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New Energy Resources in the Making

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List of abbreviations

kWh	kiloWatt-hour
ReN	Renewable energy
Ademe	French Environment and Energy Management Agency
DSO	(Electricity) Distribution System Operator

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TSO	(Electricity) Transportation System Operator
SAS SAES	SAS Ségala Agriculture et Energie Solaire
ERDF	French grid manager Distribution System Operator
EDF	Electricité de France
Solar PV (or PV)	Solar Photovoltaic
DLS	Distributed Load Shedding

1 Introduction

It has become usual to approach renewable energy resources as mere physical flows (e.g., of water or wind) whose (physically limited) natural reconstitution guarantees their 'renewable' status and makes them eligible vectors for energy transitions (Verbruggen et al. 2010). Renewable energies are also commonly associated to alternative political ideals—such as downscaling, distributed and more democratic energy production, energy autonomy, and so on. Such ideals partly rely on the assumption that the shift from fossil to non-fossil energies equates to a shift away from physically concentrated energies (oil, coal…) towards less concentrated, flowing energies (wind, sun, marine currents…). Such appraisals are partly flawed. For instance, some unconventional energies (e.g., shale gas, coal gas, oil shale…) are fossil energies: they are less concentrated than conventional fossil energies but are nonetheless developed by the same actors and under the same type of politics. The physical approach to renewable energy resources leaves uncharted other resources—such as land, landscape, wildlife, and local solidarities—which are commonly engaged in the development of 'renewable' energy projects. It makes these other resources harder to acknowledge, and contributes to the neglect of the rich web of socio-material relations underlying the development of renewable energy resources. In naturalising the property of 'renewability', it makes it harder to discuss the democratic dimension of their development.

As Timothy Mitchell (2011) suggested it, materiality may matter for the type of politics that is constructed around energy resources. Following the socio-material processes through which different energies take on political significance, is a way to overcome ready-made dichotomies such as 'renewable'/'non-renewable' or 'non-fossil'/'fossil'. The relevant question, then, is how matter comes to matter as energy (whatever its concentration or carbon content) and what type of politics this builds.

The question has become all the more critical for 'renewable' energies since they are industrially developed and globally financed. Many attempts have been made to understand the tensions stirred by renewable energy developments. However, they have mostly focused on reasons for opposition or on patterns of development, without necessary articulating these understandings with that of the processes through which renewable energy resources are brought to existence.[1]

This chapter attempts to do this by following renewable energy resources in their making. It builds on a set of case studies in order to explore the socio-material processes through which entities such as wind, solar radiation, energy users' practices, and wood stumps come to be assembled as renewable energy resources. In so doing, it challenges the presupposition that renewable energy resources are inherently sustainable, and argues that only concern for the social and situated dimension of their development—and due processes—can endow them with the property of sustainability.

The chapter builds on previous works and analytical strands, notably the attempt of Richardson and Weszkalnys (2014) to propose a comparative framework for analysing the materiality of resources. We share their interest in following the processes through which 'entities-that-are-there' become energy resources, and in the importance of materialities in such processes (we will return to these terms below). As energy resources are proposed and not given by nature, entities *become* energy resources. In so becoming, these entities are engaged in socio-material assemblages, which leads to changes in their properties and boundaries. In taking a process approach to these changes, it is thus important to account for the full series of transformations that unfolds from the untamed energy stock (or flows) to readily usable energy entities. We use the categories of commodity chain and commodification analyses (Hartwick 1998; Castree 2003) to operationalise our exploration. They help us focus on the transformations in processes of becoming energy resources, and connect these transformations with their political effects.

In exploring the democratic dimension of resource making, the singularities of each resource prove as decisive as the ways in which processes and resources are scaled up. We propose *pooling* as an encompassing relational notion in order to capture the ways in which differences are handled and entities are scaled up in order to assemble energy resources. The analysis opens up a discussion on the relationship between forms of pooling and the democratic dimension of energy transition processes.

The first part of the chapter presents our approach. The second part discusses a set of case studies with four different energy technologies: onshore wind power, solar photovoltaics (Solar PV), biomass energy, and distributed load shedding (DLS) in the electricity sector (demand-response). The third and final part discusses our results, emphasising the importance of accounting for the material and relational dimension of new energies in examining their potential role in a sustainable energy transition.

2 Becoming an Energy Resource

Natural resources have been approached from a variety of perspectives. Recent critical appraisals in the social sciences, particularly anthropology and human geography, share the premise that '"natural resources are not naturally resources" but the product of cultural, economic and political work' (Bridge 2010, quoting Hudson 2001). These analyses have explored various dimensions of their making.[2]

In the subfield of energy resources, these studies have mostly addressed fossil energies, with some exceptions.[3] The development of non-fossil energy resources, probably because it is more recent, has not been thoroughly covered. It has, however, stirred protest and controversy around its environmental impact[4] and social dimension.[5] Analyses of these have mostly been focused on policy framings, and have left unchallenged the (often implicit) idea that renewable energy resources are inherently more sustainable than other energy resources.[6]

This section builds on analyses of natural resources in order to set out our methodology for analysing the emergence of different energy resources. The first part introduces the idea that resources are not given.

The second underlines the importance of acknowledging materiality in describing and following the emergence of energy resources. It defines resources as a proposition (in Latour's sense) and brings together a set of notions in order to operationalise the notion. The third part proposes a stylisation of the process of becoming an energy resource and a methodology for its analysis. The fourth explains how we intend to articulate the analysis of this process to that of its political effects.

2.1 Shifting Ontologies

In their explorations of natural resources, scholars have emphasised the political and economic dimensions of these resources, as well as their shifting ontologies. For instance, Ferry (2002) has analysed the work and discourse of a Mexican silver mining cooperative in turning silver into what she terms an 'inalienable commodity', meaning a commodity that, while exchanged in market systems, 'retains a connection to incommensurate and inalienable forms of value [patrimonio]' (p. 351). Weszkalnys (2011, 2013, 2014) has analysed the socio-political and material attempts at (de)constructing the longstanding association of oil to a resource curse, in the specific case of the African Atlantic island state of São Tomé and Príncipe. Both analyses offer a good illustration of a collective attempt at changing both the way in which a resource is defined and the economic/sociopolitical potential associated with it. Such stories echo local discourses and practices of appropriation around renewable energy projects that have been observed in France (Nadaï and Debourdeau 2015), as well as attempts at differentiating and politicising the 'renewable' electricity kiloWatt-hour (kWh) in certain countries (Summerton 2004).[7]

Renewable energy resources, because they are abundant, flowing, and sometimes ubiquitous, act as recipients for moral or political ideals: they 'remind us that our electricity comes from somewhere', 'they confronts us with the responsibilities created by our demand for energy' (Pasqualetti 2000); they allow for decentralised energy production, democratic productive organisation, and energy autonomy (Scheer 2007). These visions and potentials are important, if only because they underlie innovative experiments (Seyfang et al. 2013; Nadaï et al. 2015). Nonetheless, within a few decades, renewable energies have also been scaled up as a global sector of capitalist activity. Certain descriptions of the conditions under which certain developments are currently undertaken evoke concepts such as primitive accumulation, enclaves, colonisation, and so on (as for instance in the Isthmus of Tehuantepec: see Howe and Boyer 2015)[8] and remind us that renewable energy resources are subject to diverse development paths. Setting aside cases that might be deemed extreme, scholars have pointed at the progressive fossilisation of renewable energies as they are developed by historical energy operators and adapted to fossil energy interests, institutions, and infrastructures (Evrard 2013; Raman 2013). These analyses clearly show that these new energies are poised between very different models of development which associate to them very different types of politics whose democratic reach needs to be analysed.

This should be enough for us to take leave of ready-made dichotomies (renewable/non-renewable) and try follow the hybrid and shifting ontologies of new energy resources—meaning the ways in which they are known, defined, and practised, and the potential that is attached to them. As emphasised by Richardson and Weszkalnys (2014), such ontologies can only be understood through analyses that incorporate the materiality of these resources.

2.2 Materiality and Becoming

The role of materiality has been acknowledged and conceptualised in different ways in the social sciences, only some of which concern resources. In STS, following suits with Latour proposal to overcome the separation between nature and culture (1991), the assemblage—or the agencement—of humans and non-humans has been foregrounded as a source of agency underlying the properties of things.[9,10] In anthropology, a significant body of work has taken an interest in the material dimension of social interactions, particularly exploring the role of commodities and artefacts as physical constituents of sociocultural practices (Appadurai 1986; Miller 1987, 1998). In resource geography, the becoming of natural resources—which has long been recognised (Zimmerman 1933)—was first approached from perspectives interested in the production or social construction of nature.[11] The recent penetration of STS and anthropology has, however, triggered a renewal in approaches,[12] taking things and materials as both productive assemblages (Bridge 2006, Bakker and Bridge 2006, pp. 18–19). These changes also went along with a shift in focus, from activities such as agriculture, fishing, hunting, or foraging, to resources and activities that are more common in developed economies, such as: water (e.g., Folch 2015), minerals, oil (Weszkalnys 2011, 2013, 2014), gas (Kaup 2008), forests, and biodiversity, as well as a few cases of renewable energy resources (Howe 2014 and Pinker 2018, for wind; Alexander and Reno 2014, for waste).

Energy, like many other types of resources, is extracted from milieux or vectors, such as subterranean geological formations or wind, which are often thought of as given and natural. But the limitations of this understanding become evident when we consider a broader spectrum of resources, such as biomass (woods and forests have changed through history) and DLS (which is currently under construction in the electricity sector through contracts with and the equipment of households; see below). Thus, resources are not simply given. Milieux and vectors present themselves in more or less articulated ways as energy resources. When it comes to the question of how an entity can be turned into an energy resource, the term 'materiality' takes on a particular meaning.

Matter is not indifferent. It is neither inert nor unlimitedly malleable. For instance, the capacity to stock or release oil, controlling prices, is decisive in the fight against unconventional fossil energies. So is the differential in the underground concentration of these unconventional resources, which influences—but does not determine—the cost of their extraction. Materiality in such a process can thus be regarded as a *proposition* in the sense proposed by Bruno Latour (2004). For Latour, a proposition (unlike a statement) is not true or false, but more or less articulate. Articulation is the process by which a proposition becomes sensible and comes to matter. It is an endless process which takes on board material and artificial components. It is a process of assemblage.

Importantly, Tim Ingold (2007)[13] recently called for prudence in our use of the notion of agency. In using it, he felt was projecting principles of distributed action onto a substrate matter (material) that remained inactive in the analyses. He suggested instead envisioning a 'world of materials' (as opposed to a 'material world')—'life [for both humans and non-humans][14] itself undergoes continual generation in currents of materials' he wrote (Ingold 2007, p. 32)—in order to tell the *stories* of the properties of materials. In short, he advocates engaging in the material analysis of social relations, instead of doing a sociology of the material. Cronon's following of grain in his analysis of the making of the metropolis of Chicago (1991) is for us a reference in this undertaking, even if we do not follow a historical timeline or specifically analyse the joint spatial structuring of a region.

The first attempts at drawing more systematically on these explorations of materiality in order to explore the 'resourceness' of resources are still recent (Ferry and Limbert 2008; Richardson and Weszkalnys 2014). They conceptualise resource making as a material process, meaning the 'conjunction of the material and the social, without the social swallowing the material' (Knappet 2007). They take issue with a narrow focus on commodities, a reduction of materiality to either substance or pure discursive construction. They present resource-making as a process of boundary-making, emphasise its non-linear and hybrid dimensions and call for looking at materiality at any point in this process. In other words, they argue that resources do not exist in fixed and finite states, and that their analysis should follow their transformations and circulation among multiple states of being.

