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Rethinking the governance of energy infrastructure: Scale, decentralization and polycentrism

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ABSTRACT

Providing societies with reliable energy services, fighting energy poverty and mitigating climate change entail a crucial infrastructure component. Both the energy access and the low carbon challenge require more decentralized energy solutions and a change in the energy infrastructure paradigm. Yet, physical energy infrastructure co-evolves with socio-economic institutions, actors and social norms. This may produce inertia against change. The energy challenge also requires solutions at multiple scales and may entail elements of common pool resource problems. Therefore, the governance of energy infrastructure needs to be polycentric. This allows for contextualization, experimentation and innovation. The article concludes by sketching routes of further research into the energy infrastructure governance nexus in social science research.

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1. Introduction

Ensuring reliable energy services, fighting energy poverty and mitigating climate change all entail a crucial infrastructure component. Across-the-board coverage requires integrated and interconnected energy infrastructure, whereas low carbon infrastructure solutions are highly localized, both in terms of energy supply and demand patterns. At the same time, energy infrastructure is characterized by the involvement of a vast number of actors, each coming with distinct and particular sets of interests; its impact on other sectors is significant due to sheer scope and scale [1]; it is subject to and interacts with a complex and multi-layered set of institutions, laws, regulations and policies; and its life span stretches across several decades. Balancing the need for large scale infrastructure with local and contextualized solutions therefore presents an unprecedented governance challenge. What is more, governance arrangement will need to remain open to learning and to adapt to changing environments, in order to keep energy infrastructure resilient. In other words, governance arrangements susceptible to facilitating energy access and low carbon transition need to be dynamic rather than static. This warrants a rethink of the governance of energy infrastructure.

This article discusses three key features in the academic literature pertaining to energy infrastructure and governance: the embeddedness of physical energy infrastructure within and its co-evolution with socio-economic institutions, regulatory agencies, incumbent market actors and social norms; multiple scales in sustainable infrastructure solutions; and elements of common pool resource problems. Therefore, as this article argues, the governance of energy infrastructure needs to be polycentric. This allows for contextualization, experimentation and innovation, which can lead to sustainable infrastructure solutions and learning across scales.

As a corollary, a polycentric approach may offer a promising way to further investigate the energy infrastructure conundrum. Given the scope and breadth of the existing literature, this article is not in a position to provide a comprehensive review of the pertinent works in this field, nor does it aspire to revolutionize energy governance research. Instead, it aims at providing pointers to crucial aspects in infrastructure governance and deliberately makes a choice in arguing that infrastructure problems should be primarily seen in the context of the energy access and low carbon challenge. This makes energy infrastructure part of the global fight against energy poverty and climate change, and hence subject to a multi-scale governance challenge.

The next section defines energy infrastructure and briefly reviews the literature on infrastructure governance. Section 3

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elaborates on infrastructure as socio-technical systems, followed by a discussion of the scale dimension (Section 4) and common pool resource aspects in infrastructure (Section 5). The last section concludes by sketching routes for further research into energy infrastructure governance.

2. Defining the energy infrastructure and governance nexus

A functioning energy infrastructure – more precisely, the service it provides – is essential to modern societies. Energy infrastructure electrifies homes, heats houses, connects producers and consumers in a market, and transports energy carriers of high calorific content across countries or whole regions. In short, it is essential for the functioning of the economy and for maintaining welfare. Energy infrastructure also forms a significant part of a country's capital stock. According to a recent McKinsey study, the value of a country's overall infrastructure stock (including energy but also roads or waterways) on average amounts to 70% of its GDP [2].

As a corollary, in order to maintain or improve existing energy infrastructure, the public and private sectors need to spend considerable amounts of money. As the International Energy Agency (IEA) estimates, some USD 1.6 trillion or 1.5% of global GDP are needed per year until 2035 to meet demand and existing policy goals [3]. If additional pressing challenges such as fighting climate change and providing access to the energy poor are to be met, this number will even go up. Tackling the energy poverty challenge, which essentially consists of providing 1.3 billion people with access to modern energy services, will add an increment of USD 1 trillion in cumulative investment until 2035 [4] (see also Van de Graaf, Bazilian and Nakhooda in this special edition [5]). An additional USD 16 trillion of energy-related investment, a significant share of which into infrastructure, is required to decarbonize energy production and use, and to stabilize concentrations of greenhouse gas emissions at 450 ppm, the benchmark concentration of CO_2 for avoiding the worst consequences of climate change [3].

