CHAPTER 10

Challenges Ahead: Understanding, Assessing, Anticipating and Governing Foreseeable Societal Tensions to Support Accelerated Low-Carbon Transitions in Europe

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Abstract Addressing global climate change calls for rapid, large-scale deployment of renewable energy technologies (RETs). Such an accelerated diffusion constitutes a new phenomenon, which challenges existing analytical approaches. The implied fundamental reconfiguration of energy systems will inevitably involve adjoining shifts in the structure of energy markets, the socio-cultural significance of energy and related rules and institutions—producing new societal tensions that are largely understudied. This chapter draws on insights from socio-technical,

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social-ecological and techno-economic systems studies to better understand, assess and support the exploration of low-carbon futures. We sketch out an agenda that encompasses four major tasks for governing the energy transition: i) a richer understanding of the dynamics of socio-technical and social-ecological systems; ii) multidimensional assessments of prospective environmental, social and economic impacts of these transformations; iii) methods that enable actors to anticipate future impacts in their everyday innovation and decision practices; and iv) elaborate new governance arrangements to tackle the upcoming transformations.

Keywords Sustainability transition • Innovation • Systems • Governance challenges • Renewable energy • Interdisciplinary

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10.1 Introduction

Addressing the problems of climate change and dwindling non-renewable energy resources whilst ensuring energy security calls for the rapid and large-scale deployment of renewable energy technologies (RETs) (IEA 2015), to make up between 45% and 97% of gross final energy consumption by 2050, depending on scenarios (European Commission 2011). In order to meet the European targets, RET deployment needs to rapidly shift from early niche activities to a phase of accelerated diffusion. Since 2005, considerable progress has been made: the share of renewables is on its way to 20% and above 30% in a number of frontrunner countries (Fig. 10.1)—although there is substantial variation between countries. For technologies like solar photovoltaics (PV) or biogas, actual diffusion even significantly exceeded expectations in some countries (EEA 2017a). The higher diffusion rates have been possible thanks to a combination of ambitious targets, economic incentives (e.g. feed-in tariffs), substantial experimentation, regulatory adaptation (e.g. wind zoning laws), the emergence of industrial opportunities and the involvement of a wide range of actors.

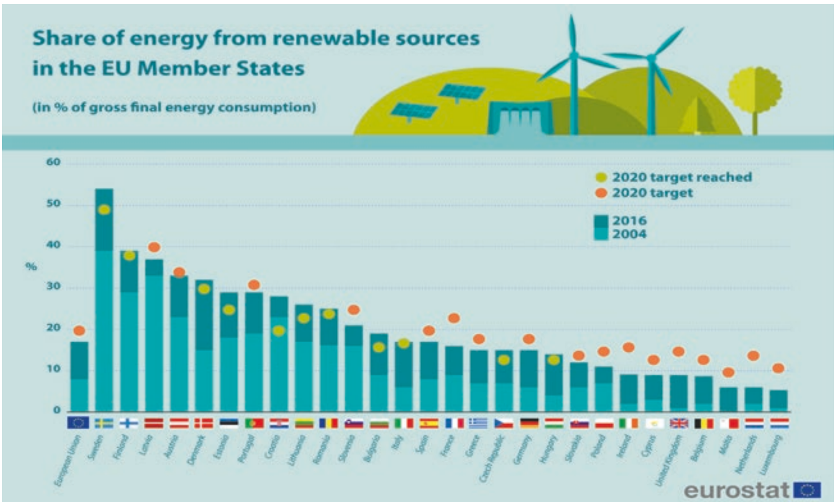

Fig. 10.1 Share of energy from renewable sources in the EU Member States. Source: Eurostat (2018)

Our core hypothesis is that as we enter this new phase of accelerated diffusion, we are presented with a new kind of phenomenon, which is characterised by different combinations of drivers and causal mechanisms (Markard 2018). Accelerated diffusion of RETs involves the transformation of existing systems, that is, mainstreaming and embedding of such technologies in society, the risk of massively disturbing existing social and natural environments, the challenging of established firms (incumbents), institutions and infrastructures. These system transformations are likely to involve tipping points (Westley et al. 2011; Olsson et al. 2006), requiring inter alia the consideration of rapidly shifting system configurations, an ability to reconsider units of analysis (e.g. from isolated technologies to systems) and core causal (innovation) mechanisms (Haydu 2010; Suurs and Hekkert 2009). For instance, it may require shifting our focus from the development and deployment for specific technologies (e.g. solar PV, off-shore wind) to questions of interactions, system integration and reconfiguration of whole electricity systems, implying different challenges for governance. The extant analytical frameworks that deal with the emergence of new technologies seem not well prepared for this task, as most research to date has focused on the early phases of RET diffusion, which do not generate deep impacts on overall energy system configurations and are relatively inoffensive to established actors.

