kV lines have been built from Kerch in Russia to the Crimean peninsula, and the electricity bridge was opened in the presence of President Vladimir Putin in May 2016. Previously, acts of sabotage had led to widespread electricity cuts in Crimea.[103]

Parallel synchronisation with Moldova has its pitfalls, too, because of the country's reliance on the Moldovskaya GRES power plant park in the breakaway Republic of Transnistria, which not only ensures a large part of Moldova's electricity supply[104] but also supplies electricity to Ukraine and Romania. The large plant with its 2.5-GW capacity belongs to the Russian company Inter RAO, which supplies gas from Russia through Gazprom subsidiaries Tiraspoltransgaz and Moldovagaz. Transnistria has not been paying for this gas, however, so that — according to Gazprom — it had by May 2021 accumulated a debt of almost US$7 billion.[105] A gas price conflict between Russia and Moldova was only settled in November 2021.

The synchronisation process goes far beyond issues of physical interconnectivity.

All this proves that the synchronisation process goes far beyond issues of physical interconnectivity. The disconnection of Ukraine and Moldova from the IPS/UPS will have a technical, economic and political impact on Russia and Belarus.[106] On the technical side, there has been great progress in ENTSO-E's cooperation with Ukrenergo and Moldelectrica. But the far bigger hurdles are at other levels, namely those of network operation, market, transparency and data exchange. While Ukraine and Moldova are members of the European Energy Community, adopting its complex rules — which require deep structural reforms[107] — is proving to be a political and regulatory challenge. Today, safety and environmental standards

Ukraine Policy Note (Berlin: Berlin Economics, May 2021), https://www.lowcarbonukraine.com/wp-content/uploads/Synchronising-Ukraine%C2%B4s-and-Europe%C2%B4s-electricity-grids.pdf.

103 Vladimir Soldatkin, "Putin Says Crimea Now Free of Reliance on Kiev for Its Power", *Reuters* (online ed.), 11 May 2016, https://www.reuters.com/article/us-russia-crimea-power-idUSKCN0Y21K5.

104 "Moldavskaya GRES Increased Electricity Production by 11% in First Quarter", *Infotag*, 2 June 2021, http://www.infotag.md/economics-en/292336/.

105 Iulian Ernst, "Gazprom Makes New Attempt to Force Moldova to Pay Breakaway Transnistria's Gas Bill", *bne IntelliNews*, 19 May 2021, https://intellinews.com/gazprom-makes-new-attempt-to-force-moldova-to-pay-breakaway-transnistria-s-gas-bill-210875/?source=moldovabne.

106 Maria Pastukhova and Kirsten Westphal, *A Common Energy Market in the Eurasian Economic Union*, SWP Comment 9/2016 (Berlin: Stiftung Wissenschaft und Politik, February 2016, https://www.swp-berlin.org/publikation/a-common-energy-market-in-the-eurasian-economic-union; Zachmann and Feldhaus, *Synchronising Ukraine's and Europe's Electricity Grids* (see note 102), 5.

107 See chapter "The European Union: From Cooperation to Electricity Market Integration" (p. 14).

as well as grid codes and market and transparency rules must be implemented to ensure that not only the physical operation of the grid but also the electricity market functions. Here, both countries still have a difficult road ahead of them.[108] Even if the above-mentioned aspects appear to be primarily technical and regulatory in nature, they are at heart a matter of national security. Independence and sovereignty in Ukrainian electricity supply is not only limited by synchronous grid operation with the IPS/UPS; it is above all affected by the involvement of Ukrainian oligarchs in non-transparent deals (with Russia, among others). This causes dependencies among companies and leads to the rules of the market being undermined.

Continental Europe: The Centre of an Attractive Electricity Area

Europe's synchronised continental grid is a centre of gravity spanning an increasingly integrated electricity market. It creates a strong sense of "electricity solidarity" and "common destiny" within its bounds. The European legal and economic area coincides largely (if not completely) with the geographical extent of the five interconnected grids. "Electrified Europe", however, has never been identical with political union. That said, the European integrated electricity grid contributes to cohesion and inclusion and thus forms the socioeconomic backbone of the EU, the European Energy Community, the European Free Trade Association (EFTA) and the European Economic Area (EEA) as critical infrastructure.

Europe's electricity grid and electricity system have several levels: the technical and operational level, the infrastructural level, the political-regulatory level and the trading and market level. The different levels have their own "subsidiarity" and spatiality. That is, the electricity grid

and its technical and operational organisation do not form spaces that are entirely congruent with its price zones or trading centres and only overlap with them partially. However, the political authority to set rules is clearly located in the EU. The high degree of institutionalisation guarantees a largely symmetrical division of power and shared responsibility between the countries.

The densification not only of these techno-political but also socioeconomic transactions is visible. In addition to physical interconnectivity, electricity trading is also being expanded in order to minimise electricity price differences (see Map 5). The politically set market areas are particularly decisive for the respective opportunities and possibilities of socioeconomic participation and access to stable, secure and low-priced electricity supply. Electricity grids thus play an important role in European cohesion. Although the entire EU is not connected in a single synchronised grid, the guiding principle of interconnectivity between the five integrated electricity grids and the integration of "electricity islands" into the grid and the market applies. Deepening and widening will continue to set the agenda. As the electricity system weans itself off fossil fuels, the topography of the grid will permanently change. In Germany for example, as nuclear and coal-fired power located near consumers will be shut down, renewably generated electricity will have to fill the gap. To achieve this, the interconnection must be condensed, for example by HVDC lines such as SüdLink. These lines should have a total capacity of 4 GW, which corresponds to the capacity of more than four conventional power plants. In May 2021, the international counterpart NordLink,[109] with a capacity of 1.4 GW, began connecting a German substation with a Norwegian substation in order to exchange surplus German wind power for Norwegian hydropower. This in turn can be used to stabilise the German grid.

In view of the developments outlined above, we can expect the physical and economic boundaries of the existing electricity systems to increasingly soften and shift. It is of geopolitical significance that electricity interconnection will henceforth expand more intensively across the territory and thus extend beyond the limits of EU jurisdiction. This is because optimal solar and wind sites are located in the continental and maritime regions neighbouring the EU. With this, the demands for control and governance in the electricity neighbourhood will rise. At the same time, the expansion of the European continental grid will reveal the shortcomings of regulatory fault lines

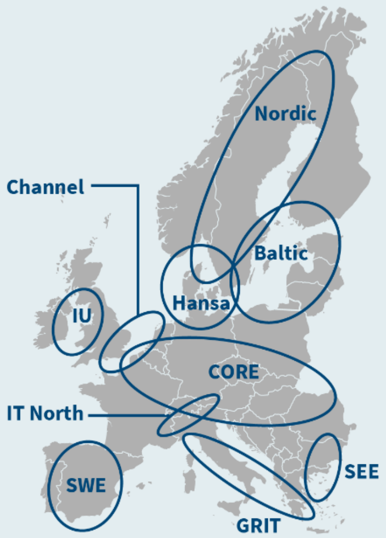
108 Interviews with former and current EU officials and US experts. See also "Exploring Ukraine's Long-term Energy Security on the Path towards Decarbonisation", webinar, Centre for European Policy Studies (CEPS), Brussels, 5 May 2021, https://www.ceps.eu/ceps-events/ukraine-long-term-energy-security/.

109 "NordLink", *Tennet*, https://www.tennet.eu/our-grid/international-connections/nordlink/.

and grey zones across infrastructures.[110] Physical and trade interconnectivity is part of electricity market integration. Interoperability of systems and cross-border lines as well as technical integrity and security are addressed in a comprehensive regulatory framework. However, there are clear gradations between centre and peripheries — not only in terms of interconnection and trade contacts but also in terms of rule making and strength projection. Outside the EU, there are inconsistencies in the adoption of market rules and in the exchange of electricity data., the EU's CO_2 border adjustment mechanism will perspectively also lead to new frictions. The densification of infrastructure as well as political, economic and social transactions becomes visible in the centre and decreases in concentric circles on the periphery. Thus, while convergence and inclusiveness is growing in the centre, divergences are emerging in peripheral areas, and potentially divisive fault lines are emerging at the outer borders.

Map 5

Planned development of ten capacity calculation regions



Source: entsoe.eu
Translation and adaptation: 2021 Stiftung Wissenschaft und Politik

More than in the past, electricity grid and electricity market integration is gaining importance in geo-economic competition.

The appeal of the ENTSO-E network and its impact on its neighbourhood are high, especially since Russia's 2014 annexation of Crimea introduced a climate of heightened security concern. After 2000, the accession (or at least the prospect of accession) of Central European, Eastern European and Southeastern European countries to the EU substantially drove the expansion of the electricity network. The European Energy Community was a prime instrument of advancing physical and market integration. The more sophisticated the Acquis Communautaire and the rules for network operation became, however, the more stringent the requirements for the partner countries. Today, the motto "Rules before Joules" shapes the EU's electricity policy with its partner countries. More than in the past, electricity grid and electricity market integration contributes to geo-economic competition. This is because such integration serves to establish norms, standards, market opportunities and technologies. The energy transformation can be an accelerating factor here, on the one hand reinforcing divergences in a previously integrated electricity grid and electricity system, and on the other reconfiguring a market.

Security concerns have in the past increased awareness of asymmetric dependencies of certain regions on Russia. The Baltic countries furnish one example. Ukraine is another. The loss of trust and deterioration of political relations can over time take the form of infrastructural decoupling. For example, Ukraine's electricity grid interconnection with continental Europe is tightly linked to a broader context of geopolitical tension with Russia, especially for the US. For this reason, the role of geopolitical rivalries involving Russia as well as distant actors like China and the US should not be underestimated.[111]

110 See Indra Øverland, Ellen Scholl, Kirsten Westphal and Katja Yafimava, *Energy Security and the OSCE: The Case for Energy Risk Mitigation and Connectivity*, SWP Comment 26/2016 (Berlin: Stiftung Wissenschaft und Politik, May 2016), https://www.swp-berlin.org/publikation/energy-security-and-the-osce; Maria Pastukhova and Kirsten Westphal, *Eurasian Economic Union Integrates Energy Markets – EU Stands Aside*, SWP Comment 5/2018 (Berlin: Stiftung Wissenschaft und Politik, January 2018), https://www.swp-berlin.org/publikation/eurasian-economic-union-integrates-energy-markets-eu-stands-aside; Zachmann and Feldhaus, *Synchronising Ukraine's and Europe's Electricity Grids* (see note 102), 5.

111 See U.S. Department of State, "Joint Statement of the United States and Germany on Support for Ukraine, European Energy Security, and our Climate Goals", media note

In the EU neighbourhood, phenomena of competing vectors of interconnection and permeability to political power are evident at different levels of the electricity system. These include electricity generation, grid expansion and system operator takeovers. Here China's global electricity interconnection initiative is particularly noteworthy. Not only does it hold stakes in the electricity grid operators of Greece[112] and Portugal,[113] but it is also indirectly enmeshed in Italy's TERNA Spa.[114] It furthermore finances interconnectors such as Ariadne (see p. 21) and is increasingly supplying key equipment and components that combine hardware and software. At the same time, centrifugal forces are shaping other dynamically emerging electricity regions, including the electricity space around the Persian Gulf.

(Washington, D.C.: Office of the Spokesperson, 21 July 2021), https://www. state.gov/joint-statement-of-the-united-states-and-germany-on-support-for-ukraine-european-energy-security-and-our-climate-goals/.

112 "China's State Grid Seals Acquisition of Stake in Greek Power Grid", *Reuters* (online ed.), 20 June 2017, https://www.reuters.com/article/greece-stategrid-powergrid-idAFL8N1JH32G.

113 "State Grid Buys Stake in Portugal REN", *China Daily* (online ed.), 3 February 2012, https://www.chinadaily.com.cn/bizchina/2012-02/03/content_14534924.htm.

114 CDP Group, "CDP: 40.9% Stake in CDP Reti Transferred to State Grid and Italian Institutional Investors", press release, Rome, 27 November 2014, https://www.cdp.it/sitointernet/page/en/cdp_409_stake_in_cdp_reti_transferred_to_state_grid_and_italian_institutional_investors?contentId=CSA11238.

Two Fluid Infrastructurised Spaces in Eurasia: Central Asia and the South Caucasus

Thirty years after the dissolution of the USSR and its integrated electricity grid, electricity infrastructurised spaces in Eurasia are now undergoing rapid reorganisation. Especially in Central Asia and the South Caucasus, regional as well as transcontinental initiatives are creating new dynamics in shaping electricity interconnectors, both within the two regions and with the participation of external actors. In both of these formerly peripheral border areas the process of regional electricity interconnectivity is driven by systemic, socioeconomic and geopolitical factors, with the energy transformation playing an increasingly important (but still subordinate) role. Processes, dynamics and actors differ regionally.

Russia is trying to create technical-regulatory convergence.

Among external actors, Russia still occupies a significant though no longer exclusive position in both Central Asia and the South Caucasus. Russia is trying to create technical-regulatory convergence through the establishment of a common electricity market — the Eurasian Economic Union (EAEU) — as well as through existing infrastructure links and grid synchronisation. Russia thus aims to counter its loss of influence in both regions and respond to increasing regional and extra-regional attempts at grid reintegration. Russia's economic interests also act as drivers here. Through the EAEU electricity market and transregional interconnectors, the country wants to tap new markets in the Middle East and Asia for its electricity surplus. However, it faces resistance from local actors and growing influence from external actors. Russia has long ceased to be the sole political and technical-regulatory driver of integration in either region.

In both regions, national, systemic, socioeconomic as well as partly diverging geopolitical goals of the individual countries reinforce the asynchrony in the development of network, regulatory and market spaces. They limit the scope of action and the chances of success of regional approaches. This in turn offers external actors an opportunity to influence the region.

Slowly but steadily the orientation of electricity vectors and infrastructure is therefore changing away from the historic centre of gravity: Russia. It is true that interconnectors and electricity links with other electricity spaces — apart from Russia — are still largely underdeveloped. However, both Central Asia and the South Caucasus are increasingly unable to resist the pull of other centres with their respective integration initiatives, spheres of influence, and spatial conceptions. In addition to Russia to the north and the EU to the west, these include China to the east. Meanwhile, to the south Turkey, Iran and, in the future, India will prove influential. And although the US is itself far removed from Eurasia, its geostrategic interests and technical-regulatory, developmental and financial instruments continue to exert considerable influence. Moreover, the US — in encouraging infrastructural links between the South Caucasus and Europe and between Central Asia and Southeast Asia and India — is actively seeking to contain Russian and Chinese influence. The withdrawal of US troops from Afghanistan could significantly limit US influence on Central Asia's integration processes for the time being, however.

Historical Review: From the Soviet integrated electricity grid to the disintegrated infrastructurised space

In Soviet times, the electricity grid and electricity infrastructure of the five Central Asian and the three South Caucasian Soviet republics were part of the USSR's cross-border transmission network (Unified Power System, UPS). For Moscow, they thus constituted an essential technical-regulatory and geopolitical instrument for consolidating its influence in Eurasia.

