



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Energy, economics, and performativity

Citation for published version:

Silvast, A 2017, 'Energy, economics, and performativity: Reviewing theoretical advances in social studies of markets and energy', *Energy Research & Social Science*, vol. 34, no. December, pp. 4-12.
<https://doi.org/10.1016/j.erss.2017.05.005>

Digital Object Identifier (DOI):

[10.1016/j.erss.2017.05.005](https://doi.org/10.1016/j.erss.2017.05.005)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Energy Research & Social Science

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



Energy, Economics, and Performativity: Reviewing Theoretical Advances in Social Studies of Markets and Energy

Antti Silvast
Research Fellow
B.1 Chisholm House
High School Yards
Edinburgh, UK
EH1 1LZ
antti.silvast@ed.ac.uk, antti.silvast@gmail.com

Accepted for publication in *Energy Research & Social Science*, 34, December 2017, 4-12.

Abstract

For many years, energy market design has held great promises as a solution to current energy issues; ranging from increasing international trade to emissions reduction, the securing of future electricity capacity, and increasing flexibility amid growing intermittent renewable energy resources. The emerging economic understandings of the energy infrastructure motivate conceptual and methodological innovations in the social sciences, which this paper pursues. Its first part describes recent advances in social studies of markets, which seek greater appreciation of the role of economics in the formation of markets via economic theories, instruments, and many other means. The second part focuses on emerging studies which draw on these approaches to examine energy systems including their markets, liberalisation, and sustainability. The essay brings together social studies of markets with energy and opens up important topics for understanding current energy transitions. These include how financial systems can be treated as key components of the socio-technical energy system in transition; and conversely, how the case of energy adds to the theories of social studies of markets and economics by highlighting manifold interdependencies between economics, engineering problems, existing infrastructures, and political contentions when market-based energy is at stake.

Keywords: social studies of markets; performativity; economics; energy and electricity; infrastructure; liberalisation

Acknowledgements

I acknowledge the helpful comments from Robin Williams, Donald MacKenzie, Mark Winskel, Ronan Bolton, Janette Webb, David Hawkey, Mikko J. Virtanen, Onur Özgöde, Henrik Karlström, Ken McKinnon, Harry van der Weijde, Alastair Heggie, Tim Schulze, Andreas Grothey, Ian Wallace, and four anonymous reviewers. An earlier version of this paper was presented at the the Collaboration on Knowledge Infrastructures and Energy workshop, organized by University of Edinburgh, Business School and Science, Technology and Innovation Studies and Copenhagen Business School, at the University of Edinburgh, 6-7 June 2016. I thank the participants for their valuable feedback. The preparation of this work was in part supported by the European Commission Horizon 2020, Scottish ClimateXChange and Princeton University, Princeton Institute for International and Regional Studies, Global Systemic Risk Research Community.

Introduction

For many years, energy market design has held great promises as a solution to current energy issues; ranging from increasing international trade to emissions reduction, the securing of future electricity capacity, and increasing flexibility in electricity distribution amid growing intermittent renewable energy resources. Energy policy makers, engineers, and market designers find common ground in optimizing complex infrastructures through market mechanisms, such as introducing time-dependent electricity prices (OECD & IEA 2005, 2011; European Commission 2011) and various kinds of energy trade from real-time and day-ahead to carbon emissions trading and futures exchanges much further ahead in time (European Parliament & Council 2009; European Commission 2015). Expertise on energy economics and energy market behaviour has been organized through specialized associations, journals, and conferences for several decades: the International Association for Energy Economics was founded in 1977 to further “the knowledge, understanding, and application of economics across all aspects of energy” (IAEE 2016), while the British Institute for Energy Economics dates to 1985. Economic assumptions about energy market participants have also been embedded in ICTs that bring together economic energy producers and consumers in new ways, exemplified by ‘smart’ energy meters that are rolled out on a large scale in a great number of countries all over the world (see e.g. European Commission 2011; UK Parliament 2016; UK National Infrastructure Commission 2016).

The emerging energy infrastructure and its economic understandings open up several points of entry for social science research. While many policies and experts concur on the economic benefits of optimizing infrastructures via market mechanisms, others, inspired by social science perspectives, may see these economic assumptions about energy producers and consumers as ‘under-socialized’ and incomplete. As many have pointed out, a number of issues around current energy demands and environmental problems may not fit into a sharp economic framing: social practices of energy use (Wilwhite 2008; Shove 2010; Shove et al. 2012) and sustainability transitions (Verbong & Geels 2007; Geels & Schot 2007) are notably ‘embedded’ in social relations and the wider society in a rich variety of ways. Modern economics, in contrast, assumes that economic agents and their activities are ‘disembedded’ from society (Callon 1998).

But there is also another option for participating in these debates. It draws from recent advances in social studies of markets, which seek greater appreciation of the role of economics in the formation of markets via economic theories, instruments, and many other means. As such, this approach – rather than treating it as a mere ideology – takes economics seriously as knowledge and activity that participates in actually shaping the economy and the society more widely (Breslau 2013). This *social studies of markets* explores economics pragmatically by its successes or failures in those particular instances where it was used by actors (MacKenzie et al. 2007). While these studies advance a number of concepts, an oft-cited term summarises their contribution by arguing that economics is *performative*. This means that the use of economics not only describes, but also participates in changing reality to more – or less – accordance with economic theory than before (MacKenzie 2007; Callon 2007).

Recently, a growing number of social science works have drawn on these approaches to

examine energy systems, markets, and diverse topical energy issues; from renewable energy integration to electricity capacity, liberalization, and sustainability. With some notable exceptions of critical analysis (especially Karlstrøm 2012; Breslau 2013; Jenle 2015), these works utilize social studies of markets mainly to show that these perspectives can be applied to contemporary energy markets, energy transitions, and related issues. Meanwhile, in other discussions, critiques of the performativity concept and the social studies of markets show an impressive breadth. The critics argue that performativity simply recapitulates the professional ideology of economists by assuming that markets confirm economic theory; furthermore, in many empirical cases, markets do not function in practice as economic theory foresees (see e.g. Miller 2002; Aspers 2005; Mäki 2013). On a more positive note, there is already evidence that energy social research poses unique strengths in addressing some of these critical issues in the social studies of markets (e.g. Breslau 2013). My essay brings the social science perspectives on markets and energy together and asks the following questions:

- What novel and interesting results do social studies of markets perspectives bring to energy social research?
- What unique insights can the study of energy bring to the social studies of markets and its critics?

Regarding the first question, the essay develops the argument that financial systems should be treated as key components of socio-technical energy systems and reviews a number of studies that attain this aim, starting from classic work within Science and Technology Studies (STS) literature. This focus means not only that social studies of markets can be mapped onto the study of contemporary energy markets – even if that is of considerable interest as I try so show. Rather, social studies of markets help unpack how the configuration of financial systems – shaping and shaped by economic theory, measuring techniques, economic actors, and financial products – greatly matters for what the existing energy systems are like and how they may be transformed toward greater sustainability.

