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Accountability and Sustainability Transitions

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Abstract

What constitutes a sustainability transition? This question is important for analyzing energy transitions and in the broader realm of socio-material systems. We identify sustainability transitions as premised on changes in flows of legitimacy and on shifts in the accountability mechanisms that regulate these flows. Legitimacy flows to organisations through accountability regimes of inputs (standards and assessments), outputs (sanctions) and outcomes (structural and material change). This legitimacy allows organisations to access resources necessary to compete and to thrive. Changing accountability regimes lead to sectoral transitions, and the values underlying these changes determine implications for sustainability. We define accountability as the basis of legitimacy, and identify accountability relations as legitimacy tests. Conformance with norms yields legitimacy. Failing tests of accountability yields sanctions that undermine the relevant actions and actors. Contestation and adaptation of accountability mechanisms lend themselves to empirical observation. Their analysis evidences whether accountability is strongly substantiated, a hollow performance, or an expression of authoritarianism or radical liberalism. It enables characterisation of sectoral transitions in relation to sustainability, and identification of mechanisms to institutionalize accountability relations that integrate ecological limits and justice considerations into socioeconomic dynamics, to advance sustainability transitions. To demonstrate its explanatory power, we analyse solar energy uptake in Portugal, a rapidly growing niche, as a purported case of sustainability transitions. This empirical analysis juxtaposes the promise of movement to a more equitable, low-carbon energy future with institutional and material inertia. We draw on expert interviews, field observation and secondary research to apply accountability analysis to this energy transition case. Our approach targets both formal and informal means of legitimation. Assessment and sanctions serve as markers of the changing accountability regime that characterises sectoral transition.

Highlights

- Analyzes sustainability transitions in terms of accountability and legitimacy
- Proposes and demonstrates a methodology for accountability analysis
- Includes both formal and informal factors in assessing a sociotechnical transition
- Accountability is substantive, hollow or replaced by authoritarianism or liberalism
- Empirically analyzes uptake of solar energy in Portugal in terms of accountability

1. Introduction

Scholarship on sustainability transitions is burgeoning and splintering, which can be a strength as well as a weakness. Within the "evaluative" stream in the literature (Loorbach et al 2017), a range of seemingly distinct questions structure the field: what constitutes transitions, when is a claim of transition valid, and how to recognize 'success'? The domains assessed and targeted for sustainability transitions can be characterised as socio-material systems, such as energy systems that introduce greenhouse gases such as carbon dioxide into the atmosphere and cause climate change, thereby triggering reflexive assessment of risk, rights and responsibilities. Informed by contrasting theories of change, varied research streams feature different methods and data types, philosophies of science, and ambitions. These vary from densely analytical and theoretical, historical and descriptive, to action-oriented and prescriptive.

Despite this diversity, the common problem framing hinges on the establishment – or institutionalization - of a disruptive innovation trajectory. In reviewing the sociotechnical transitions literature a decade ago, Smith and Stirling (2010) commented:

> *Acknowledged to be the most important element, institutionalization is considered least in the transition management literature (Smith and Kern 2009). This is the point at which serious commitments are needed, to such an extent that the incumbent regime suffers and is undermined if they are not made (Smith et al. 2005, Shove and Walker 2007). Politically and economically, institutionalization is very difficult. It involves mobilizing serious selection pressures against the incumbent regime and redirecting vast institutional, economic, and political commitments into promising niches along desired pathways.*

As highlighted in this quotation, system transformation involves shifting resources away from a set of powerful actors and practices (Stirling 2019). We identify accountability as a concept and set of

practices with potential to advance sustainability transitions. As emerging scholarship suggests (cf. Sareen and Haarstad 2020), accountability can be analysed in ways that are responsive to specific contexts, and can thus support better analysis of specific cases than idealised models of sustainability transitions.

For us, accountability is a process of assessment through which some actor or action is evaluated in relation to contextual norms or institutional logics. Moreover, accountability demands that these evaluations are linked to rewards and sanctions that reshape competitive dynamics and the demography of relevant populations (e.g., firms, technologies, routines). We identify an opportunity to advance an analytical and potentially practical programme of research focused on accountability. Drawing on neo-institutional theory (Suchman 1995), we define accountability as *a process of social regulation premised on grants of legitimacy to actors that conform to institutionalized norms*.

In this paper, we derive a methodology for conducting accountability analysis and we apply it to the case of solar energy uptake in Portugal, a growing niche (Pinho and Hunter 2019). Our analytic focus is on specifying if and how observed shifts in accountability can be usefully understood as the instutitionalization of a sustainability transition. Extending work by Kraft and Wolf (2018), we argue that attention to processes and practices of accountability – and the legitimacy flows attached to accountability – can support critical and empirically informed assessments of sociotechnical transitions. We develop a conceptual and operational approach to identify changes in environmental governance that shape behaviours, technical practices and, over time, the composition of populations of economic actors (*i.e.*, organisational ecology or demography). The institutional shifts that we identify as driving socio-material change represent selection pressures in environments characterised by competition. For example, new regulations, taxes, prices, and social norms reward some set of actors/actions and disadvantage those that fail to read or actively disregard these signals. These shifts in social regulation stem from, and inform, new understandings and emergent social norms (cf. Lund 2016). To some extent, this reference to a shifting competitive landscape can be understood through reference to evolutionary mechanisms (Nelson and Winter 1982), Schumpetarian dynamics and organisational ecology (Hannan and Freeman 1984). More generally we refer to multi-scalar socio-material systems in which population dynamics – and the behaviours of individuals in the population – are mediated by changes in material, structural and relational domains.

In short, behaviours that have implications for sustainability (e.g., investments in energy infrastructure and changes in relevant public policies) are subject to varied assessments and the results of these assessments condition future prospects for individuals and classes of actors within variously specified

populations. The standards of assessment and the implications of these 'accountability tests' – i.e., redistribution of privileges and duties – are continuously subject to contestation and change. As we define it, a sustainability transition is a change in accountability regime (*i.e.*, the full range of assessments and selection mechanisms at work in and on some specified domain). Study of changes in accountability assessments, mechanisms, and procedures can be a means of evaluating progress (such as the growth and consolidation of a low-carbon niche), lack of progress (such as persistence and reaffirmation of commitments to fossil fuel energy sources), and twists and turns in sustainability transitions.

We provide a brief overview of sustainability transitions, in terms of both sociotechnical aspects and institutional dimensions, and their relationship with accountability. This leads us into an urgent call for moving beyond normative appeals and institutional design efforts organised around ideal types, which tend to mute the applied value of both sociotechnical and institutional analyses (*cf.* Porter et al 2000). Extending Kraft and Wolf's (2018) and Sareen (2019) and co-authors' empirical engagement with accountability, we propose a critical realist approach based on the empirics of transition within any sector or locale, rather than on assumptions that privilege formal configurations of institutional authority and information transmission. Our approach has potential to capture social dynamics that can reshape socio-material relations and distributions of risk (substantive accountability), as well as capacity to identify gestures that merely serve to perform accountability and "sustain the unsustainable" (Blühdorn 2007) (hollow accountability). Beyond diagnostic applications, the concepts and methodology we develop can serve to identify windows of opportunity for strategic interventions to advance sustainable transitions.