Although Moscow did not act as a physical control centre, it did act as a central regulatory and technical authority that guaranteed the stability of the electricity supply and, where possible, defused political and social distribution conflicts. With the expansion of an electricity regulatory area spanning the entire USSR, Moscow was able to guarantee the electricity supply and create regulatory convergence. Not only this. Crucially, it also secured peripheral border areas to the south and east in a geopolitical sense. Infrastructure was key to sealing these areas off from external actors.

When the USSR collapsed, a fragmentation of the integrated regional integrated electricity grid and the unified electricity regulatory space ensued. National electricity grids were hastily created, and with them came partial market-oriented reforms.[115]

Geopolitically, the end of the unified Soviet integrated electricity grid also ended Moscow's exclusive role as the sole centre of gravity and regulatory political power in Central Asia and the South Caucasus. This enabled the opening of the two regions to the east, south and west. At the same time, renationalisation did not result in the creation of corresponding autonomous regional governance mechanisms and sets of rules. As a consequence, intraregional energy and electricity trade collapsed in the course of the 1990s and in the first decade after 2000.[116] In Soviet times, the integrated grid known as the Central Asian Power System (CAPS) had been physically connected to the Soviet UPS (also sharing its technical and regulatory norms), but it was not synchronised with it.[117] Only in 2001 was it first synchronised with the Russian UPS as part of the IPS/UPS integrated electricity grid to stabilise the grid frequency. The states of Central Asia were increasingly determined to pursue an energy policy of national self-sufficiency, however, and this included regional decoupling and international integration into global commodity markets. As a result of constant water and border disputes, first Turkmenistan (2003), then Uzbekistan and finally Tajikistan (2009) left the CAPS. This brought an end to the regional integrated electricity grid as an instrument for stabilising electricity supply. There were negative consequences especially for Tajikistan and Kyrgyzstan.

A similar process took place in the South Caucasus, albeit in the absence of an earlier regional integrated electricity grid. Being rather small, the electricity grids of the three South Caucasian countries (Georgia, Armenia and Azerbaijan) had not been built for national or regional self-sufficiency. Rather, under the UPS they were an annex to the unified electricity grid of the neighbouring North Caucasus. In the years after the fall of the USSR, the three countries therefore had to focus mainly on stabilising their respective national grids, ensuring basic supply of electricity and building national markets.[118]

While these developments in Central Asia and the South Caucasus have significantly limited Russia's influence, they have at the same time dissolved both regions "from within" and made them susceptible to the influence of external actors. This double process has increased centrifugal force, pulling these regions away from the old centre of gravity. New centres and markets with different integration initiatives are gaining appeal. This has opened up greater opportunities for connecting both regions to other power networks and integrated electricity grids. These include Central Asia to China; Central Asia and the South Caucasus to Iran; and the South Caucasus to Turkey.

115 Anatole Boute, *Energy Security along the New Silk Road: Energy Law and Geopolitics in Central Asia* (New York: Cambridge University Press, 2019), 89–91.

116 Coordinating Dispatch Center Energia, "The Interconnected Power Grid of Central Asia: Regional Trade Outlooks", presentation at the 27th CAREC-ESCC Meeting, Ashgabat, 13–14 March 2018; Coordinating Dispatch Center Energia, "Current Status and Development Prospects of the Central Asian Unified Energy System", presentation at the 27th CAREC-ESCC Meeting, Tashkent, 10 April 2019, https://www.carecprogram.org/uploads/4.-Dispatch-Center_Mr-Shamsiev.pdf.

117 Yuri N. Rudenko, "Electric Power Development in the USSR", presentation at the First Energy Conference Israel — Former USSR, 13–15 May 1991, 3, https://inis.iaea.org/collection/NCLCollectionStore/_Public/25/011/25011834.pdf.

118 Ibid.

Russia’s Reintegration Attempts: The Eurasian Economic Union Electricity Market

Since the creation of the EAEU in 2014, Russia has been trying to counter disintegrative tendencies in the electricity sector as well. It is guided in this less by the desire to encourage the energy transformation than by geopolitical and economic motives.

At the infrastructural level, the Russian UPS remains interconnected with both the CAPS in Central Asia and the networks of Georgia and Azerbaijan under the IPS/UPS system, thereby operating in parallel with them. Since the Russian UPS regulates the grid frequency of the entire area of the Commonwealth of Independent States (CIS) — especially for Central Asia — the Ekibastuz-Shimkent intra-Kazakh north-south route is a significant source of Russian influence. It is the only link that can absorb or compensate for possible grid frequency fluctuations in the CAPS. But even in the case of Georgia and Azerbaijan, grid synchronisation and physical interconnection with Russia through existing high-voltage lines remain essential for stability.[119] As a result, Russia retains a residual technical influence on the two infrastructurised spaces (see Map 6, p. 32), although electricity dispatch planning — despite institutions such as the CIS Electric Power Council[120] — still takes place nationally.

At the market and institutional level, Russia is therefore attempting in the long term to offer the Central Asian EAEU members Kazakhstan and Kyrgyzstan an external regulatory-institutional framework and a liberalised market. The same is true for Armenia in the South Caucasus. To this end, a common EAEU electricity market is to be created by 2025.[121] However, this market and legal-regulatory space would not be congruent with the infrastructurised space (regional grid) of the two regions.

In this way, Russia is creating new regulatory and market fault lines in Central Asia and the South Caucasus. Nevertheless, Russia also intends to have a geopolitical and geo-economic impact on regional integration processes by driving regulatory or infrastructural-technical convergence — or both. Moscow is indeed trying to develop regional interconnectors to assure future exports of its own electricity to Turkey and Iran as well as to China and India.[122]

Despite all the progress made, however, Russia’s plans for deeper integration repeatedly meet regional resistance and come up against technical and political hurdles. One main obstacle is Russia’s prominent political-regulatory and economic role in the market. Another is formed by asymmetries in the structure, performance and organisation of the national electricity markets. Moreover, other external actors — especially China, Turkey and Iran — are also increasingly pursuing integration initiatives, competing with Russia for Central Asia and the South Caucasus in a way that limits Moscow’s influence.

New Regional Dynamics and the Pull of New Gravitational Centres

Beyond Russia’s integration efforts, plans in both Central Asia and the South Caucasus have been developed or revived, especially since the early 2010s, to recommission, expand and modernise intraregional electricity grids and to create transregional electricity markets. These reintegration plans also stem from the planned expansion of renewable energy. Indeed, in order for countries to increase their share in the national electricity mix, a regionally functioning grid is necessary to stabilise the electricity supply. Plans to expand renewable energies are indeed increasingly finding their way into the national energy strategies of almost all regional players. In some countries — namely Georgia, Kazakhstan and Uzbekistan — solar

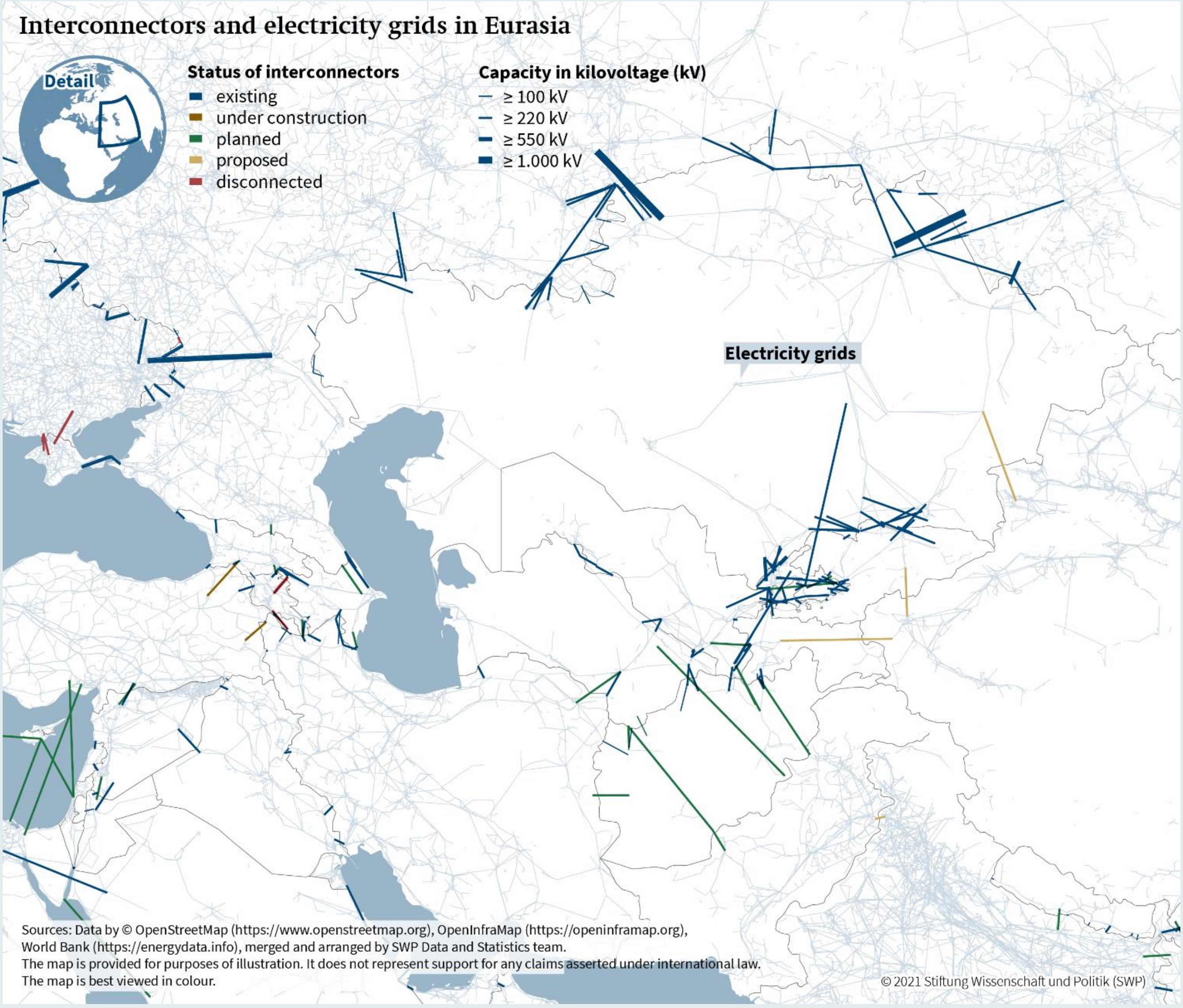
119 Energia, “The Interconnected Power Grid of Central Asia” (see note 116), 9. To stabilise the grid and improve IPS/UPS parallel operation, a second intra-Kazakh 500-kV transmission line was built between the Ekibastuz substation and Shu between 2004 and 2010.

120 *CIS Electric Power Council* (website), http://energo-cis.ru/enmain/.

121 Pastukhova and Westphal, *Eurasian Economic Union Integrates Energy Markets* (see note 110); Zachmann and Feldhaus, *Synchronising Ukraine’s and Europe’s Electricity Grids* (see note 102), 5.

122 Oleg Marchenko et al., “Rossiya v evraziiskoi elektroenergiticheskoi integrazii” [Russia in Eurasia’s Electricity Integration], *Mirovaya Ekonomika I Mezhdunarodn’e otnosheniya* [World Economy and International Relations] 62, no. 6 (2018): 21, 25, https://elibrary.ru/item.asp?id=35101362; see also Lev Belyaev, Lyudmila Chudinova and Sergei Podkovalnikov, “Russia’s Electric Power Reintegration with Central Asia and Caucasus and Entering South Asia and Middle East Electricity Markets”, *E3S Web of Conferences* 209, no. 04001 (2020), https://www.e3s-conferences.org/articles/e3sconf/pdf/2020/69/e3sconf_energy-212020_04001.pdf.

Map 6



and wind energy offer promising prospects, and electricity consumption and export potential are increasing. However, decarbonisation of national economies to protect the environment and stop climate change is not a priority, especially in resource-rich countries. These goals remain subordinate to maintaining national security, increasing electricity exports and achieving stable, affordable electricity and energy supplies.

For the countries of Central Asia and the South Caucasus, geopolitical motives continue to shape this new phase. On the one hand, regional integration is also seen in the electricity sector as an instrument of countering the influence of external actors. On the other hand, interconnector projects are still characterised by mistrust, location conflicts and latent competition for market share and political influence. Geopolitical motives thus act as both drivers and obstacles. Here it is essential to distinguish between the developments in Central Asia and the South Caucasus.

Integrated electricity grid Central Asia: Regional reintegration attempts and the growing influence of China and Iran

In Central Asia, changes primarily in Uzbekistan have led to renewed and lively discussion of projects and initiatives to reactivate the CAPS as a regional synchronised integrated electricity grid. Some of these are even being implemented. Uzbekistan has always occupied a key position in the regional electricity grid of Central Asia, which at present only connects the electricity grids of southern Kazakhstan, Kyrgyzstan and Uzbekistan. Not only is Uzbekistan the largest producer[123] and consumer of electricity (with a more than 30 percent increase since 2000).[124] It also has a relatively developed and tightly meshed national electricity grid. Due to its central geographical location and existing infrastructure, Uzbekistan connects the CAPS grid with Tajikistan and Turkmenistan and, in the future could also be linked to Afghanistan.

Since taking office in 2016, Uzbek President Shavkat Mirziyoyev has been pursuing an ambitious course of reform.[125] This includes modernising and expanding the entire electricity grid and all electricity generation capacities. In addition, regional electricity connections are to be put back into operation in order to increase international electricity trade.[126]

Accordingly, electricity exports have started between Kyrgyzstan and Uzbekistan[127] and between Uzbekistan and Tajikistan.[128] Electricity interconnectors among the countries have been built or reactivated. Finally, in 2019, Turkmenistan declared its intention to resume exporting electricity to Uzbekistan,[129] although the two grids still do not operate synchronously.

Noticeable improvements in intraregional cooperation in the electricity sector and in the construction or recommissioning of interconnectors are undoubtedly the first steps towards fully reactivating the CAPS and building more transregional interconnectors with neighbouring regions and electricity areas. However, this positive development continues to be countered by latent geopolitical and geo-economic conflicts of interest over market shares, electricity exports and regional leadership claims. There are three factors to consider here.

First, the regional electricity grid still lacks a common technical-regulatory level of coordination for the integrated operation of dams, water storage and commodity generation.[130] Second, there are no higher-level or intra-governmental regional institutions that would coordinate the technical and regulatory harmonisation of national markets and their reforms, nor are there any to promote the establishment of a legal-regulatory and market space. Third, geopolitical conflicts become even more visible when it comes to implementing interconnected intraregional and transregional electricity infrastructure projects. This applies above all to the expansion of the important electricity links to Afghanistan, Pakistan and Southeast Asia within the framework of the Central Asia-South Asia (CASA-1000) project.[131] Interconnectors to Afghanistan are essential here to linking Central Asia to the South Asian electricity markets and, in the long term, India.

Uzbekistan's decision to revisit its previously negative position on CASA-1000[132] and to develop links

123 "A Closer Look at the Rapidly-growing Power Industry in Uzbekistan", *NS Energy* (online ed.), 30 July 2019, https://www.nsenergybusiness.com/features/power-industry-uzbekistan/.