2.3 Process

Building on these insights, we propose to follow the transformations of renewable energy resources from a state of heterogeneity—as they appear in their milieu—to a more homogeneous and stable state, suitable for use. Along the way, we describe the stories of the materials (their changing properties), and the strategies and rivalries through which socio-technical collectives try to take advantage of the possibilities (concentrations, accumulations, re-allocations…) offered all along these transformations.

In working from this proposal, we incorporate *three methodological propositions* in our analysis: (i) the first is the imperative to focus on transformations, that is, to follow *resources as they are transformed* from production to use; (ii) the second is to account for *materiality as relational*, that is, to approach materiality and its properties as stemming from assemblages (including artefacts, infrastructures, knowledge, discourses, practices…). As Ingold (2007) suggests, materiality can be accounted for by *telling the stories* of these properties as they emerge in the flows of materials (how they come into being). (iii) The third methodological proposition is to *follow resource ontologies*, that is, to account for the various ways in which resources are known, experienced, valued, and defined by the different actors involved in their successive transformations, the properties that are associated with these resources, and the interplay (tensions or synergies) that results from these multiple ontologies.[15]

We thus consider the process of becoming an energy resource as a set of transformations from untamed, heterogeneous, or difficult-to-access forms of energy (wind, solar radiation, marine currents, wood biomass…) to the production of energy services, possibly but not necessarily including the consumption of a standard energy commodity (kilowatt-hours, calories…). In a first approach, this process may be described in terms of six transformations, as seen in Fig. 1.

'Things-that-are-there', in their supporting environment, must be qualitatively specified as an energy deposit, and their energy potential most often quantified. For instance, in the case of wind energy, national institutions map wind speed on their territory, wind farm developers install measuring poles at the site where they plan to develop a wind farm. The corresponding entity (the wind) must also be harnessed through specific socio-technical devices (rotating blades) and operations in order to extract its energy (the kinetic energy of the wind is converted into mechanical energy through the rotation of the blades). Since this primary form of energy cannot be used directly, the potential energy contained in it must be extracted and converted (the rotation is converted into electrical energy by an alternator). This secondary

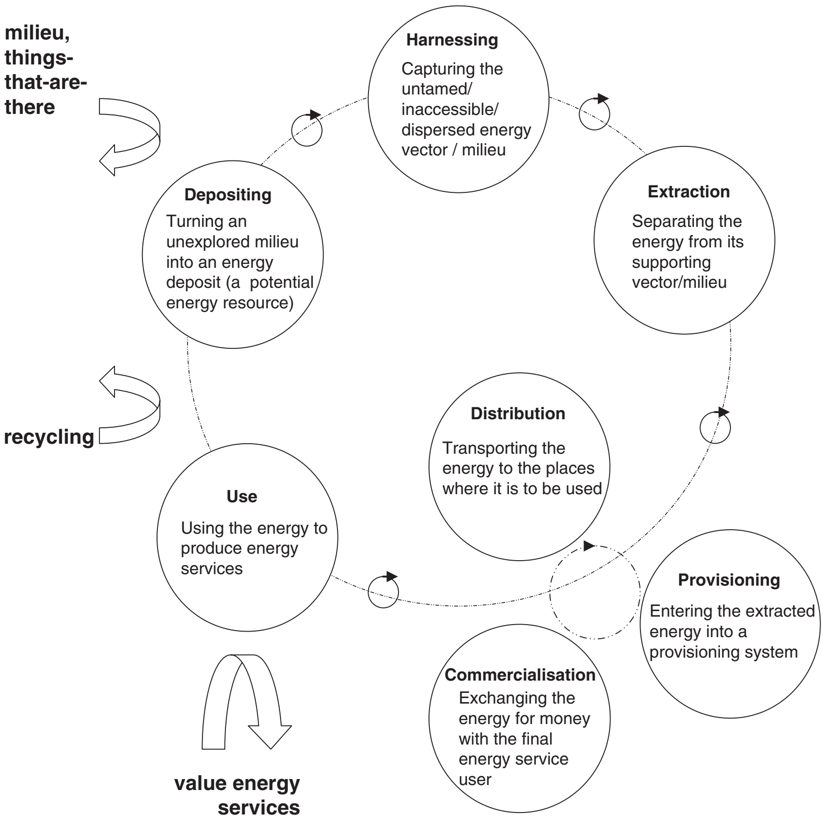

Fig. 1 The process of becoming an energy resource

energy may need to be provisioned in order to postpone its use in case of self-consumption, or to scale it up and make it potentially available for widespread uses. This can be done through physical processes (the electrical energy can be converted into chemical matter/energy through a battery) or other socio-technical devices or infrastructure (for instance, by injecting the electricity into a widely interconnected electrical grid, which makes it possible to average out variations in local production). The energy thus obtained and provisioned can then be distributed (circulated through the grid to the end users) and, possibly, commercialised (offered for sale under different commercial contracts and qualifications).

Each of these transformations involves actors (e.g., national energy agencies, wind power developers, turbine makers and insurance companies for the turbines, wind farm developers, local territories and territorial institutions, landowning farmers, grid operators, utilities…), socio-technical devices (e.g., measuring poles, paperwork, turbines, grid infrastructure, computers, software, meters…), social-natural environments (e.g., wind, birds, bats, landscapes…), know-how, etc. Their assembly must be articulated so as to allow for continuity and stability at each stage of the process and across the whole process. This has ontological consequences, as it yields a relational assemblage in which the attribution, roles, and affordances of these entities are redefined.

Figure 1 sketches this process as a loop in order to account for the possibility of recycling energy (e.g., heat recycling in co-generation processes, using 'fatal' energy…). This way of sketching the process also aims to allow for the steps in the process not being aligned in succession.[16] This figure should thus be regarded as an experimental step, a way of structuring our inquiry and learning from case studies.

2.4 Political Effects

Our interest in analysing this process is to explore its democratic dimension: that is, to acknowledge the various entities engaged in the making of energy resources, the changing properties of these entities and their resulting capacity to be recognised as relevant to this process.

To continue on with our example, wind is not the only resource engaged in converting wind into a consumable (potentially green) kWh. It is thus important to account for the resources other than wind—such as wildlife, farmers' land, landscapes, and local solidarities—that are engaged in this becoming, and to highlight the extent to which they are given room to be accounted for and become relevant in the development of wind power.

In order to specify this, we take inspiration from notion proposed by commodity chain analysis. Recent work in critical geography has

Table 1 Dimensions of the commodification process (*Source* Nadaï and Labussière, inspired by Castree, 2003)

• *Privatisation*: assigning rights to a named individual, group or institution
• *Alienability*: the possibility, for the commodity, of being physically and morally separated from its seller
• *Individuation*: the representational and physical act of separation from a supporting context (water from its environment)
• *Abstraction*: the assimilation of the qualitative specificity of a thing to the qualitative homogeneity of a broader type or process (allows, for instance, for unproblematic equivalence, as when a wetland here is made replaceable by a wetland elsewhere)
• *Valuation*: how things take on specific form of value (for instance, blindly profit-driven in capitalist society)
• *Displacement*: how something appears as other than itself (spatiotemporal separation of production and consumption, so that, for example, you cannot see the exploitation of South African workers included in Italian handmade gold jewellery)

used the notions of 'commodity' and 'commodification' to highlight that the status of commodity, rather than being intrinsic to entities, is assigned to them. Commodification,[17] the process by which commodities are constructed, can thus be regarded as a work of framing, attaching/detaching, and assembling. Capitalist commodification is broadly associated with a set of dimensions (cf. Table 1), not all of which are required (Castree 2003).[18]

These dimensions help us tease out and think through the transformations by which entities are detached from their surrounding environments and appropriated as energy resources, as well the ways in which such transformations are made legible to all, or not. It is thus important to highlight what commodity chain analysts have termed 'displacement': the fact of making the thing appear different to different actors (Hartwick 1998)[19] in order to limit widespread politicisation of issues.

In what follows, we will underline different articulations between displacement and ways of pooling energy (§4.1). We will emphasise the political effects of *pooling* and how these are smoothed by displacements, especially in the functioning of the electricity grid (§4.2). However, displacement, as understood by Marxist analysts, would not have any relevance to the analysis of political effects if resources did not change affordances and identities as the process of their becoming unfolds. Displacement thus should be regarded as a particular instance of what Mol (1999) termed multiplicity, an instance in which the multiple ontologies of something are purposefully kept separated. It contrasts with both the case of anaemia in Mol's analysis and her definition of multiplicity as a situation in which conflicting ontologies interfere and can become mutually supportive. This suggests that we should not limit our exploration to pinpointing the political effects of displacements, but try to chart the multiple ontologies at work in the processes that we explore, as well as their political implications.

As a way to test the analytical potential of our framework, we explore processes of becoming in four different resource cases: wind, solar, biomass energy, and DLS. These cases include electrical and non-electrical vectors, as well as different types of sourcing of energy production. Some appear more 'nature-like' (wind, sun, biomass), while one (distributed load shedding) has a more striking social dimension.

3 Energy Resources and Their Becoming

In what follows, we use the case of French wind power to develop our methodology and follow the transformations of wind into an energy resource in detail. The other case studies are not as detailed. We focus our exploration on dimensions that we feel are complementary in order to set the stage for a final discussion on pooling, multiplicity, and their political effects.

3.1 French Onshore Wind Power

Powering the Wind, Liberalising the Electricity Sector

In France, as in many other countries, the development of wind power has leaned on the progressive adoption of a favourable policy framework. After a period of ambivalence during the mid-nineties, this framework was marked by a decisive step in the early 2000s with the adoption of a fixed feed-in tariff, above the market price, for kWh of renewable energy.

This was part of a process of liberalisation of the electricity sector in the EU, which was gradually implemented in France and which deeply modified the country's energy sector. France unbundled its former electricity monopoly and initiated a diversification of its electricity through a series of measures, including the adoption of the feed-in tariff for renewable electricity (2001).

The feed-in tariff represents first and foremost a techno-economic framing. By granting (for 20 years) a tariff above the market price for any renewable energy (ReN) kWh, it targets private developers as economic actors and aims to trigger investments in wind power technology. This economic incentive was complemented with two important measures: Wind farms were granted the status of electricity-generating facilities (authorisation of production) as well as priority for injection into the grid. As of the year 2001, these were the only measures that had been adopted, a situation which clearly reflected French regulators' belief that economic incentives and private business alone could take charge of assembling the wind as a source of power.

Contrary to expectations, many different interests and concerns were triggered by these measures. The **electrical grid operator** expressed concern with the impact of a decentralisation of electricity production and the variability of wind power production ('intermittency') on the functioning of the grid, and in particular on short-term balancing and long-term capacity management. **Wind power developers** complained about the multiple issues they faced in developing their projects, such as considerations of landscape, fauna, and flora in impact studies, and grid connection authorisations. They continuously demanded that the state streamline procedures (Nadaï and Labussière 2009). **Local inhabitants** perceived the development of (privately owned) wind power as a radical change in the French state's approach to energy. They bemoaned both a departure from the public interest and the private appropriation of the wind, which they often claimed to be a local/collective/territorial resource. Building on the ecological political ideal associated with renewable energies, **local collectives** engaged in alternative ways of developing and appropriating wind power projects and the electricity that came out of them (Nadaï and Debourdeau 2015). Surprisingly, **legal doctrines** had left the ownership of the wind unspecified (Le Baut-Ferrarèse 2012). Both in the EU in general and in France in particular, wind power policy emerged in midstream, with a heated debate on the merits of different policy instruments (i.e. pricing, bonuses, quota certificates), setting aside, unchallenged, the status of the resource and its modes of appropriation. In many places, this contributed to making the distribution of wind power benefits problematic, for this issue had to be resolved in and around individual projects, in a context where actors' interests were already formed (some had invested funds, others had expectations).