We structure our argument as follows: Section 2 contextualises accountability and legitimacy within environmental governance scholarship, and Section 3 presents our accountability analysis framework. Section 4 applies our framework to dynamics of solar energy uptake in Portugal. The empirics emphasize the ambiguity of the sociotechnical dynamics, and the analysis demonstrates how an accounting of accountability allows us to make sense of the dynamics. The concluding discussion in Section 5 reflects on our proposed strategy to characterise sustainability transitions, and we articulate programmatic implications for future research.

2. The accounting of accountability and legitimacy under transition

This section first introduces and links sociotechnical and institutional dimensions of transitions, and then argues for the need to focus on accountability relations to characterise sectoral transitions.

2.1 Sociotechnical and institutional dimensions of transitions

The idea of sociotechnical transitions originates in science and technology studies (STS), which has sought to explain how some technological innovations come to have broad effects on society, while others do not. Within STS thinking, a technological innovation becomes widespread not simply due to its own characteristics, but by amplifying existing social and economic structures and trends. This emphasis on social embeddedness highlights the *socio*technical dimension of sustainable transitions; technological change is always mediated by social practices, institutions, markets and political economic relations (Rip and Kemp, 1998). Within the social sciences, the significance of social dimensions of technology and processes of technological change is now quite well-established (Healy and Barry 2017). Within engineering and the biophysical sciences, there is increasing awareness of the relevance of the social dimensions of technology and knowledge generation (Palmer 2012; Kates et al 2001). This basic framework is central to tremendous investments in research in the past 15 years (e.g., within the European Union (EU) Framework Programme for Research and Innovation) regarding the conditions under which technological innovations could drive low-carbon, sustainable transitions.

The research on sustainability transitions can be disaggregated into at least four specific strands (Markard et al 2012). These are *transition management* and *strategic niche management*, which are oriented towards understanding how transitions can be purposely engendered, and the *multilevel perspective (MLP) on sustainability transitions* and *technological innovation systems*, which both take a systems approach to understanding transitions. Prominent among these, the MLP understands transitions as a non-linear process that evolves as a result of the interplay between three analytical levels, namely a technological niche, regime and landscape. It is a sort of non-determinant "garbage can model" (Cohen et al 1972), where multi-dimensional consideration of punctuated equilibria serves as a means to integrate inertial and disruptive factors.

The ontology that underlies most research on sustainability transitions, as of much thematic social science scholarship, is that (1) technological innovation defines transitions, and (2) transition dynamics are structured by a relatively coherent system (Sareen and Haarstad 2018). The perspective has been criticised for both lacking a sense of geographical complexity (Bridge et al 2013; Hansen and Coenen 2015), and for favouring a systems perspective that emphasizes path dependence and stability over disruption and emergence (Haarstad and Wanvik 2016). Within sustainable transitions research, the frequent choice of historical, large-scale examples such as shifts from coal to oil and then on to gas does not allow for appreciation of specific actors' roles and grounded, lived experience. Systems of

innovation thinking similarly risks structural determinism (Mostafavi et al 2011). Analysis of dynamics including growth in renewable energy production, shifts in automobile ownership, and changes in diet must include analysis of agency and localised politics. Such a grounded, actor-centred approach is needed in order to inform strategic, constructive engagement with sectoral and societal transformations.

Neo-institutional theory regards transitions to be a matter of institutional design. Analytical treatment of organisational configurations that structure the (re)distribution of authority across levels of social organisation – participation, devolution, decentralisation, polycentricity – and of (re)distribution of property rights – state property, private property rights, common property, open access commons – and information channels – transparency, disclosure, right-to-know provisions – focus on formal representations. This research has produced a great deal of knowledge regarding access rules and processes for making and revising such rules (Vatn 2009; Epstein et al 2015). The field emphasizes organisational principles and attention to contextual factors, but conceptualizing transitions as a challenge that hinges on adaptation of design principles to local contexts is reductive (Epstein et al 2015). Environmental economics of the 1990s was focused on "getting the prices right" (Deaton 1998), and despite early preemptive cautioning (Cleaver 2000; Mosse 1997; Giddens 1989) and a broader focus introduced by ecological economics on "getting the (plural) values right" (Spash 2012), the past 25 years of environmental governance work has approached transition as a matter of "getting institutions right" (Rodrik 2004). We argue for a need to go beyond attention to institutional design (i.e., forms of ownership, specification of rights and responsibilities, monitoring and information reporting pathways) and formal institutions (i.e., forms of ownership, specification of rights and responsibilities, monitoring and information reporting pathways). We discern a need for more investment in analysis of *de facto* processes of social regulation that restructure practices and populations (i.e., disruptive interventions that drive changes in the distributions of specific behaviours, such as pollution, and the characteristics of some population, such as electricity producers).

There is mounting evidence that existing socio-material trajectories are not responsive to efforts to define and promote "good governance". For example, GHG emissions in 2017 increased globally at a rate above 3%, despite new scientific evidence of environmental change (IPCC 2018), the Paris Accord, and the many and variously scaled sub-national climate change mitigation initiatives. In this context, we perceive a need to advance analysis of the enabling and constraining effects of institutional change. We identify study of *accountability* – which we understand in terms of social relations of discipline that shape socio-material development – as an emerging focus of analysis and practice, as part of the broader relational turn in the social sciences (Boggs and Rantisi 2003; also see Jessop 2000). This is a

shift away from attention to abstract processes of institutional design and toward attention to *a dynamic through which institutional change alters behaviours of people and organisations* to deliver material outcomes that can conceivably advance sustainability.

2.2 Why focus on accountability relations under sustainability transitions?

In calling for attention to shifts in the disciplining effects of institutions, we aim to advance a symmetrical analysis in which the likelihood of discipline contributing positively to shared ecological security and social equality is equal to the likelihood of advancing crony capitalism, distributional inequities, and authoritarianism. Analytical treatment of accountability should address questions regarding the relationships between more or different accountability and a range of normative aims (e.g., the 17 Sustainable Development Goals) in varied contexts. At the same time, a programme of research organised around this theme must address critical questions including how accountability relations implied by monitoring programmes, eco-labeling, environmental management systems, and offsetting schemes, for example, are implicated in our capacity to satisfy ourselves with empty gestures that legitimate existing socio-material relations and "sustain the unsustainable" (Blühdorn 2007; Blühdorn and Deflorian 2019; Sareen and Grandin 2019). By examining how accountability structures interactions at and across multiple scales, we engage critically with who holds whom to account, based on what standards, and in support of whose objectives. At the level above individual accountors and accountees, our treatment of accountability addresses changes in demography and sociotechnical practice. For us, accountability has potential to change the distribution of actors in the relevant population and the distribution of behaviours that give rise to sustainability concerns (e.g., pollution, ecosystem simplification, over-consumption of fossil fuels). A sustainable transition implies a population-level change. This would typically involve a mixture of demographic churn (entry and exit) and adaptation (new technical practices and/or new organisational strategies) (Smith et al 2005).