124 IEA, *Uzbekistan – Countries & Regions* (webpage), https://www.iea.org/countries/Uzbekistan.

125 Andrea Schmitz, *Uzbekistan's Transformation: Strategies and Perspectives*, SWP Research Paper 12/2020 (Berlin: Stiftung Wissenschaft und Politik, September 2020), https://www.swp-berlin.org/publikation/uzbekistans-transformation.

126 Uwe Strohbach, "Foreign companies stir up Uzbek power sector", *Germany Trade & Invest (GTAI),* 4 June 2020, https://www.gtai.de/gtai-de/trade/branchen/branchenbericht/usbekistan/auslaendische-unternehmen-wirbeln-usbekischen-stromsektor-auf--256558.

127 Kamila Aliyeva, "Kyrgyzstan to Resume Power Exports to Uzbekistan despite Accident at Bishkek TPP", *Azernews* (online ed.), 30 January 2018, https://www.azernews.az/region/126287.html.

128 Asian Development Bank (ADB), ed., *TAJ: Reconnection to Central Asian Power System Project*, Project no. 52122-001, October 2018, 6, https://www.adb.org/sites/default/files/project-documents/52122/52122-001-rp-en.pdf; "Tajikistan Resumes Power Exports to Uzbekistan", *The Economist* (online ed.), 27 April 2018, http://country.eiu.com/article.aspx?articleid=1286668312&Country=Tajikistan&topic=Economy&subtopic=Forecast&subsubtopic=Economic+growth.

129 "Uzbekistan to Import Turkmen Electricity", *BT Business Turkmenistan* (online ed.), 3 December 2019, https://business.com.tm/post/4810/UsbekistanUsbekistanUsbekistan-to-import-turkmen-electricity.

130 World Bank, *Study on Strengthening the Central Asia Power System (CAPS)*, Central Asia Energy-Water Development Program, Program Brief no. 1 (Washington, D.C., November 2015), http://documents1.worldbank.org/curated/en/866191467998204221/pdf/101742-BRI-CAPS-PB-Box393265B-PUBLIC.pdf.

131 Boute, *Energy Security* (see note 115).

132 "Uzbekistan Supports CASA-1000 Project — Kamilov", *The Tashkent Times* (online ed.), 29 November 2018, https://tashkenttimes.uz/world/3235-UsbekistanUsbekistanUsbekistan-supports-casa-1000-project-kamilov.

with Tajikistan and Afghanistan[133] makes it easier, at least on paper, to implement the project. However, the country's motives are not free of geopolitical considerations. Indeed, they harbour potential for further conflict in the region; because of Uzbekistan's key position in the regional electricity grid, building the high-voltage line to Afghanistan would provide a more direct link to CAPS than via Tajikistan. Uzbekistan would open up an additional regional market for its own electricity exports but would thereby compete directly with Tajikistan for export volumes and as an electricity hub.

Turkmenistan, with similar motives, is pursuing two parallel interconnection projects, TUTAP (Turkmenistan – Uzbekistan – Tajikistan – Afghanistan – Pakistan) and TAP (Turkmenistan – Afghanistan – Pakistan), which partly complement and partly compete with CASA-1000. The TAP project in particular serves Turkmenistan's goal of gaining access to South Asia's electricity markets, especially Pakistan, by exporting 4,000 MW annually.[134]

The EU has extended cooperation with the region to the electricity system as part of the European Green Deal.

Weak technical-regulatory cooperation and simultaneous intraregional geopolitical competition for routes and market share open the door to extra-regional projection of political power. The US, as a power far removed from this space, has always supported both the CASA-1000 and TUTAP projects, not only in terms of development policy (namely with its development agency United States Agency for International Development, USAID) but also technologically and financially (via the World Bank and the Asian Development Bank). The US goal is twofold here: to stabilise Afghanistan by linking the country with Central Asia and to contain Russian and Chinese influence. The EU for its part has expanded its cooperation with the region within the framework of the European Green Deal (for example, as part of the EU4Energy initiative as well as with the new program Sustainable Energy Connectivity in Central Asia[135]) to include the electricity system. Its aim here is to promote the expansion of renewable energies. It must be noted, however, that the US and the EU still have little influence over the region's integration processes. These are much more closely intertwined with (and increasingly dependent on) initiatives coming from closer to home. The interests of neighbouring powers therefore play a greater role than those of the EU and the US. Apart from Russia, these centres consist mainly of China to the east and Iran to the south – powers that are taking advantage of the fluid situation in order to assert their influence. In this context, the withdrawal of NATO troops from Afghanistan in August 2021 and the subsequent seizure of power by the Taliban further limits the West's ability to exert influence and essentially grants Russia, China and Iran more power to shape the entire region.

China's interest in the region in the electricity sector is indeed growing extremely rapidly. Its approach reflects the fluid organising principle of the techno-political infrastructurised space. Its main feature is the growing control over the flow of electricity outside a spatially defined jurisdiction. In a speech to the United Nations General Assembly in 2015, President Xi Jinping announced China's ambitious project to create a global electricity grid (its Global Energy Interconnection, or GEI). The project envisions global interconnection of once fragmented national electricity grids, thereby accelerating the transformation from fossil fuels to an energy system free of hydrocarbons. Its three pillars are clean energy, smart grids and the massive expansion of transcontinental HVDC lines.[136] The use of HVDC, which China has been pursuing since 2009, is intended to enable DC and AC transmission over long distances and with minimal transmission loss.

133 Mir Haidar Shah Omid, "ADB Pledges $70m to Fund Surkhan-Pul-e-Khumri Power Line", *Tolo News*, 16 February 2018, https://tolonews.com/business/adb-pledges-70m-fund-surkhan-pul-e-khumri-power-line.

134 ADB, "Power Interconnection Project to Strengthen Power Trade between Afghanistan, Turkmenistan, Pakistan", press release, 28 February 2018, https://www.adb.org/news/power-interconnection-project-strengthen-power-trade-between-afghanistan-turkmenistan-pakistan.

135 European Commission, "European Union Approves First Actions for Central Asia in Line with the European Green Deal Priorities", press release, Brussels, 19 May 2020, https://ec.europa.eu/international-partnerships/news/european-union-approves-first-actions-central-asia-line-european-green-deal-priorities_en.

136 Edmund Downie, *China's Vision for a Global Grid: The Politics of Global Energy Interconnection*, Reconnecting Asia (Washington, D.C.: Center for Strategic and International Studies [CSIS], 13 February 2019), https://reconnectingasia.csis.org/analysis/entries/global-energy-interconnection/.

In Eurasia, the project is closely linked to China's wide-reaching Belt and Road Initiative, which aims to link the economic areas of Asia with those of Eurasia, Europe and Africa by developing transcontinental and transregional infrastructure projects and economic corridors. With BRI China aims to open up new markets and secure raw materials. Central Asia plays a key role in this. Through the construction of HVDC lines, the region could become a significant electricity transit bridge between the Chinese and European electricity markets along two of three possible east-west electricity corridors.[137] At the same time, the region's solar, wind and hydroelectric potential would make Central Asia a major electricity supplier for China's central and eastern provinces. This would essentially make the Chinese market the new centre of gravity for Central Asia's electricity flows and grids.

Plans to construct interconnectors and HVDC lines between China's western provinces and Central Asia are still in their early stages, and there are currently no connections between the region and China's electricity grid. However, China is discussing the construction of three HVDC lines with Kazakhstan and Kyrgyzstan as part of the larger GEI plan to link China with the electricity grids of Central Asia and Europe.[138] In addition, Chinese companies are involved in constructing national electricity lines for countries in the region — notably the north-south electricity link in Kyrgyzstan.[139] They are similarly involved in constructing transregional electricity interconnectors, such as upgrading and reactivating the electricity link between Uzbekistan and Tajikistan.[140] These companies act less as direct investors than as contractors according to the EPC model (engineering, procurement, construction). In this form of project management for infrastructure construction, the contractor commits to handing the finished structure over to the client on a turnkey basis.[141] At the same time, Chinese companies have for the past decade been investing increasingly in the construction of hydropower plants and dams in Kazakhstan, Uzbekistan and Tajikistan.[142]

It should be noted that China's direct regulatory-normative influence on Central Asia's electricity system remains limited at present, even though its interest in it is growing and the country is participating more intensively in regional infrastructure projects, including interconnectors and power plants. Unlike Russia or the EU, China has no stated interest in techno-regulatory convergence in the region. But it does want to spread its own technological standards and financing models, which traditionally go hand in hand with Chinese investment activities. China's direct investment in Central Asia's electricity system is expected to increase as BRI and GEI gain momentum. This would lead to a de facto transfer to the region of Chinese technological-regulatory standards and, in the longer term, could cause Central Asia to reorient itself in terms of infrastructure.[143]

To the southwest, Iran is an often overlooked but increasingly important player in the electricity sector. In recent years, it has increased its electricity plant capacity sharply — by 9.6 GW — so that it had an installed capacity of 82.7 GW in late 2019/early 2020.[144] Iran plans to export the additional volumes, become a

137 Mircea Ardelean and Philip Minnebo, *A China-EU Electricity Transmission Link: Assessment of Potential Connecting Countries and Routes* (Luxembourg: Publications Office of the European Union, 2017), 76—78, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/china-eu-electricity-transmission-link-assessment-potential-connecting-countries-and-routes.

138 Global Energy Interconnection Development and Cooperation Organization (GEIDCO), *Connotation of Global Energy Interconnection* (Beijing, October 2016), 15; ADB, ed., *Tajikistan: Power Sector Development Master Plan Final Report*, ADB Grant No: 0213-TAJ (Mandaluyong City, Philippines, February 2017), 19, 27, https://mewr.tj/wp-content/uploads/files/Power_Sector_Master_Plan-Vol1.pdf.

139 "Kyrgyzstan Hails 'Historic' China-financed Power Line", *chinapower.com.cn*, 31 August 2015, http://en.chinapower.com.cn/2015/08/31/content_2956.html.

140 "China to Restore Power Line between Uzbekistan and Tajikistan for $25 Million", *New Europe* (online ed.), 24 September 2020, https://www.neweurope.eu/article/china-to-restore-power-line-between-Uzbekistan-and-tajikistan-for-25-million/.

141 IEA, ed., *Chinese Companies Energy Activities in Emerging Asia* (Paris, April 2019), 9, https://www.iea.org/reports/chinese-companies-energy-activities-in-emerging-asia.

142 Farkhod Aminjonov et al, "BRI in Central Asia: Energy Connectivity Projects", *Central Asia Regional Data Review* 22 (2019): 1—14, http://osce-academy.net/upload/file/22_BRI_Energy.pdf.

143 Boute, *Energy Security* (see note 115), 95.

144 Robert Espey, "Iran Continues Power Plant Capacity Expansion", *GTAI*, 26 October 2020, https://www.gtai.de/gtai-de/trade/branchen/branchenbericht/iran/iran-setzt-ausbau-der-kraftwerkskapazitaeten-fort-569496.

major electricity exporting country, and in this way emerge as a regional hub for Middle East, the Caucasus, Southeast Asia and Central Asia.[145]

In Central Asia, Turkmenistan has been connected to the Iranian electricity grid since 2004. Since 2003, Turkmenistan's electricity grid has operated synchronously with Iran's, and the two countries trade electricity through the interconnectors.[146] Since 2018, another high-voltage transmission line has been under construction to significantly increase exports to Iran.[147] The discussed resynchronisation of Turkmenistan with the Uzbek (and thereby the Central Asian) electricity grid would involve Turkmenistan desynchronising from Iran. However, it would remain connected to the country via DC coupling. This would make Turkmenistan an electricity transit bridge and enable Iran to continue exchanging electricity with Central Asia as well as transferring electricity to and from this region.

Route intersection in the South Caucasus: Reorganisation through external centres – the EU, the EAEU, Turkey and Iran

Unlike Central Asia, the South Caucasus does not have a regional electricity infrastructure that could one day function independently of the electricity grids of external actors. Moreover, due to the geographical conditions, the realisation of intraregional electricity connections is even more intertwined with the interests and plans of competing centres of outside political power than is the case in Central Asia. In addition to the EU and Russia, Turkey and Iran also vie for influence in the region. Historical conflict lines within the South Caucasus moreover make its states particularly vulnerable to projections of external strength.

145 Simon Watkins, "Iran Is Building a Massive Energy Network to Boost Its Geopolitical Influence", *Oilprice.com*, 8 October 2020, https://oilprice.com/Energy/Energy-General/Iran-Is-Building-A-Massive-Energy-Network-To-Boost-Its-Geopolitical-Influence.html.

146 "Power Transmission Line Connects Turkmenistan, Iran", *New Europe* (online ed.), 29 August 2004, https://www.neweurope.eu/article/power-transmission-line-connects-turkmenistan-iran/.

147 "Energy Minister: Iran, Turkmenistan to Launch 2nd Power Line Soon", *Energy Central News* (online ed.), 30 March 2018, https://energycentral.com/news/energy-minister-iran-turkmenistan-launch-2nd-power-line-soon-0.

While this could change soon, China and its related BRI and GEI projects do not yet play a large role in the South Caucasus. At present, it is the EU and the EAEU that offer partly contradictory integration models and alternative sets of rules in the region. These rules overlap in an uncoordinated manner.[148] Both actors are pursuing the goal of regionalising and liberalising national electricity markets. The risk, however, could be that new regulatory-technological and normative fault lines emerge, and with them, greater political fragmentation. Nor should Turkey and Iran be neglected. Their importance is growing due to their support, as part of their respective regional expansion plans, for the establishment of transregional electricity corridors through the South Caucasus.[149]

Various interconnectors planned or under construction are intended to improve intra-regional electricity supply and at the same time connect the region to transregional electricity corridors that are also planned. These interconnectors are intended to complement and complete the Black Sea Energy Transmission Network along the east-west axis, a project supported by Georgia, Azerbaijan, Turkey and the EU. However, they intersect with two planned and partly competing electricity corridors: one connecting Iran, Armenia, Georgia and Russia, the other connecting Iran, Azerbaijan and Russia. These two corridors are in turn supported by Russia and Iran. The plans and strategies of Armenia, Azerbaijan and Georgia are thus closely intertwined with those of various external centres and are in effect largely determined by them.

Georgia joined the EU Energy Community as a full member in 2017. As a result, the country undertook regulatory reforms of its electricity market in line with the EU model. Following "rules before Joules", it implemented the requirements for unbundling, third-party network access, privatisation and price liberalisation. This in turn has enabled Georgia to diversify the sources of its electricity imports and reduce its dependence on Russia. Furthermore, the country plans to synchronise its electricity grid with the European continental grid. At the same time, Georgia wants to become a north-south/east-west electricity transit hub and export electricity. The synchronisation with the EU grid would be done through the Turkish grid. As part of the synchronised European continental inter-

148 Pastukhova and Westphal, *Eurasian Economic Union Integrates Energy Markets* (see note 110).

149 Ibid.

connection, Turkey therefore plays a crucial role both as an electricity sales market for Georgia and as a possible electricity transit bridge to Europe. The latter aligns with Turkey's geopolitical interest in becoming a regional electricity hub. Georgia's grid operator, Georgian State Electrosystem (GSE), is already cooperating with ENTSO-E.[150] And — like Turkey — it plans to become a regional electricity hub.[151] At the same time, Georgia is also developing its interconnectors with Armenia,[152] Azerbaijan[153] and Turkey[154] as part of the Black Sea Energy Interconnection.