For the second question, along with others (Karlstrøm 2012; Breslau 2013; Jenle 2015), the essay argues that encountering energy as a topic for the social studies of markets leads to a fruitful revision of these approaches and useful clarifications against their critics. Here, I show that many criticisms seem to assume a stripped-down version of the performativity thesis, where markets are direct materializations of economic theory. However, the case of energy – and indeed, recent decade's advances in social studies of markets (MacKenzie 2007, 2008; McFall 2010; MacKenzie & Spears 2014) – do not conform to this stripped-down understanding of performativity. Market-based energy provision clearly depends upon political contentions, engineering issues, and histories in interplay with economics and social studies of market provides useful tools for studying how this manifests in practice. However, some contradictions in social studies of markets – especially concerning their key concepts and scopes – may continue to blur this valuable contribution as I discuss below.

While this essay reviews several works in energy social research, the relationship between the selected studies and the field at large should be clarified. A recent review of this field (Sovacool 2014) finds case studies on a particular energy technology, studies at length on particular countries, and quantitative methods – such as economic modeling, econometric analysis, and cost benefit analysis – to be prominent in the energy social science discussion.

Where many studies hence use economics tools across different aspects of energy, much fewer have developed social studies of markets types of questions: concerning how knowledge about energy markets and their participants may bring about these subjects rather than merely describing them (for key exceptions see Cointe 2015; Skjølvold & Lindkvist 2015; Cherry et al. 2017). Furthermore, in disciplinary terms, sociology, anthropology, and STS remain relatively minor points of departures in energy social research, but have unique insights in rethinking the relationship between energy, economics, and performativity. This essay contributes to energy social research by raising these types of viewpoints and their relevance in understanding both energy transitions and advances in the social studies of market programme.

In two ensuing parts of this essay, I discuss first social studies of markets and then energy social research that utilizes it. Both parts are structured similarly. They start with explaining how these research areas emerged in relation to other perspectives on similar issues; their key concepts and focuses with examples; what problems and critiques are associated with these research lines; and how bringing together social studies of markets with energy social research provides useful tools for further addressing some of these problems and critiques. A concluding part summarises these contributions and identifies further challenges in this area for future research.

Part I: Reviewing social studies of markets and performativity

Social studies of markets within economic sociology

Modern economics has had a critical relationship to many social sciences, sociology particularly, since their onset in the 19th century (Wagner 2001). Strictly speaking, mainstream economics is interested in efficient allocation of resources and does not consider the conditions that make market exchanges possible and hold social order together (Cochoy et al. 2010, p. 140). The typical sociological counterargument is that this offers merely one framing of social reality among many others and as such, generates unrealistic assumptions about rational economic agents and the utility that they seek (Breslau 2013, p. 831). Economic sociology contributes to the understanding of the economy – and market capitalism more particularly (e.g. Boltanski & Chiapello 2005) – via studying its contextual, historical, and institutional aspects (Wagner 2001). These themes have renewed their importance after the banking and debt crises that broke in 2008 (e.g. Centeno & Cohen 2010; Knorr-Cetina & Preda 2012; Petropoulous & Tsobanoglou 2014).

Within this much broader field of economic sociology, this essay focuses on a small subset that is called *social studies of markets* (a name this essay uses) or *social studies of finance*, a field intrinsically linked with Science and Technology Studies (STS). In the 1990s, certain market scholars, especially the French sociologist Michel Callon (1998), begun to distance themselves from social science thinking that regards economics as a mere ideology. In so doing, their focus on economics, the economy, and society shifted considerably. Rather than embedding calculative economic actions and markets within the wider society – as many social scientists had already done – they wanted to examine economic calculations, actions,

and markets as such as their research objects. The concern became which processes “make calculative economic action and markets possible” (MacKenzie 2006, p. 12).

The concept of *economics* as these scholars have understood is broad if somewhat ambiguous. On the one hand, economics includes all types of economic thought and activities that are utilized in knowing the economy: not only economic theory, but also economic instruments, procedures, data, marketing, and accounting practices both within and beyond the academia. Political theorist and historian Timothy Mitchell (2005, p. 298) includes design and marketing of goods, calculations and forecasts by banks and investors, business school and law school case studies, think tank activities, and international development as exemplars of this economics in the widest meaning. This constitutes an expertise that Callon famously named as “economists in the wild” in contrast to academic “caged economists” (Callon et al. 2002, p. 196). So, in one way, *economics* includes all knowledge that constitutes the *economy* (Breslau 2003). On the other hand, when these scholars have studied economics, it has usually started with a fairly disciplinary understanding, focusing on specific market-like arrangements (Callon 1998; Breslau 2013) or financial equations and their use (MacKenzie 2003; Callon 2007). In sum, the point here seems to be about not limiting empirical investigations to economics in universities, but implicitly accepting a disciplinary self-understanding of economics when focusing these investigations.

One thing that economics does – via marketing, statistics, planning, and consumption for example – is that it constitutes the very idea of the ‘economy’ (Mitchell 2005). Social studies of markets, however, advances a considerably stronger claim than this: that economics is *performative*. This means that economics not only describes, but also participates in performing and hence actually changing the economy and the society more widely (Callon 1998; Mitchell 2005; MacKenzie 2007; Cochoy et al. 2010). It does this, for example, by configuring what economic objects are like: in practice, economics creates market rules and agents, even the entities that these agents can exchange (Breslau 2013, p. 829). Discussing energy and economy, Mitchell (2011, p. 174) explains this dynamic against the critique of economics as a mere system of ideas.

The broader criticism that economists are trapped in their system of ideas misses the mark. Like their critics, orthodox economists care about the world. They care about it, however, in a different way. They do not want to alter their ideas to make them like the real world; they want to alter the real world to make it perform according to their ideas. (Mitchell 2011, p. 174.)

This claim that theories become validated because people believe in them is potentially interesting and has been widely applied beyond the social studies markets. Social sciences and humanities research, on different occasions, has found utterances (Austin 1962), legal documents (Faulkner 2012), gender discourse (Jackson 1999), technological promises (Pollock & Williams 2010), and concepts of the nature (Abrams & Lieu 2011) to be performative. This means that they not only describe, but also participate in performing, for example, laws, gender, or technology.

In spite of its wide applications, performativity is still far from an unproblematic concept in social science and humanities research. To root social studies of markets to the debate on performativity, I will briefly explain how it came to study performativity, and how the concept

has changed and also critiqued over a long period of time. I then claim and demonstrate how energy social research presents a particularly promising perspective for addressing some of the long-term problems identified in the performativity literature.

Speech acts and social institutions as performativity

Like social studies of markets (MacKenzie 2001, 2007; Callon 2007) acknowledge, the term *performativity* comes from the linguistic philosophy of J. L. Austin (1962). Austin's philosophy is commonly discussed as a *speech act theory*. This is because he analyzed special sentences, such as declarations, wills, bets, and promises, and their distinctively active traits (see e.g. Abrams & Lieu 2011; Faulkner 2012). If stated by appropriate persons in the right circumstances (Austin 1962, pp. 14-15), these sentences become *performative* in that they do not merely describe actions, but rather *are* actions, or a part of them.