The accelerated diffusion of RETs is expected to be analytically more complex than the early phase (Markard 2018). New analytical perspectives should in particular inform about new ways of i) understanding the phenomenon at hand, ii) assessing related impacts, iii) anticipating implications for innovation strategies and institutional design and iv) dealing with new associated governance challenges. In taking account of such considerations, we here explore the relevance of deploying existing socio-technical, socio-ecological and techno-economic analytical frameworks, the need for revisiting their core assumptions, and the potential for developing greater alignment and effective bridges between approaches (Turnheim et al. 2015; Cherp et al. 2018). We posit that a crucial task for overcoming inevitable blind spots of any individual approach (e.g. socio-technical approaches lack detail of ecological impact dimensions) will be to provide the means for greater alignment between approaches by means of an overarching frame.

Concerning the development of such an overarching interdisciplinary frame, we consider needs for adjustments (within specific approaches) and disciplinary integration (across approaches). We specifically attend to the following questions:

- *Are existing frameworks fit for purpose in this new phase of accelerated diffusion?*
- *Do they address the core mechanisms of the new phase?*
- *And if not, how can they be adjusted or complemented with different perspectives?*

In this chapter, we provide tentative answers to such explorative questions and provide implications for policy and practice in dealing with accelerated RET diffusion.

10.2 What Does RET Accelerated Diffusion Look Like and How Can We Make Sense of It?

Systems perspectives are crucial for understanding the successful development, implementation and accelerated diffusion of new technologies, because the success of this transformative process depends on a wide range of interacting social, economic, technological and environmental factors (EEA 2017b). We consider three relevant but distinct analytical approaches as starting points:

- Techno-economic systems approaches provide the most conventional frame for the study of system change (e.g. in quantitative models and scenarios) but tend to favour technological substitution patterns and neglect reconfigurational change and its unfolding over time.
- Socio-technical approaches emphasise system interactions relevant to innovation dynamics and their governance, rooted in co-evolutionary understandings of change, but tend to be less detailed on specific environmental impacts.
- Socio-ecological approaches problematise interactions of social structures and environmental systems, conceptualising change in terms of dynamic equilibria and tipping points, but tend to be less informative about how systemic change can be achieved.

In the acceleration phase, the new socio-technical systems of RETs undergo rapid change and lead to a multitude of impacts both on environmental and socio-economic dimensions. As a consequence, we need to better understand the new quality of the underlying processes. Table 10.1 maps out the kinds of processual shifts that can be observed between i) an

Table 10.1 Differences in formative and reconfiguration phase of energy systems change across multiple dimensions

	Formative/niche phase	*Acceleration/regime reconfiguration—signs of stress*
Incumbents positioning towards the new technologies	Incumbent actors' discourse is characterised by a combination of a) ignoring, downplaying or discrediting emerging transformative discourse and b) acknowledging emerging issues and seeking to shape broad discourses Incumbent actors marginally explore alternative options (e.g. RETs) as part of early portfolio diversification strategies Industry associations show a closed industry front	Incumbent actors may show signs of erratic behaviour, strategic reorientation and divergence (heterogeneity) Incumbent actors' strategies become increasingly characterised by ambidexterity: focusing on exploiting established options and exploring new portfolios more systematically (e.g. buying up successful new entrants, integrating in-house projects) Industry associations are increasingly stretched due to conflicting and diverging interests of their members Accordingly, more specialised challenger associations become prominent
New entrants positioning towards the new technologies	New entrants introduce and trial out a wide range of new options and technologies (no clear dominant design) New discourse coalitions and advocacy alliances emerge, generating significantly coherent alternative narratives (e.g. broad RET agenda) Broad agendas emphasising societal benefits (e.g. climate mitigation) allow the coexistence of a variety of options and visions (including radical visions)	New entrants experience difficulties with scaling up business (e.g. in terms of finance, customer base, logistics), signalling a need for new business models New entrants shift emphasis on economic attractiveness over societal benefits New entrants increasingly engage with mainstreaming and standardisation (which can lead to a watering down of initial ambitions and radical visions) Alternative visions become increasingly specific (e.g. related to particular options such as solar PV), resulting in the possible emergence of conflicts

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Table 10.1 (continued)