Sustainability transitions can be defined as pathways through which socio-material changes reduce environmental risks. Sustainability transitions scholars are currently trying to integrate power, politics and culture into their systems thinking approaches (*cf.* Turnheim et al 2015; Cherp et al 2018; Sareen and Haarstad 2020). Accountability analysis approaches complex systems in a way that respects the multiple layers and players involved, and attends to power relations as constituted by actors' capacity to change formal and informal standards and codes of legitimacy, and the potential to distribute sanctions and rewards that can drive population or even systems change. For example, consider how scientific and popular understanding of risks of climate change might trigger redistribution of

government subsidies, strategies of institutional investors, and cultural codes that shape the social license to operate of firms in the energy sector.

For us, accountability is *a set of relational practices that mediate flows of legitimacy to organisations* (Kraft and Wolf 2018). Legitimacy is defined as a critical resource organisations need in order to function and reproduce their status in competitive contexts. It is the means through which organisations derive authority and reproduce access to resources (*e.g.*, respect in the community, license to operate in the civic sphere, public subsidy, access to capital, customer and workers' loyalty). This follows from Suchman (1995, p. 574) who views legitimacy as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions". Legitimacy flows to organisations when they are regarded as having internalised institutional norms derived from foundational aspects (*i.e.*, deep structures) of society (*e.g.*, family, community, market, government). As expressed by Kraft and Wolf (2018, p. 7-8):

> *Within the organizational literature, specifically neo-institutional theory, all organizations require legitimacy (Meyer and Rowan, 1977; Suchman, 1995). Without legitimacy, organizations cannot gain necessary resources and, therefore, struggle. Organizations objectively possess legitimacy, but create it subjectively (Suchman, 1995). Organizations strategically engage in practices and deploy symbols to acquire legitimacy as an operational resource (Dowling and Pfeffer, 1975). Legitimating actors perceive organizations as legitimate when organizations incorporate institutions into their structures (Meyer and Rowan, 1977).*

Kraft and Wolf (2018) focused on formal accountability relations as represented by material artefacts such as contracts, laws, eco-certifications, and public commitments expressed in press releases and annual reports. Yet accountability relations are expressed in informal ways. As represented by the sociological concept of embeddedness (Granovetter 1985), action is situated or contextual. Normative and cognitive elements of institutions structure interactions and discipline behaviour, hence the need to address informal aspects of accountability and changes in accountability relations and procedures. That said, empirical work on informal accountability may require deep ethnographic analysis. It is not clear how the various disciplinary traditions of case study methodology (cf. Yin 2017) can support commitments to address both formal and informal aspects of accountability regimes. Whereas Sareen (2019) proposes empirical attention to practices of legitimation; here we build on Kraft and Wolf (2018) to argue for an emphasis on assessment and sanctions as the two core relational practices that constitute accountability.

The first practice centres on information flows that support assessment, and the second on the willingness and ability to sanction. At base, accountability refers to accountors obtaining information (accounts) of behaviours of accountees. This information is assessed in relation to a set of standards or norms (i.e., institutions), and a judgement is made. This judgement is focused on the extent to which an accountee has *successfully incorporated institutions into their structures. Institutions are the values, formal and informal rules, beliefs, and assumptions that define a field of social interaction* (Meyer and Rowan 1977). In our treatment, this process of assessment constitutes an accountability 'test'. Audits and disclosures represent common oversight mechanisms that contribute to information flow, transparency, and accountability.

Sanctioning is the second element of accountability relations. Accountees found to have successfully internalised relevant institutions receive grants of legitimacy from accountors. This legitimacy positions them to compete in the next period of an ongoing process of assessment. Those who fail an accountability test confront the risk of having flows of legitimacy withdrawn. When the implications of loss of legitimacy constitute a significant risk to the organisation – e.g., jeopardising their solvency, legal and social right to operate, or their relations with lenders, customers, workers, or peers – we can say they have been sanctioned. *Interruptions in flows of legitimacy pose risks that structure thought, deed and strategy.* Conversely, when emerging or acclimating actors gain legitimacy for new actions, positive sanctions may support the expansion of such behaviours and corresponding socio-material changes, reconstituting the field.

In our view, treatment of accountability within the environmental governance literature has emphasized the information question without equal investment in the question of sanctions and selection pressure. Mol's (2006) work on informational governance is important in this context. Information flows are seen as being endowed with capacity to coordinate people and material so as to achieve social regulation. This line of thinking can be linked to neoliberalism and faith in self-organizing systems (Bonanno and Busch 2015). We identify a need to engage critically with conceptions of social regulation defined in terms of production and access to information.

Information and assessment have been privileged in critical treatments of metrics, quantification, and accountability within STS. This research stream highlights how historically structured political economic and social relations condition how varied aspects of environment are represented, constituted, and ignored. Höhler and Ziegler (2010, p. 420) explicate this need to refocus: "We suggest moving beyond discussing the rise of accounting as a scientific practice that needs to be assessed

critically for its presumptions of commensurability of numbers and nature; we propose to also examine the significance of ecological accounting practices for economic and political accountability." Whitney and Kiechle (2017, p. 2) note that existing scholarship has "established that institutions quantify nature not only to make it legible, but also to guide policy decisions and plans that would shape the future of the environment." Thus, this research stream has highlighted the social construction of the environment and the political economic implications of collapsing its multidimensionality and multiscalar complexity into tidy categories and discrete vectors. We identify efforts to address how assessment tools and routines translate into socio-material change as less successful. Our approach addresses this weakness by focusing on the *mechanisms through which accountability is linked to discipline (i.e., selection pressure), changes in the population of actors and behaviours and, ultimately, to socio-material relations*.

Our position is both *normative* (i.e., focused on a particular problem that we specify) and *analytical* (*i.e.*, focused on evaluating a theory-based proposition). We identify a need for changes in social and material dynamics to avoid serious (*i.e.*, practically irreversible) consequences of existing trajectories. Sustainable transitions is a broad reference to programmes of change along these lines. As part of an effort to support sustainable transitions, we identify an urgent need for concepts and empirical tools to make sense of opportunities and challenges. By making an accounting of accountability mechanisms and changes in accountability environments, we identify a potentially promising means of analyzing changes in socio-material systems. Our thesis is that accountability and selection pressure are critical elements of sustainable transitions.

3. An accountability analysis framework

We have organised this section in two parts: 3.1 introduces a three-step cycle of inputs, outputs and outcomes through which to map changing accountability regimes during sectoral transitions, then 3.2 introduces a 2x2 'LASH' matrix as the format in which accountability analysis yields results.

3.1 Changing accountability regimes and the reflexive cycle of sectoral transition

Advancing an analysis of accountability dynamics requires the following data: **(1a – standards)** an account of existing accountability standards or norms and current debates regarding potential changes to those standards; **(1b – assessments)** an account of accounts given and accounts taken; **(2 – sanctions)** an account of sanctions imposed and rewards distributed, as justified through reference to accountability tests; **(3a – structural change)** an account of shifts in relevant behaviours and actions

(*e.g.*, solar energy deployment and acts that enable solar deployment) attributable to shifts in standards, assessments and sanctions (*i.e.*, an assessment relative to a counterfactual); and **(3b – material change)** an account of institutionalization of new material practices (*e.g.*, reductions of greenhouse gas emissions) that can be attributed to specific accountability mechanisms.