It is important to clarify that this relationship between speaking and doing is *constitutive* (Mäki 2013). Uttering a sentence such as above does not cause anything – rather, it constitutes it. As such, this does not open up interesting empirical inquiries because these special sentences constitute their own reality every time that they are used. Having said that, Austin (1962) and others in his tradition distinguish two types of performatives: “illocutionary performatives, which pronounce a reality, and perlocutionary performatives, which in felicitous conditions *may* make certain things happen” (Cochoy et al. 2010, p. 142; original emphasis). The latter are of great interest for empirical study. Especially Callon (2007) takes performativity rather directly from Austin and this distinction between performances and bringing about actions is of great importance for understanding his scope (Mäki 2013).

Take this claim by the European Commission (2015, p. 3) as an example: “an integrated energy market is needed to create more competition, lead to greater market efficiency through better use of energy generation facilities across the EU and to produce affordable prices for consumers”. According to the speech act theory, this sentence does not describe a reality of what the energy market does. It actually pronounces this reality (*illocutionary performative*) – or, in suitable conditions, at least makes it possible once the sentence has been transformed to European law and rules that energy market actors in Europe must follow (*perlocutionary performative*). This focus on creativity is crucial for the concept of performativity in the social studies of markets: not only language, but also economic knowledge *is* action that may bring about its own assumptions.

However, sociologist Donald MacKenzie, another founder of social studies of markets, received the concept of performativity through a slightly less direct route. His understanding most likely diffused from the Edinburgh-based sociology of knowledge and its *performative theory of social institutions* (Barnes 1983). The theory is associated with sociologist Barry Barnes; MacKenzie (2007) indeed names a particular performativity concept of his *Barnesian*. This sociological performativity theory states that *social concepts*, or *institutions*, do not refer to objects external to the concepts themselves. Rather, once actors believe in social concepts, they begin to perform them in ways that then confirm the concepts (Schyfter 2009, pp. 37-39).

Arguably, financial theories and terminologies are bona fide social concepts: “finance theory makes a world rather than just describes a world” (MacKenzie 2001, p. 138) and this loop between the two is *performative* in that the utilization of financial concepts “increase(s) the

validity of finance theory's assumptions" (ibid, p. 118). An example from energy would be an energy producer and energy retailer signing a futures contract in an energy stock exchange to hedge the energy price (Nord Pool Spot 2009). If at the time of delivery, the actual energy price is higher than the hedged price, the producer has to pay the retailer this price difference. By utilizing financial concepts, economic ideas about mutual obligation are hence reinforced by these actors and activities.

In sum, social studies of markets operate with two basic kinds of performativity: general consideration of the relationship of economics to economic life (from Austin) and more specific inquiries on how the use of economics increases the validity of economic theory in particular cases (from Barnes). Understanding this difference is crucial for qualifying the critiques against the social studies of market programme and the concept of performativity.

Performativity critiques

Not everyone has been convinced that the concept of performativity is a useful way of understanding economies and economics. Especially concerning the social studies of markets, criticisms of the performativity thesis show an impressive breadth. Energy market scholar Daniel Breslau (2013, p. 830) summarises three main lines of attack. First, to many, the performativity approach seems to assume a technocratic narrative: markets will simply materialize rather linearly from economic theory (Mäki 2013; Pollock & Williams 2015). Second, by assuming that economists are market designers and that markets confirm economic theory, performativity recapitulates the professional ideology of economists themselves (Miller 2002; Aspers 2005). Third, viewed in practice and in empirical detail, markets rarely function exactly like economic theory has foreseen. Economists talk about imperfect competition; but economic sociology could claim that markets are socially embedded and also "products of a political process" (Breslau 2013, p. 830) including ongoing contention and struggle. Also, more generally, the lack of empirical studies of performativity is a staple of recent discussions (Cochoy et al., 2010; Pollock & Williams 2015), yet also shared by the founders of this research such as MacKenzie and his colleagues (2007).

These are important critics concerning the use of performativity. Some of them are answerable by clarifying the social studies of markets programme. All of these issues benefit from more empirical research – as the last critique notes. Let me start with the former and then move to the latter point. The criticisms seem valid, but mainly to a stripped-down version of the performativity thesis, where markets are direct materializations of economic theory. Recent social studies of markets – especially in the Edinburgh tradition, following the lines by Barnes – do not however assume that reality simply confirms economics as a result of performativity. They are centrally concerned in nonlinear, practical interrelations between economic innovations and their uses (MacKenzie 2008). This scope includes failed innovations and even *counter-performativity*, such as financial crashes, where "use of an aspect of economics alters economic processes so that they conform less well to their depiction by economics" (MacKenzie 2007, p. 76; also MacKenzie & Spears 2014).

This research has developed an interest in these issues by a detailed *pragmatist programme of research* (McFall 2010): studying economic statements as successful or failed in the practical instances where they are used, embedded in bodily, linguistic, and social conditions (MacKenzie et al. 2007, p. 14). In sum, recent openings are explicit that social studies of

markets benefits from sharp questioning of which aspects of economics is used in economic practice, what effects it has had, how these effects appeared and why, and how that possibly altered processes to conform more or less to economic theory (e.g. MacKenzie 2007; Pollock & Williams 2015).

Research which takes social studies of markets into explicit consideration and examines the energy infrastructure illustrates how these thoughts were appropriated in a societal arena where economics plays a major role. I argue that analyzing this economic configuration, of current and past, energy infrastructures offers several further ways to answer to critical issues in the social studies of markets. By looking at pragmatic situations in economic thought about energy, this case pinpoints highly dynamic relations between energy economics and markets: where experts first attempt to frame energy economically, energy provision changes as the result of this framing activity, but it also usually defies framing in unexpected ways and creates new problems that need to be tamed by further economic framings.

Part II: At the intersection of economics and infrastructures

Financial systems in energy histories

The electricity infrastructure is a complex assemblage. It is uncertain that it holds together and functions appropriately. Its functioning demands active taming of uncertainties in different locations and by different procedures. Very often, among other practices, this taming work requires utilizing economic knowledge. (Silvast & Virtanen 2014.)

Historian Thomas P. Hughes (1983, 1989) popularised the notion of infrastructures as *large technological systems*: networks of physical artifacts, organizations, legislation, scientific works, and natural resources in a single system. The common name for these systems that combine technologies and resources with social organisation is *socio-technical* (e.g. Verbong & Geels 2007). However, also financial systems have been key parts of these socio-technical structures. The early electrical inventors provided “their inventions with the economic, political, and other characteristics needed for survival” (Hughes 1989, p. 63). The pioneering electricity supply systems expanded mainly to attain economic goals, especially an economic energy mix (e.g. linking coal power in one place with hydro power elsewhere) and a high load factor (the ratio of production to consumption) that would lower costs and increase efficiency (Hughes 1989).