Georgia will have to reconcile these plans with different and partly conflicting technical and normative sets of rules, however. In particular, synchronisation with the European grid would probably entail Georgia disconnecting from the Russian and Azerbaijani grids as well as from the IPS/UPS integrated electricity grid, so that connection with the latter would only be possible in asynchronous operation. Such a development could cause economic problems for the country. It could jeopardise grid stability in the transformation phase, for example, or make bilateral electricity trade with Russia and Azerbaijan more difficult. Geopolitical consequences are also conceivable, for example if Moscow decides to punish Georgia for its decision and the ensuing diminishment of Russian influence.

Armenia is in a similarly tight spot. It is the only country in the region with membership in the EAEU and, as such, the opportunity to participate in its future single electricity market. At the same time it has also had observer status in the EU Energy Community since 2011. When it joined the EAEU in 2015, however, Armenia lost its prospects of becoming a member of the EU Energy Community, a factor that gives rather limited value to its observer status. Armenia had planned to become a transit bridge between Iran and Russia, indirectly gaining access to the Turkish electricity market and diversifying its electricity supply.[155] These plans are thwarted in three ways: first, Georgia — but not Armenia — is now part of the European Energy Community; second, Armenia must participate in the single EAEU electricity market; and third, Armenia's grid is exclusively synchronised with Iran's grid.

In the case of Armenia, in addition to the EAEU, Iran is particularly important. At the moment, Iran remains Armenia's only market for electricity sales. Iran wants to export more electricity in all directions and is therefore very involved in efforts to bring two competing trans-Caucasian north-south corridors into operation. In 2016, Iran, Armenia, Georgia and Russia agreed on a roadmap for establishing a north-south electricity corridor, including expanding interconnector capacity and grid synchronisation by 2019.[156] But this has not yet begun.[157]

In addition, Iran announced in 2019 that it will participate in an alternative project that bypasses Armenia. This will further fuel intra-regional competition among electricity corridors. Since March 2019, Iran, Azerbaijan, and Russia have been negotiating the synchronisation of Iran's electricity grid with those of Azerbaijan and Russia.[158]

Turkey's radius for projecting strength is widening.

While the EU-EAEU competition for regulatory and technical integration has a negative impact on the regional infrastructurised space (especially of Armenia and Georgia), Iran has placed Azerbaijan at the

150 ENTSO-E, *"ENTSO-E Member Companies"* (webpage), https://www.entsoe.eu/about/inside-entsoe/members/.
151 GSE, *Cooperation with the Energy Community* (webpage), http://www.gse.com.ge/about-us/international-affairs/Cooperation-with-ENTSO-E.
152 Kreditanstalt für Wiederaufbau (KfW), "Zuverlässige Stromversorgung für Armenien", press release, Frankfurt, 9 December 2014, https://www.kfw.de/KfW-Konzern/Newsroom/Aktuelles/Pressemitteilungen-Details_249920.html.
153 Abdul Kerimkhanov, "Azerbaijan Lays New Electric Transmission Lines to Georgia, Iran", *Azernews* (online ed.), 10 October 2019, https://www.azernews.az/business/157074.html.
154 GSE, *International Affairs, Cross-Border Connections*, http://www.gse.com.ge/about-us/international-affairs.
155 Irina Kustova, *Regional Electricity Cooperation in the South Caucasus: Cross-Border Trade Opportunities and Regional Regulatory Uncertainties* (Brussels: Energy Charter Secretariat Knowledge Centre, 2016), 17, https://www.energycharter.org/fileadmin/DocumentsMedia/Occasional/Regional_Electricity_Cooperation_South_Caucasus.pdf.
156 "Armenia, Georgia, Iran, Russia Agree on 'Energy Corridor'", *Azatutyun.am*, 13 April 2016, https://www.azatutyun.am/a/27672792.html.
157 Alexandr Avanesov, "Experts from Armenia, Iran, Georgia and Russia to Discuss Technical Solutions for the Construction of the North-South Energy Corridor in Tehran", *ArmInfo*, 9 April 2019, https://finport.am/full_news.php?id=37997&lang=3.
158 "Iran's Power Grid to Connect to Russia via Azerbaijan: Energy Min", *MORE News Agency*, 6 March 2019, https://en.mehrnews.com/news/143143/Iran-s-power-grid-to-connect-to-Russia-via-Azerbaijan-energy.

centre of the north-south connections between the Russian and Iranian electricity grids. Azerbaijan also benefits along the east-west axis, namely from Turkey's new activism. Conditions were changed by the Second Karabakh War of autumn 2020, which resulted in a loss of Armenian territory and new border demarcations. For the first time, a land corridor across Armenia will connect Baku with the Azerbaijani exclave of Nakhichevan (the Nakhichevan corridor) — making it possible to establish direct infrastructural and economic links between Turkey and the territories reclaimed by Azerbaijan on the Iranian border. The link bypasses Georgia. This is just one of several indications that Turkey's radius for projecting power is widening — not only in the eastern Mediterranean and the Black Sea region but also to the South Caucasus. This new reality may moreover lead to a reordering of the regional electricity infrastructurised space.

A New Space of Connection and Competition

Of the larger region that links Europe and Asia, it can be said that Central Asia and particularly the South Caucasus — albeit under different conditions and to varying degrees — both show a high degree of dynamism in the development of electricity interconnectors. Regional reintegration attempts, the high degree of permeability in these two regions to political power and influence, and the increasing influence of new external actors (in addition to the traditional gravitational pull of Russia) are turning two formerly peripheral areas into fluid spaces of interconnection *and* competition in the electricity sector. In the process, there are areas of overlap at national, regional and transregional levels — especially involving network spaces, legal spaces and market spaces. Regional regulatory and institutional fault lines are emerging, or existing ones are solidifying. Significantly, both Central Asia and the South Caucasus are no longer exclusively subject to the influence of Russia. Rather, they are experiencing the pull of neighbouring centres of gravity to their east, west, and prospectively also their south. As a result, both are becoming part of a larger contiguous space that stretches from the Black Sea across the Middle East to the Indian Ocean and all the way to Greater Asia. This space, heretofore characterised by weak networks and incomplete connections, is just beginning to take on solid contours.

Greater Asia: South, Southeast and Northeast Asia

In the second half of the 20th century, Greater Asia was still considered a contested (maritime) periphery in which the great powers of the Cold War — the US the USSR, and later China — vied for power and influence. Since the beginning of the 21st century, this area has undergone major changes, however. Different dynamics are at work in the subregions of South Asia, Southeast Asia and Northeast Asia. The socioeconomic spheres and infrastructurised spaces that have emerged in the process reflect power shifts and the emergence of new centres of regional power. Whereas Soviet-Russia played a significant role in the infrastructural development of its allied countries in Southeast and Northeast Asia, such as Vietnam, North Korea and Mongolia, today Russia exerts little influence in these subregions. The US on the other hand has been able to maintain its position as an important external actor. It does so, among other things, by contributing to infrastructural development of South and Southeast Asia via international finance institutions and other finance initiatives.

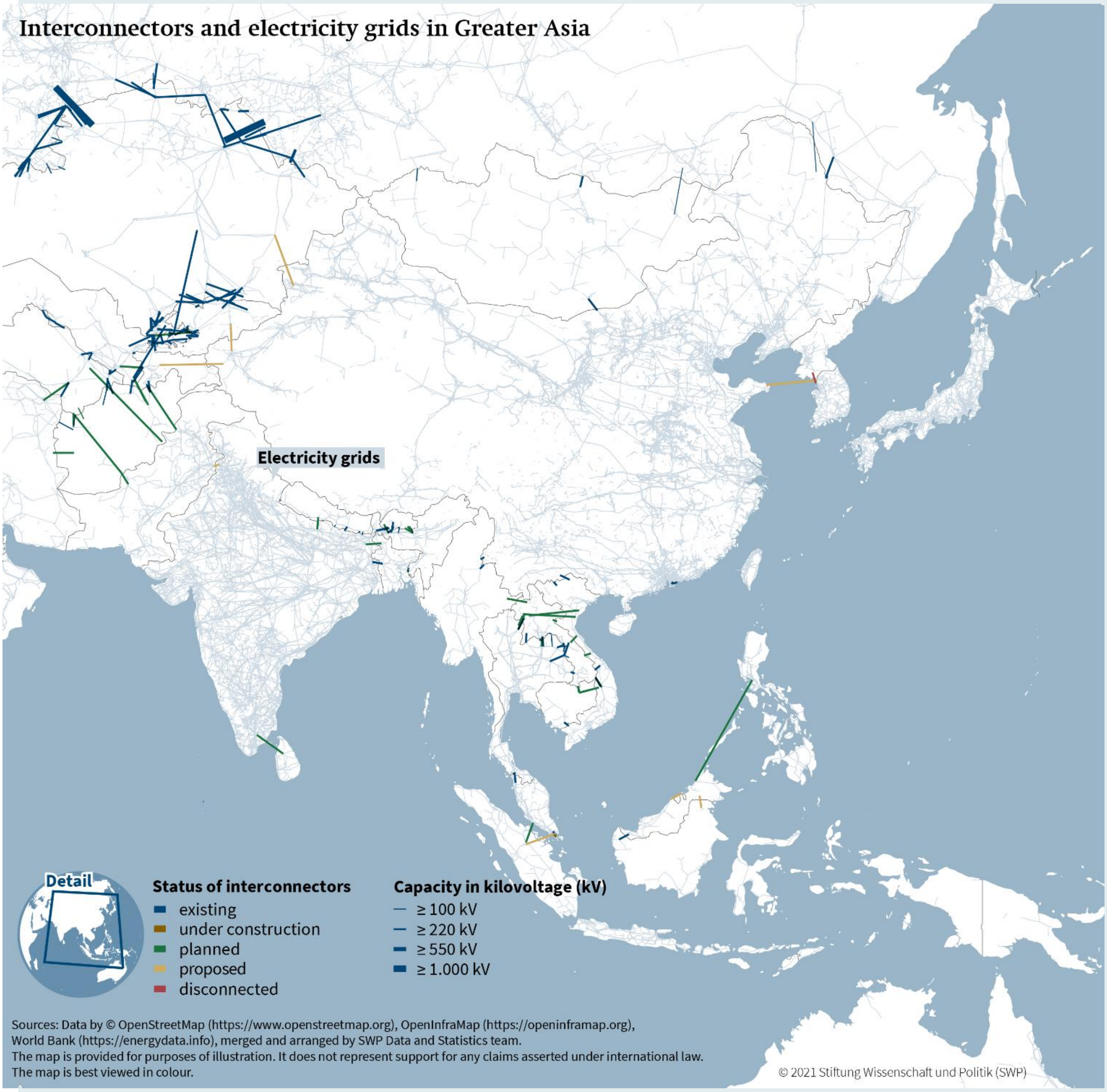
China's rise as a regional and continental powerhouse has been linked to the expansion of (and integration with) its national electricity grid.

China's economic and political rise to a regional and later continental powerhouse in the late 20th and early 21st centuries has been closely linked to the expansion of and integration with its national electricity grid. Since the 2010s, China has been pursuing a multi-vector interconnectivity strategy. This strategy aims to strengthen connectivity within the national electricity system by expanding HVDC lines and to promote the export of HVDC technology to other parts of Asia. To this end, China is investing not only in interconnectors with neighbouring countries but also increasingly in the expansion of national transmission lines of countries that are strategically important to BRI and GEI. Other Northeast Asian countries with densely interconnected network spaces, namely South Korea and Japan, have so far played a marginal role in promoting regional interconnectivity. Japan's rather passive stance derives from its isolated geography and its lack of a national connectivity strategy. The South Korean national connectivity strategy is meanwhile still in embryo.

Finally, India has emerged as a densely interconnected space and a new regional power centre for South Asia. The country is pushing for more regional interconnectivity both bilaterally and within various organisations for economic cooperation and integration. With the notable exception of Pakistan, all of the countries in South Asia are connected to India's electricity grid network via bilateral interconnectors. India has thus become an influential stakeholder shaping the vectors of interconnectivity; it aims to gradually develop an international integrated electricity grid in the region. For this purpose, the Nepali and Bangladeshi grids are to be synchronised with the Indian grid. The peripheral space belonging partly to India's traditional sphere of influence (Nepal and, to a lesser extent, Pakistan) and partly to China's (Myanmar, Cambodia) is thus claimed by both regional centres (see Map 7, p. 40).

In addition to geopolitical drivers, the socioeconomic development agenda continues to dominate regional connectivity efforts. The energy transformation is also becoming more important in this context; this is increasingly seen as integral to socioeconomic development but also as a tool for establishing technical and infrastructural superiority.

Map 7



Historical Review: Emergence of Infrastructurised Spaces and First Attempts at Integration

The history of the electricity system in Greater Asia dates back to colonial times, when the first lines were installed to increase the efficiency of industrial sites. A more intensive expansion of bilateral interconnectors did not take place until after decolonisation in the second half of the 20th century during an era that saw the gradual electrification and industrialisation of Asia. Interconnectors consisted mainly of cross-border low-voltage lines set up for purely practical reasons, such as to connect smaller generation sites in one country with demand sites in another country, if these were poorly connected to their own national grids.

The use of cross-border high-voltage transmission lines began in the 1970s. These were built as part of larger infrastructure projects, mostly hydropower plants, which were designed not only as economic but also as political cooperation projects. Indeed, hydropower remains one of the most important areas of cooperation between India and Bhutan, for example, as well as between Thailand and Laos and between Myanmar and the People’s Republic of China.

The expansion of both the respective national electricity grids and the interconnectors was largely paid for by multilateral development banks — above all the World Bank and the Asian Development Bank — but also directly by the USSR and the US in the course of their struggle for hegemony in Greater Eurasia. Both the USSR and the US continuously focussed on financing the development of the electricity system as part of critical infrastructure and the backbone of industrialisation. As a consequence, many coal and hydroelectric power plants, as well as the high-voltage transmission lines in Mongolia, Vietnam, North Korea, China, and to some extent India, are equipped with Soviet technology from the 1960s and 1970s. The extent of Soviet presence is particularly evident in the electricity system of Mongolia and North Korea. After 1990, when such financial assistance and technology transfer ceased, bringing North Korea’s electricity system to the point of collapse. Mongolia’s electricity system, which had been steadily expanding since the early 1960s, took a nosedive beginning in 1990; electricity generation did not reach pre-crisis levels until the mid-2010s. The oldest bilateral interconnectors in Northeast Asia, namely between Mongolia and Russia[159] and between China and Russia, were also largely financed by the USSR.

US government involvement in the Asian electricity system began during reconstruction after the Second World War. Support for national governments in Asia in the electricity sector has since then been a central feature of both US bilateral assistance programs and the American-dominated Bretton Woods international financial institutions.[160] For decades, the World Bank’s largest single activity was electricity system lending. By about 1980, some 40 percent of its total lending for electricity sector had gone to South Asia and East Asia.[161] US involvement through via agencies such as USAID or the Millennium Challenge Corporation (MCC) is still visible today, especially in the infrastructurised space of Southeast Asia.