Thus the establishment of the conditions for wind to become an energy resource—what we are calling its 'powering'—followed, in France, a path that has framed wind power as a privately developed, grid-connected, publicly supported and regulated form of energy. Along the way, this impelled actors to find ways of assembling the proliferating materiality of the wind, of the turbines and of their electrical outcomes, with other types of materiality already in place in several spheres of action, such as landscape uses/protection and the electrical grid.

A chain of transformations of energy from the wind emerged, partly inherited from the existing French electrical system. It structures a displacement of this energy, which is perceptible in the disconnection between the controversies surrounding projects development and electrical consumers' depoliticised perception of the associated kWh. In what follows we will specify the mechanism and political effects of this displacement.

Mapping the Wind, Averaging Out Turbulences, Channelling Explorations and Powers

Wind is a complex phenomenon. It is a part of local weather as well as of multi-scalar meteorological systems. Wind can be patterned on a given scale and turbulent and unpatterned on other scales. The existence of wind as an energy certainly does not date from the time of industrial wind power: wind has long allowed birds to migrate, boats to sail, and mills to grind. But the *powering* of the wind, defined as its assemblage with electricity (as an energy vector), is unprecedented. This is all the more true under feed-in tariff support of the French type, which turns the power from the wind into a grid-connected type of energy and frames the issue of averaging wind variations as a large-scale grid-related issue.[20]

In France, one of the first operations underlying the powering of the wind was the mapping of average wind speed over the entire French territory. This was jointly initiated during the 1990s by the French Environment and Energy Management Agency (Ademe) and the French regions, with a view to providing wind power developers with clues about which regions are windier. Wind mapping was also always closely articulated to grid-related issues: the question of how much wind power could be integrated into the grid without unbalancing it is central. This politicisation of the turbulence of the wind was explicit in 2005 parliamentary discussions in which ecologists foregrounded the existence of three distinct wind basins in France, advocating for the possibility of averaging out variations in production on a national level. The issue has since persisted, again featuring in a recent debate about the feasibility of 100% renewable electricity production in France. This scenario, recently issued by the Ademe, was advocated on several grounds, including a detailed, online, multi-scalar mapping of wind speeds and variations, which demonstrated that variations in wind power production can be average out on a day-to-day basis at a regional scale.[21] This spatiotemporal ordering of the turbulence of the wind not only changes how it is qualified (wind is no longer an untamed resource); it also posits regions as potential key actors in its powering.

Harnessing the Flow and Extracting and Appropriating Energy

One of the first operations in harnessing the wind is to approach its force on a finer scale, that of the siting of the turbines. Measuring poles, set up for a few months, are the usual way that developers gauge the presence and energy of the wind on a site. The pole allows a blade to be placed at a sufficient height to avoid ground-level turbulence.

It replicates the logic and design of horizontal axis turbines, the most developed technology, in harnessing the wind.

The physical encounter of the wind with the blades of the wind turbine extracts the kinetic force of the wind (individuation) and turns it into a mechanical force (rotation). It is also the point where the wind's energy is appropriated. While the legal status of the wind has remained undefined, its conversion into a mechanical force through the rotor of the machine transfers it to the machine's owner: the developer.

Displacing Energy, Scaling Up the Power of the Wind

The rotating blades drive a gear system which allows a shaft alternator (1500 rpm) to generate electricity. But the electrical grid is an assemblage that imposes standards: any electrical flow intended to circulate in the grid—to be 'injected' into it—must meet specific technical requirements. Grid injection requires a physical transformation of the electrical current that comes out of the alternator: a transformer located in the tower of the wind turbine increases the voltage up to 20 kV.

This physical transformation underpins a change in the status of the kWh. Once it has been injected into the grid, a kWh coming out of the turbine becomes part and parcel of the electrical flow, like any other kWh, renewable or not. Not only is its geographical origin (coming out of this specific wind farm) lost, but its 'renewable' origin is also physically blurred. It would be lost altogether had a system of 'guarantee of origin' not been created,[22] which allows for the circulation and trading of the 'renewable' labelling of wind power electricity. At the point of injection, this quality is detached from the physical electrical current and abstracted as an informational asset: a certificate, which is in fact a computer file. This certificate can then be traded and re-bundled with the conventional electrical current as a commercial 'green electricity' product, and offered as such to end users by some electricity producers.

The individuation of wind electricity—in Castree's sense of a separation of this electricity from its supporting environment and context—is thus at the core of this chain of operations. Importantly, this 'individuation' results in a pooling of kWhs and the loss of their singularity.

Their collective origin (as the outcome of a particular wind farm) is detached from them, re-cast as a generic attribute (renewability), and materialised by a computer file that can be traded and re-bundled with any standard kWh. This displacement is not hidden to the final electricity consumer. Commercial contracts blankly state that, by contracting green electricity, final users only contribute to the overall remuneration of renewable electricity producers to the extent of their purchase. Yet, the eligibility of a production infrastructure to the 'guarantee of origin' is ultimately[23] based on the Energy Code definition of 'renewable energy', which clearly naturalises it: the Code simply lists a few types of energies that are considered renewable, without any consideration or provision regarding the ways in which they were actually assembled as energy resources. Therefore, while the displacement that takes place in the guarantee of origin is transparent to the final consumer, its meaning—that is, the extent to which the projects remunerated through the renewable certificate were actually assembled in a sustainable way or not—cannot be traced.

Grid Electricity as a Complete Extractive Energy

Electricity (in the grid) here appears as a vector that almost completely separates the energy from its supporting environment, because it simultaneously erases both its geographical origin and its qualitative construction. The only dimension of the original resource that lingers on in grid electricity is its quantitative variations. As has been emphasised in many studies, the 'intermittency' of wind electricity is perceived as a threat to both grid management practices and the environmental performance of wind energy[24] (e.g., Howe and Boyer 2015). The remaining quantitative variability of this electrical production is mainly addressed through the development of backup capacity and the scaling-up of the grid: grid interconnection allows averaging out variations in electrical production from different areas, regions, and countries in Europe. Importantly, the way in which the variations of the wind resource are averaged out—either through depositing (see above) or through electrical organisation (backup capacities and interconnection)—is decisive for the politics of wind power, because it determines who is empowered in framing its potential (local authorities or the grid manager).

In the end, because of the grid-connected construction of wind power, the process through which wind becomes an energy resource is roughly divided into two parts (see Fig. 2).

In the *upstream* part of the process, made up of '*depositing - harnessing - extraction*', the untamed wind is turned into uneven, but appropriated, electrical energy, to be injected into the grid. On a practical level, this covers the mapping of wind deposits on various scales, the development of wind farm projects including their siting, and the extraction/conversion of the wind's kinetic energy by the turbines. This is thus the part of the chain in which territorial resources such as land, landscape, and local collectives are brought into project development and planning.

The *downstream* part is made up of '*provisioning - distribution - commercialisation*'. Here the kinetic energy of the wind, once extracted through the turbine as appropriated but uneven electrical energy (alternator), enters a genuine commodification process, including both the physical transformation of the energy (transformer, merging with the broader electrical flow) and its abstraction as an informational asset (standard kWh; certificate of guarantee) that can be separately traded and re-bundled as a marketable product ('green kWh'). As they are faced with somewhat standard commodities—this green differentiation still remains marginal in France (and in other countries)—users and uses are somewhat sidetracked in this process (this is why 'use' does not appear in Fig. 2).[25]

Previous case studies in the academic literature have emphasised the difficulties faced in attempting to assemble wind power projects in a sustainable way at the local level (Labussière and Nadaï 2014; Jolivet and Heiskane 2010; Aitken 2010a). Seen from a local perspective, these difficulties are often perceived, and have been thematised, as resulting from inadequate spatial planning (Aitken 2010b; Geraint et al. 2009). Our analysis sheds a more incisive light on these difficulties and on the role of French institutions. By dividing the chain into two parts, feed-in tariffs and guarantees of origin create a break in the articulation of sustainability and renewability. In the upstream part of the chain, the

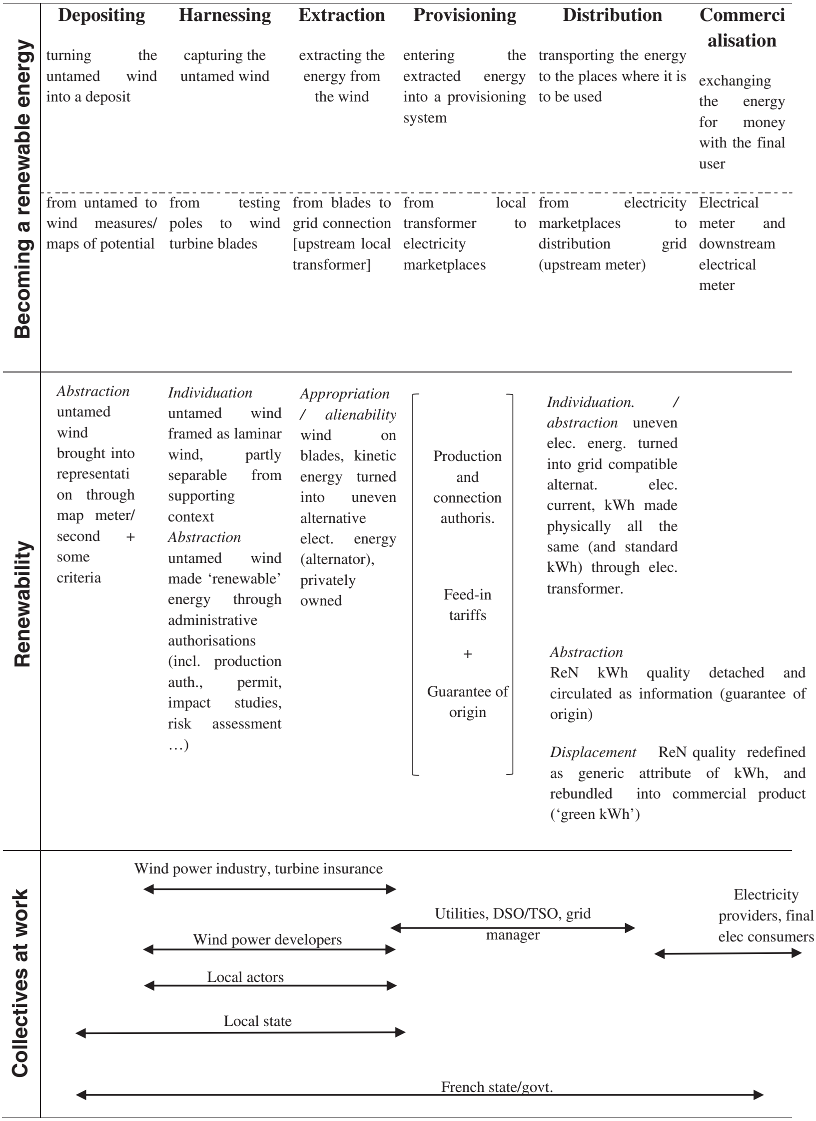

Fig. 2 Wind and the process of becoming an energy resource (*Source* Nadaï and Labussière 2017)

construction of sustainability for wind energy wrestles with the materiality of many resources. This construction often gives rise to challenges at the local level. In France, the administrative authorisation of projects establishes a distinction, and a clear-cut separation, between renewability and sustainability. Sustainability is addressed implicitly through project authorisations and is left unapparent in the downstream part of the chain. Distinctly and separately, renewability is circulated in the downstream part of the chain. It goes unchallenged partly because its reduction to a physical dimension is enshrined in the legal and regulatory environment in which the feed-in tariff is embedded (authorisation of production, Energy Code): any project using wind energy is automatically defined as 'renewable'.