This article therefore focuses on key elements that characterize energy infrastructure as part of a larger energy system, and deliberately discusses the energy infrastructure and governance nexus in the context of energy access and the low carbon challenge. For the purpose of this article we define governance as the institutions, mechanisms and processes through which economic, political and administrative authority is exercised. This definition builds on an extensive literature arguing that governance has gone beyond government, and acknowledges the important role that private actors and civil society play in policy making (pars pro toto see [6–8]). Importantly, governance as an analytical concept allows studying arrangements that are non-hierarchical, multi-level or network based, and acknowledges the high degree of complexity facing modern policy problems – such as the ones surrounding energy infrastructure.

Energy infrastructure comprises the physical infrastructure required for producing, transforming, transmitting, distributing and storing energy. As a research object, energy infrastructure has received great attention, and a comprehensive review of existing works would be beyond the scope of this article (a Google Scholar search on the term produced 1,970,000 hits in January 2014).[1] By contrast, the literature referring to energy infrastructure as a governance challenge seems to be restricted to a few key themes. One strand of the available literature focuses on project governance. These works tend to center on the planning and implementation of large scale physical infrastructure. As studies show, complicated decision making processes may lead to delay or failure in energy megaprojects, such as pipelines or nuclear power plants [9,10]. Such projects involve multiple stakeholders and actors, which calls for 'effective governance' of infrastructure in order to cope with coordination problems. This literature ties back into the governance of large scale infrastructure projects (see, for instance, [11]).

A related strand of works focuses on challenges surrounding opportunistic behavior due to displaced agency. Here the emphasis is on contracting and how to properly govern public–private partnerships, and for political and regulatory risk (see, for instance [12]). Adopting yet another perspective on infrastructure, certain studies inquire into the governance of networks. These works are most interested in the distribution and transmission of (energy) infrastructure. Related, some works also conceptualize energy as systems, with infrastructure playing an important role in facilitating energy flows within the system [13,14]. Increasing attention is paid to governance for critical infrastructure protection, particularly on behalf of key energy authorities, such as the EU, which are concerned about their infrastructure's resilience against shocks or cyber attacks [15]. Energy infrastructure governance has also come to be analyzed with regard to its crucial role in disaster management and development [16]. In conceptual terms, research on critical infrastructure protection embraces the notions of diversity, resilience and interdependence among key actors [17].

In all, the existing but limited literature on energy infrastructure governance is mainly interested in managing large scale network projects, handling contractual relations between public and private parties or critical infrastructure issues. The governance of energy infrastructure, however, needs to go beyond existing agendas and include the goals of providing for comprehensive energy access and fighting climate change. Defined this way, the governance of the energy infrastructure nexus comes with the additional normative requirement of contextualizing energy infrastructure solutions so that the latter are able to contribute to global energy policy goals.

3. Socio-technical systems and the call for decentralization

Infrastructure is part of larger contexts – economic sectors (e.g. transport), national markets (e.g. for electricity) or a specific industry (e.g. photovoltaic). It is therefore important to view infrastructure as evolving with and being shaped by factors other than technology. As an important strand in innovation research has shown, technology co-evolves with institutions, societal actors and policies, eventually forming socio-technical systems (pars pro toto see [18–20]). This obviously also holds true for the physical components of technology. Conceptualizing infrastructure in general and energy infrastructure in particular as socio-technical systems is helpful in that it points to their embeddedness within the surrounding environment.

Numerous examples, such as Hughes' seminal study on the evolution of the US electricity sector, illustrate that large technological systems (LTS), such as energy networks, are deeply intertwined with the overall structure of society [21]. In fact, it is this very socio-economic and normative embeddedness that makes an LTS work properly in the first place and allows it to evolve further [22]. This, in turn, also implies that technological systems change in conjunction with changes in society and the economy, with impulses going both ways. As a corollary, the deep embeddedness of energy technology within the surrounding environment may lead to resistance

[1] There obviously exist strong differences between the types of infrastructure required for different energy fuels (such as oil, coal or biofuels) or sources (primary sources such as hydrocarbons and secondary sources such as electricity or refined energy products). This article however deliberately abstains from discussing them separately. Instead, common elements are stressed, notably scale, socio-technical systems and CPR problems.

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