In the United States already in the 1920s, the privately owned electric utility industry was dominated by holding companies – companies that own the stock of other companies but usually do not produce their own services or goods. During that period, this ownership model also caused public controversy and arguments for greater government control of electricity utilities, culminating in the Public Utility Holding Company Act of 1935, soon after which the number of holding companies diminished. To the public, holding companies appeared mainly as vehicles of bankers and stock brokers, both groups with growing influence at the time.

Hughes (1983), though, gives greater attention to how holding companies brought together centralized engineering, management, and financing in a socio-technical manner. Early

figures in holding companies, such as Samuel Insull, had roots in engineering and management and emphasized the principles of systems management and control. However, they found they needed an ally in financial expertise to expand the electricity system:

In their management of the holding companies, these men insisted on the introduction of systems technology and management. In order to introduce capital-intensive and large-scale regional technology, however, they had to find ways to finance large-scale investments. (Hughes 1983, p. 393).

Today, as financial energy is often associated with nation-wide or integrated international markets (e.g. European Commission 2015; UK National Infrastructure Commission 2016), it is also worth adding where the perceived benefits of holding companies lay. Early US government reports saw key gains of holding companies not only at the large scale but in localities: in serving small communities by merging them to a wider system and hence providing them with more centralized engineering, management, and financing (Hughes 1983, p. 394).

Mitchell (2008) has considered the great importance of economics in the modern electricity supply industry and reads Hughes's (1983) findings from that point of view. He summarises that not only did initial electricity networks compile humans and electrical technology into a single structure. Nor were market participants situated outside of power systems, waiting to accept technology or not once it diffused to markets. Rather, market calculations were present from the earliest designs of electricity networks. These calculations brought electricity supply together to become a "wiring network, connecting generators, light bulbs, buildings, shoppers, consumer desire, and capital investment" (Mitchell 2008, p. 1117). They formed a system that "tied together humans and electrons, the flow of electric current and the flow of capital, imagination and illumination, the calculation of the cost of copper wiring and of its conductivity" (ibid).

While economic and market-based thinking has become popular with infrastructures (e.g. Graham & Marvin 2001; Collier 2011; Webb 2014), Mitchell's (2008) important observation is that they were not absent from building earlier energy networks and the problem solving that it involved. More recent research has continued this line of research, though often with only implicit reference to energy histories. I will now review these works placing them under three broad thematic areas: studies of configuring market-based energy, of expertise and knowledge around these issues, and of more detailed studies of the organisation of the energy market.

Configuring market-based energy

The first important context of discussing energy and economics centres on human actors and practices, styles of reasoning, local conditions, calculations, and other techniques that keep infrastructures afloat and how (Appel 2012). They often do so on sites where the effects of economic knowledge would be very difficult to overlook as a purely practical matter.

Anthropologist Stephen Collier (2011) shares in the social studies of markets in his ethnography of restructuring infrastructure industries in former Soviet Russia. He notes how new types of energy meters, targeted subsidies, and incentive pricing – among other "micro-economic devices" (Callon 1998) – may extensively contribute to the possibilities of changing

large-scale provisions like Soviet-era district heating networks. This alleged potential of economics and economic markets in changing infrastructures has been shown in several other cases. It underpins widest debates about European energy: the European Commission's (2015) programmes for building a single trans-European electricity grid are practically inseparable from the "idiom of a shared and single market" (Opitz & Tellmann 2016). Infrastructure planning in Africa shares similar traits, permeated by problem formation in financial terms (Mizes 2016).

In summary, many contemporary infrastructure projects seem to be reprogramming infrastructures by using economic knowledge which seems a privileged way of so doing (Graham & Marvin 2001, p. 34). But as anthropologist Canay Özden-Schilling (2016b) reminds us, the actors in this field – even those designing energy markets – are not just using academic economics, but have to interact with various other types of experts.

The burden and risk of creating organizing frameworks for buying and selling electricity now falls on a new, dispersed set of experts: electrical engineers who design markets (engineer-economists, if you will), traders employed by the buyers and sellers (i.e., generators and utilities), and computing experts who assist both market designers and traders. (Özden-Schilling 2016b.)

In her ethnographic examination, it was not a simple task to create the US electricity market frameworks. Her research draws from Callon (1998) to pay "attention to the processes by which they (markets) are made real, more or less successfully" (Özden-Schilling 2016a, p. 74). This attainment is not some simplistic narrative of market designers creating a market that then changes infrastructure, but brings together electrical engineers, utilities, and computing experts to continuously work on what constitutes the market for electricity.

Knowledge and expertise of the energy markets

Another group of research overlaps with the first, paying close attention to the dynamics of expertise that Özden-Schilling (2016b) described. The key focus here has been on how market energy is produced by experts via distinctive knowledge, modelling tools, and many other tools besides. Partially, the energy market and its participants may be performed by overarching economic promises and visions (Pollock & Williams 2010): for example, imaginations about users of 'smarter' market-based electricity grids (Skjølsvold & Lindkvist 2015) or about ways of living in future low-carbon houses (Cherry et al. 2017) can shape future policies, design, and development choices.

Sociologist Janette Webb (2014) brings a perspective on detailed expert techniques together with social studies of markets when she focuses on the expansion of the UK's emerging district heating networks, by looking at its investment practices. For Webb (2014), social studies of markets provide tools for a detailed investigation of how "market facts" are produced and reinforced by various types of energy experts, or undermined by them in other occasions. These market facts, also including "metrics", might include rates of return on infrastructure investment, where the research could ask how their production brings "particular kinds of economy, economic actors, and material outcomes into being" (Webb 2014, p. 48). As Webb (2014) points out, the same facts and metrics have performative effects: they can undermine the very business case of expanding district heating infrastructures, even if their value in

increasing sustainability can be rigorously demonstrated with other means.

MacKenzie (2009) himself has vied for more attention, in research and policy circles and beyond, to the detailed calculative mechanisms that constitute markets in trading carbon emissions. Economic facts and metrics are important in many sides of producing sustainable, secure, and efficient energy infrastructures: including not only emissions trading schemes, but also energy market analysis (Özden-Schilling 2016a). Perhaps more surprisingly, public regulation of market failures in electricity distribution is also deeply embedded in economic thought and tools. Rather than command and control, it actually aims at supporting energy market competition through oversight rather than directly intervening in markets and the economy (Bolton & Foxon 2013). Regulation stresses 'fairness' in energy provisions but reprograms it by using economic theory and procedures (Collier 2011).

Likewise, in market-like arrangements for securing future electric power capacity investments in the eastern US, economic theory was built into the market rules hence replacing other different value criteria. In practice, economics established the standards for measuring and comparing the 'fairness' of capacity exchanges, as opposed, for example, to deciding capacity by political negotiations (Breslau 2011, 2013). In the view of Breslau (2013, p. 2), a "performativity literature" needs to be drawn upon in order to understand how this happened; it considers "economics in terms of practices for defining rules, agents, and even the entities exchanged in markets. Correspondences between economic theory and economic reality are not discovered but built."