Importantly, *this distinction and separation allow renewability to be detached from the material dimension of the resources and attached to the materiality of a tradable certificate (the guarantee of origin).* It paves the way for the commercial re-bundling of renewability into 'green' electricity—a more encompassing notion—and for its large-scale trading on the electricity market.

This comes on top of the support granted through the tariff. It results in an additional incentive to develop projects which does more than accelerate the pace of wind power development: it favours market-based assemblages over territorial ones. Indeed, since any project that succeeds in getting the administrative authorisations—whatever the actual sustainability of its assemblage—then stands on equal footing with other projects, those that gain these authorisations with the least work are better off.

'Aeolian Politics', Manoeuvring Through the Materiality of the Electrical Grid

Many, if not most analyses of the development of wind power have highlighted the upstream part of the chain, emphasising tensions and oppositions associated to cognate resources (land, landscape…). Howe and Boyer (2015) proposed the notion of 'aeolian politics' as a way of deconstructing wind power as a unified object, inviting us to explore the 'multiple and contingent political trajectories of the wind, as it is domesticated for electric energy'.

Although a great deal remains to be explored, following electricity from its emergence in the turbines through its transformations and circulation in the grid allowed us to highlight the centrality of powering as the socio-material operation of assembling the wind with electricity and the electrical grid. It suggests that actual aeolian politics, while multiple, as Howe and Boyer argue, is specifically a politics of manoeuvring through the materiality of the electrical grid and its scaling-up (through individuation and displacement). Aeolian politics works around and in the interstices of the grid. This manoeuvring depends on multiple factors, including the flexibility offered by the type of technology used to harnessing the energy, as we will now see it with cases in solar PV development.

3.2 Solar Photovoltaics

The powering of solar energy shares a great deal with that of wind power in the associated manoeuvring through the socio-material organisation of the electrical grid.[26] Compared to wind power, however, important differences have arisen in the case of photovoltaics because of the materiality of the technology developed to harness it, notably its modularity. Existing PV technology has been conceived and designed on the basis of modular panels, allowing projects to be developed very simply, on a variety of scales and with limited technical requirements. This allows for a certain flexibility in how projects are approached. It also makes PV development very sensitive to price changes, both in the value of the feed-in tariff and in the price of the panels sold on a global PV panel market as the PV industry develops. Accordingly, case studies on this resource reveal a greater diversity of attempts to politicise the upstream part of the chain than for wind power (even though ours is a restricted sample, which does not include any off-grid cases).

Modulating Projects, Tailoring the Resource

An example within the great variety of PV projects are three collective PV projects carried out in France: 'Les Fermes de Figeac', a mutualised PV project carried out by an agricultural cooperative in the Ségala-Limargue area, in the Lot department (southwestern France) (see Cointe 2016), and two 'Fermes Solaires' collective PV initiatives developed in the Rhône-Alpes region. Here we explore how the depositing, harnessing of the solar resource were arranged materially and collectively, and how the modularity of PV was exploited to tailor and construct the resource in ways that (more or less successfully) attached it with specific social and political objectives.

Arguably, at the beginning of the 'Fermes de Figeac', project, the resource (or the deposit) did not exist independently: the physical solar resource itself was not evaluated in detail, only estimates of mean annual solar radiation were used in the business model. Instead, the resource was constructed in relation to the territory of the project, the planned organisation and objectives of the project (selling electricity on the grid, developing a new source of revenues and activities for the territory). It was approached rooftop by rooftop, according to the particular rooftops' exposure to sunshine, the material and legal feasibility of installing PV panels on each roof, the possibility of connecting the installation to the electric grid at a reasonable cost, and the capacity of the owners of the buildings to contribute financially to the project. Rooftops that did not meet required conditions were excluded.

The Rhône-Alpes 'Fermes Solaires' PV initiatives somewhat confirms the idea that the solar resource is constructed through assembling the project. Yet, they offer a slightly more detailed perspective on this assembling and its implication for the resource. In 2010, in the Rhône-Alpes region (south-eastern France), eight pilot initiatives for the development of cooperative solar PV projects were launched. Their initiators' ambition was to develop coherent multiple-roof/multiple-roof-owner (public and private) projects. These projects were again to be based on grouped rather than isolated roofs, taking into account cognate issues such as landscape, granting access to solar benefits to all, and prioritising energy-efficient roofs. This partly came as a reaction to the then-dominant form of PV projects approached as financial assets by private developers.

As in the Fermes de Figeac case, the constitution, or depositing, of the solar resource called for the selection of a common pool of roofs, and this operation required taking into account their multiple heterogeneities (surfaces, slopes, orientations, ownership, architecture, landscape and co-visibility issues, distances to grid connection points). The way in which roofs were added or subtracted from the pool, and the dimensions that were taken into account in making these decisions, however reflected the way in which local actors took hold of the resource (Fontaine and Labussière 2015).

In the first case study, in the Regional Natural Park of Pilat (RA1), project managers started working with GIS software and datasets. They created maps of solar intensity (hours of sunshine/year) and landscape impact (underlining areas with more or less co-visibility with the future PV developments), adding factors related to the features of the roofs, such as the owner's motivations and the specific feed-in tariff category corresponding to the type of roof. The maps were then juxtaposed in order to identify promising areas and groups of roofs that matched all factors (good solar intensity, low landscape impact, good surfaces with good feed-in tariffs, roof owner's involvement). This in turn allowed the grid manager (DSO-ERDF) to assess connection costs. As the local grid architecture did not match with the most promising groups of roofs, these costs ended up being too expensive for the project, which had to adapt to the capacities of the grid. However, the logic of identifying promising groups of roofs was not abandoned and the project managers continued to use the maps to combine a large set of dimensions while meeting the constraints imposed by the grid. The same logic ruled over the final assessment and adjustment of the project's financial viability. Eventually, the project succeeded in dealing with grid constraints while maintaining a collective, innovative approach to the solar resource, one that approached it not only in terms of its physicality (solar intensity) but also of a sum of related materialities.

In the second case, in the Regional Natural Park of Massif des Bauges (RA2), local project managers also sought to assemble a collective project, but they proceeded in a different way and relied on other instruments. While the pilot site was first selected by exploring the same dimensions as in the Pilat project, they then proceeded by translating the potential of each roof into a quantitative index in order to rank them in a table and only keep those corresponding to the best lines/scores. When the grid managers reported the corresponding grid connection costs, not only did many roofs become too costly to connect, but the gap between the roofs was so wide that the owners of the most profitable ones decided to leave the collective operation and opt for individual developments. The project was then restarted within a larger perimeter, including dispersed roofs with few elements of collective coherence. Some roofs were chosen for their economic profitability in order to offset less profitable ones.

Both collectives started to produce electricity between late 2014 and early 2015, with operations pooling seven or eight roofs and producing similar amounts of power (70 and 60 kWp). However, the solar resource assembled in the two was qualitatively different, as the project in the Massif des Bauges did not incorporate the many dimensions and forms of materiality that the Pilat collective succeeded in taking on board.

In both of these projects the status of the solar resource was neither discussed per se nor agreed upon in advance. Its status and content emerged in-the-making, as the solar projects were developed. The architecture of the electric grid was a key disruptive factor, because it imposed a spatial structure, through connection costs, that did not match the solar deposit as assembled by local collectives. In this context, different approaches to project development seemed to underwrite different potentials. One logic of adding and subtracting roofs to the collective entity contributed to making heterogeneity an asset, while another made it a barrier. Such differences also underlie the resulting distribution of revenues from the project, as we will now detail in the case of the 'Fermes de Figeac'.

Tailoring the Resource, Tailoring the Politics of Redistribution

Les Fermes de Figeac' consists in a 'diffuse' PV installed on about a hundred rooftops. The PV installations on all of the roofs in project are owned and operated by a single entity, SAS Ségala Agriculture et

Energie Solaire (SAS SAES). This entity pools the solar resource and sells it to Electricité de France (EDF), the former electricity monopoly of France, which is in charge of managing the feed-in tariff, after which it proceeds downstream in the same way as any other form of electricity fed into the grid. In the case of the Fermes de Figeac, the revenues are then mutualised and distributed among the owners of the roofs on which the PV systems are installed. Here we explore how the harnessing, and extraction of the solar resource were arranged materially and collectively in this case, and how the modularity of PV was exploited to develop a mutualised project that nevertheless fits with the individual investment logic of feed-in tariffs.

To harness solar radiation and mutualise the resulting returns, the rooftops had to be collectively pooled. This required the deployment of financial, technical, and social resources in order to redefine the rooftops' status, transforming them into power plants. To this end, roofs were rented to the private entity set up for the purpose (SAS SAES), and their owners contributed 20% of the investment required to purchase and install PV panels on them. The SAS SAES then centralised all the administrative, financial, and technical procedures to install the PV park and trade the power generated. To capture as much of the dispersed solar energy as possible, the SAS SAES also established a system of collective monitoring and territorialised maintenance that aimed to increase performance. It thus made the most of its precise knowledge of both the geographical area and the group of farmers and buildings in the project to optimise maintenance and maximise its control of the resource.

The extraction of the resource then takes place 'within' the PV installations. The conversion of solar radiation into electric current is encapsulated in the photovoltaic cell, and the conversion of this direct current into alternating current virtually identical to that which circulates through the grid takes place via the balance-of-systems components of the PV installations (particularly inverters). The project is also equipped to monitor harnessing and extraction, relying on meters and on information transmitted by inverters and centralised by the SAS SAES, which operates all the installations. The maintenance system—and the collective surveillance encouraged by mutualisation, in which all lose if one panel has a problem—is designed to ensure that extraction goes well and to ensure rapid action on potential failures or accidents, but other than that the collective is not directly involved in extraction.

The modularity of PV thus allowed the cooperative to develop a project in which extraction remained dispersed, while the resource was harnessed collectively. Mutualisation, which was made possible by a combination of material, organisational, and financial displacements and negotiations, serves as the matrix for a collective and politicised pooling of the resource. The modularity of PV technologies, combined with the organisation of the downstream chain (provision, distribution, and commercialisation) around the central electricity grid, are crucial in this model, because they make possible its peculiar spatial articulation. The PV installations are dispersed across a large geographical area, and their product is 'virtually' concentrated in the possession of a single owner which then redistributes the resulting revenues.

All together, these PV case studies reflect the difficult but nonetheless possible politicisation of the socio-material construction of the PV resource around, or in the interstices of, the dominant mode of pooling the electrical resource. They also point at the decisive role of both materiality and how it is assembled (hierarchy vs. contiguity, market framing) in the becoming of solar radiation as an energy resource. Just as these factors are decisive for the pooling of the resource (depositing/harnessing), so they are for the course of policy instruments (overflowing/reframing of PV feed-in tariffs), as we will now illustrate.