We note that points **(1a)** and **(1b)** are inputs within an accountability regime; **(2)** is the output of an accountability regime; and **(3a)** and **(3b)** are, respectively, proximate and ultimate outcomes of an accountability regime.

We identify changes in accountability mechanisms as the single most important element of an analysis of sustainability transitions focused around accountability. New laws, new administrative rules, redirection of subsidies, judicial rulings, as well as new professional practices, new social practices, and new justifications (*i.e.*, references to alternative bases of legitimacy) are the kinds of empirical evidence we identify as most important for assessing potential for restructuring of a given sociotechnical domain.

Accountability is premised on obtaining *accounts* of actions. These accounts are created through disclosure by accountees – voluntary or mandated – or through some form of monitoring or audits performed by accountors or their agents. The central issue here is obtaining information to support an assessment and subsequent judgement as to whether an accountee has conformed or failed to conform to some norm or test. This process of obtaining information and using it to make a judgement is, however, only a precursor to processes through which accountability produces changes. Going beyond analysis of accountability in terms of discovery (i.e., the information problem), we emphasize sanctions (i.e., penalties that significantly diminish accountees' access to resources). The flip side of sanctions is incentives. Being subject to accountability tests puts an accountee at risk of sanction, but at the same time these tests are an opportunity to reproduce or perhaps strengthen flows of legitimacy from accountors. This legitimacy supports access, subsidies, social license to operate, and status in planning and public perception, all of which enhance security and competitiveness. We define sanctions in terms of discipline that structures thinking and action. Diminished access to resources constitutes loss of competitiveness, a strategic consideration and in some cases an existential threat. This dynamic reshapes populations, physical infrastructures, and, consequently, sustainability outcomes.

We have conceptualised sectoral transitions as a three-step cycle: standards and assessment as *inputs*, followed by sanctions as *outputs*, followed by structural and material changes as *outcomes*. Figure 1 visualises this cycle in a manner that highlights pathways.

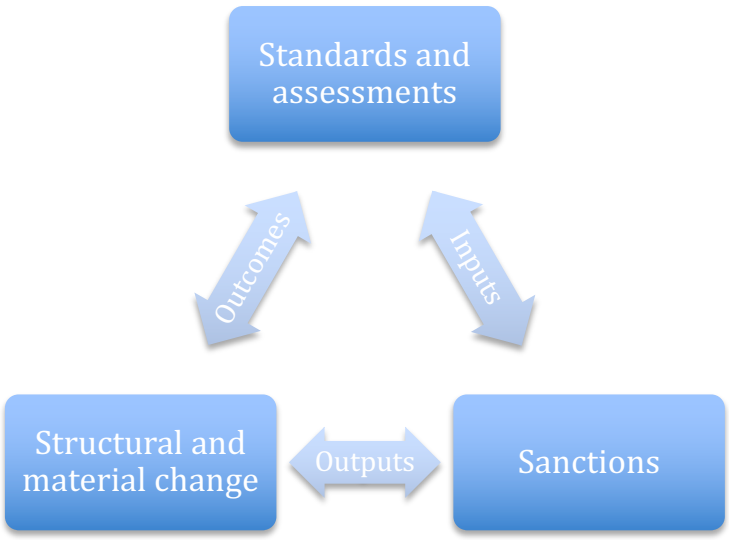

Figure 1 Changing accountability regimes and the reflexive cycle of sectoral transition

The *inputs* include the population of actors and the range of production, consumption and investment behaviours, i.e., actions including what takes place within data infrastructures, that can be observed empirically. Attention to these inputs can make accountability mechanisms – and changes in those mechanisms – visible. For example, when a firm makes a major acquisition, analysis of the press release can identify connections between competitive strategies and changing institutional context. When regulations require an electricity supplier to provide information on its greenhouse gas emissions, this can be scrutinized. Thus, we can observe how the inputs of an accountability regime, (1a) standards and (1b) assessments, are shaped, emerge and play out in symbolic and discursive ways. Such cognitive and cultural shifts are precursors to actions that reshape sectoral practices.

The *outputs* include concrete actions in the form of sanctions, both positive (incentives, rewards) and negative (penalties, surcharges), that impact the field of actors and actions. They feature the operational aspects of accountability in practice, both formal (laws and administrative rules) and informal (the interpretation of applicability and extent of sanctions to cases). Attention to these dynamics can provide insights on political, cultural and ontological shifts that follow from expert and popular assessments of socioecological risks and what constitutes prudence, justice, and appropriate behavior. For example, when a ministry introduces new permitting procedures or new oversight routines, these are obviously relevant. The emergence of carbon liability as a central concern of

investors may drive changes in taxes, subsidies, and trade in carbon certificates – concrete manifestations of a change in thinking as a new social and economic calculus. This calculus reflects the linkage between climate risks and the expectations of economic actors. It constitutes accountability relationships between greenhouse gas emitters and a range of actors who evaluate their conformance with evolving standards of probity.

The *outcomes* include multi-scalar budgetary priorities and industrial reorganisation in response to the selection pressure exerted by sanctions. They capture the reshaping of competitive dynamics through both new institutional structures and new physical infrastructures. Attention to such restructuring can provide direct observations of changes due to new relations of accountability. It is in this domain that the outcomes of an accountability regime, (3.1) emergent change and (3.2) structural change, can be examined and characterised as institutionalization.

In sum, within any given sector, claims that characterise change as sustainable are situated within the cycle represented in Figure 1: from inputs to outputs to outcomes. These changes interact reflexively (as depicted by the two-way arrows), hence in actuality these relationships flow both ways, but our input-output-outcome ordering has heuristic value for accountability analysis. Generally speaking, standards determine the data we have on a sector, such as energy, and assessments draw on such data to debate and enact decisions. These inputs inform the articulation and enforcement of sanctions. New sanctions in turn lead to changes in the population of actors, the governance practices and structures of institutions, and the physical infrastructure that comprises the sector.

As we are primarily interested in analysing changes in an accountability regime during sectoral transition, the main results of accountability analysis focus on (part 1b) assessment and (part 2) sanctions. In 3.2 below, we present a 2x2 matrix that considers and characterises their intersections.

3.2 The 2x2 'LASH' matrix for case results of accountability analysis

Our treatment of accountability within sustainability transitions is closely linked to concerns about authority and discipline (Wolf 2020). Such a framing demands that we critically analyse how discipline is exercised – by whom, on whom, for what purposes, subject to what controls. Our conception of accountability as a social process predicated on interplay between assessment and sanctioning positions us to identify four ideal-type 'worlds' of accountability (Table 1). As discussed above, our approach is symmetrical in that we aim to account for all potential states of the world, not just some normative conception of what is needed to progress toward a specific conception of sustainability.

Assessment of organisations or actions can be informed by deliberative processes (Hajer et al 2003), or not. In other words, in working to make sense of relations of accountability, on one axis we must assess the extent to which the criteria of assessment, accountability tests, reporting and data collection protocols, and determinations of conformity with standards are transparent and premised on deliberative and inclusive processes. On the other axis, we must assess the extent to which accountability assessments are backed by sanctions and whether such sanctions can bring about structural and material change. Integrated reflection on these two axes gives rise to four possible states (Table 1). In a given social context, we may observe i) radical liberalism or laissez-faire tendencies (L), authoritarianism or private interest governance (A), strongly substantiated accountability (S), and hollow accountability (H). In this respect, we view accountability as a thoroughly ambiguous resource in relation to social justice, good governance, and potential to advance sustainability.