The first subregional attempts at electricity connectivity integration occurred in the 1980s within the framework of regional integration associations. In Southeast Asia, an association of electricity utilities (Heads of ASEAN Power Utilities/Authorities, HAPUA) was established in 1981 under the auspices of the Association of Southeast Asian Nations (ASEAN), with the main objective of developing regional electricity grids. Although economic integration in South Asia has also progressed with the help of ASEAN’s regional counterpart — the South Asian Association for Regional Cooperation (SAARC) — connectivity in the electricity system is mainly still being pursued bilaterally. In Northeast Asia, cooperation on electricity grid connectivity remains in a preliminary stage. Discussions on the establishment of a regional electricity grid have been underway since the mid 1990s, but ideas have only been partially implemented since the late 2010s as part of China’s GEI connectivity strategy (see Map 1, p. 12).

New “Integration Wave” – New Power Relations

Infrastructurised spaces in South Asia: India as the starting point for subregional electricity grid connectivity

The further development of bilateral relations in South Asia gained new momentum in the 2010s, when several bilateral HVDC lines between India, Bangladesh, Bhutan and Nepal became operational. India took the lead in this regard. India’s conflicted pre- and post-colonial history, multiple territorial claims and de facto position as a regional hegemon complicate further progress in promoting regional connectivity cooperation. However, the combination of socioeconomic and geopolitical drivers has led to an accelerated integration of South Asia’s infrastructurised spaces. On the one hand, it is being pushed by

159 G. V. Lukina and G. Tumannast, “Sostoyanie Elektroenergetiki Mongolii” [The State of Mongolia’s Electricity Sector], *Westnik IrGTU* 53, no. 6 (2011): 127—29, https://cyberleninka.ru/article/n/sostoyanie-elektroenergetiki-mongolii/pdf.

160 James H. Williams and Navroz K. Dubash, “Asian Electricity Reform in Historical Perspective”, *Pacific Affairs* 77, no. 3 (2004): 411—36.

161 Hugh Collier, *Developing Electric Power: Thirty Years of World Bank Experience* (Baltimore and London: Johns Hopkins University Press [for the World Bank], 1984), 19, http://documents1.worldbank.org/curated/pt/446371468740393127/pdf/multi-page.pdf.

the economic growth and rising electricity demand of the countries involved — most notably India itself. On the other hand, regulatory reforms in the Indian jurisdiction contributed to this development; in 2016 and 2019, India adjusted its electricity import-export guidelines to encourage cross-border electricity trade.[162]

China's influence in the region has also grown significantly over the past few years, largely due to the scope of BRI in South Asian countries. This has created a sense of urgency on India's part to strengthen regional infrastructural, regulatory and institutional linkages across strategically important sectors, of which interconnectivity is one.

The lynchpins here are India-Nepal electricity trade and India's involvement in Nepal's electricity system. Although Nepal has huge hydropower potential and aspires to become the "battery of South Asia", the country is currently a net importer of electricity, with about half of its electricity supply coming from India. Nepal's hydropower growth has been hampered by slow execution and a slow — at times paralysed — decision-making process. In addition, Nepal's electricity grid is weak, and its electricity demand is relatively low. In 2014, the governments of Nepal and India signed an agreement to enable cooperation in the electricity system, including via development of transmission networks and electricity trading.[163] But due to the India-Nepal border conflict of 2015 and the subsequent humanitarian crisis in Nepal, the agreement has yet to yield visible results. Only in recent years has the bilateral energy dialogue regained momentum; in October 2019, another agreement was signed to build a new cross-border transmission line, to be followed by the synchronisation of the Nepali and Indian electricity grids.[164] This project is still at a proposal stage, however, and is hampered by unresolved land acquisition issues and, above all, by geopolitical tensions involving not only India but also China and the US.

The project is planned with 20 percent equity and 80 percent debt, the latter largely provided by the Nepal Compact.[165] This is an agreement between the Nepalese government and the US-backed MCC to finance electricity grid infrastructure and road projects of strategic importance, with US$500 million earmarked for this purpose. The Compact has yet to be approved by Nepal's parliament due to internal party conflicts and divided public opinion. Many see the Compact as part of the US Indo-Pacific policy to counter China's BRI. This puts Nepal in a precarious position, as it is also involved in the planning of a cross-border twin electricity line with China, in parallel with its negotiations with India. The recent border tensions in the Kalapani region (an area claimed by India and Nepal) have further aggravated the situation.

Connectivity cooperation with Bangladesh occupies a special place in India's regional efforts, as the country plays a key role in connecting India's northeast to the "mainland". India's eight northeastern states — which are otherwise connected to the rest of the country via a slender 22-kilometre-wide corridor known as India's "Chicken's Neck" — are home to a population of over 45 million. These states share a border with Myanmar and are central to India's Look/Act East Policy. This policy aims for India to cultivate comprehensive economic and strategic relations with the nations of Southeast Asia in order to bolster its position as a regional power and counter China's strategic influence. After India and Bangladesh signed the Power Sector Cooperation Agreement in 2010, the first interconnector was established in 2013 and expanded in 2019.[166] India's Palatana power plant, itself a symbol of cooperation between the two countries, is a prominent part of bilateral electricity relations. While electricity supplies from India help solve

162 Nitin Kabeer, "Cross-Border Power Trading Can Be the New Frontier for Solar Growth", *MERCOM India*, 19 March 2019, https://mercomindia.com/cross-border-trade-solar-growth/.

163 Government of Nepal and Government of India, *Agreement between the Government of Nepal and the Government of the Republic of India on Electric Power Trade, Cross-border Transmission Interconnection and Grid Connectivity* (Kathmandu, 21 October 2014), https://www.moewri.gov.np/storage/listies/May2020/pta-english-21-oct-2014.pdf.

164 Prahlad Rijal, "Nepal, India Agree to Build New Butwal-Gorakhpur Transmission Line with Equal Equity Investment", *The Kathmandu Post* (online ed.), 15 October 2019, https://kathmandupost.com/money/2019/10/15/nepal-india-agree-to-build-new-butwal-gorakhpur-transmission-line-with-equal-equity-investment.

165 Millennium Challenge Corporation, *"Nepal Compact"* (webpage), https://www.mcc.gov/where-we-work/program/nepal-compact.

166 Government of the People's Republic of Bangladesh, *Power and Energy Sector: Multi-Year Public Investment Programme (MYPIP)* (Programming Division, Planning Commission, Ministry of Planning, March 2018), https://plandiv.portal.gov.bd/sites/default/files/files/plandiv.portal.gov.bd/publications/20cbd3b3_9ef2_4c74_84b0_103813ae36fc/MYPIP-P&E.pdf.

the problem of electricity shortage in the eastern part of Bangladesh, Bangladesh for its part ensures smooth transportation of heavy project equipment and turbines to Palatana through its territory by land and water from Haldia port in West Bengal.[167] In September 2018, the two countries also agreed to construct transmission lines in a synchronous mode to ensure smooth electricity exchange.[168] Combined with the envisioned synchronisation of Nepali and Indian electricity grids, this is expected to form the first multilateral synchronised electricity grid in South Asia.

India’s cooperation with Bhutan in the hydropower sector has meanwhile reached a new level since the mid-2010s. Underpinning this is the intergovernmental agreement on the development of joint venture hydropower projects. Several new cross-border HVDC lines at a total cost of around US$310 million are projected to offload electricity from various proposed hydropower projects in the Himalayan country.[169] In 2019, India and Bhutan signed ten MoUs agreeing in in principle to broader cooperation in energy, space, IT, aviation and education. These laid a new foundation for bilateral cooperation on connectivity.[170] Although India has recently been running a surplus in electricity generation and has even recorded some small exports to Bangladesh and Nepal, its demand for Bhutan’s hydropower is expected to increase. In fact, India sees this as an essential part of its plans to aggressively expand wind and solar power generation capacity — if not for the base load, then certainly to cover the vast balancing power requirements for grid stability.

India’s historically tense relations with Pakistan have a special place in India’s regional integration efforts. Efforts to advance electricity grid connectivity between the two countries have traditionally had a strong security component. The first project, proposed by India in 1998, envisaged power imports from Pakistan but was abandoned largely because both sides failed to reach an agreement on tariffs. Since then, a new project has been under discussion — this time to supply electricity from India to Pakistan’s power-hungry demand centres. In March 2014, a draft was presented of the basic agreement that had been prepared by the energy ministries of the two states. Admittedly, no further concrete bilateral steps have been taken since. It nonetheless appears that at least the Indian side sees a synchronous connection of Pakistan’s electricity grid to India’s electricity market via a multilateral regional grid as a way to solve bilateral security and electricity trade issues.[171]

Other Asian powers are also interested in Pakistan’s electricity and energy sector, which gives Pakistan some leverage over India. While India has so far been unsuccessful in kicking off bilateral cooperation, Japan and especially China are emerging as new players. In 2017, Japan agreed to a loan of US$24 million to enable the implementation of the Islamabad—Burhan Transmission Line Reinforcement project, which will more than triple current electricity supply.[172] In the context of the China-Pakistan Economic Corridor (CPEC) — a key component of the BRI, with the primary goal of eventually securing China’s access to Pakistan’s Gwadar Port — 20 out of 51 bilateral agreements are related to energy (as of 2018). The construction of five electricity generation projects has already begun. Under the CPEC, China is also financing and developing a HVDC line between power-hungry Lahore and coal-fired power plants in south-

167 “Tripura to Supply Additional 60 MW to Bangladesh”, *Business Standard* (online ed.), 4 March 2017, https://www.business-standard.com/article/news-ians/tripura-to-supply-additional-60-mw-to-bangladesh-117030400306_1.html.

168 Prahlad Rijal, “Nepal Likely to Export Power to Bangladesh Using Indian Grid”, *The Kathmandu Post* (online ed.), 16 October 2019, https://kathmandupost.com/money/2019/10/16/nepal-likely-to-export-power-to-bangladesh-using-indian-grid#:~:text=Prahlad%20Rijal&text=Nepal%2C%20India%20and%20Bangladesh%20are,power%20through%20India’s%20transmission%20network.

169 Government of India, Ministry of Power, International Cooperation, *Interconnection with Neighbouring Countries*, https://powermin.gov.in/en/content/interconnection-neighbouring-countries.

170 “India, Bhutan Vow to Strengthen Ties, Ink 10 MoUs”, *The Hindu* (online ed.), 17 August 2019, https://www.thehindu.com/news/national/pm-modi-inaugurates-mangdechhu-hydroelectric-power-plant-in-bhutan/article29120270.ece.

171 “SAARC Countries Planning to Set Up Common Power Grid”, *Financial Express*, 12 September 2014, https://www.financialexpress.com/archive/saarc-countries-planning-to-set-up-common-power-grid/1288066/. See also *Building Peace through Trade. The Future of India-Pakistan Trade & Economic Relations* (Jaipur: CUTS International, 2013), 55.

172 Embassy of Japan in Pakistan, “Japan Provides 2.665 Billion Yen for Islamabad and Burhan Transmission Line Reinforcement Project”, press release, Islamabad, 4 May 2017, https://www.pk.emb-japan.go.jp/itpr_en/00_000159.html.

ern Pakistan.[173] Should India seek connectivity with Pakistan on a model similar to its connectivity with Nepal or Bangladesh — i.e., interconnection with further synchronisation — it will likely have to open its market to electricity produced in various projects under CPEC and also within the aforementioned Central Asia South Asia (CASA-1000) project as well. This applies to India's role as an importer as well as a transit country to Bangladesh, Myanmar and beyond.

In recent years, China has increased its presence in another "difficult" neighbour of India: Sri Lanka. Even before it launched the BRI, China had started investing in Sri Lanka's energy sector, namely coal-fired power plants. In 2017, China continued its efforts by proposing to finance a plant powered by liquefied natural gas.[174] In the context of China's increased presence, India intensified its own negotiations with Sri Lanka on a cross-border electricity line, which has been under consideration since 1970. The interconnector under discussion would link the southern Indian district of Madurai with Sri Lanka's North Central province and would also allow Sri Lanka access to electricity exports from Nepal and Bhutan.

Along with India's efforts towards interconnectivity with adjoining countries, transregional connectivity is also gaining importance.

In addition to India's efforts to push interconnectivity with the countries bordering its own infrastructurised space, it is also giving more attention to transregional connectivity. Since India unveiled its Look/Act East Policy in 2014, Southeast Asian countries, and Myanmar in particular, have gained strategic importance. The first India-Myanmar interconnector was commissioned in 2016. Furthermore, when senior Indian officials delivered medical supplies to Myanmar in October 2020 to combat the Covid-19 pandemic, the two countries reached a general agreement to further strengthen their partnership in capacity building, electricity and energy as well as to deepen economic and trade ties. Among other things, discussions were held on establishing a high-capacity high-voltage transmission line. Discussions also advanced on the construction of low-voltage radial transmission lines connecting India's north-eastern provinces with Myanmar.[175]

Parallel to various bilateral cooperation initiatives, multilateral efforts to bolster regional and transregional connectivity in South Asia's electricity system intensified, especially in recent years. However, when it comes to efforts taking place within the framework of the largest regional forum, SAARC, India's dominant role is more of a hurdle than a driver. Due to the volatile and uncertain political climate and, not least, the strained political relations among some member countries (particularly India, Pakistan and Afghanistan), SAARC has been a forum based on the principle of unanimity and its many decisions have been of a non-binding nature from its inception. The inherent inertia of SAARC processes is also reflected in the electricity sector.

In contrast, smaller cooperation formats specifically designed for cooperation in the economic and infrastructure sectors, show a more dynamic development. For example, both the Bangladesh, Bhutan, India, Nepal (BBIN) integration initiative established in 1996 and the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) founded in 1997 were revived in late 2010s through newly launched connectivity projects. Plans under discussion within BBIN include trilateral power trade involving Bangladesh, Nepal and India. As a starting point, the Bangladesh-Nepal cooperation agreement signed in August 2018 envisages power exports from Bangladesh to Nepal. Here, India would act as a transit country and allow Nepali electricity flows access to its transmission system.

Cooperation in the electricity sector as part of BIMSTEC was initiated by India. In 2016 it convened the BRICS-BIMSTEC Leaders' Retreat, which brought together heads of state from BIMSTEC member countries (Bangladesh, Bhutan, India, Myanmar, Nepal, Sri Lanka, and Thailand) with leaders from the BRICS

173 China Pakistan Economic Corridor (CPEC), *"Matiari to Lahore ±660kV HVDC Transmission Line Project"* (webpage), http://cpec.gov.pk/project-details/17.

174 World Bank, ed., *Sri Lanka. Energy InfraSAP: Final Report*, Report no. AUS0000803 (Washington, D.C., April 30, 2019), http://documents1.worldbank.org/curated/en/843901561438840086/pdf/Sri-Lanka-Energy-Infrastructure-Sector-Assessment-Program-Executive-Summary.pdf.