Fluid Technology, Ubiquitous Resource and the Challenging of the Tariff

One striking difference between solar PV and wind power has been the rhythm and fluidity of PV development, which ended up challenging the management the PV tariff in several countries, including France (Cointe 2015). In France and many other countries, PV panels have been turned into financial products through market-based *agencements* (Debourdeau 2011). Modular design and market framing allowed a great variety of actors to benefit from feed-in tariffs, provided they developed PV as a somewhat standard market product: individual projects, individual profits, simple design (plug-and-play). This contributed to making PV development extremely sensitive to price variations (feed-in value, price of PV panels on the global market) and extremely difficult for policymakers to follow and monitor in order to dynamically adjust the feed-in tariff. The beneficiaries of this tariff were also so heterogeneous that it was very difficult for them to come together as a collective, which made collective negotiations around the tariff almost impossible. This contributed to challenging and reframing the tariff, with a brutal stop-and-go approach to policy design, in an attempt to control and regulate PV development, to limit its collective and political costs.

These elements of the uneven success of solar radiation's becoming an energy resource suggest two remarks concerning the role of materiality in such processes of becoming. First, compared to wind power, the socio-materiality of PV technology resulted in strikingly different effects. Second, the contrast between the difficulty of building a collective around a socio-economic device (feed-in tariffs) and the pooling which happened around roofs (material things) underlines the significance of the present chapter's focus on socio-materiality.

3.3 Biomass Energy, Configuring Access, Qualifying the Resource

Biomass is a *distributed* kind of thing. It presents itself in a spatially, physically, and temporally distributed manner that relates to the singular stories of vegetal entities, their implantation, their appropriation, and their temporalities (growth/harvesting cycles, becoming through exploitation or events such as storms…). Accordingly, the biomass case studies that we explore below emphasise issues of accessing distributed and often already-appropriated biomass matter and in conceiving ways of profiting from it as energy. These result in biomass energy assemblages that give certain kinds of biomass (stumps, small woods) new affordances while allocating power to certain actors. They also take part in attempts to balance material cycles (carbon), which is key in biomass energy production. Stock and flow have to be managed in accordance with the temporality and spatiality of plants' growth cycles. The management of harvesting is thus also key. The two French case studies that we will now present, in the Aquitaine (Dehez and Banos 2017) and Rhônes-Alpes regions (Tabourdeau and Chauvin 2015), illustrate contrasting assemblages and forms of energy-becoming of biomass resources.

Aquitaine is a region within the Landes de Gascogne, a large area of privately owned pine forest land on the French Southwest Atlantic coast, where the paper industry is a major presence. Recently, the establishment of a biomass energy sector in the Aquitaine region has put strains on the wood resource. Technological upscaling (installation of new boilers in the paper industry) in a post-storm context (1999) favoured the take-off of tree stump harvesting and processing (for energy). As the strain on the resource remained intense, Aquitaine paper producers began to develop control over the resource in Dordogne, a nearby forest area.

These strategies can be regarded as an attempt to balance material (carbon) cycles. The exploitation of tree stumps as an energy resource has two statuses: as an input when left to decompose on the spot; and as an output when harvested and processed for energy production. Both the work involved in processing tree stumps (grinding, calibration, drying…) and the characteristics of the energy equipment used (boiler size and capacity to process heterogeneous wood matter) are essential in adjusting the conversion of a stock of heterogeneous matter (wood stumps) into an energy resource. As part of this assemblage, ongoing issues about information concerning the resource and the access to it (its localisation and quantification) reflect active strategies used to maintain control over it.

In Rhône-Alpes (a second case study), the materiality of this access to the wood resource is managed through collective databases: these are aimed at harmonising and making more transparent the assessment of the resource coming from different actors. Information about deposits is organised in terms of two broad categorisations: heat vs. electricity, first, and collective, private, or industrial use, second. In this encoding, the socio-materiality of the wood—such as the difficulties of spatial access, the temporality of the resource (regeneration/renewability), or its pooling (negotiation of a collective contract)—is no longer readable. Undeveloped parcels are encoded as 'inaccessible', which significantly blurs the assessment of the actual wood resource.

While in the Aquitaine, spatial and physical access to tree stumps is easy and thus not an issue (flat land, lines of trees), this is not the case in Rhône-Alpes (steep slopes, bushes…). In order to fine-tune their assessment, Rhône-Alpes foresters used to describe deposits in a step-wise manner, considering (i) the 'morphology of the resource', then (ii) a 'theoretical potential' derived from a purely forestry-based vision, and finally (iii) an 'economic potential' reflecting profitability as assessed according to the current availability of the wood resource. Although this description was more sophisticated, it continued to deduce the size and the characteristics of the actual deposit from the individual assessments of private owners.

In order to reopen a potential for exploitation of the resource, foresters started to share and collectivise the available information on the resource. Sharing these data allowed them to collectively challenge the conditions of its accessibility and overcome the frequent tendency to equate 'unexploited' and 'inaccessible' biomass. A plot that could not be accessed individually (a particular plot by its individual owner and the owner's equipment) could become accessible once pooled together with other plots and owners, under conditions of collective investment. A potential that was deemed to be unexploitable could be brought into a social and material re-composition. Here, the conditions of access to the resource were re-composed, as were the related property rights: the wood had to be delivered in common, meaning that the resource only had value within a collective undertaking.

In this process, the boundaries of the common good were reconsidered. The neoclassical appraisal of the wood resource, which describes it as 'rival' and 'exclusive', was challenged by the emergence of a political and philosophical sense of shared property—a commons—co-activated by and benefiting all players. This common good was no longer approached solely in terms of its economic appraisal: it was endowed with a political dimension. This allowed for a collective undertaking in the distribution and the marketing of the resource, under the ægis of producers' groups. Pooling also enabled the targeting of new market segments such as biomass energy producers, who require regular deliveries and homogeneous quality, both of which can be maintained through the pooling of the wood resource.

These biomass case studies foreground examples of resource materiality that is distributed, and raise issues of access to these resources. They show that the way such issues are overcome can challenge the way the resource is described or classified, and lead to contrasting outcomes. Access can remain attached to pre-existing individualities which, as dominant stakeholders (such as the monopsony in Aquitaine), end up pre-empting it. In this case, the resource remains distributed. But access can also be reopened by taking advantage of flexibilities in the attachments and classifications of the resource, conferring new affordances upon it as a commons (in Rhône-Alpes). These two routes give rise to opposed forms of becoming for the resources—either mining-like and almost 'fossilised' (Aquitaine), or collective and sustainably geared (Rhône-Alpes).

Beyond this contrast, the differences between the two biomass case studies also underline the ontological dimension of a socio-material approach to the resource. Most significantly, in the Rhône-Alpes case, the biomass resource ended up becoming re-patterned and ubiquitous in that—as in the PV case studies—its potential ultimately stemmed from project development (after its re-patterning as a collective entity).

3.4 Distributed Load Shedding in the Electricity Sector (Demand-Response), Controversy around Pending Material Appropriations

Distributed load shedding (DLS) involves aggregating the load shedding actions of consumers connected to the electricity distribution networks (mainly on heating installations). This service—that is, an erased kWh—can then be sold to the grid operator in order to help it manage the real-time balance between production and consumption in the power system.

As its name suggests, DLS can be regarded as a distributed resource. It deals with individual uses of electricity, regarding them as malleable practices that afford the possibility of saving kWh (not-consuming them) in order to resell them. It thus frames people as distributed sources of potential kWh. Load shedding requires these people to be accessed in one way or another in order to categorise and sort the flexibility of their uses, and either prevent these uses or displace them in time.

The becoming of uses (as resources) is thus poised between two different key operations. The first is identifying, accessing, and contracting with a population of potential users (depositing/harnessing), allowing the installation of the required equipment in their homes and the monitoring of the electrical flux (extraction). The second is developing the shared calculative rules, devices, and agreements that allow the spared kWh to be valued as commodities on the electricity market (provisioning, distribution, commercialisation).[27]

Many different issues were raised by this activity, and it is not our aim to cover and explore them in this chapter (see Chapter 3, for a slightly more in-depth exploration, and Reverdy (2017), for a detailed presentation of the case study). Our point here is to show how the development of this resource has ended up challenging the organisation of the electrical grid, rather than merely manoeuvring through it.

Practically, load shedding operations are activated through in-home boxes that are remotely controlled by an operator. This operator contracts with final electricity consumers who agree to allow certain home appliances to be disconnected within certain timeslots, when needed by the operator. In France, this operator can offer the erased kWh on what is called the 'balancing mechanism' (BM), managed by the national transport system operator (TSO) and providing a real-time reserve of power that the TSO can use to balance the grid. Offers are remunerated on a pay-as-bid basis. The process of transforming electricity uses into an electricity resource, as we understand it, thus includes various intertwined steps, such as exploring household consumption patterns (depositing); approaching households, agreeing on potential erasing schedules, and proposing a commercial offer/contract (depositing/harnessing); installing in-home boxes to directly control certain appliances (during contracted schedules) so as to shut them off in case of grid unbalancing (harnessing); contracting with the grid operator on ways to trace back, value, and remunerate the aggregate difference between the anticipated baseline and actual consumption (provisioning/distribution/commercialisation). In commodification language, these steps abstract, individuate, value, and privatise the erased kWh.

In France, a private French firm (Voltalis) began to develop DLS in 2006, with a business model wherein the only remuneration to final consumers was through savings on electricity. As Voltalis's activity grew, controversy began to arise as to the status of the 'erased kWh' that Voltalis was selling on the BM.

The energy regulator's attempt at a market framing of Voltalis's activity—i.e. saying that Voltalis should just sell its (erased) kWh on the BM—raised endless controversy about the dimensions and perimeter of the erased kWh. Who owned these unconsumed kWh: their producer, the consumer, or their eraser Voltalis? Who should pay for them? On what grounds? In particular, other BM participants (electricity providers) argued that Voltalis should compensate them for the erased kWh because, as regular electricity providers of Voltalis's clients, they were committed to injecting the kWh into the grid, which then enabled Voltalis to (re)sell them on the BM. Of course, Voltalys disagreed.

It is not our goal here to describe this controversy (for an analysis, see Reverdy 2017). But it is interesting and relevant to note that the solution that has since been adopted is the political reframing of DLS as an emergent activity (instead of a mature market activity), worthy of state support because of its potential environmental benefits (energy savings). Eventually, DLS firms are currently supported by the French state through a tender system, but they have to compensate electricity providers for a portion of the electricity that they erase. The status of DLS has thus been dissociated from the BM, while still maintaining a relationship to it through partial compensation for the electricity on which it relies.

What seems significant for our material approach to energy resources is the fact that the Voltalis controversy directly targets the collective organisation of the grid. Unlike wind power or solar PV, Voltalis's intended business model did not play with this organisation, it challenged it. Its claim to legitimate appropriation of kWh in the flux could not help but stir controversy, since the material scaling-up of the electrical system (complete individuation and complete abstraction) relies precisely on suspending the question of the origin and appropriation of the electrons in this flux: only the inputs and outputs are appropriated, whereas the origin and material appropriation of electrons within the flux are indistinct. Hence the description above of electricity as a complete extractive energy (§3.1): asking who owns a definite electron or kWh in the grid does not make sense. Any assertion relating to either the origin or appropriation of a kWh cannot be proved or refuted on the basis of the materiality of grid electricity.[28]

As Thomas Reverdy points out (2017), while economic calculation was able to introduce some ordering into the arguments of in this controversy, it was unable to clear up appropriation issues and make DLS a full-blown resource for the electricity market. Our material analysis suggests that the limited capacity of economic calculation to overcome this controversy is precisely due to its limited ability to account for the materiality of grid electricity.[29] In other words, following materiality allows for a different, more insightful viewpoint, which connects the issues raised by DLS with the specific socio-material way in which the grid organises scaling-up, making (grid) electricity into a fully extractive form of energy.