Table 1. The LASH matrix for accountability analysis: Assessment and sanctions

	Ability and willingness to sanction	**No ability and willingness to sanction**
Deliberative assessment	(S) Strong accountability	(H) Hollow accountability
No deliberative assessment	(A) Authoritarianism	(L) Laissez-faire

The LASH matrix provides a basis to characterise the accountability regime for a given sector in relation to the four ideal-types. Is accountability substantive or hollow? If substantive (i.e., sanctioning based on assessments premised on standards derived from deliberative process), the sector will directly reflect the values that structure the accountability tests. Applied to a sustainability transition, substantive accountability takes the form of institutionalizing new selection pressures that can ostensibly restructure material dynamics (from dependence on fossil fuels to low-carbon energy, for instance). If hollow, accountability mechanisms function to document and transmit accounts of gaps between standards of socially acceptable behaviors and real-world practices, but sanctions are inadequate to produce change. Hollow accountability mechanisms have a performative aspect whereby they produce legitimacy without corresponding changes in the material system. Applied to sustainability transitions, hollow accountability is the principle vehicle for maintenance of cognitive dissonance and business-as-usual (Wolf 2020; Sareen and Grandin 2019).

Under conditions of authoritarianism and *laissez-faire*, there is no deliberative assessment, hence the conditions for strong accountability are not in place. Under authoritarianism, legitimation is monopolised by an administration that can level sanctions on any basis of their choosing, whereas under conditions of radical liberalism there are no standards and no central authority. The rise of authoritarian populism (McCarthy 2019), on the one hand, and deregulation ushered in by the turn 'from government to governance' (Capano et al. 2015), on the other, highlights the contemporary relevance of these quadrants of the LASH matrix.

A focus on accountability and legitimation pathways simultaneously *speaks to a conceptual understanding of institutionalization within sustainability transitions and a set of empirical research strategies*. This theoretical framing and methodological scheme can support critical and constructive analyses. The analytical characterisation of interplay between understanding, values, standards of assessment, sanctions, selection pressure, and material change can help make sense of dynamics of social regulation and environmental governance. Specifically, we offer a means to assess potential restructuring of sectors through institutionalization of new values and new modes of competition. To demonstrate the explanatory power of our approach, we conduct an empirical accountability analysis of a case focused on energy transition – one of the most important and urgent sectoral transitions. We are concerned with solar energy uptake in Portugal as the growth of a technological niche that prima facie constitutes a sustainability transition towards a national and regional low-carbon emission energy profile (cf. Pinho and Hunter 2019).

4. Accountability analysis of sectoral change: Solar energy uptake in Portugal

We conducted an accountability analysis to characterise solar energy uptake in Portugal. We assess inputs, outputs and outcomes during the period 2017-2018. This feeds into our characterisation of accountability relations into the quadrants of the LASH matrix in Section 5. Our attention is focused on changes, debates about potential changes, and lack of changes. The assessment is based on 80 interviews conducted during five months of fieldwork (two months in 2017, one month in 2018, two months in 2019) with various experts and sectoral stakeholders, in-depth field observations including site visits to solar projects, and desk research. Based on our interest in changes in accountability and flows of legitimacy, we focus on assessments and sanctions – enacted or absent – in the Portuguese energy sector. Sanctions need not only be negative, but can be positive, in support of strategies that comply with transitions to sustainability – *e.g.*, regulatory changes that enable rapid uptake of renewable energy technologies. Our treatment is not aimed at comprehensiveness. Rather, we focus on demonstrating the value of accountability analysis for assessing prospects for a sustainability

transition. After a case summary in 4.1, we conduct accountability analysis in 4.2. The latter sub-section highlights specific accounting mechanisms, and how they were distributed and interacted.

4.1 The accountability regime of solar energy uptake in Portugal

Portugal is a long-standing leader in renewable energy in Europe, a region that set some of the world's most ambitious targets for climate change mitigation and specifically energy transition during the 2017-2018 period of the case study. While Portugal's energy sector was long dependent on fossil fuel imports, over the decades it developed large hydro (since the 1980s) and wind power (since the 2000s), with emerging solar capacity (since 2008) and the best solar irradiation conditions in Europe. During 2017-2018, Portugal underwent a change from seeing renewable energy as a burden on taxpayers that had to be subsidised, to putting in place highly ambitious policies premised on rapid unsubsidised growth in renewable energy. In line with its contribution to European Commission carbon emission reduction targets, Portugal aimed to attain 31% total energy supply from renewable sources by 2020, with an increase to 47% by 2030. This included the growth of solar energy from 0.4% in 2015 to 1.9% in 2020 and 9.9% by 2030 within its energy mix, with the latest and most ambitious target set by its government at the end of 2018 in its Carbon Neutrality Roadmap 2050 and National Energy and Climate Plan 2030.

As typical in most countries, Portugal's energy sector is chiefly steered by national regulatory, executive and political bodies, who set standards following a corporatist model common of significant state involvement even under privatisation of sectoral components. A vertically integrated incumbent, Energias de Portugal (EDP), controls the lion's share of energy generation and electricity distribution. In recent decades, EDP has been privatised, and significant energy infrastructure such as the electric transmission grid has moved out of direct state control. The country's energy sector is also populated by a handful of retailers, associations and consultancies, including many solar developers who constitute population churn in the sector as new entrants during the past decade.

Notable solar capacity first appeared in 2008 with what was briefly the world's largest solar park, Amareleja, drawing on subsidised tariffs – in other words, positive sanctions to encourage early growth of a niche. The Portuguese government also subsidised small-scale solar uptake, and capacity gradually grew during the 2010s, but limited to a small role as well below 1% of total electricity generation. Allegations of political corruption surfaced in relation to wind power contracts during the late 2000s, and with renewable energy politicised during the 2011 elections, financial support for wind and solar power dried up, exacerbated by a recession period when fiscal tensions ran high. By 2015, when

Portugal steered clear of financial jeopardy and the generally pro-renewables Socialist minority government replaced the Social Democrats, it faced a context where subsidised renewable energy had become a politically untenable line. Small-scale solar uptake slowed to a trickle as incentives for selling power back to the grid shrank and prolonged the period for return on investment. In the few cases where subsidised tariffs had been pre-committed, utility-scale solar plants came up till 2017. But remarkable cost decreases in photovoltaic solar technology – more than eight-fold within a decade – led to solar developers queueing to install over 2.2 Giga Watts (GW) of *unsubsidised* solar capacity, nearly thrice the commissioned solar capacity of 800 Mega Watts (MW) in 2017. New selection criteria were developed to allocate limited grid capacity to these competing actors in a growing niche. Portugal's first unsubsidised solar plant was grid-connected in 2018.