The organization of energy markets

A third group of studies continues these themes by further detailing of how the relationship between economic theory and markets gets built in practice. Within this focus, it is also again deeply indebted to the social studies of markets. Working from this perspective, business scholar Trine Pallesen (2015) studies the French energy feed-in-tariffs – a financial support mechanism for renewable energies – and argues that by integrating wind power into the electricity grid, the feed-in-tariffs markedly changed the 'value' of wind power. No longer a factor in energy supply security, local decentralized energy, a solution to climate change, or part in decarbonisation – all values associated with wind power in society – the economic valuation turned wind power into simply 'electricity' (see also Karnøe 2012).

Introducing wind power into the electrical grid detached the good from its producer, allowing its circulation outside the site of production, but simultaneously performed a qualification by which wind power became simply electricity. In other words, the detachment performed via the connection to the grid was not simply a detachment from the producer, but also from the technology of production. (Pallesen 2015, p. 132.)

Rather like Özden-Schilling's (2016b) frameworks for US electricity markets, this valuation of wind was not a simple practice. It required considerable expert work: from assembling statistics to writing and publishing reports, electricity system management, and calculations of what 'fair' profitability means in the case of wind. But as a result, wind power was made commensurable with other forms of energy: for example, a market good that could be traded against nuclear energy in the power markets.

It is important to clarify the extent to which economics hence performed the value of wind

power as a market commodity. One could certainly argue that the feed-in tariff showed that wind power is not a pure market commodity like, for example, nuclear energy is – otherwise, wind would be valued at market price, not by first compensating its costs. Pallesen's point seems to be that the tariff did allow wind to circulate as a commodity in the power markets. Even so, the value of wind energy was not hence fixed as a market fact (see also Cochoy et al. 2010; McFall 2010). As Pallesen (2015, p. 144) notes, its "sameness and differences" to other energy forms remained controversial and subject to further scrutiny. Yet, the feed-in-tariff always remained at the middle point of these debates; in terms of performativity, an economic instrument, including all the work that went into producing it, altered the 'value' of an energy source to conform more to economic theory than it had done before. Even this effect was probably not inevitable nor fixed: comparably, feed-in-tariffs for solar photovoltaics have proven to be difficult attainments and unstable instruments all around Europe (Cointe 2015).

Similar themes were developed in another study on wind power and the Danish electricity system, with a particular focus on the world's first and largest transnational power stock exchange, Nord Pool (Jenle 2015). Nord Pool allows trading energy generation in Scandinavia, parts of Germany, and the Baltic countries. By an explicit empirical stance on performativity, the work shows how integrating more wind power to the Danish system – a country famously reliant on wind energy – was carried out by experts by introducing and then reconfiguring electricity markets including Nord Pool.

Here, economic markets functioned as tools that would balance electricity supply and demand amid increase in wind power; economic metrics provided the objectives that this market should attain. In effect, economics began to overlap with the remit of (and was influenced by) expert knowledge on control systems engineering. But this was not a static relationship. The performativities of economics changed during Danish wind power evolution. Starting out as an analytical programme – standing outside of the power market as it were, like mainstream economics – later market designers sought to change retail electricity markets so it would better resemble economic models – just like the performativity thesis expects (Mitchell 2011, p. 174).

Performativity theory imposed on energy markets?

At this point, one may ask what is at stake in this research discussion. Is it merely that social studies of markets and performativity literature are helpful in explaining market energy? Indeed, while critiques of social studies of markets and their use in this energy context are rare, Jenle (2015) provides a helpful discussion that brings together many concerns from the above and that I hence summarise here.

Jenle (2015, p. 221) acknowledges earlier research on Nord Pool in the social studies of markets programme, done in Finland (Silvast 2015) and Norway (Karlstrøm 2012) respectively. But he is also critical of this research. For different reasons, he argues that both of these studies are preoccupied with theories and concepts from social studies of markets and leave little room for unpacking empirical experiences on energy markets. As many critics of performativity would agree, he says that these earlier analyses attempt to confirm that Nord Pool resembles economic design and principles. He also points out that such a conclusion is fairly trivial: professionals in market design and management obviously want to create markets that operate in accordance to economic theory.

This critique is poignant and Jenle's (2015) findings above about different performativities in Nord Pool – including what economics was supposed to do, how it attained it, and what other knowledge was employed when constructing the power market – are most appropriate. However, this essay has argued, social studies of markets considering energy provides helpful tools to address this critique, as the two other Nord Pool case studies illustrate.

In the Norwegian case, to understand “economists’ influence in policy matters”, technology scholar Henrik Karlstrøm (2012, p. 21) acknowledges the concept *performativity* to explain them in the Norwegian deregulated power market. However, he remains careful. Norway was among the pioneering free electricity markets in the world in the 1990s, an example in market design that many other countries followed. By examining the history and construction of this market starting from the 1970s, Karlstrøm however concludes that “the performativity perspective, especially the strong version where theory is taken to do all the work on its own, cannot account for the observations related to the deregulation of Norwegian electricity markets.” (Karlstrøm 2012, p. 33).

There were many reasons for why a strong performativity thesis was unhelpful in his study. Not convincing others purely with their new theories, economists depended on their professional resources in political arenas to achieve a deregulated electricity market. Energy policy makers actually resisted the framing of electricity as a pure financial commodity and introduced moral considerations into market mechanisms. Norwegian electricity-using households were concerned of the environment and wanted to save energy rather than to be seen as economic actors on the energy markets, at least primarily – a somewhat dubious finding in a country whose nearly all electricity is produced from hydropower and hence renewable. Various public authorities also resisted the notion to which electricity is an economic commodity and security of supply only its externality (to use economic terminology, see Callon 1998). Instead, they sought to reinforce political responsibility for security of supply even in a liberalized electricity market.

These conclusions are not mere performativity theory and not that far removed from Jenle's (2015) observations: where Jenle (2015) focuses on the interplay of economics with control systems engineering, Karlstrøm (2012) studies the interplay of economics with public politics. The author's (Silvast 2015, p. 18) earlier paper on Nord Pool in Finland also tried to argue that economics rarely influences the economy in predictable ways or directly. Instead, it is more interesting to ask where the impacts of markets designed by economics lie, what counter-effects the markets had, and how these effects were captured by introducing other further economic arrangements – ex-post energy balancing markets, futures markets, or Breslau's (2013) capacity markets are all good examples. Karlstrøm (2012), drawing from Callon (1998), and I both named this dynamic as ‘framing’ and ‘overflowing’: market-based energy is born by first defining agents, objects, goods, and merchandise economically; then, things defy this framing and create overflows, which are contained by further framing (see also Cointe 2015).

The dynamics of electricity network and market regulation demonstrate this observation further (Kaijser 1994; Lagendijk 2008; Silvast 2017). Modern power markets are certainly ‘framed’ by an economic logic in some areas such as sales and marketing; but the ‘overflows’ of these frames are strongly regulated by public authorities and legislations in other matters such as security of supply, electricity quality, and consumer pricing, or more recently, support mechanisms for renewable energy (Bolton & Foxon 2013). Economics is mimicked and

redeployed rather than directly followed in these market designs that seem to be untypically alert to market failures.