4 Resource Materiality and the Democratic Energy Transition

Our aim in exploring the making of energy resources in this chapter was: (i) to acknowledge the role of materiality in energy transition processes in order to better understand political and democratic issues associated with these processes, such as opposition to project development, unfair wealth distribution, unfair appropriation of or privileged access to resources…; and (ii) to propose an analytical framework that could build on past analyses of natural or fossil resources in order to address cases of renewable energies, potentially in a comparative setting.

The analyses above prove that our framework works for very different types of energies, and can thus be regarded as an invitation to follow the becoming-an-energy-resource of other entities. This framework potentially allows the mapping of the full process of transformations involved, from production to commercialisation and use, and their articulations. Building on Tim Ingold's (2007) suggestion, we have followed materials (e.g., wind, electricity, biomass…) as they circulate and undergo transformations. The processes we have described can be regarded as stories that acknowledge materiality, without conjuring notions aimed at resolving the origins of actions, such as 'agency', 'inertia' or '*faire faire*'. In so doing, these stories allow us to point up some interesting singularities in the processes of resource making, and their political consequences.

It should be noted here that the reach of the chapter mirrors that of the set of case studies under consideration. Notably, as they all deal with grid-connected or industrial forms of energy production, their scaling-up of energy change is achieved through processes aimed at converting energy into market commodities. This should not be taken to mean that such a scaling-up is the only path to widespread energy change, rather it highlights the need to extend the type of analysis undertaken here to other types of transition processes (such as grassroots-led microgeneration, microgrids, self-consumption experiments…).

4.1 Pooling and the Scaling-Up of Energy Resources

As Richardson and Weszkalnys (2014) points it out: 'what makes something become a resource is its use for an end, particularly the creation of wealth'. Since all our case studies deal with grid-connected or industrial forms of energy production, this 'creation of wealth' supposes reaching a sufficient enough scale for economic activity. The case studies we have analysed display very different ways of pooling energy resources in order to scale up energy change processes. These are summarised in Fig. 3.

Pooling takes place through various means depending on the case: physical conversion, regulatory requirements and qualifications, market pooling, spatial assembly (mapping) or hierarchical ordering

	Depositing > Harnessing > Extraction > Provisioning > Distribution > Commercialisation > Use
Electricity (wind power, DLS)	**Patterning** **physical pooling** (conversion) upstream <<<< (displacement) >>>> downstream grid connection **regulatory pooling** (feed-in, guarantee of equivalence) acceleration, leeway, tensions around resources not accounted for closing access <<<< | <<<.............**market pooling**.................................. impossibility to challenge the grid organisation
PV Rhône Alpes	case RA1 **spatial pooling** **(contiguity)** << grid spatiality / connection costs < multi-dimensional reconfiguration > -- case RA2 **hierarchical pooling** **(ordering)** << grid spatiality / connection costs < incompatibilities >
PV Figeac	**collective pooling** (roofs) (mutualisation) dispersed (modularity) but learning<< sharing << coordination benefits (mutualisation)
Biomass, Aquitaine	**technological** fossilisation << monopsony << **pooling** (boilers)
Biomass, Rhône-Alpes	**collective informational pooling** >> reopening access, politicising the commons >>>>>>>collective marketing >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

Fig. 3 Forms of pooling of energy along the process of emergence of renewable energies

(table, quantification), collective assembly (mutualisation), technological pooling (around a technological solution). Ways of pooling have major effects on how and whether different entities become relevant in processes of , as well as for the outcomes of these processes.

In the Fermes de Figeac, the collective harnessing of the sun led to learning and increased collective sensitivity and reactivity to fluctuations and cycles of solar energy. In Aquitaine, the expansionist logic induced by the upscaling of the boilers (technological upscaling leading to demand for more resources) led to the development of new access to the resource (in Dordogne) through a framing as a pure stock (fossilisation). Biomass Rhône Alpes, a non-electrical case study, is an interesting case of pooling that proceeded downwards through the political construction of a resource as a commons.

The electrical case studies all together reflect the central impact of the organisation of the power grid. Apart from DLS, the assemblage of energy resources is worked out *with* and *around* the structuring of the electrical grid (feed-in tariff, guarantee of origin) and the market. This results in a partition of the process (into up- and downstream components) and in a displacement of 'renewability', preventing widespread politicisation of its content on the electricity market. With this displacement, the local tensions raised by the production of a wind, PV, or biomass kWh are not conveyed to green consumers by the so-called 'green' kWh. The tendency, at least in France, not to account for all the resources required to turn the wind into an energy resource, thus cannot be corrected by a widespread politicisation of the green kWh.

Grid electricity is a form of complete extraction of energy, which paves the way for equivalence and abstraction as it blurs the material origins of the energy. 'Erases' would be too strong of a term, because the 'intermittency' of wind power reflects the resistance of untamed wind, which lingers on in electricity provisioning.

The passing-through electricity has ambiguous consequences for the upstream part of the chain. On the one hand, the (downstream) homogenisation of materiality, its provisioning through the grid, and market *agencements* boost the volumes that can be exchanged. The associated prospects of value result in strong incentives for project development (upstream), which translate into a pressure to streamline development processes and make unconventional projects harder to carry through, as illustrated by some wind power case studies and by the Rhône-Alpes PV case study (RA2). On the other hand, the separation of the two parts of the commodity chain leaves the upstream part of the chain relatively independent of the downstream part. This allows some room for manoeuvre in terms of socio-material organisation in the upstream part, for better (as illustrated by the Figeac experience or the Rhône-Alpes RA1 case study) or for worse (as illustrated by some wind power cases).

4.2 The Political Effects of Pooling

The way in which pooling is undertaken has various political effects that induce tensions in the processes, such as transferring power to certain actors at the cost of genuine energy transition processes (biomass in Aquitaine); acceleration of project development processes at the cost of a proper acknowledgment of the materialities engaged in them (solar PV, wind power); the spurring of individual initiatives that conflict with attempts at collective endeavours (wind power); and the upstream/downstream divide (with dual effects resulting in a manoeuvring through the materiality of the grid organisation). These effects are summarised in Table 2.

Importantly, the case studies we present also suggest that different ways of pooling the resource have different relationships to appropriation. Patterning plays on a pre-individual level of the unformed thing and leaves the question of appropriation unresolved (wind and sun are not appropriated before becoming an energy resource). Ways of pooling that occur at the level of harnessing seem to be endowed with a potential to change appropriation, probably because harnessing and investment in technological artefacts (turbines, PV panels, boilers, meters) actually are the operations through which flowing energies are appropriated. Market pooling (monopsony, electrical pooling) is anchored in the ongoing, often individual, appropriation of the resource, which it plays with by aggregating greater or lesser numbers of owners, without

Table 2 The political effects of pooling and their content

Political effect	Content	Pooling (socio-material)	Case studies
Upstream/downstream divide	The energy commodity does not convey the politics of its emergence (displacement) > dual effect: power to grid incumbents (Voltalis controversy); leeway for politicisation of projects (Figeac, Pilat) > incentive to develop projects/acceleration (streamlining), recursive effects (see below, wind power)	Physical pooling (electricity as a complete extractive energy) Regulatory pooling (energy code + feed-in + guarantee of equivalence) Market pooling (electricity grid and electricity market)	All electrical case studies
Upstream chain controlled by downstream actors (extraction≫depositing, harnessing)	Technology upscaling in the downstream chain underlay a 'mining' of the resource (fossilisation of Dordogne massif) (Aquitaine biomass) > power to downstream actors over extraction	Technological pooling (upscaling) Market pooling (monopsony)	Biomass (Aquitaine)
Recursive effects (extraction≫depositing)	Conflicts in upstream part > depositing limited by conflicting strategies in harnessing	Contradictory pooling (private harnessing conflicting with collective harnessing)	Wind power

(continued)

Table 2 (continued)

Political effect	Content	Pooling (socio-material)	Case studies
Acceleration	Bringing materiality into socio-material *agencements* which ease its processing along the chain (accessing tree stumps, not accounting for all resources in wind power development) > tensions around project development (wind power, solar PV), resource (Aquitaine)	Market and regulatory pooling (> see above on upstream/downstream divide)	Wind power, Biomass (Aquitaine)
Instrument framing/instrument overflowing	Difficulty accounting for singularities and dynamics of situations in instruments and regulation > Fragility, stop-and-go (PV) > Strain on resources not accounted for (biomass, PV, wind power)	Regulatory pooling (feed-in, administrative grid connection authorisation, construction permits)	Wind power, PV solar, biomass

challenging existing patterns of ownership. These differences should be explored farther.

To a certain extent, the range of case studies analysed in this chapter does not allow a full exploration of this question, as they mostly cover electrical energy and grid-related cases. These emphasise scaling-up through large-scale socio-material organisation (grid, electrical market) rather than through the dissemination of project practices.

5 Conclusion

We opened this chapter with a discussion of the fossil vs. renewable energies distinction. We highlighted the democratic and moral ideologies associated with renewable energies, as well as the reductive physical characterisation underlying their regulatory framing.

The social sciences have foregrounded the importance of the materiality of fossil energies in the political construction of democracies. Recently they have begun to challenge the fossil vs. renewable distinction by pointing out ways in which renewable energies have been handled through the same institutions and political practices as fossil energies. Building on these developments, we have proposed to contribute to a more symmetrical analysis of the diverse forms of energy resources, attending to the materiality and political role of renewable energies.

Starting with the assumption that energy resources are not given by nature, but come into existence through socio-material processes, we have built on recent developments in critical social science and proposed a framework for following the material assemblage of various renewable energy resources. The analytical framework proposed in this chapter is its first outcome, to be developed and applied in further studies.

Our analysis also points out how integrating materiality into the analysis—i.e. following material circulations and transformations—enables a more accurate understanding of the singularities of different resources and the shaping of the power relations which emerge in their construction. The materiality of renewable energy resources is both a part of and a product of their processes of assemblage. It contributes to steering these processes, but also leaves room for them to take different courses, allowing for more or less democratic paths. In contrast to the political ideals often associated with them, renewable energies can be fossilised, to borrow a notion from Raman (2013). This can take various forms, as explained in our analyses above, such as 'mining' strategies that do not allow for a sufficient regeneration of the resource (Dordogne) or do not acknowledge the varied materialities engaged in project development (solar PV, Rhône-Alpes RA2, wind power); undue forms of appropriation (Aquitaine).

Interestingly, the course taken by these processes partly depends on the ways in which these resources are scaled up through what we term their 'pooling'. For certain resources, certain ways of scaling up the resource lead to fossilisation (e.g., market pooling, for wind). Alternatives do, however, exist (e.g., patterning the wind), which can only be highlighted through material analysis, as they are precisely rooted in ways of assembling materiality.

Pooling is certainly not specific to non-carbon energies. However, as these new forms of energy are mostly diffuse, and have in common a materiality that has not already been concentrated in space over geological time, concentrating them requires the colonisation of a diversity of milieux and operations on an unprecedented scale. Our analysis points to a variety of ways of pooling that are both material and organisational, and sheds light on some of their political effects.

Importantly, our analysis suggests that pooling can operate through different ways and that decisions about how to scale up the energy transition through resource pooling present a genuine political and democratic challenge. Sustainability and democracy thus cannot be regarded as inherent attributes of renewable energies: they are a possibility that depends on their socio-material pooling.