	Formative/niche phase	*Acceleration/regime reconfiguration—signs of stress*
Policy	Development and deployment policies focus on generating support for R&D and learning and developing new market niches	Existing policies lag behind the realities of accelerated diffusion, resulting in a mismatch between policy instruments and their goals (e.g. German feed-in tariffs are being portrayed as cross-subsidies for Chinese PV production, urgency of sunset clauses) Increased policy expenses may erode legitimacy; controversies arise over policy adaptation and reorientation Unintended effects of early support policies generate increasing legitimacy challenges prompting review, refocus or policy phase-out New policy issues emerge: standardisation support, system integration, dealing with incumbents, dealing with potential losers and conflicts
Markets and legitimation	(Proto-) markets are actively constructed by RET proponents Wide price gaps between established and renewable energy technologies Public raise questions about the value and relevance of RETs	Users become increasingly familiar with RETs Declining costs, cost differential between conventional energy and RETs narrow down RETs become gradually legitimated and mainstreamed
Technology	Focus on radical innovation. Diverse offer of technical solutions to societal problems	Focus on incremental improvements Complementary innovations and increasing interactions between RETs Selection of innovations and embedding in society Focus on shaping system architectures (e.g. new structure of transmission grids) and supporting arrangements

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	Formative/niche phase	*Acceleration/regime reconfiguration—signs of stress*
Infrastructure	Experiments at different scales with radically new infrastructure solutions (e.g. smart grids); large-scale incremental change upgrades to infrastructure (e.g. more, bigger and longer transmission lines)	Unanticipated problems emerge, such as unstable grids (see effect of RETs on Spanish grid stability) Investments in novel infrastructures go to scale (e.g. rapid roll-out of charging points for electric vehicles)
Research	Uncertainty and disagreement on what the new dominant technology will be (e.g. electric vehicles vs. hydrogen fuel cell vehicles over past 15 years)	Convergence on (cognitive) expectations and visions for the future (as solutions get selected)
Finance and other resources	Exploring new business model innovations (e.g. renting out energy-saving appliances or RETs). Many start-ups are able to get funding for initial experimentation and market introduction	Many start-ups have problems getting finance for independent scaling up and are acquired by incumbents. Human resources challenges: need for reskilling workforce (from fossil fuel to RET) Need to mobilise significant capital for scaling up
Ecological dynamics and environmental impacts	Benign interactions and marginal stresses Low consideration of trade-offs	Increasing pressure on environmental dimensions for RETs: acute environmental impacts and potential tipping points; dwindling ecological systems and potential loss of ecosystem functions; and acute competition for space and land Pressing need to consider trade-offs (e.g. biomass and food, PVs and mineral extraction) Experimentation with new arrangements to handle impacts (e.g. zoning for wing, limitations for certain kinds of biomass)

early formative phase of diffusion, characterised by experimentation and the formation of niche markets that may require R&D support and measures to protect alternatives from mainstream selection environments, and ii) an acceleration phase, characterised by the rapid scaling of RET diffusion and their integration into larger technical, societal and environmental systems—in paths that are yet to stabilise. Table 10.1 focuses specifically on identifying the signs of stress that we are likely to evidence in such processual shifts (from early stages of socio-technical diffusion to accelerated diffusion and from benign socio-ecological interactions to increasing stresses and pressures). Mapping these signs of stress against current developments indicates that in many cases we have entered this new acceleration phase.

The impact of the RET transition on different environmental and socio-economic dimensions and the associated governance challenges will become much clearer as the acceleration phase progresses. However, the implications of the Collingridge dilemma (Collingridge 1980) become apparent in this case and lend some urgency to better understand the dynamics as they unfold: at first the transition is still malleable and can be steered, but information about in which direction to steer in is limited as the potential consequences of the different transition pathways remain unclear. As some transition pathways are abandoned, and others gain momentum and become embedded in society, the consequences become clear, but the pathways are more difficult to shape due to multiple sources of lock-in (Klitkou et al. 2015).

Hence, while this acceleration phase is a typical 'hot phase' characterised by disruption, high uncertainty and fluidity (Callon 1998), it is a decisive moment in which the overall direction of change is likely to be settled, with implications on how the transition will unfold and what kind of system we will end up with. Consequently, a reflexive attitude towards the impacts of disruption and emergent governance challenges is key, so that we can anticipate and adequately guide the transition process at this critical determining point in time, after which we are likely to witness a new phase of stabilisation and lock-in. Influencing these new forms of lock-in becomes a relevant undertaking.