Many ethnographic and field studies show a similar result: economic framing of energy is a precarious achievement and many aspects of it defy framing. In post-Soviet Russia and its infrastructure deregulation (Collier 2011), the predominantly US economic theories and practices regarding the free market were situated and shaped by what was already in place in the local field: the styles of reasoning that were applied by local people, climate conditions like a cold country, and the existing already installed infrastructures.

Similarly, when photovoltaics in France were subject to enter the energy markets, their economic framings turned out to be highly fragile, often incomplete and contested (Cointe 2015). Other studies on the everyday work of energy market trading and analysis come a similar result. To produce an energy market trade during action, some practices are primarily economic such as pricing practices, others more infrastructural such as databases (Özden-Schilling 2016a), yet others more oriented to skills, local knowledge, public service ethos, and working habits (Silvast 2011). In all cases, 'frames' do not hold together without continuous work and staying alert to their 'overflows'.

In sum, an empirical stance on performativity is commendable to address problems in a stripped-down version of the concept: where markets simply materialize from economic theory. Study of energy seems to provide a unique case to bring social studies of markets forward in this manner. The encouraging result of this review essay is that while the 'theorcity' of social studies of energy markets remains a problem to some, there is no shortage of empirical research in this area from different perspectives and concerning very different market arrangements in energy. Let me end up by summarising the new openings and the further challenges that performativity research poses in energy.

Discussion and conclusions

This review essay brought together social studies of markets with energy research. It posed and answered two questions: how can energy social research learn from advances in the social studies of markets, and conversely, how can problems identified in social studies of markets be addressed by unique insights from energy social research? I started by explaining the origins and main criticisms of social studies of markets and its *performativity thesis*: which posits that economics not only describes, but also takes part in changing reality to more, or sometimes less, accordance with economic theory. The second part of the essay introduced studies of energy from a social studies of markets point of view and argued that the concept holds much promise in energy social research, and vice versa, that energy research can address some of the challenging issues debated around social studies of markets and performativity in particular.

Considering the first contribution – how social studies of markets can contribute to energy social research, including energy transitions – it is well worth asking where this discussion stands at the moment. In social studies of markets, there is some indication that the literature has moved on from performativity: either because the concept is too sweeping to guide inquiries or because it has become internalized as common background knowledge. Some other emerging and influential concepts in this field include *valuation* (Helgesson & Muniesa 2013) and *market devices* (Muniesa et al. 2007). While these concepts seem to be largely

complementary to performativity, this essay recognises particular strengths of the performativity thesis as such, similarly to many others (Cochoy et al. 2010; McFall 2010; Breslau 2013; Pollock & Williams 2015).

In energy study, performativity and social studies of markets point out how economic facts, metrics, calculations, and statements at large materialize and matter for the energy infrastructure, creating conditions for how this infrastructure can be designed, operated, and imagined. A helpful question to guide these inquiries concerns *what performs what* (Mäki 2013). In the studies reviewed here, on the left side of this relation are business models, market and cost calculations, capital investments, micro-economic devices, policy programmes, organizing frameworks, economic promises, oversight, market designs, and feed-in-tariffs. On the right of the relation, this review suggests these participate in shaping at least the electricity and heating systems as such, restructuring of infrastructures, transnational power grids, energy trade and market analysis, energy policies and development choices, business cases, activities against carbon emissions, governance of market failures, fairness in energy provision, valuation of renewable energy, and its integration to modern power grids. While clearly not exhaustive, this list may help focus further research questions on the ways in which economics reshapes energy provisions.

It is not only possible to apply these concepts to the study of market energy – though, as this review suggests, much more remains to be studied about them. Performativity has also yet rarely explored repercussions in studies of sustainable energy transitions. It pinpoints how economic facts concerning renewable energy, intermittency of renewables, energy efficiency, and many other things are not mere ideologies, but can have tangible effects on energy provision that should be studied in greater detail. Indeed, the stabilisation of relevant market mechanisms – for example, financial support for renewables or electricity capacity markets – has received considerable attention by energy policy makers over the past years. This essay has presented examples and guidelines of how energy social research can follow these debates more closely with social studies of markets tools and hence participate in them. Speaking about carbon emissions markets some years ago, MacKenzie (2009) argued that researchers play a crucial role in bearing more light to critical and detailed market facts and metrics, witnessing how they work, offering cues for social learning, and even participating in making markets more effective by co-designing them with other experts. If we accept that configuration of financial systems is critical to understanding current energy systems and moves to their sustainability, then detailed inquiries such as this are an area for future research.

On the other way around, such energy research also provides unique input to the problems associated with performativity: mainly against the claim that it simply assumes that reality conforms to economics via performativity. I would like to suggest four contributions on this intersection: scale, temporal change, overflows, and framing work. First, performativity in energy can work at vastly different *scales*, from overarching economic statements to detailed calculative mechanisms shaping the energy infrastructure. Capturing the diversity of these performativities and effects is a formidable task (Pollock & Williams 2015). Secondly, performative effects are not fixed but *change* over time and as energy systems and markets as such are altered (Jenle 2015).

This temporal dynamic relates to the next point. Because ‘framing’ energy economically affects

the subject that it is trying to contain, it often has unpredictable ‘*overflows*’ – which then need to be contained by further ‘framing’. Both successes and failures of energy markets to materialize would provide more insights into how this happened in practice – the Scandinavian power market, Nord Pool, often figures as an example of a ‘success’, while European emissions schemes or the Californian electricity crisis could serve examples of widely contested market arrangements, even ‘failures’ to some. The study of these cases leads to my last point which is that constructing a market takes *work*: frames are not formed lest by continuous efforts of stabilising them by experiments and trials, policy reports, statistics, ‘responsible’ consumers, studies, calculations, and many other means besides. For reasons outlined above, more studies of how this happens in the case of energy should be of considerable interest to social studies of markets.

Developing these research lines further also remains challenging for various reasons. Considering its scope first, social studies of markets offers no ready answer of what *economics* and the *economy* can possibly be in different empirical cases. Their relationship remains somewhat circular: economics knowledge is utilised to know the economy, which as such is constituted by this knowledge. In practice, as I have argued, many studies resolve this dilemma of where to start by choosing to study particular *energy markets* – as they are defined by experts – and focusing on them to analyze economics and economy. The fact that there are multiple energy markets (Frankel 2015) with various levels of concreteness and abstractness – from day-to-day stock exchanges to markets for electricity capacity contracts years ahead – offers several potential case studies to this end, though also begets that their diversity is appreciated by studies.

In a general sense, it seems that analysis that chooses to do social studies of energy markets needs to focus on two separate but related objects: the abstract relations between economics and economies and detailed practices in particular markets. Clearly such an analysis cannot prioritize either, but has to go back and forth between social science theories and everyday practices. To do this move, ethnography is a particularly appropriate method and is shared by many studies collected to this essay. Other methods, including quantitative, longitudinal analyses of market facts prior and after economisation (MacKenzie 2006) or the history of critical problems in market energy (cf. Hughes 1989) are as promising, however.