175 Dipanjan Roy Chaudhury, "India, Myanmar Achieve Concrete Outcomes in Energy, Security, Connectivity and Health Sectors", *The Economic Times* (online ed.), 5 October 2020, https://economictimes.indiatimes.com/news/politics-and-nation/india-myanmar-achieve-concrete-outcomes-in-energy-security-connectivity-and-health-sectors/articleshow/78497185.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst.

(Brazil, Russia, India, China, South Africa). During the retreat, the decision was taken to initiate the BIMSTEC Grid Interconnection.[176] BIMSTEC is also working closely with the South Asia Regional Initiative for Energy Integration (SARI/EI), which is funded by the US development agency USAID and aims to promote regional electricity grid integration and cross-border energy trading in eight South Asian countries.[177]

Finally, in 2018, India’s Prime Minister Narendra Modi announced another integration initiative: One Sun, One World, One Grid (OSOWOG). It aims to create a global ecosystem of interconnected renewable energy resources, primarily solar power. As such, it appears to be India’s “green answer” to China’s GEI, which has similar goals and timeframes and is designed in a similar way. The OSOWOG concept is also in line with India’s “Make in India” policy,[178] with its focus on creating a domestic manufacturing base, including for solar and electricity transmission equipment. Some international organisations, including the International Solar Alliance and the World Bank, have welcomed India’s connectivity vision. Indeed, the Indian government has now signed a letter of intent with the latter to develop an initial feasibility study and proceed with implementation. The initiative also occupies a central position in recently established bilateral cooperation dialogues on connectivity, such as those between the UK and India[179] and between India and the EU.[180] Finally, OSOWOG seems to be a logical addition to (or continuation of) the Build Back Better World (B3W) initiative established at the 2021 G7 summit, as it could help B3W gain credibility in the Global South.

Peripheral connectivity: Southeast Asia’s institutionalised but diffuse infrastructurised space

India and (to a much greater extent) China are increasingly engaged as regional powerhouses in Southeast Asia’s electricity system. However, interconnectivity in this subregion has advanced almost exclusively on a bilateral basis albeit within the subregional institutional framework of ASEAN and such forums as the Greater Mekong Subregion (GMS) and the Brunei Darussalam — Indonesia — Malaysia — Philippines East ASEAN Growth Area (BIMP-EAGA). With the exception of Vietnam and Cambodia, which operate in a synchronous mode, the national electricity grids of Southeast Asian countries are not synchronised with each other. Overall, the region continues to be a diffuse space without clear political power centres. At the same time it boasts dynamic infrastructural and institutional development.

So far there are nine high-voltage electricity lines in Southeast Asia: between Cambodia and Vietnam; Indonesia and Malaysia; Laos and Vietnam; Malaysia and Singapore; Malaysia and Thailand; and between Thailand and Cambodia. In addition, another 16 electricity lines are planned, all linked to the concept of the ASEAN Power Grid, which was introduced in 2007.[181] This concept provides countries with a vision and a broad regulatory framework, but negotiations and planning for interconnectors continue to take place largely bilaterally between the governments and the respective state-owned utilities. One exception so far has been the trilateral talks involving Thailand, Laos and Malaysia, which led to the first trilateral power purchase agreement in 2017. Under it, Malaysia is to import electricity from Laos via Thailand.

Another subregional organisation has developed alongside ASEAN — namely the aforementioned GMS. It aims to foster the economic development of the countries sharing Mekong River resources: Cambodia, Laos, Myanmar, Thailand, Vietnam and the

176 Government of India, Ministry of Power, *Memorandum of Understanding for Establishment of the BIMSTEC Grid Interconnection* (BIMSTEC Leaders’ Retreat, 2016), https://powermin.nic.in/en/content/memorandum-understanding-establishment-bimstec-grid-interconnection.

177 ADB, Asia Regional Integration Center, *“South Asia Regional Initiative for Energy Integration (About)”*, https://aric.adb.org/initiative/south-asia-regional-initiative-for-energy-integra tion#:~:text=South%20Asia%20Regional%20Initiative%2FEnergy’s,India%2C%20Pakistan%2C%20Nepal%2C%20Sri.

178 Make in India, “About Us” (webpage), http://www.makeinindia.com/about.

179 Government of India, *Roadmap 2030 for India-UK Future Relations Launched during India-UK Virtual Summit* (4 May 2021), https://www.mea.gov.in/bilateral-documents.htm?dtl/33838/Roadmap+2030+for+IndiaUK+future+relations+launched+during+IndiaUK+Virtual+Summit+4+May+2021.

180 European Commission, *EU-India Connectivity Partnership* (Brussels, 8 May 2021), https://www.consilium.europa.eu/media/49508/eu-india-connectivity-partnership-8-may-2.pdf.

181 ASEAN, *Memorandum of Understanding on the ASEAN Power Grid* (Singapore, 23 August 2007), https://policy.asiapacificenergy.org/sites/default/files/Memorandum%20of%20Under standing%20on%20the%20ASEAN%20Power%20Grid.pdf.

Chinese provinces of Guangxi and Yunnan. In 2002, an intergovernmental agreement on regional electricity trade was adopted by the GMS member states. The development of the regional electricity market is envisaged to take place in four stages, from bilateral electricity transactions to a liberalised regional electricity market.[182] Despite progress made in the first decade after 2000, the detailed regulatory framework for the subregion is yet to be developed.

Cooperation on electricity grid connectivity among the island states of Southeast Asia is being pushed mainly bilaterally but along the lines of the BIMP-EAGA integration initiative, which was established in 1994.[183] One of the completed priority projects is the first between Indonesia and Malaysia, the Trans-Borneo Power Grid Sarawak-West Kalimantan line, commissioned in 2016.

Even though Southeast Asia has more or less been left to itself in promoting cross-border connectivity and integrating the subregional infrastructurised space, China is taking an increasingly prominent role in developing national electricity grid infrastructure for the subregion's respective member states. Even before it launched the BRI, China was one of the most important trade and investment partners for its Southeast Asian neighbours Myanmar, Laos, and Vietnam, investing heavily in local electricity generation capacity — mostly hydropower but also coal and nuclear power.[184] Chinese companies are now involved in electricity generation projects in all ASEAN countries, with the Chinese electricity industry providing the full supply chain, from planning and design through equipment supply and construction, and often including operation and maintenance. China is also heavily involved in developing Cambodia's electricity grid. Chinese companies developed most of Cambodia's transmission lines, with the newest one inaugurated in 2017. In the Philippines, China's State Grid Corporation holds a 40-percent stake in the National Grid Corporation of the Philippines (NGCP), which operates the country's entire electricity transmission network. This has led to many domestic political disputes in the Philippines, as the electricity grid is increasingly perceived as a matter of national security.

Much like India, China is striving for increased infrastructural connectivity with the subregion. In contrast to India, however, China has been much more efficient on the implementation front, partly thanks to China's historically close political and socioeconomic ties with its southern neighbours. In addition to interconnectors with Laos, China has three interconnectors linking it to Myanmar and five to Vietnam.

Northeast Asia: Coalition of the unwilling and China's "integration push"

In Northeast Asia, bilateral electricity trade is conducted via the respective bilateral interconnectors between Russia and Mongolia and between Russia and China, which have existed since Soviet times and were expanded in the first decade after 2000. However, the existing interconnectors have low capacity and, apart from the electricity mix in Mongolia, they have no significant impact on the energy balance in the region.

Northeast Asia's interconnectivity potential has been discussed in various forums for over three decades.[185] Numerous bi-, tri- and multilateral interconnection proposals of regional and transregional scale have been developed by national research institutions and in collaboration with international organisations such as the Asian Development Bank (ADB) and the Energy Charter. The most technically advanced initiative proposals are the Asian Super Grid (ASG), the North-East Asian Power System Interconnection (NAPSI) and the North-East Asia Energy Interconnection (NEAEI). All three aim to create a regional transmission grid powered in part by the electricity generated in the windy, sun-rich areas of the Gobi Desert in Mongolia (Gobitec). Until the mid-2010s, however, the numerous visions of connectivity did

182 Ramesh Ananda Vaidya et al., "Electricity Trade and Cooperation in the BBIN Region: Lessons from Global Experience", *International Journal of Water Resources Development* 37, no. 3 (2021): 439—65, https://www.tandfonline.com/doi/pdf/10.1080/07900627.2019.1566056?needAccess=true.

183 "BIMP-EAGA: Turning Remote, Isolated Areas into Economic Engines", *ADB News*, 24 June 2019, https://www.adb.org/news/features/bimp-eaga-turning-remote-isolated-areas-economic-engines.

184 Tian-tian Feng et al., "Electricity Cooperation Strategy between China and ASEAN Countries under 'The Belt and Road'", *Energy Strategy Reviews* 30 (2020): 1—20, https://www.sciencedirect.com/science/article/pii/S2211467X20300651.

185 Economic and Social Commission for Asia and the Pacific (ESCAP), ed., *Regional Power Grid Connectivity for Sustainable Development in North-East Asia: Policies and Strategies* (New York: United Nations, December 2020), https://www.unescap.org/resources/regional-power-grid-connectivity-sustainable-development-north-east-asia.

not move beyond academic discourse — hampered by the historically tense political situation, the lack of an institutional framework and the need to first integrate national electricity grids.

The high-level cooperation on electricity grid connectivity was initiated by a MoU signed in 2016 by SoftBank Group (Japan), State Grid Corporation of China (SGCC), South Korea’s Korea Electric Power Corporation (KEPCO) and PJSC Rosseti (Russia). The stakeholders committed to jointly exploring opportunities for an interconnected electricity grid in Northeast Asia. A year later, another MoU was signed: KEPCO and SGCC and the Chinese company Global Energy Interconnection Development and Cooperation Organisation (GEIDCO) expressed their intent to build a submarine interconnector between China and South Korea, with construction planned to begin in 2022.

Political factors are the biggest obstacle to promoting cooperation on electricity grid connectivity in Northeast Asia.

So far, however, these intentions are only on paper. Political factors are the biggest obstacle to promoting cooperation on electricity grid connectivity in this subregion. One factor complicating potential cooperation is that North Korea is not participating in any of the current discussions on electricity grid connectivity — although it is an integral part of most proposed region-wide interconnection projects. Indeed, to connect the wind and hydropower potential of Russia’s Far East to South Korea and possibly Japan as cost-effectively as possible, transmission lines would have to pass through North Korea. Another factor is that the Japanese government has so far been reluctant to engage in high-level cooperation — although SoftBank, one of Japan’s three largest telecommunications companies, is willing to invest in the proposed Asian Super Grid. Among the reasons for Tokyo’s reluctance are security concerns regarding electricity grid integration and the resulting potential dependence on Chinese or South Korean electricity systems. In addition, the Japanese government fears political manipulation of electricity trade, which might be the case for example if the regional interconnection were to run through North Korean territory. A more technical reason for Tokyo’s hesitation is that Japan’s electricity grid itself is not yet integrated well enough.

Russia for its part has only a moderate interest in the above connectivity initiatives. While it participates in the high-level talks, it does not claim regional leadership. The Siberian and Far Eastern grids bordering China and Mongolia have excess electricity generation capacity, and Russia could profit from boosting its electricity exports. However, bilateral formats seem sufficient for achieving this. So far, Russia seems to place little emphasis on developing its rich hydroelectric and wind resources in the region for bulk electricity transmission to neighbouring Northeast Asian countries.

Given Russia’s rather unmotivated approach and Japan’s great caution towards regional electricity grid integration, China has taken the lead in regional connectivity efforts. Along with China, Mongolia is also keenly interested in strengthening regional electricity connectivity. It hopes to boost its own economic growth via exports of renewable electricity from the Gobi Desert and to thereby bolster its own position in the region vis-à-vis both Russia and China. South Korea also supports regional cooperation; in addition to its long-term ambition to be the “bridge” between Japan and the Eurasian continent, it hopes to increase the share of renewable electricity in its own electricity mix through increased connectivity. At the same time, it also hopes to stabilise its own electricity grid.

According to the connectivity visions described above, the legal-regulatory spaces are to remain unchanged. This is because, in the short to medium term, they envision only bilateral, treaty-based trade formats. In the long term it is likewise hard to picture a “community of shared destiny” in this subregion. The area’s fraught history and on-going security concerns are likely to prove impediments to realising strong interconnectivity in the future.

Greater Asia thus continues to represent a patchwork landscape grouped around several centres. It is in a state of continuous development. The political-regulatory spaces are still defined by territorial jurisdiction — i.e., national borders. But in some cases, the political-regulatory level no longer coincides with the market level. Cross-border electricity trade mainly takes place within bilateral agreements, although the first trilateral models are also emerging.

At the technical-operational level, differences can be observed between the two regional centres of India and China. India pursues interconnectivity with neighbouring countries as a “natural” extension of its national infrastructurised space. It does this both by developing bilateral interconnectors and through efforts to extend its own network space by fostering synchronisation with Nepal's and possibly also Bangladesh's integrated electricity grids.

While China is also participating in the development of interconnectors with its immediate neighbours, such as Mongolia and Myanmar, it is investing more in the development of national electricity infrastructures for strategically important countries on its periphery, such as Pakistan, Cambodia, and Nepal. China's interconnectivity vectors are therefore much less "linear", but they are by no means arbitrary. They are firmly anchored in the BRI, with its growing emphasis on electricity grid connectivity. This can be observed not only within the GEI but also with the newly initiated Belt and Road Partnership for "Green Development", which China established shortly after the 2021 G7 summit in response to B3W. It has so far been signed by 29 BRI countries.[186]

Southeast Asia remains a peripheral subregion, but it is the most dynamic one in terms of regulatory development. The first cross-border legal-regulatory spaces are beginning to emerge within the framework of regional integration institutions, especially ASEAN and HAPUA, underlining the indispensable role of institutions in developing a "community of shared destiny".

Especially in South Asia and Northeast Asia, the energy transformation is becoming an important driver.

Especially in South Asia and Northeast Asia, the energy transformation is becoming an important driver. In the medium term, India sees imports of hydroelectric power from neighbouring countries as an important stabilising factor for further expanding its own variable renewable energy sources, namely solar and wind. In Northeast Asia, the currently dominant visions for regional interconnectivity centre on the idea of renewable energy exports from the Gobi Desert. In light of the CO_2 neutrality targets announced by China, Japan and South Korea in the fall of 2020, one can expect electricity grid connectivity in Northeast Asia to gain momentum in the coming years.

186 People's Republic of China, Ministry of Foreign Affairs, "Initiative for Belt and Road Partnership on Green Development", Communiqué, Beijing, 24 June 2021, https://www.fmprc.gov.cn/mfa_eng/wjdt_665385/2649_665393/t1886388.shtml.

Conclusions and Recommendations

Five Conclusions

This study offers five conclusions.