10.3 Do Existing Frameworks and Policies Suffice?

Existing analytical and associated policy approaches like socio-technical and socio-ecological frameworks say little about the specific mechanisms at play in the acceleration phase. Despite a number of historical case studies covering entire (energy) transitions (see Martínez Arranz (2017) for a review), transitions studies have primarily focused on how the formative phases of energy transitions can be stimulated. Phases of rapid regime reconfigurations have gained much less attention also because they have only recently started to appear in empirical reality. The question that emerges is: 'How can new frameworks be developed that are able to account for the inherent uncertainty, turbulence, conflicts, struggles playing out in this disruptive phase?'

Within the socio-technical literature, different systems perspectives can be identified. The Multi-Level Perspective is useful for describing the overall characterisation of transitions dynamics as the interplay between exogenous pressures and forces of creative destruction emerging in protected spaces that put pressure on the established technologies and infrastructures that provide societal functions like energy provision. But it tends to overlook the micro-level mechanisms underpinning specific diffusion processes. These processes may be better captured by the Strategic Niche Management framework that focuses on the role of visions, learning and building social networks in the development and accumulation of niches (Schot and Geels 2008). The accelerated diffusion phase has mostly been conceptualised as a problem of stacking policy-protected niche markets (called niche accumulation). Recent developments about *niche empowerment* consider issues of wider embedding (Raven et al. 2015). The technological innovation systems approach provides an explicit stage model of the maturation of novel technologies and products. It emphasises core processes that come to bear in technology maturation and market expansion (Bergek et al. 2008; Suurs and Hekkert 2009). Finally, the more generic concept of transformative system failures by Weber and Rohracher (2012) are a fruitful starting point for understanding the dynamic (governance) challenges of transitions but do not differentiate between the stages of system development. Particularly useful for dealing with the uncertainty of acceleration is the concept of branching points as it can suggest where/when opportunities for directional governance may be expected and focus attention where reflexivity regarding impacts is most critical (Rosenbloom et al. 2018).

Research on socio-ecological systems come in two guises: the Natural Science approach uses concepts like tipping points to assess the global impact of RET transition on the planetary boundaries of the Earth system. The Social Science approach is more solution-driven, locally oriented and, like the socio-technical systems field, incorporates actors, institutions, networks and infrastructure. Reviewing the socio-ecological systems literature, O'Brien et al. (2017) identify three main analytical approaches:

- resilience approaches that build on ecological understanding
- pathways approaches that outline different trajectories to meeting sustainability goals
- spheres of transformation approaches that highlight the practical, political and personal domains for effectuating transformation

Although socio-ecological approaches are useful for understanding the social and environmental impacts of accelerated RET diffusion, their major drawback lies in their inability to explain how desirable systemic change could be achieved (*Ibid*). SES could profit from considering insights from the STS literature dealing with transitions. The other way around, recent studies have suggested that transitions research could also be inspired by SES concepts, such as the resilience of transition pathways, for better characterising and steering the acceleration phase. The idea is that the transition process itself, having a normative goal in the energy transition, should be resilient, that is, should be able to continue on the pathway even if major changes in the overall policy environment occur (Binder et al. 2017).

Within techno-economic approaches, Integrated Assessment Models have proven useful by providing quantitative models that incorporate technical, economic and social factors to predict long-term (2050 and 2100) impacts on climate change, resources and biodiversity (van Vuuren and Hof 2017). Notably, it was the Integrated Assessment Models that most clearly indicated the certainty of catastrophic climate change impacts in the absence of drastic policy interventions (Cherp et al. 2018). One of the drawbacks of Integrated Assessment Models is however that their mathematical functions assume a relatively smooth RET diffusion and do not take into account 'major or abrupt shocks, tipping points or any other non-linear system behaviour' (EEA 2017b, pp. 14–15) which typically characterise adoption and transition processes (Geels and Schot 2007; Rogers 2003).

To conclude, although the socio-technical, socio-ecological and techno-economic perspectives continue to develop and borrow from each other, they warrant further conceptual development to better understand, assess and deal with the new governance challenges associated with the accelerated diffusion of RETs.

10.4 Implications for Policy and Practice

Reflecting on what the different systems literatures have uncovered on the transition to RETs so far, we provide some preliminary warnings for policy, practice and research.