At the same time, by its dual focus, social studies of energy markets also seems to face two different pitfalls. One is preoccupation with a priori theory of economics, economy, and markets that often remains too generic to guide empirical inquiries. Namely, if one already knows that economics always constitutes economies and markets, there is little reason to study how this happens, rather similarly to those performative sentences that always constitute their own realities. An opposite pitfall is immersion in everyday market practices, which may be too blurry and interconnected with other components of the energy system to uncover how economic thought works in them. In many way, the good ways to avoid these risks are contained in earlier social studies of markets: sharp focus on a specific case, good command of its particularities, clarity when presenting these results, and innovative and constant linking of market particularities with a programme of social science research. With the key part that financial systems play in energy systems and their transitions by implication, there is much more room for studies that advance this knowledge.

References

- S. Abrams and M.E. Lien, Performing nature at world's ends, *Ethnos* 76 (1), 2011, 3–18.
- H. Appel, Offshore work: oil, modularity, and the how of capitalism in Equatorial Guinea, *Am. Ethnol.* 39 (4), 2012, 692–709.
- P. Aspers, Performativity, neoclassical theory and economic sociology, *Econ. Sociol. Eur. Electron. Newslett.* 6 (2), 2005, 33–39.
- J.L. Austin, *How to Do Things with Words*, 1962, Clarendon Press; Oxford, UK.
- B. Barnes, Social life as bootstrapped induction, *Sociology* 17, 1982, 524–545.
- L. Boltanski and E. Chiapello, *The New Spirit of Capitalism London*, 2005, Verso; UK—New York, NY, French original 1999.
- R. Bolton and T. Foxon, Urban infrastructure dynamics: market regulation and the shaping of district energy in UK cities, *Environ. Plann. A* 45, 2013, 2194–2211.
- D. Breslau, Economics invents the economy: mathematics, statistics, and models in the work of Irving Fisher and Wesley Mitchell, *Theor. Soc.* 32, 2003, 379–411.
- D. Breslau, What do market designers do when they design markets? Economists as consultants to the redesign of wholesale electricity markets in the United States, In: C. Camic, N. Gross and M. Camont, (Eds.), *Social Knowledge in the Making*, 2011, Chicago University Press; Chicago, IL—London, UK, 379–404.
- D. Breslau, Designing a market-like entity: economics in the politics of market formation, *Soc. Stud. Sci.* 43, 2013, 829–851.
- M. Callon, Introduction: the embeddedness of economic markets in economics, In: M. Callon, (Ed), *Laws of the Markets*, 1998, Blackwell Publishers; Oxford, UK, 1–57.
- M. Callon, What does it mean to say that economics is performative?, In: D. MacKenzie, F. Muniesa and L. Siu, (Eds.), *Do Economists Make Markets? On the Performativity of Economics*, 2007, Princeton University Press; Princeton, NJ, 311–357.
- M. Callon, C. Méadel and V. Rabearisoa, The economy of qualities, *Econ. Soc.* 31, 2002, 194–217.
- M. Centeno and J. Cohen, *Global Capitalism: A Sociological Perspective*, 2010, Polity Press; Cambridge, MA.
- K.K. Cetina and A. Preda, (Eds.), *The Oxford Handbook of the Sociology of Finance*, 2012, Oxford University Press; Oxford, UK.
- C. Cherry, C. Hopfe, B. MacGillivray and N. Pidgeon, Homes as machines: exploring expert and public imaginaries of low carbon housing futures in the United Kingdom, *Energy Res. Soc. Sci.* 23, 2017, 36–45.
- F. Cochoy, M. Giraudeau and L. McFall, Performativity, economics and politics: an overview, *J. Cult. Econ.* 3 (2), 2010, 139–146.
- B. Cointe, From a promise to a problem: the political economy of solar photovoltaics in France,

Energy Res. Soc. Sci. 8, 2015, 151–161.

S. Collier, *Post-Soviet Social: Neoliberalism, Social Modernity, Biopolitics*, 2011, Princeton University Press; Princeton, NJ.

European Commission, A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy. COM/2015/080 Final, 2015.

European Commission, Smart Grids. From Innovation to Deployment, SEC(2011) 463 Final, 2011.

European Parliament & European Council, Concerning Common Rules for the Internal Market in Electricity and Repealing Directive 2003/54/EC, Directive 2009/72/EC, 2009.

A. Faulkner, Law's performativities: shaping the emergence of regenerative medicine through European Union legislation, *Soc. Stud. Sci.* 42, 2012, 753–744.

C. Frankel, The multiple-markets problem, *J. Cult. Econ.* 8 (4), 2015, 538–546

F.W. Geels and J. Schot, Typology of sociotechnical transition pathways, *Res. Policy* 36 (3), 2007, 399–417.

S. Graham and S. Marvin, *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition*, 2001, Routledge; London, UK.

C.F. Helgesson and F. Muniesa, For what it's worth: an introduction to valuation studies, *Valuat. Stud.* 1 (1), 2013, 1–10.

T. Hughes, *Networks of Power: Electric Supply Systems in the US, England and Germany, 1880–1930*, 1983, Johns Hopkins University; Baltimore.

T. Hughes, The evolution of large scale technological systems, In: W. Bijker, T. Hughes and T. Pinch (Eds), *The Social Construction of Technological Systems: New Directions in the Sociology History of Technology*, 1989, MIT Press; Cambridge, MA, 51–82.

IAEE (International Association for Energy Economics), 2016. Main web site. <http://www.iaee.org/> (last ahttp://www.iaee.org/ (Last Accessed 30 June 2016).

S. Jackson, Feminist sociology and sociological feminism: recovering the social in feminist thought, *Sociol. Res. Online* 4 (3), 1999, Last Accessed 30 June 2016 <http://www.socresonline.org.uk/4/3/jackson.html>.

R.P. Jenle, Engineering Markets for Control: Integrating Wind Power into the Danish Electricity System, Doctoral Thesis, 2015, Copenhagen Business School, Department of Organization.

A. Kaijser, *I fädrens spår: den svenska infrastrukturens historiska utveckling och framtida utmaning* [In the Tracks of the Fathers: The Historical Development and the Future Challenges of the Swedish Infrastructure], 1994, Carlsson; Stockholm, SE.

H. Karlstrøm, Empowering Markets? The Construction and Maintenance of a Deregulated Market for Electricity in Norway. Doctoral Thesis, 2012, Faculty of Humanities, Norwegian University of Science and Technology (NTNU); Trondheim.