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Notes

1. See for instance Devine-Wright (2010), Walker and Cass (2007).
2. Such as the ways in which access to resources is achieved (primitive accumulation, enclaves, colonies… see Bridge 2010, 2014), the joint production of identities (e.g., race, Baldwin 2009) or ontologies (e.g., resources as patrimony, Ferry 2002; oil as curse, Weszkalnys 2014; fracking as a change in environment, Pearson 2016), and the role of materiality (Bakker and Bridge 2006; fluidity of oil, Mitchell 2011; electrical grids, Bennett 2005; machine and matter in pit mining, Rolston 2013; natural gas extraction, Kaup 2008).
3. See for instance Folch (2015), Bonta (2007).
4. See for instance Frolova et al. (2015), on landscape and wind power; Willow et al. (2014) on non-conventional fuels; Raman (2013) on rare earths and wind power; Willow and Wylie (2014) on local environments, ground-water resources, and fracking; Nadaï and Labussière (2010) on birds and onshore wind power; and Nadaï and Labussière (2014) on marine environments/fishing resources and offshore wind power.
5. See for instance Aitken (2010a) on benefit sharing and wind power; Aitken (2008) on power allocation and wind power; Wolsink (2012) on wind power and appropriation; and Nadaï and Labussière (2017) on landscape commons and wind power.
6. There are some noteworthy exceptions. Howe and Boyer (2015), for instance, have talked of 'aeolian politics' as a way to 'unwind "wind power" as a consolidated conceptual object' and address the manifold effects and ways of mattering of wind energy in the Isthmus of Tehuantepec (Mexico). Sujatha Raman has explored the controversy around rare earth minerals and their relationship to renewable energy development. She described this development as 'fossilised', in the sense that it is enmeshed with the same interests and politics as fossil energies (Raman 2013). Nadaï and Labussière (2017) point at the ways in which shared resources engaged in wind power projects in France, such as relational and landscape resources, have gone almost entirely unacknowledged in the development of these projects. If anything, these explorations suggest an urgent need to extend the critical analysis of the making of natural/energy resources into renewable energy resources, if we want to better understand the tensions that surround

their development and bring energy transition processes onto a more democratic path.

7. Summerton analyses the co-construction of devices, infrastructure, and consumers around electricity branding. An example of a different, more explicitly politicised model is the French cooperative electricity producer Enercoop, which refuses to use tradable certificates of (green) origin for kWh in order to ensure the genuinely renewable origin of the kWh it sells (and not a nuclear kWh cloaked in 'green' through the purchase of a green certificate). This refusal is grounded in a political line that is intended to allow Enercoop consumers to regain power over the sourcing of energy. https://www.enercoop.fr/decouvrir-enercoop/notre-projet.
8. The Corner House, a campaign group, recently issued a report, drawing on academic research, pointing at the politics of unifying energies under the broad heading of 'Energy', and arguing for an understanding of energy as a commons: http://www.thecornerhouse.org.uk/sites/thecornerhouse.org.uk/files/Energy%20Security%20For%20Whom%20For%20What.pdf.
9. The point was made in a debate with Lemonnier over the agency of human and gun (Latour 1996; Lemonnier 1996). Latour argued that neither the gun or the human was at the origin of action, but that the active agent was human-with-gun, and that any attempt at isolating either individual element was a dead end.
10. Emilie Gomart (2002), analysing the emergence of methadone as a therapeutic agent, argued that substances acquire properties through socio-technical arrangements. Michel Callon (2008) drew on developments in the sociology of markets, inspired by STS, to insist on the crucial importance of materialities for 'understanding the shaping of agencies and their competencies'. Woolgar and Lezaun (2013), in a recent discussion on a possible ontological turn in STS, discussed the relationship between the ways in which materiality is framed, the roles assigned to entities, and the emergence of distributed capacities for action. In these analyses, agency, described as both a resistance of things and a capacity to 'make [someone/something] do [something]' (*faire faire*), has been characterised as a relational and distributed capacity for action, stemming from socio-technical assemblages (or *agencements*) in which materiality is key.
11. Here we draw on Bakker and Bridge (2006). For the 'production of nature' strand, nature as a product of social relations underlies the development of capitalism. The 'social construction of nature' strand

looks at discursive constructs about nature, either to refute them or to shed light on the social significance of material world. These have been criticised for not sufficiently appreciating differences in capacities for action, notably between living and non-living entities (such as mineral matter, metals, etc.), and for dealing with them in a residually somewhat dualist way (i.e. subjects having agency, which they express 'on and through' objects).

12. Bakker and Bridge categorise them as follows: commodity chain analyses, which expand the analysis of materiality along the full chain from production to consumption (Hartwick 1998, 2000); work on corporeality, examining the materiality of texts (Kay 2000) and the relationship between identity and the bodily experience (Butler 1993); and work on hybridity, which includes investigations on multiplicity, the hybrid dimension of things, and the emergence of qualitatively different materialities (e.g., the cyborg metaphor of Haraway 1991; Law and Mol 1995 on multiplicity; Whatmore 2002 on hybrid species and spaces).
13. This was part of discussions between Tim Ingold (2007) and advocates of material culture analysis (Miller 2007).
14. Our addition.
15. As emphasised by Annemarie Mol, conflicting versions of an entity can also support one another, a phenomenon she terms 'multiplicity' and associates with a specific type of politics (ontological politics), in which we are thus faced not with exclusive alternatives, but with such co-existent interacting versions (Mol 1999).
16. For instance, the presence and importance of provisioning, commercialisation, or distribution depend on the type of process in place (e.g., commercialisation may not be part of the process in self-consumption). Depositing, harnessing, and extraction may also work together non-sequentially, with harnessing and extraction informing *ex post* the operation of depositing and allowing for learning and adjustment.
17. Commodification was first described by Marx through the concept of commodity fetishism.
18. Castree (2003) opposes the idea that 'there is or should be just one Marxian "essential" reading of capitalist commodification' (p. 274) and proposes a set of 'principal elements' that are part of commodification according to the 'work of contemporary Marxists writing about nature' (p. 278).
19. Displacement can be achieved through various means, such as physical/spatial distance, discourse framing, back-staging … As argued

by Hartwick (1998) in the case of gold, the commodity chain can be structured so as to manage discontinuities and *not* make perceptible the conditions of production at certain stages of the chain (the condition of African workers and their families in the extraction of gold) to actors active at other stages of the chain (Italian jewellery consumers).

20. The amount of kWh produced by a turbine, and hence the amount of support to production through feed-in tariffs, is measured by a meter, which materialises the frontier between the private productive entity and the publicly managed grid. Under this socio-material organisation, connection to and injection into the grid is a precondition of 'feed-in' support (as its name clearly states).
21. https://www.actu-environnement.com/ae/news/eolien-avis-ademe-maillage-territoire-foisonnement-lisser-production-26797.php4.
22. In 2006 in France, then updated (2012) and harmonised at the EU level with the adoption of the Renewable Energy Directive (2009).
23. That is, through the autorisation of production, which refers to the Energy Code.
24. Because backup capacities, working with gas or coal, have to be developed and turned on in order to offset the variability of wind power production.
25. The scenario is different, of course, in the case of off-grid wind power developments (for an example, see Pinker, 2018).
26. In France, solar PV is also supported by a feed-in tariff and guarantees of origin, and has mostly developed as a grid-connected form of energy. As in the case of wind power, these have structured a division of the chain into upstream and downstream parts.
27. For the same reasons as in the wind power case studies considered above, the stage of 'using' the energy is not foregrounded here: erased kWh and standard kWh just blend together in the electrical flow, making their origin indistinct at the stage of use.
28. To be clear, being a 'complete extractive energy' is a (socio-)material property of *grid* electricity. It is not a substantive property of electricity in general, as it certainly does not hold for off-grid electricity.
29. We could even argue that the limited ability of economic reasoning to sort out this controversy probably lies in its own denial of the material differences at issue: for economists, a grid kWh just is a grid kWh, as witnessed by the French Enercoop controversy about guarantees of origin (cf. Note 6).

Bibliography

Aitken, Mhairi. "Wind Power and Community Benefits: Challenges and Opportunities." *Energy Policy* 38, no. 10 (October 2010a): 6066–6075.

Aitken, Mhairi. "Why We Still Don't Understand the Social Aspects of Wind Power: A Critique of Key Assumptions Within the Literature." *Energy Policy* 38, no. 4 (April 2010b): 1834–1841.

Aitken, Mhairi, Seonaidh McDonald, and Peter Strachan. "Locating 'Power' in Wind Power Planning Processes: The (Not So) Influential Role of Local Objectors." *Journal of Environmental Planning and Management* 51, no. 6 (2008): 777–799.

Alexander, Catherine, and Joshua O. Reno. "From Biopower to Energopolitics in England's Modern Waste Technology." *Anthropological Quarterly* 87, no. 2 (2014): 335–358.

Appadurai, Arjun. *The Social Life of Things: Commodities in Cultural Perspective*. Cambridge: Cambridge University Press, 1986.

Bakker, Karen, and Gavin Bridge. "Material Worlds? Resource Geographies and the 'Matter of Nature'." *Progress in Human Geography* 30, no. 1 (2006): 5–27.

Baldwin, Andrew. "Carbon Nullius and Racial Rule: Race, Nature and the Cultural Politics of Forest Carbon in Canada." *Antipode* 41, no. 2 (2009): 231–255.

Bennett, Jane. "The Agency of Assemblages and the North American Blackout." *Public Culture* 17, no. 3 (2005): 445–465.

Bonta, Mark. "Deleuze and Space by Ian Buchanan and Gregg Lambert." *Annals of the Association of American Geographers* 97, no. 4 (2007): 811–813.

Bridge, Gavin. "Material Worlds: Natural Resources, Resource Geography and the Material Economy." *Geography Compass* 3, no. 3 (2006): 1217–1244.

Bridge, Gavin. "Resource Geographies I: Making Carbon Economies, Old and New." *Progress in Human Geography* 35, no. 6 (2010): 820–834.

Bridge, Gavin. "Resource Geographies II: The Resource-State Nexus." *Progress in Human Geography* 38, no. 1 (2014): 118–130.

Butler, Judith. *Bodies That Matter: On the Discursive Limits Of 'Sex'.* London: Routledge, 1993.

Callon, Michel. "Economic Markets and the Rise of Interactive Agencements: From Prosthetic Agencies to Habilitated Agencies." In *Living in a Material World*, edited by Pinch Trevor and Richard Swedberg, 29–55. Boston: MIT Press, 2008.

Castree, Noel. "Commodifying What Nature?" *Progress in Human Geography* 27, no. 3 (2003): 273–297.

Cointe, Béatrice. "From a Promise to a Problem: The Political Economy of Solar Photovoltaics in France." *Energy Research and Social Science* 8 (2015): 151–161.

Cointe, Béatrice. "Le tarif d'achat photovoltaïque comme outil d'innovation territoriale: l'exemple des Fermes de Figeac." *VertigO* [En ligne] 16, no. 1 (May 2016). http://vertigo.revues.org/17040.

Cronon, William. *Nature's Metropolis: Chicago and the Great West, 1848–1993*. New York: W. W. Norton, 1991.

Debourdeau, Ariane. "De la 'solution' au 'problème': la problématisation de l'obligation d'achat de l'énergie solaire photovoltaicque en France et en Allemagne." *Politix* 24, no. 95 (2011): 85–109.

Dehez, Jeoffrey, and Vincent Banos. "Le développement territorial à l'épreuve de la transition énergétique. Le cas du bois énergie." *Géographie, économie, société* 19, no. 1 (2017): 109–131.