Our accountability analysis examines sectoral changes during this period of high uncertainty and dynamism for solar uptake. The period was marked by both structural and material changes. Structurally, a new Ministry of Environment and Energy Transition was created in October 2018 and articulated an ambitious national vision for solar energy uptake involving new grid capacity allocation mechanisms. Materially, by 2018, Portugal's electricity mix featured 1.5% solar energy, a promising increase from 0.4% in 2015 and on course to the 1.9% target by 2020. In Table 2, we present an overview of the initial and final status of inputs, outputs and outcomes for the 2017-2018 study period. Subsequently, in 4.2 we analyse the uneven and indeterminate processes through which existing sociotechnical arrangements were critiqued and new knowledge and values were established to shape processes of selection; in other words, a change in accountability regime.

Table 2. Changes in inputs, outputs and outcomes in Portuguese solar energy uptake (2017-2018)

	Initial status (2017)	**New status (2018)**
Inputs: ***1. Grid geography*** ***2. Small-scale solar***	1. Grid infrastructure transmitted wind and hydro power up north, favoured coal (base load) and gas (flexibility), and had limited capacity free in solar-rich Southern Portugal	1. Grid investment plans fell short of enabling solar uptake in accordance with its economic competitiveness, constraining developers to target areas with available grid capacity
	2. Smaller distributed solar capacity was limited to self-consumption or low feed-in tariffs, thus upholding	2. Energy retail was bureaucratically restricted to large players, which held back citizen prosumers and

	entrenched grid operation logics with no scope for local aggregation	community energy initiatives from revenue sharing from solar uptake
Outputs: ***1. Conventional governance*** ***2. Public resistance*** ***3. Solar finance***	1. The usual experts from large-scale, entrenched organisations decided solar uptake protocols and pathways, although a change was signalled	1. Public engagement was limited to marginal consultation; criteria for the siting and extent of solar uptake were translucent during 2017-2018
	2. Despite strong public resistance, the government was ambivalent on offshore oil efforts until a statement for energy transition in late 2018	2. Substantive cuts to fossil fuel use remained anathema to powerful sectoral decision-makers at the expense of holding up solar uptake
	3. Banks and investors worked out power purchase agreements (PPAs) to finance solar parks without tariffs or subsidies, and solar developers began to see wholesale energy market trade as a viable option	3. A wholesale electricity market with payments for 'flexibility' meant recognizing big earnings (€24 million during 2017) from renewable energy export and halting reserve capacity payments to gas (€20 million p.a.)
Outcomes: ***1. Solar licensing*** ***2. Institutional reconfiguration***	1. Solar park developers submitted expressions of interest, an ad hoc committee evaluated them based on a vaguely specified set of factors, then issued licenses thrice a year with a 2-year timeline for installation	1. Approved developers built plants, asked for and got extensions, or traded licenses, while those without licenses continued to queue, leading to speculation over solar licenses and delays in installing solar capacity
	2. Energy portfolio relocated from the Ministry of Finance to the new Ministry of Environment and Energy Transition, and National Energy and Climate Plan 2030 and Carbon Neutrality Plan 2050 launched	2. Old license system dismantled to increase transparency, and solar auctions of 1.75 GW capacity declared for mid-2019 with options of competitive tariffs or grid access payments with PPAs or market trade

4.2 Accountability analysis: Inputs, outputs and outcomes

4.2.1 Inputs: Standards and assessments

In terms of inputs, the two key factors examined below are transmission grid geography, and the integration of small- and medium-scaled solar power generation. This is informed by empirical observation of how the population of actors used specific metrics and information about energy infrastructure to shape sectoral change; the application of standards and assessment in practice. These ontologies and cognitive processes supported normative reflections around solar uptake, to inform and catalyse the adaptive evolution of accountability mechanisms.

Grid geography: Portugal is weakly integrated into the European transmission grid due to its isolated geography, geopolitics, and investment requirements. Historically, Portugal's transmission grid has been weak in the solar-rich southern regions which are sparsely populated and relatively poor except at the southern coast. Solar uptake is complementary with other renewables, which are concentrated up north with better grid infrastructure, high tariff industrial consumers, and the country's two main urban centres, Lisbon and Porto. Two coal thermal plants take up 1.9 GW grid capacity and gas sources help adjust supply levels to balance variable renewable energy sources and demand fluctuations; national demand peaks at about 8 GW. Domestic grid investments planned for the next decade in 2017 included strengthening and expanding transmission capacity in Portugal's southern region. But these plans only promised 800 MW additional capacity for solar PV uptake by 2024-26, an amount already exceeded by licensed solar projects in 2018. The basis for justifying particular grid infrastructure logics thus exhibited strong path dependency, privileged inertia and linked it with stability. This put the onus on sectoral entrants like solar developers to battle against odds that favoured existing players, rather than providing a truly level playing field. Thus, solar developers were constrained to target areas where grid capacity remained available based on use by existing sources, rather than on the economic competitiveness of the technology. In mid-2018, the European Commission committed €578 million to expand interconnectivity between Portugal, Spain and France. This included some strengthening of the grid in southern Portugal, creating scope to add more solar capacity even though standards and modes of assessment for electric grid use persisted.

Small-scale solar: Initial incentive schemes promoted small-scale distributed solar uptake for home energy use and prosuming to the electric grid, which grew in the early 2010s. But before it reached 200 MW nationally, these schemes were removed; during 2017-2018, small-scale solar registered very little growth relative to large-scale plants. One technological niche, solar thermal, was already relatively widespread among the middle class, and grew very little. Another niche, household and community solar generation, could not benefit from prosuming to the grid as regulations mainly supported self-consumption, instead of sale to neighbours, use by multiple households or sale to the grid at a fair price. These standards actively constrained small-scale solar energy, and small-scale

storage costs were not yet competitive. Legislation held back changes that could encourage growth, e.g., local aggregation of solar capacity and revenue sharing between prosumers and energy retailers. Notably, financial benefits of distributed solar uptake through avoided transmission infrastructure investments were marginal in public discourse on solar uptake, despite the efforts of the solar energy cooperative Coopérnico and environmental organisations like Zero. Some initiatives, including by Lisbon municipality, did get off the ground, but legislative change came later, in 2020.

Overall, the studied period saw little substantive change in standards and modes of assessment in relation to solar uptake. Established criteria and sensibilities dominated governance and investment decision-making, exhibiting the path dependence typical of energy infrastructure and its governance. At the same time, we observed contestation and movement applied to the electric grid and prospects for integrating small- (household) and medium- (community) scaled solar power into the energy mix. New values, opportunities and arguments were championed, and new actors made inroads into debates and decision-making fora. These dynamics pointed to plausible pathways for new standards and modes of assessment that could create space for a technological niche to grow.

4.2.2 Outputs: Sanctions

In terms of outputs, we examine conventional governance modes, public resistance against fossil fuel expansion, and the emergence of financing mechanisms for solar energy. In determining the nature of sanctioning, we attended to legal, political and financial changes that exerted pushes and pulls on various actors and actions in Portugal's energy sector to create conditions for material change.