P. Karnøe, How disruptive is wind power? A lesson from Denmark, *Debating Innov.* 2 (3), 2012, 72–77.

- V. Legendijk, *Electrifying Europe: The Power of Europe in the Construction of Electricity Networks*. Doctoral Thesis Dissertation, 2008, Aksant Academic Publishers; Amsterdam, Eindhoven University of Technology.
- L. McFall, Pragmatics and politics: the case of industrial assurance in the UK, *J. Cult. Econ.* 3 (2), 2010, 205–223.
- D. Miller, Turning Callon the right way up, *Econ. Soc.* 31, 2002, 218–233.
- J.C. Mizes, Who owns Africa's infrastructure?, *LIMN* 6 (7), 2016.
- D. MacKenzie, Physics and finance: S-terms and modern finance as a topic for science studies, *Science Technology & Human. Technol. Hum. Values* 26, 2001, 115–144.
- D. MacKenzie, An equation and its worlds: bricolage, exemplars, disunity and performativity in financial economics, *Soc. Stud. Sci.* 33, 2003, 831–868.
- D. MacKenzie, *An Engine, Not a Camera: How Financial Models Shape Markets*, 2006, MIT Press; Massachusetts, MA.
- D. MacKenzie, Is economics performative? Option theory and the construction of derivatives markets, In: D. MacKenzie, F. Muniesa and L. Siu, (Eds.), *Do Economists Make Markets? On the Performativity of Economics*, 2007, Princeton University Press; Princeton, NJ, 54–86.
- D. MacKenzie, Ten precepts for the social studies of finance, In: D. MacKenzie, (Ed), *Material Markets: How Economic Agents Are Constructed*, 2008, Oxford University Press; Oxford, UK, 8–36.
- D. MacKenzie, Making things the same: gases, emission rights and the politics of carbon markets, *Account. Organ. Soc.* 34, 2009, 440–445.
- D. MacKenzie, F.F. Muniesa and L. Siu, Introduction, In: D. MacKenzie, F. Muniesa and L. Siu, (Eds.), *Do Economists Make Markets? On the Performativity of Economics*, 2007, Princeton University Press; Princeton, NJ, 1–19.
- D. MacKenzie and T. Spears, 'A device for being able to book P&L': the organizational embedding of the Gaussian Copula, *Soc. Stud. Sci.* 44, 2014, 418–440.
- U. Mäki, Performativity: saving Austin from MacKenzie, In: V. Karakostas and D. Dieks, (Eds.), *Perspectives and Foundational Problems in Philosophy of Science*, 2013, Springer; Dordrecht, GE, 443–453.
- T. Mitchell, *Carbon Democracy: Political Power in the Age of Oil*, 2011, Verso Books.
- T. Mitchell, Rethinking economy, *Geoforum* 39 (3), 2008, 1116–1121.
- T. Mitchell, The work of economics: how a discipline makes its world, *Eur. J. Sociol.* 46 (2), 2005, 297–320.
- F. Muniesa, Y. Millo and M. Callon, An introduction to market devices, *Sociol. Rev.* 55 (2), 2007, 1–12.
- Nord Pool Spot, *The Nordic Electricity Exchange and the Nordic Model for a Liberalised Electricity Market*, Nord Pool Spot, Lysaker, 2009.

- OECD & IEA (International Energy Agency), *Learning From Blackouts. Transmission System Security in Competitive Electricity Markets*, 2005, IEA; Paris.
- OECD & IEA (International Energy Agency), *Saving Electricity in a Hurry*. Information Paper, 2011, IEA; Paris.
- S. Opitz and U. Tellmann, Europe's materialism: infrastructures and political space, *LIMN* 6 (7), 2016.
- C. Özden-Schilling, Expertise in the grid, *LIMN* 6 (7), 2016.
- C. Özden-Schilling, The infrastructure of markets: from electric power to electronic data, *Econ. Anthropol.* 3 (1), 2016, 68–80.
- T. Pallesen, Valuable Assemblages—or Assembling Values. In: M. Kornberger, L. Justesen, J. Mouritsen and A. K. Madsen (Eds), *Making Things Valuable*, 2015, Oxford University Press; Oxford, UK, 126–147.
- N. Petropolous and G. Tsobanoglou (Eds), *The Debt Crisis in the Eurozone (EZ): Social Impacts*, 2014, Cambridge Scholars Publishing; Newcastle upon Tyne, UK.
- N. Pollock and R. Williams, The business of expectations: how promissory organizations shape technology and innovation, *Soc. Stud. Sci.* 40, 2010, 525–548.
- N. Pollock and R. Williams, *How Industry Analysts Shape the Digital Future*, 2015, Oxford University Press; Oxford, UK.
- P. Schyfter, *Entangled Ontologies: A Sociophilosophical Analysis of Technological Artefacts, Subjects, and Bodies*. Doctoral Thesis, 2009, University of Edinburgh, Science, Technology and Innovation Studies.
- E. Shove, Beyond the ABC: climate change policy and theories of social change, *Environ. Plann. A* 42 (6), 2010, 1273–1286.
- E. Shove, M. Pantzar and M. Watson, *The Dynamics of Social Practice: Everyday Life and How It Changes*, 2012, Sage Publications; London, UK.
- B.K. Sovacool, What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda, *Energy Res. Soc. Sci.* 1, 2014, 1–29.
- A. Silvast and M. Virtanen, Keeping systems at work: electricity infrastructure from control rooms to household practices, *Sci. Technol. Stud.* 27 (2), 2014, 93–114.
- A. Silvast, Design, Deregulation, and Reregulation of the Nordic Power Markets in Finland: An Empirical Exploration of the 'Performativity' Thesis. Working Paper, 2015, Science, Technology and Innovation Studies, Energy and Society Research Group, University of Edinburgh, 18 May 2015. Available: http://www.sps.ed.ac.uk/__data/assets/pdf_file/0009/175707/Silvast_performativity_WP-18May2015.pdf.
- A. Silvast, *Making Electricity Resilient: Risk and Security in a Liberalized Infrastructure*, 2017, Routledge; London.
- A. Silvast, Monitor screens of market risks: managing electricity in a Finnish control room, *STS*

Encounters 4 (2), 2011, 145–174.

T.M. Skjølsvold and C. Lindkvist, Ambivalence, designing users and user imaginaries in the European smart grid: insights from an interdisciplinary demonstration project, *Energy Res. Soc. Sci.* 9, 2015, 43–50.

UK National Infrastructure Commission, Smart Power. National Infrastructure Commission Report, 2016.

UK Parliament, Inquiry into Smart Meters Launched, 2016, <http://www.parliament.uk/business/committees/committees-a-z/commons-select/science-and-technology-committee/news-parliament-2015/smart-meters-inquiry-launch-15-16/>. (Last Accessed 30 June 2016).

H. Verbong and F.W. Geels, The ongoing energy transition: lessons from a socio-technical multi-level analysis of the Dutch electricity system (1960–2004), *Energy Policy* 35 (2), 2007, 1025–1037.

P. Wagner, *A History and Theory of the Social Sciences: Not All That is Solid Melts into Air*, 2001, Sage; London, UK.

J. Webb, Evaluating urban energy systems in the UK—the implications for financing heat networks, *Sci. Technol. Stud.* 27 (3), 2014, 47–67.

H. Wilhite, New thinking on the agentive relationships between end use technologies and energy-using practices, *Energy Efficiency* 1 (2), 2008, 121–130.