- *Act now:* First, the transition to RETs is happening at an increasingly rapid pace at global, European, country and regional scales. As momentum increases, the window of opportunity for steering the transition process and its various local components in a given direction is closing. Since it will be increasingly difficult to shape the further development the farther the scaling has progressed, policy should provide clear, long-term goals while remaining flexible enough to acknowledge and accommodate the inherent uncertainties of societal transitions.
- *Target the whole system and all stages of the innovation process:* Providing such normative directionality means that existing policies and governance structures need to be adapted to adequately steer the transition process. This means moving beyond conventional innovation policies directed towards R&D and including multi-stakeholder governance arrangements and demand-side instruments that reward the uptake of renewable energy-related technologies and penalise polluting options.
- *Involve different stakeholders in reflexive governance:* To support good decisions, it is important to critically assess the different social and environmental impacts on the system and further open up normative discussions by involving different stakeholder groups. These stakeholders should be approached equally, lest the discussion is captured by the power of vested interests. Reflexivity regarding the direction of the transition, emerging impacts and societal goals remains crucial during the phase of acceleration, particularly when critical choices need to be made at transition branching points (cf. Rosenbloom et al. 2018). The concept of resilience of transition might provide a good starting point for policy development.
- *Consider how to overcome path dependencies and vested interests:* Furthermore, it is important to note that as the transition progresses and RET diffusion accelerates, decisions regarding directionality become increasingly political as their impact increases. Vested interests become more seriously threatened by new economic powers,

and incumbents have to increasingly commit to and select within the new options, while abandoning the old. They have a history of opposing and shaping political decisions that are not in their favour and although opposition becomes increasingly illegitimate, shaping endeavours may increase as the stakes increase (Wesseling et al. 2014). Closed industry fronts of opposition to change can be broken by engaging with individual, innovative companies instead of industry associations that typically prefer the status quo (*Ibid.*).
- *Deal with the potential losers of transition:* The transition will ultimately happen and there will be losers. It is important to acknowledge this and the fact that doing nothing means favouring the status quo and can have even higher societal costs on the long-term than timely adaptation. Instead, policy should proactively deploy strategies to deal with losers, for example, develop re-education schemes for those currently employed in those sectors that are to be phased out.
- *Account for differences in transitions across time and space:* Given that diffusion and system integration dynamics unfold at different speeds and in qualitatively different ways across countries and regions (e.g. around different interests and trade-offs, due to different resource endowments, strength of local coalitions and ante-coalitions), the issue of dealing with such variations becomes a new priority that is especially salient at for European governance.

10.5 How to Proceed?

To systematically approach the governance challenges associated with accelerated RET diffusion, we distinguish four analytical challenges that the aforementioned systems literatures will have to tackle in the future:

1. *Understanding system dynamics*: First it is important to develop a better understanding of the potential socio-technical/socio-ecological dynamics of the new acceleration phase, as literature has done for the formative stage of the sustainable energy transition (see Table 10.1). This requires an inventory of the recent contributions in the different systems literatures that shed insights in the explosive dynamics of this stage, such as concepts like branching points, system resilience, tipping points and so on, and explore cross-fertilisation across these literatures to develop new or existing frameworks.

2. *Assessing signs of systemic stress*: This deeper understanding should then inform assessment of the social, environmental (ecological and space) and economic impacts of accelerated RET diffusion. One way of doing so is by providing signs of 'stress' that indicate acceleration and critical decision making at branching points.
3. *Anticipating future social and ecological impacts*: New understandings about system dynamics and their impacts should inform individual actors in anticipating the future impacts of their decisions made today. Examples of anticipatory approaches include value-based designs and constructive technology assessment (Truffer et al. 2017).
4. *Transforming systems and their governance:* Other than informing individual actors, new understandings about system dynamics and their impacts should also inform system-level governance structures to steer the direction and rate of the transition process. An example of such an approach is transition management (Kemp et al. 2007), although it has so far focused on the formative stage of transition. These approaches should direct system transformation on the basis of the social, environmental and economic impacts of different transition pathways, which is currently overlooked in particularly the socio-technical literature (Kemp and Van Lente 2011).

10.6 Final Reflections

The increased rate of deployment of RETs is a welcome sign of progress towards low-carbon transitions. It comes with new challenges that this chapter has sought to highlight. Our core hypothesis suggests that as we enter this new phase, we are confronted with a qualitatively different phenomenon that warrants a new reflection concerning the appropriateness of current analytical and governance approaches. The complexities, uncertainties, temporal and political issues involved need to be more centrally recognised as the keys to effective and legitimate interventions. The increased engagement of a variety of Social Science perspectives with core-related issues is a significant strength to draw on, continuously improve and cross-fertilise (Castree et al. 2014; Cherp et al. 2018; Kuzemko et al. 2016; Stirling 2014; Turnheim et al. 2015). A new wave of interdisciplinary research is emerging that explicitly recognises the task at hand. This chapter has built on and contributed to this collective effort by charting a possible way forward.

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