Conventional governance: During 2017 and 2018, solar energy received modest political support, and techno-economic competitiveness was represented as mediating Portuguese solar uptake. This was tempered by bureaucracy, policy lacunae, and perverse incentives (*e.g.*, to stall solar uptake, or to speculate on licenses). Power differences among stakeholders proved problematic, with partial interests being represented via associations, and preferential access to information and to decision-making forums for traditionally influential, networked actors, e.g., when nominating members to committees to make decisions concerning the electric grid. This raises questions of democratic process and splintered representation. Despite the country's high irradiation potential and complementarity between solar and more extensive renewable energy sources, the state stalled on favourable legislation for small-scale solar prosumers beyond self-consumption. The status quo favoured the incumbent while blocking democratisation of the energy sector. For instance, a solar festival in Lisbon in 2018 to popularise this energy source was prominently sponsored by the incumbent, while issues

like the lack of legislative support for community solar energy projects remained marginal. Numerous taxes were lumped into the fixed component of electricity bills, rather than being recovered through direct means. So citizens were treated as consumers and price-takers, not co-participants in the energy sector, while conventional authorities decided how energy companies should conduct themselves. This lack of state support limited debates around solar energy to technocratic issues without substantive public engagement. Overall, the state maintained an essentially top-down system while limiting platforms for public debate on imaginaries of solar energy futures. Such conventional governance prevented rapid multi-scalar growth of the niche.

Public resistance: Controversy on prospecting for oil off Portugal's western shore reigned from 2017 till mid-2018. Public protests highlighted threats to the environment and the prosperous coastal tourism sector, as well as the financial and moral folly of being a late entrant to a fossil fuel sector incompatible with addressing climate change. Citizens with knowledge of the energy sector, when interviewed, expressed frustration at regressive state policies that did not take a clear stance to exit fossil fuels and enable solar energy uptake at all scales during the study period. One consortium that sought an offshore oil prospecting license was dismissed. Then, with the new ministry's formation in late 2018, came a clarifying statement barring future consortia. Portugal's renewable energy leader credentials were accompanied by strong public political emphasis on financial benefit. Recovery from recession in 2015 and the politicisation of renewable energy made subsidies for solar infeasible, even as historical sectoral debt from other sources was placed on citizens via fixed costs in electricity bills. Energy transition with solar uptake was contested in multiple domains, including the socio-cultural. Wildfires during 2017 and 2018 led to significant loss of life and property. The fires influenced popular perceptions on the urgency and necessity of energy transition, by framing them as being not only an economic but also an environmental and personal security issue. The quarterly ECO123 from the Monchique region of the Algarve – which experienced devastating wildfire during 2018 – explicated links between environmentally responsible choices and wellbeing, encouraging just energy transitions and profiling leaders of such initiatives in Portugal. By adding public legitimacy to assessments that favoured rapid solar uptake and sanctions against fossil fuel persistence, environmental movements in response to such phenomena (including a massive flood that affected the capital Lisbon) strongly swung political stakes towards climate action ahead of the 2019 national election.

Solar finance: Solar energy is an intermittent (daytime generation only) source with a forecastable output profile (predictable energy production), whose financial viability depends on being able to sell energy to the wholesale electricity market during specific times of day. With a significant volume of variable energy sources, including wind energy, in the supply mix, the Iberian electricity market moved

towards valuing flexibility in its wholesale trade (IEA 2016). In 2017, the Portuguese government announced discontinuation of longstanding annual €20 million payments for strategic reserve capacity to gas, which can be quickly ramped up. Meanwhile, renewable energy exports through grid interconnections generated €24 million in revenue during 2017. This convinced solar developers that investments could be recovered, especially with energy prices in France expected to stay high for several years due to nuclear plant maintenance operations. Solar developers, foreign banks and investors developed financial instruments for power purchase agreements (PPAs, where businesses contract large-scale solar power, giving developers an assured source of revenue) and Portugal's first unsubsidised solar park was grid connected by summer 2018. Those interviewed estimated 7-8 year payoff periods for 25-year solar plants. Investment capital to build solar plants that would trade on the wholesale electricity market became available during 2018 as well. This marked a remarkable shift from 2017, when national discourse framed renewable energy projects as creating a debt burden for citizens and unlikely without publicly subsidised tariffs.

Overall, the period saw Portugal manage a crisis of public accountability on energy transitions and gradually move to a more reasoned discourse on solar uptake (cf. Sareen 2019). More transparent energy governance emerged and ways to secure public benefits were considered. Yet representation of stakeholder interests remained uneven. Entrenched historical patterns of incentives, constraints and authoritative decision-making continued to structure thought and deed in a top-down sector.

4.2.3 Outcomes: Structural and material change

In terms of outcomes, we profile two key arenas that shape prospects for solar power: energy production licensing processes and stuttering growth, and the emergence of a new ministry and selection mechanisms for solar uptake. The former were structural changes that exerted selection pressure to modulate competitive dynamics. They manifested as social controls and institutions, or mechanisms for accountability. The latter were material changes. They moved the ecological impact of Portugal's electricity sector towards lower greenhouse gas emissions.

Solar licensing: The Directorate General for Energy and Geology (DGEG), a national executive agency, allocated licenses for solar parks. During 2017 and 2018, it operated three annual windows to apply for these licenses. Solar developers submitted expressions of interest that far exceeded available grid capacity. Queues went over 2.2 GW while DGEG commissioned a handful of projects, which would have brought total national solar capacity close to 1 GW. But not all of this was installed within a two-year timeline, and one-year extensions were granted to delayed projects. Through this process,

targeted increases in solar power were achieved as represented by a formal licensing process, yet this energy supply was not fully realised. Perceptions arose that some developers had curried favours to gain licenses. Moreover, a translucent allocation process that featured an ad hoc selection committee and rough guidelines did little to assuage doubts. Interviewed solar developers and ministry officials voiced a concern that a speculative market was emerging around solar licenses, with buyers profiting by selling licenses to foreign investors. This risked driving up costs to developers and, eventually, consumers, through what amounted to rent-seeking practices around greenfield development activities (*e.g.*, land acquisition, environmental impact assessments, license procurements). Despite these problems, a number of grid-scale solar parks did come up during this period, and national solar installed capacity surpassed 650 MW.

Institutional reconfiguration: The national regulator Entidade Reguladora dos Serviços Energéticos (ERSE), executive agency DGEG, the political office of the Secretary of State of Energy (SSE), and numerous sectoral actors and associations sought to further their interests during this period of sectoral change. In late 2018, there was a cabinet reshuffle a year ahead of national elections. This relocated the energy portfolio from the finance ministry to the environment ministry, which was later renamed the Ministry of Environment and Energy Transition and a new SSE took office. By the end of 2018, the ministry had launched a draft National Energy and Climate Plan 2030 in line with EU mandates for member states, a Carbon Neutrality Roadmap 2050, and scheduled 1.75 GW of solar auctions for July 2019. Interviewed ministry representatives explained that the aim was to clear up the messy backlog of licenses, and presented the reliance on auctions as a means to ensure transparency and mitigate speculation.[1] A market mechanism such as auctions was popular amongst solar developers as it would offer a level playing field and facilitate their access to project finance.