Devine-Wright, Patrick. "Place Attachment and the Social Acceptance or Renewable Energy Technologies." In *Psychological Approaches to Sustainability: Current Trends in Theory, Research and Applications*, edited by Victor Corral-Verdugo, Cirilo H. Garcia-Cadena, and Martha Frias-Armenta, 337–359. New York: Nova Science Publishers, 2010.

Evrard, Aurélien. *Contre vents et marées. Politiques des énergies renouvelables en Europe*. Paris: Presses Académiques de Sciences Po, 2013.

Ferry, Elisabeth. "Inalienable Commodities: The Production and Circulation of Silver and Patrimony in a Mexican Mining Cooperative." *Cultural Anthropology* 17, no. 3 (2002): 331–358.

Ferry, Elisabeth, and Limbert Mandana, eds. *Timely Assets: The Politics of Resources and Their Temporalities*. Santa Fe: School for Advanced Research Press, 2008.

Folch, Christine. "The Cause of All Paraguayans? Defining and Defending Hydroelectric Sovereignty." *The Journal of Latin American and Caribbean Anthropology* 20, no. 2 (2015): 242–263.

Fontaine, Antoine, and Olivier Labussière, "Politics of the Sun: The Art of Growing without Destroying Solar Energy Entities, under Reviewing." PACTE Working Paper, Grenoble, 2015.

Frolova, Marina, María José Prados, and Alain Nadaï, eds. *Renewable Energies and European Landscapes: Lessons from Southern European Cases*. New York and London: Springer, 2015.

Geraint, Ellis, Richard Cowell, Charles Warren, Peter Strachan, Joseph Szarka, Richard Hadwin, Paul Miner, Maarten Wolsink, and Alain Nadaï. "Wind Power: Is There A "Planning Problem"? Expanding Wind Power: A Problem of Planning, or of Perception? The Problems Of Planning—A Developer's Perspective Wind Farms: More Respectful and Open Debate Needed, Not Less Planning: Problem "Carrier" or Problem "Source"? "Innovative" Wind Power Planning." *Planning Theory & Practice* 10, no. 4 (2009): 521–547.

Gomart, Emilie. "Methadone: Six Effects in Search of a Substance." *Social Studies of Science* 32, no. 1 (2002): 93–135.

Haraway, Donna. *Simians, Cyborgs, and Women: The Reinvention of Nature.* London: Free Association Books, 1991.

Hartwick, Elaine R. "Geographies of Consumption: A Commodity Chain Approach." *Environment and Planning D* 16 (1998): 423–437.

Hartwick, Elaine R. "Towards a Geographical Politics of Consumption." *Environment and Planning A* 32 (2000): 1177–1192.

Howe, Cymene. "Anthropocenic Ecoauthority: The Winds in Oaxaca." *Anthropological Quarterly* 87, no. 2 (Spring 2014): 381–404.

Howe, Cymene, and Dominique Boyer. "Aeolian Politics." *Distinktion: Scandinavian Journal of Social Theory* 16, no. 1 (2015): 31–48.

Hudson, Ray. *Producing Places.* New York: Guilford Press, 2001.

Ingold, Tim. "Writing Texts, Reading Materials. A Response to My Critics." *Archaeological Dialogues* 14, no. 1. (2007): 31–38.

Jolivet, Eric, and Eva Heiskanen. "Blowing against the Wind—An Exploratory Application of Actor Network Theory to the Analysis of Local Controversies and Participation Processes in Wind Energy." *Energy Policy* 38 (2010): 6746–6754.

Kaup, Brent Z. "Negotiating Through Nature: The Resistant Materiality and Materiality of Resistance in Bolivia's Natural Gas Sector." *Geoforum* 39, no. 5 (2008): 1734–1742.

Kay, Lily E. *Who Wrote the Book of Life? A History of the Genetic Code*. Stanford: Stanford University Press, 2000.

Knappet, Carl. "Materials with Materiality?" *Archaeological Dialogues* 14, no. 1 (2007): 20–23.

Labussière, Olivier, and Alain Nadaï. "Unexpected Wind Power 'Potentials': The Art of Planning with Inherited Socio-geographical Configurations (France)." *Scottish Geographical Journal* 130, no. 3 (2014): 1–15.

Latour, Bruno. *Nous n'avons jamais été modernes – Essai d'anthropologie symétrique*. Paris: La Découverte, 1991.

Latour, Bruno. “Lettre à mon ami Pierre sur l’anthropologie symétrique.” *Culture matérielle et modernité, Ethnologie française* 26, no. 1 (Janvier–Mars 1996): 32–37.

Latour, Bruno. “How to Talk about the Body.” *Body & Society* 10, no. 2–3 (2004): 205–229.

Law, John, and Annemarie Mol. “Notes on Materiality and Sociality.” *Sociological Review* 43 (1995): 274–294.

Le Baut-Ferrarèse, Bernadette. *Traité de droit des énergies renouvelables*. Paris: Éd. Le Moniteur, 2012.

Lemonnier, Pierre. “Et pourtant ça vole! L’Ethnologie des techniques et les objets industriels.” *Culture matérielle et modernité, Ethnologie française* 26, no. 1 (1996): 17–31.

Miller, Daniel. *Material Culture and Mass Consumption*. Oxford: Basil Blackwell, 1987.

Miller, Daniel. *Material Cultures: Why Some Things Matter*. Chicago: University of Chicago Press, 1998.

Miller, Daniel. “Stone Age or Plastic Age?” *Archaeological Dialogues* 14, no. 1 (2007): 23–27.

Mitchell, Timothy. *Petrocratia. La démocratie à l’âge du carbone*. Alfortville, Editions Ere, 2011.

Mol, Annemarie. “Ontological Politics. A Word and Some Questions.” *The Sociological Review*, 47, no. 1 (1999): 74–89.

Nadaï, Alain, and Ariane Debourdeau. “Actions, séquences, ‘épreuves de transition’ dans les Crêtes Pré-Ardennaises (CCPA).” In *La sociologie de l’énergie – Gouvernance et pratiques sociales*, edited by Marie Christine Zélem and Christophe Beslay, 63–72. Paris: CNRS, Collection Alpha, 2015.

Nadaï, Alain, and Olivier Labussière. “Wind Power Planning in France (Aveyron): From State Regulation to Local Experimentation.” *Land Use Policy* 26, no. 3 (2009): 744–754.

Nadaï, Alain, and Olivier Labussière. “Birds, Turbines and the Making of Wind Power Landscape in South France (Aude).” *Landscape Research* 35, no. 2 (2010): 209–233.

Nadaï, Alain, and Olivier Labussière. “Recomposer la mer pour devenir offshore: le projet éolien de Veulettes-sur-Mer.” *Nature, Sciences, Sociétés* 22 (2014): 204–218.

Nadaï, Alain, and Olivier Labussière. “Landscape Commons, Following Wind Power Fault Lines: The Case of Seine-et-Marne (France).” *Energy Policy* 109 (2017): 807–816.

Nadaï, Alain, Olivier Labussière, Ariane Debourdeau, Yannick Régnier, Béatrice Cointe, and Laure Dobigny. "French Policy Localism: Surfing on 'Positive Energie Territories' (Tepos)." *Energy Policy* 78 (March 2015): 281–229.

Pasqualetti, Martin J. "Morality, Space, and the Power of Wind-Energy Landscapes." *Geographical Review* 90, no. 3 (July 2000): 381–394.

Pearson, Thomas W. "Frac Sand Mining and the Disruption of Place, Landscape, and Community in Wisconsin." *Human Organization* 75, no. 1 (2016): 47–58.

Pinker, Anabel, "Tinkering with Turbines: Ethics and Energy Decentralisation in Scotland." *Anthropological Quarterly* 91, no. 2 (2018).

Raman, Sujatha. "Fossilizing Renewable Energies." *Science as Culture* 22, no. 2 (2013): 172–180.

Reverdy, Thomas. "The Valuation of Negawatts: The Controversial Articulation of Demand-Side Management with the French Electricity Markets." Paper presented at the 2017 Conference of the European Group for Organisational Studies, Copenhagen, Denmark, 2017.

Richardson, Tanya, and Gisa Weszkalnys. "Resource Materialities." *Anthropological Quarterly* 87, no. 1 (2014): 5–30.

Rolston, Jessica Smith. "The Politics of Pits and the Materiality of Mine Labor: Making Natural Resources in the American West." *American Anthropologist* 115, no. 4 (2013): 582–594.

Scheer, Hermann. *Energy Autonomy: The Economic, Social and Technological Case for Renewable Energy*. London: Earthscan, 2007.

Seyfang, Gill, Jung Jin Park, and Adrian Smith. "A Thousand Flowers Blooming? An Examination of Community Energy in the UK." *Energy Policy* 61, no. 13 (2013): 977–989.

Summerton, Jane. "Do Electrons Have Politics? Constructing User Identities in Swedish Electricity." *Science Technology Human Values* 29 (2004): 486.

Tabourdeau, Antoine, and Christophe Chauvin. "Le bois-énergie en Rhône-Alpes: Vers une intelligence commune." <hal-01236598>, 2015.

Verbruggen, Ariel, Manfred Fischedick, William Moomaw, Tony Weir, Alain Nadaï, Lars J., Nilsson, John Nyboer, and Sathaye Jayant. "Renewable Energy Costs, Potentials, Barriers: Conceptual Issues." *Energy Policy* 38, no. 2 (February 2010): 850–861.

Walker, Gordon, and Noel Cass. "Carbon Reduction, "The Public" and Renewable Energy: Engaging with Socio-technical Configurations." *Area* 39, no. 4 (2007): 458–469.

Weszkalnys, Gisa. "Cursed Resources, or Articulations of Economic Theory in the Gulf of Guinea." *Economy and Society* 40, no. 3 (2011): 345–372.
Weszkalnys, Gisa. "Oil's Magic: Contestation and Materiality." In *Cultures of Energy: Power, Practices, Technologies*, edited by Sarah Strauss, Stephanie Rupp, and Thomas Love, 267–283, Walnut Creek, CA: Left Coast Press Inc, 2013.
Weszkalnys, Gisa. "Anticipating Oil: The Temporal Politics of a Disaster Yet to Come." *The Sociological Review* 62, no. 1 (2014): 211–235.
Whatmore, Sarah. *Hybrid Geographies: Natures, Cultures, Spaces*. London: Sage, 2002.
Willow, Anna J., Rebecca Zak, Danielle Vilaplana, and David Sheele. "The Contested Landscape of Unconventional Energy Development: A Report from Ohio's Shale Gas Country." *Journal of Environmental Studies and Sciences* 4 (2014): 56–64.
Willow, Anna, and Sarah Wylie. "Politics, Ecology, and the New Anthropology of Energy: Exploring the Emerging Frontiers of Hydraulic Fracking." *Journal of Political Ecology* 21 (2014): 222–236.
Wolsink, Maarten. "The Research Agenda on Social Acceptance of Distributed Generation in Smart Grids: Renewable as Common Pool Resources." *Renewable and Sustainable Energy Reviews* 16, no. 1 (2012): 822–835.
Woolgar, Steve, and Javier Lezaun. "The Wrong Bin Bag: A Turn to Ontology in Science and Technology Studies?" *Social Studies of Science* 43, no. 3 (2013): 321–340.
Zimmerman, E.W. *World Resources and Industries: A Functional Appraisal of the Availability of Agricultural and Industrial Resources*. New York: Harper and Brothers, 1933.