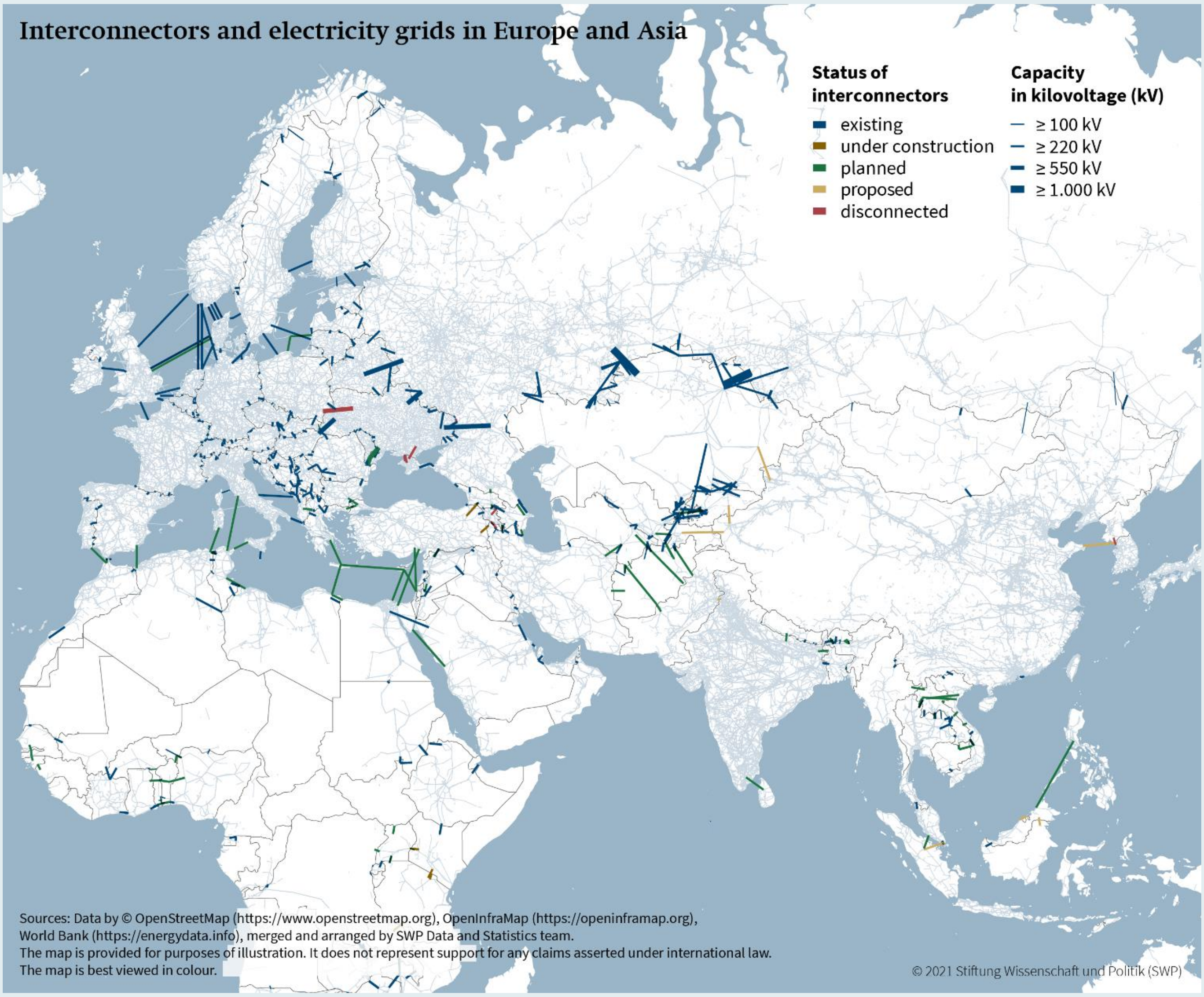
1. The geopolitical significance of electricity interconnections not only persists. It is gaining in importance. The Europe-Asia continental area boasts highly dynamic interconnectivity. It is growing together via electricity grids. And it is expanding into Africa as well as South Asia and Southeast Asia (see Map 8, p. 50). Although connectivity is centred on the "land bridge" between Europe and China, the network is also expanding into maritime areas.

2. Established "centres of gravity" such as the EU and Russia are still significant, but new ones are emerging as well, and they competing with each other for influence. These include China, Turkey and Iran. India is also gaining importance. Within the current landscape, the European continental electricity system and synchronous area forms a highly integrated and attractive centre that has grown historically and has been developed on several levels. Inclusion in this synchronized interconnected grid ties and connects neighbouring countries to the EU. The density of electricity infrastructures — but also the density of political, economic and social transactions — is visible in the European "centre", though it does decrease towards the continental and maritime peripheries. In the past, integration into the European electricity grid community was seen as a precursor to EU accession. Today, participation in the electricity community serves as the EU's "forecourt". Moreover, the high degree of integration and institutionalisation of the EU's electricity areas makes it a model for others. At the same time, the regulatory, organisational and structural challenges to jointly operating and managing the grid and the market are growing considerably. As a result, the hurdles for synchronisation are becoming ever higher, and the demarcation from other areas is deepening.

In contrast, China is pursuing a strategy of continental connectivity (or connectivity from and to China) that extends beyond existing flow spaces as part of its Belt and Road Initiative (BRI). Especially in the South Caucasus and Central Asia, infrastructurised spaces are being reorganised by reactivating and expanding intraregional and transregional interconnectors. But the level of infrastructural densification and socioeconomic transactions in the region remains low; institutional and technical-regulatory levels are still largely defined in terms of national territory; and the regional market and trade remain underdeveloped. Geopolitical motives and lines of conflict are major factors shaping developments in the South Caucasus and Central Asia. Russia's technical and regulatory influence is still strong — a legacy of the USSR — but Moscow is no longer the sole driver of regional integration processes. China, Iran, Turkey, not to mention the EU, are all expanding their spheres of influence at the techno-political and techno-economic levels. They do so to varying degrees through the transfer of rules, norms and standards. This is increasingly transforming the South Caucasus and Central Asia — two areas that were once considered "peripheral" — into a competitive, interconnected space. The European electricity grid network and the EAEU rely on an institutionalised transfer of rules and standards; in contrast, Chinese norms, standards and technologies are diffused on an ad hoc basis to serve particular interests — and thus in a manner that is far less transparent but far more subtle.

Finally, several connectivity hubs have emerged in *Greater Asia – most notably* China and India. Especially in recent years, these have driven the consolidation of regional infrastructurised spaces. The political-regulatory level in Greater Asia is still defined by territorial jurisdiction within national borders; the first multilateral trade agreements are only beginning to emerge.

Map 8



3. The connectivity environment of the Europe-Asia continental area is extremely dynamic. It is also strikingly heterogeneous, not only in technical terms of interconnectors and integrated electricity grids but also in broader terms of connectivity and integration. The three areas analysed in this paper — Europa's immediate neighbourhood; Central Asia and the South Caucasus; and Greater Asia — are by no means developing simultaneously. There are both geopolitical and socioeconomic reasons for this. Particularly in North Africa — but also to some extent in Central Asia and the South Caucasus and in Greater Asia — countries often lack the capacity and resources to develop grid infrastructure, and institutions, structures and technical know-how are lacking. The main challenges here are not only technical and operational but relate, above all, to the electricity trade. This requires, among other things, a competitive market structure, which is often absent due to the prevalence of state monopolies.

In the EU, the development of interconnectors is a normal part of institutionalised network planning and is designed to serve further market integration. The political authority of the EU and its institutions is decisive for rulemaking at all levels. It requires countries joining the European integrated electricity grid to adapt the rules for grid operation, data exchange and their electricity market to be in line with those of the EU (i.e., "rules before joules"). This leads to a phased transfer of rights and rules. In return for incorporating European rules into their national laws, countries gain the promise of participating in an electricity "community of shared destiny and solidarity"; and depending on the degree of rule adoption and price zone affiliation, they gain equal opportunities for participation based on transparent market rules — in short, access to a level-playing field.

Electricity interconnection follows different logic outside Europe, however. For one thing, geopolitical tensions in particular are hampering the development of political-regulatory measures that would increase system compatibility and interoperability. For another, specific interconnectivity vectors are being pushed at the technical-operational level as part of particular geopolitical policies — above all, those of China, Russia, Turkey and Iran, as well as India. So far only selective and decoupled connectivity elements are discernible. In the future, however, these will very likely merge into a larger whole of strategic vectors and connectivity in line with China's vision for BRI-GEI/GEIDCO (see Map 1, p. 12).

4. The main factors driving grid expansion are geopolitical interests, the on-going energy transformation, socioeconomic development, and grid stability. China is citing development and grid stability to rationalise the expansion of power plants and national grids in third countries. But the development of interconnectors between or across interconnected grids is also quite clearly based on both geopolitical deliberations and on the need to access favourable locations for renewable energy. Up until now, Sino-American rivalry has focussed predominantly on other sectors, but it is foreseeable that the US — as an extra-regional and extra-continental power — will become increasingly involved in the European and Asian electricity systems. Washington thus attempts to contain Chinese and Russian influence in strategically important border and/or bridging areas — ranging from the Western Balkans and southern Europe to the Black Sea region, Central Asia, and on to South Asia and Southeast Asia. The US is using its financial, developmental and regulatory levers to achieve this.

5. The socioeconomic and political consequences of connectivity are becoming very apparent. Electricity grids are the "script" of modern economies. They are systems that have evolved historically but are also in a state of constant change. They follow the geo-political and energy-political paradigms of their time, including the idea of shaping space politically in an inclusive manner and according to equal economic opportunities. They reflect the planning of engineers and technical possibilities. That said, electricity grids and systems reflect security policy. During the Cold War, they were understood as bulwarks of political systems (aptly illustrated by Lenin's famous slogan "Communism = Soviet power + electrification"). And they have long since become the focus of hybrid threats.

Where synchronized integrated electricity grids and legal-regulatory spaces are congruent, as they are in the EU, there are not only electricity communities that share a "common destiny" but also dense system interactions based on a largely symmetrical network of relationships, along with shared authority and responsibility. The interconnectedness that occurs here is accompanied by processes of rule-bound organisation of social and political power over a territory.[187] Furthermore, the projection of power through electricity grid interconnections and within looser infrastructurised spaces takes place in a much more diffuse way. Here, the asymmetry in the network of relationships comes into play much more strongly. Political power can then be exercised in a very polymorphic way, for example through the projection of spatial ideas and perceptions, or through technical standards and legal norms. Added to this is the real or perceived vulnerability to electricity supplies. Control over essential nodes in and between integrated electricity grids plays an important role here. These nodes can be physical, technical-operational, and market-based. That is, they can include not only the hardware (i.e., the interconnectors, network nodes, electricity generation plants) but also the software for system operations, dispatch and trading. External actors use these nodes as tools to exert pressure and influence.

This macro-analysis provides a first overview of the dynamics of electricity connectivity and of the political and socioeconomic organisation of political power within the context of electricity connectivity. The next step is in-depth analysis that provides a closer look at market structures and actors. These are easily discerned within peripheral areas, which have a high degree of permeability to external political power. But concerns are also growing in the EU and its immediate neighbourhood in response to vigorous Chinese investments in (fossil fuel) power plants and participation in electricity grid operators in Greece,[188]

187 Bridge et al., "Geographies of Energy Transition" (see note 8).

188 "China's State Grid Seals Acquisition of Stake in Greek Power Grid", *Reuters* (online ed.), 20 June 2017.

Italy[189] and Portugal.[190] On the one hand, the liberalisation and privatisation in the EU seem at first glance to open gateways for strategic investments that could increase vulnerabilities. (Here, the screening process for foreign direct investment that has been in place since October 2020 is an important way to identify and reduce these vulnerabilities.) On the other hand, transparency, competition and the unbundling of generation, grid operations and distribution also help foster resilience in the face of extensive influence.[191]

Five Recommendations for Germany and the EU

We offer the following recommendations for Germany and the EU:

1. Germany and the EU need a robust foreign policy for electricity. This includes shaping interconnectivity both as a means and as an end to strengthening and consolidating integration, socioeconomic cohesion and political authority over the EU's electricity space. The importance of electricity interconnection goes beyond the purely technical-physical dimension. In this respect, electricity grid optimisation, strengthening and then expansion[192] are vital. Equally important are interconnectivity with the southeastern peripheries and in the Mediterranean region. It is necessary to align the connectivity vectors for renewable electricity, but it is just as important for countries to orient themselves towards Europe in terms of system resilience and welfare.

2. Robust configuration of electricity grids and interconnectivity becomes even more urgent in view of the ambitious climate target of reducing greenhouse gas emissions by at least 55 percent by 2030. The EU, in the course of its own energy transformation agenda and in particular within the Green Deal, will open up new (maritime and continental) zones that provide access to necessary renewable resources and offer opportunities to expand and stabilise the European electricity grid.

3. The EU should address regulatory fault lines in its immediate vicinity that go beyond electricity lines. Interconnectivity should not only be thought of in physical and technical terms of system compatibility and interoperability. It also requires the (soft) implementation of other network codes. To this end, the rules that apply within the EU can be successively extended to these important nodes. Goals could thus be gradually applied to cross-border and cross-system interconnectors, including the 2030 target of reaching physical electricity trade of 15 percent, the planning of networks and the rules for electricity trade regulations. The fragmentation of electricity, market and legal spaces results in a loss of control and influence. From the perspective of interconnectivity, the Carbon Border Adjustment Mechanism — which creates new fault lines on the borders of the EU emissions trading system — should also be examined. The EU should pursue the important goal of promoting cohesion of the European integrated electricity grid and legal area, while at the same time avoiding confrontation with other regional integrated electricity grid areas.

4. Interconnectivity is a key area of geopolitical and geo-economic competition. This means that the EU must also play a greater role in shaping interconnectivity on its periphery. To this end, it should create or adapt institutions that enable and deepen the technical-regulatory dialogue. In any case, the EU's "soft power" is essential to weaving together the infrastructural and regulatory "patchwork". It is a matter of increasing both sovereignty and resilience in the peripheral areas with a socially and ecologically just transformation in mind. This will enable countries to take on independent roles and pursue multi-vector policies. This is crucial in those regions where the technical-regulatory level or the market-economy level (or both) are weak — and the susceptibility to the influence of external actors is correspondingly greater.

5. Finally, building on the previous points, the EU — instead of relying on legal transfer and technical-regulatory and political convergence — must take into far greater account the needs, obstacles and drivers as well as the disparities between the developments in the respective regions. To achieve this, the EU needs new instruments to make the emerging electricity spaces more resilient and, in the medium term, to promote their compatibility and interoperability with

189 CDP Group, "CDP: 40.9% Stake in CDP Reti Transferred" (see note 114).

190 "State Grid Buys Stake in Portugal REN" (see note 113).

191 European Commission, "EU Foreign Investment Screening Mechanism Becomes Fully Operational", press release, Brussels, 9 October 2020, https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1867.