Overall, the studied period featured a transition from a period in which the status of solar power in the spheres of administration, markets, and politics was unclear and weak to a more favourable, better coordinated institutional environment. Subsidy shifting, the effort to systematise licensing procedures and allocate solar capacity through auctions, the articulation of a policy vision, and robust political representation, together served to relax structural constraints. They positioned large-scale solar projects favourably within both commercial and political contexts. While limited material change took

[1] This was borne out by a successful auction for 1.35 GW of solar energy in July 2019, where one of the lots set a world record tariff of just over €15 per Mega Watt hour (MWh), and the average tariff was a shade above €20 per MWh, which compares very favourably with an average annual price of over €55 per MWh on the wholesale electricity market across all sources. This period is, however, not the focus of this article.

place during 2017-2018 (large-scale solar plants typically take 12-18 months to build), conditions for the future rapid growth of solar energy were institutionalized.

5. Characterising sectoral change in terms of accountability relations

This concluding section discusses the implications of our accountability analysis for characterising the changing accountability regime in Portuguese solar uptake. Subsequently, we abstract from this case to reflect on how accountability analysis can characterise sectoral change.

Table 3. Characterisation of accountability in solar energy uptake in Portugal (2017-2018)

	Ability and willingness to sanction	**No ability and willingness to sanction**
Deliberative assessment	(S) Strong accountability - EU and national energy targets - Solar auction mechanism	(H) Hollow accountability - Transmission capacity allocation - Ad hoc solar license procedures
No deliberative assessment	(A) Authoritarianism - Limitations on rooftop solar - Barriers for community solar	(L) Laissez-faire - Offshore oil prospecting licenses - Speculation on solar licenses

As shown in Table 3, our analysis identifies accountability relations in Portugal's energy sector in the period 2017-2018 within all four quadrants of the LASH matrix. Outcomes that displayed elements of both deliberative assessment and an ability and willingness to sanction include European Commission targets for renewable energy uptake in Portugal, in line with regional efforts for a transition to low-carbon energy. This drove Portugal's efforts to enable solar energy uptake to an ambitious extent (from less than 1 GW to nearly 10 GW by 2027), observable in its launch of a National Energy and Climate Plan 2030 and a Carbon Neutrality Roadmap 2050 in late 2018. It also announced a new structural market mechanism to allocate grid capacity and licenses for solar projects through solar auctions, the first of which was scheduled for (and took place in) July 2019. Earlier solar licensing and transmission grid capacity allocation measures during the study period, however, suggest a hollow form of accountability. The basis for allocation of grid capacity during this period was publicly contested, and limited deliberative assessment took place among policymakers. Grid and license allocation were debated among committee members. The selection procedure for licensing solar developers introduced confusion and criticism, and the opportunity for wider stakeholder involvement in the development of a national strategy for solar deployment was under-utilised. Most important for our

analysis, the assessment routines employed in the policy process were not backed up by sanctions. Solar developers who received licenses did not necessarily install solar capacity.

Turning to authoritarian forms of accountability, we emphasize treatment of small- and medium-scale solar energy projects during 2017-2018. Limitations were imposed on solar energy uptake at these scales without deliberative assessment. These sanctions stifled actors positioned to take solar projects forward, namely households and community-based energy cooperatives like Coopérnico. Such models exist elsewhere in Europe, hence their restriction in Portugal seems best explained by a tendency for the incumbent to modulate sectoral development in ways that favour its interests (Sareen and Haarstad 2018).[2] In terms of radical liberalism, two tendencies surfaced and were quashed during this period. Offshore oil prospecting licenses were pursued by an industrial consortium; public protest highlighted a lack of deliberative assessment and that such developments would reveal the state's utter lack of ability or willingness to sanction, given that fossil fuel expansion directly opposed Portugal's commitment to low-carbon energy transition. The state eventually did exercise legal authority to reject this possibility, but without a direct basis in ecological considerations. The new ministry that emerged in late 2018 proposed a strategy to address the other instance – speculation on solar licenses – through the mechanism of solar auctions with rules to tailor these to state priorities. Hence, while libertarian tendencies characterised sectoral performance for most of 2017-2018, changes to move beyond them emerged.

Overall, outcomes under Portuguese solar uptake during 2017-2018 can be seen to have been determined largely by market opportunism and regional and national political economies. We observe indications of shifts towards stronger accountability relations, with the emergence of a new ministry, national energy decarbonisation plans, and mechanisms such as solar auctions. Our accountability analysis during the 2017-2018 period finds evidence of an emerging appetite for deliberative assessment and sanctions in the rollout of solar energy in Portugal. To realise sustainability, we identify arenas for intervention, in terms of both inputs and outputs. Inputs include: clear selection criteria and timelines for large-scale solar plants; more ambitious targets for small- and medium-scale solar energy; the institutionalization of participatory procedures that involve stakeholders more inclusively and on an even footing; and ongoing public debate on how solar energy uptake can contribute to sustainable socio-material change in the energy sector. Outputs include: revised logics for grid infrastructure use to enable greater solar energy uptake over time; legislative enablements and mechanisms to support

[2] This contestation evolved beyond the studied period of 2017-2018. With the new ministry in place and the Socialist party reelected in 2019, community energy legislation did emerge in January 2020.

energy cooperatives; and clear commitment to invest in future energy infrastructure in ways that prioritise a move away from fossil fuel sources and toward rapid uptake of renewable sources like solar energy in line with emerging ambitious energy transition targets.

Thus, we go beyond characterising specific measures that can secure public benefits at a specific juncture of this sustainability transition. Rather, accountability analysis directs attention to the need for assessment and sanctions, that reflect new social values and heightened critical sensibilities compatible with sustainability, to be applied to the energy sector.

5.1 Conclusion

Our ambition with this article is primarily programmatic. We have articulated an accountability analysis framework that we hope researchers, policy actors, and practitioners will find useful. Our empirical application aimed to demonstrate its potential, rather than to unpack the case of Portuguese solar uptake in great depth. We deployed the framework to characterise the changing accountability regime within a three-step cycle of sectoral transition. Based on this analysis, we identified windows of opportunity for strategic intervention based on challenging hollow accountability, authoritarianism and libertarianism, and institutionalizing strong accountability. Our treatment encompassed both formal and informal elements of social regulation (assessment and sanctions) during sectoral change, based on empirical observation of inputs, outputs and outcomes. We argue that accountability analysis can move beyond scholarly emphasis on institutional design and governance as social inclusion and transparency, by evaluating the role of both assessment *and* sanctions in entangled processes of socio-material change. Such a technique can characterise sectoral transitions in relation to sustainability in an evidence-based, theoretically-rigorous manner. We see this sort of ideal dataset as aspirational, and encourage the Intergovernmental Panel on Climate Change and a host of national and sub-national sustainability programs to pursue such an integrated socio-material analysis of carbon governance.

Accountability analysis can serve as an integrative approach to bring together scholarship on environmental governance and sustainability transitions, while retaining sector-specific relevance. We hope that this demonstration prompts reflection on how these concepts and empirical strategies can contribute to sociotechnical transformations toward sustainability. While this programmatic article has presented the basis for this task and illustrated its potential, it must be elaborated and developed through future research. We identify a need and an opportunity to advance theoretical consistency and rigour applied to critical assessment of sustainability transitions as they play out in grounded contexts.

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