192 Grid Development Plan for Electricity, *NOVA Principle* (online ed.), https://www.netzentwicklungsplan.de/de/node/489#:~:text=NOVA%20stands%20for%C3%BCr%20grid%20optimization%2C%20%2Dverst%C3%A4rkung,before%20the%20expansion%20of%20the%20electricity%20grids.

each other and with the European area of ENTSO-E. In this context, it must pay particular attention to promoting the international validity of European norms and standards and ensuring that relevant organisations agree upon generally applicable norms and standards. Here it would be preferable to take a communicative and multilateral approach that engages China rather than excluding it. The EU should also pay attention to the diversification of processing chains, manufacturing capacities and production for large-scale generation capacities and bulk electricity systems. Following these principles, the G7's B3W initiative can also be used. The wealth of experience developing and maintaining a legal-regulatory space integrated with the market area is a major asset in the balance. While the Asia-Pacific region is the furthest away from the European network and its legal framework, the EU can nevertheless play a significant standard-setting role. In developing regional connectivity initiatives (all of which are still in their early stages), the European electricity market and interconnected grid are increasingly being referred to as a blueprint. There is therefore significant potential for the EU to help set regional norms and standards and become an influential third-party actor in shaping the continental space between Europe and Asia, thus becoming a linchpin of the Afro-Eur-Asian ellipse. The technical-regulatory dialogue and further development of an inclusive interoperability and compatibility with other electricity regions therefore has a real added value for the EU's electricity diplomacy.

Appendix

Glossary

Alternating current (AC) is the flow of electric current in which the direction of movement changes periodically, whereas with direct current (DC) it remains constant.[193] In the European integrated electricity grid, the current changes direction 50 times a second. This is then the frequency expressed in the unit of measurement hertz (Hz). Alternating current transmission dominates worldwide because it can be easily adjusted to respond to the different voltage levels of the grid.[194]

Black start is the launch of a power plant without support from the electricity grid. In the event of a widespread blackout (power outage), it is essential to have black-start-capable power plants in the grid — i.e., power plants that require neither active nor reactive electricity from the grid. Once they are running, these plants can support the start of power plants that are not black-start-capable.[195]

DC short-circuit coupling (back-to-back), or HVDC short-circuit coupling, is an installation for direct-current transmission[196] that is often only a few metres long or even located on one area. HVDC short-circuit couplings are therefore not used to bridge distances but to electrically connect AC (or three-phase) electricity grids. The grids do not have to be synchronised with each other, but above all, the energy flow can be controlled easily and in a way that serves the system.

193 “Alternating Current and Direct Current”, *Scientific Committees* (online ed.), https://ec.europa.eu/health/scientific_committees/opinions_layman/en/electromagnetic-fields/glossary/abc/alternating-current.htm.

194 “What Is the Difference between AC and DC Power?” *Power & Beyond* (online ed.), https://www.power-and-beyond.com/whats-the-difference-between-ac-and-dc-power-a-915187/.

195 “Black Start”, *NREL* (online ed.), https://www.nrel.gov/grid/black-start.html.

196 “AC vs DC Coupling: What Is It?” *Noise Engineering*, https://noiseengineering.us/blogs/loquelic-literitas-the-blog/ac-vs-dc-coupling-what-is-it.

Direct current (DC) refers to electric current whose current strength and direction do not change. In electricity transmission, alternating current (AC) has significant advantages over direct current because the latter can be easily converted into different voltage levels. However, with the mastery of converter stations that enable the conversion of alternating current into DC, high-voltage direct current (HVDC) transmission is becoming increasingly important.[197]

High-voltage direct current transmission line (HVDC line)[198] is used to transmit large amounts of electrical energy over long distances (from about 750 kilometres). HVDC lines can connect points within a country and its electricity grid as well as link national and supranational electricity grids. As direct current then flows between points A and B, two converter stations are needed to convert it into alternating current for the end users. HVDC lines are mainly used for long distances, as they have lower overall transmission losses than transmission with three-phase alternating current above certain distances, despite the additional converter losses. HVDC lines serve the system by enabling redispatch, providing reactive electricity in a dynamic way and improving a system’s black start capability. It thus has positive spillovers on system management. Most HVDC links use voltages between 100 kV and 800 kV.

Integrated electricity grid is an association of large, spatially adjacent and electrically connected electricity grids, with each sub-grid forming a self-coordinating unit. Each integrated electricity grid is characterised by the fact that all generators and consumers are operated synchronously, i.e., at a uniform grid frequency and under a common frequency control. In most cases, an interconnected network is

197 “Alternating Current and Direct Current”, *Scientific Committees*, https://ec.europa.eu/health/scientific_committees/opinions_layman/en/electromagnetic-fields/glossary/abc/alternating-current.htm.

198 “What Is HVDC Transmission? *Electrical Deck*, https://www.electricaldeck.com/2021/08/what-is-hvdc-transmission.html.

divided into several control areas, with a transmission system operator acting as the control area manager for each one.[199] A robust electricity grid is characterised by close interconnection and strong nodes (cross-border interconnection points). (Synchronized) integrated electricity grids create an integrated infrastructurised space in which electricity flows freely in all directions according to Kirchhoff's laws.[200]

Mains frequency refers to the electrical utility frequency. It is assumed that its measurement in all parts of the synchronous area results in an almost uniform value within seconds; this value differs only insignificantly at different measuring points.[201]

(N-1) criterion refers to the rule by which the resources within the control area of a transmission system operator that continue to operate after the occurrence of a failure can adapt to the new operating situation without exceeding operational safety limits.[202] Thus, each connection of a network creates a fallback option in case of congestion; in case of failure of one connection (N-1), others stabilise.

Network code is a rule for the operation of the network or functioning of the market. Network codes (actually network codes and policies) are a set of rules developed by the European Network of Transmission System Operators for Electricity (ENTSO-E) in cooperation with the Agency for Cooperation of Energy Regulators (ACER) in accordance with EU regulation (714/2009).[203] In this context, three network code "families" are important in electricity: 1) connection, i.e., requirements for generators, the code for demand response and for HVDC lines; 2) operation, as defined in the 2017 Directive[204] and the codes for emergency and restoration of electricity supply; 3) the codes for market functioning, i.e., forward capacity allocation to secure long-term trading, the code for capacity allocation and congestion management, and the code for electricity balancing.

Power purchase agreement (PPA) is a long-term electricity supply contract between two parties, usually between a power producer and a power purchaser. The PPA sets out all the terms and conditions, such as the amount of electricity to be supplied, the negotiated prices, the accounting and the penalties for non-compliance with the contract. Since it is a bilateral contract, a PPA can take many forms and be tailored to the preferences of the contracting parties.[205]

Reactive power refers to the proportion of electricity in the electricity grid that is not converted into usable energy, for example heat or kinetic energy. This portion of the current cannot be consumed for the operation of systems or devices and "oscillates" in the grid between the generator and the consumer. Reactive power only occurs in alternating current (AC) transmission and is largely undesirable because it places an additional load on the electricity grid.[206]

Rectifiers are electrical devices that can convert one type of current into another. *Rectifiers* can convert alternating current (AC) into direct current (DC) and are required, for example, in electricity supply units for operating DC devices on an alternating voltage network or for transporting current from a DC transmission line further via an alternating voltage network. *Inverters*, conversely, can generate AC from DC. For example, a common application is to convert DC from photovoltaic panels into AC for use in a building or to feed into the public electricity grid. *Inverters* convert one type of AC into another, for example from one frequency to another.[207]

Redispatch is one or more interventions in the generation output of power plants to protect line sections from congestion. If a bottleneck threatens at a certain point in the network, power plants on this side of the bottleneck are instructed to decrease their feed-in, while plants on the other side of the bottle-

199 "Technical Aspects of Grid Interconnection", *Energypedia*, https://energypedia.info/wiki/Technical_Aspects_of_Grid_Interconnection.

200 "Kirchhoff's Current Law", *Electronic Tutorials*, https://www.electronics-tutorials.ws/dccircuits/kirchhoffs-current-law.html.

201 Ibid.

202 European Commission, "Commission Regulation (EU) 2017/1485 of 2 August 2017 Establishing a Guideline on Electricity Transmission System Operation", *Official Journal of the European Union*, no. L 220 (25 August 2017): 1–120 (5), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R1485&qid=1633011636985.

203 "What Are Network Codes?" *ENTSO-E*, https://www.entsoe.eu/network_codes/.

204 European Commission, *Commission Regulation (EU) 2017/1485* (see note 46).

205 Natasha Luther-Jones, "Corporate Power Purchase Agreements (PPAs): What Are They?" *DLA Piper* (website), https://www.dlapiper.com/en/us/insights/publications/2019/11/what-are-corporate-power-purchase-agreements-ppa/.

206 Reactive Power, *Electronis-Tutorial* (online), https://www.electronics-tutorials.ws/accircuits/reactive-power.html.

207 "How Rectifiers Work – Types of Rectifiers & Their Use, Arrow Electronics", *Arrow*, 24 September 2018, https://www.arrow.com/en/research-and-events/articles/how-rectifiers-work-types-of-rectifiers-and-their-uses.

neck must increase their feed-in capacity. This creates a load flow to counteract the bottleneck.[208]

Substations are electricity grid facilities that serve to establish a connection between different voltage levels, for example from the high-voltage (transmission) level to the low-voltage (distribution) level.[209] As such, they are an essential part of the electricity system. Substations contain transformers and switchgear in which the electrical energy is transposed and distributed; they also contain equipment for measurement and control technology.

Synchronisation in an AC system is the process of matching the speed and frequency of a generator or other electricity source to a running electricity grid. An alternator can only supply power to an electricity grid if it is running at the same frequency as the grid. If two segments of a grid are disconnected, they can no longer exchange AC power until they are exactly synchronised again. Five conditions must be met for synchronisation to occur: The source — i.e., generator or sub-grid — must have the same 1) grid voltage, 2) frequency, 3) phase sequence, 4) phase angle and 5) waveform as the system to which it is synchronised. Similar to parts of an AC system, multiple AC systems can be synchronised with each other. The synchronisation process between two transmission systems or networks is a multi-year process[210] that involves several phases.[211] Prior to the actual synchronisation, a series of tests take place, both in "island mode" (i.e., disconnected state) and in "interconnection mode".

System adequacy — i.e., the interaction of generation, consumption and grid infrastructure — is regularly reviewed in the European electricity grid. In order to estimate the adequacy of generation capacities in particular, the supply situation is modelled as comprehensively as possible in order to carry out strategic planning in the areas of generation, consumption and the necessary grid infrastructure.

208 German Federal Network Agency, "*Network and System Security*" (webpage), https://www.bundesnetzagentur.de/EN/Areas/Energy/Companies/SecurityOfSupply/NetworkSecurity/start.html.

209 "What Is a Substation?" *El Pro CUS*, https://www.elprocus.com/what-is-a-substation-definition-types-of-substations/.

210 A. Mazloomzadeh, V. Salehi and O. Mohammed, "Soft Synchronization of Dispersed Generators to Micro Grids for Smart Grid Applications" (Washington, D.C.: Institute of Electrical and Electronical Engineers [IEEE], IEEE PES Innovative Smart Grid Technologies [ISGT], 2012), 1–7, doi: 10.1109/ISGT.2012.6175812.

211 See Zachmann and Feldhaus, *Synchronising Ukraine's and Europe's Electricity Grids* (see note 102), 8.

Abbreviations

ACER	Agency for the Cooperation of Energy Regulators
ADB	Asian Development Bank
APG	ASEAN Power Grid
ASEAN	Association of Southeast Asian Nations
ASG	Asian Super Grid
B3W	Build Back Better World (G7 Initiative)
BBIN	Bangladesh, Bhutan, India, Nepal (Initiative)
BEMIP	Baltic Energy Market Interconnection Plan
BIMP-EAGA	Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BRELL	Belarus, Russia, Estonia, Latvia and Lithuania
BRI	Belt and Road Initiative (Chinese Initiative)
BRICS	Brazil, Russia, India, China, South Africa
CAPS	Central Asian Power System
CAREM	Central Asia Regional Electricity Market
CASA-1000	Central Asia-South Asia
CASAREM	Central Asia South Asia Regional Energy Markets
CEER	Council of European Energy Regulators
CENTREL	Central European Electricity Network, group of TSOs from Czech Republic, Poland, Hungary and Slovakia and now part of ENTSO-E
CESA	Continental Europe Synchronous Area
CMEC	China Machinery Engineering Corporation
CNMC	Comisión Nacional de los Mercados y la Competencia (Spanish National Markets and Competition Commission)
CO_2	Carbon dioxide
Comecon	Council for Mutual Economic Assistance
CPEC	China-Pakistan Economic Corridor
Dii	Desertec Industrial Initiative
EAEU	Eurasian Economic Union
EBRD	European Bank for Reconstruction and Development
EEA	European Economic Area
EEAS	European External Action Service
EFTA	European Free Trade Association
EIB	European Investment Bank
ENTSO-E	European Network of Transmission System Operators for Electricity
EPC	Engineering, Procurement and Construction
EU	European Union
GDR	German Democratic Republic
GEI	Global Energy Interconnection (Chinese Initiative)
GEIDCO	Global Energy Interconnection Development and Cooperation Organisation (Chinese Initiative)
GMS	Greater Mekong Subregion
GSE	Georgian State Electrosystem
GW	gigawatt
HAPUA	Heads of ASEAN Power Utilities/Authorities
HVDC	High-voltage direct current (see Glossary)
Hz	Hertz
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IPS/UPS	Integrated Power System/Unified Power System of Russia
IRENA	International Renewable Energy Agency
ISA	International Solar Alliance
IT	Information Technology
KEPCO	Korea Electric Power Corporation
kV	kilovoltage
MCC	Millennium Challenge Corporation
MED-EMIP	Euro-Mediterranean Integration Project
MED-REG	Mediterranean Energy Regulators
MED-TSO	Mediterranean Transmission System Operators
MENA	Middle East and North Africa
MoU	Memorandum of Understanding
MSP	Mediterranean Solar Plan
MW	megawatt
NAPSI	North-East Asian Power System Interconnection
NATO	North Atlantic Treaty Organization
NEAEI	North-East Asia Energy Interconnection
NGCP	National Grid Corporation of the Philippines
NORDEL	Nordic regional group — synchronous grid of Northern Europe, now part of ENTSO-E
OSOWOG	One Sun, One World, One Grid (Indian Initiative)
PCI	Projects of Common Interest
PJSC Rosseti	Public Joint Stock Company “Rosseti”
RAO UES	[Electric power holding company] Unified Energy System of Russia
RPTCC	Regional Power Trade Coordination Committee
RSC	Regional Security Coordinators
SAARC	South Asian Association for Regional Cooperation
SAFTA	South Asian Free Trade Area
SAGQ	South Asian Growth Quadrangle
SAREM	South Asia Regional Energy Market
SARI/EI	South Asia Regional Initiative for Energy Integration
SASEC	South Asia Subregional Economic Cooperation
SGCC	State Grid Corporation of China
TAP	Turkmenistan – Afghanistan – Pakistan
TEİAŞ	Türkiye Elektrik İletim A.Ş.
TEN-E	Trans-European Networks for Energy
TFEU	Treaty on the Functioning of the European Union
TSCNET	Transmission System Operator Security Cooperation
TSO	Transmission System Operator
TUTAP	Turkmenistan – Uzbekistan – Tajikistan – Afghanistan – Pakistan
TW	terawatt
TWh	terawatt hours
UCPTE	Union for the Coordination of Production and Transmission of Electricity
UCTE	Union for the Co-ordination of Transmission of Electricity
USAID	United States Agency for International Development
USSR	Union of Soviet Socialist Republics