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Governance of energy transitions: about inclusion and closure in complex sociotechnical problems

Govert Valkenburg[1*] and Giancarlo Cotella[2]

Abstract

Background: When societies are faced with complex technological problems such as energy transitions, two basic approaches to governance are usually mobilized. On the one hand, there are methods that emphasize the need for enlarging the range of knowledge that is taken on board when decisions are to be made. On the other hand, there are methods that emphasize the enrolment of a broader range of actors. In practice, these approaches conflate uncritically, which fails to bring out the potential that each has for specific challenges. We investigate how these two basic approaches can be brought together more systematically, in such a way that their potential vis-à-vis specific challenges, including energy transitions, is maximized.

Methods: The article offers a conceptual exploration. Building on existing approaches, we offer a novel conceptualization of how modes in the governance of complex technological problems can be classified, using energy transitions as a strategic research site.

Results: We offer a typology of strategies built along two axes: the degree of closure, i.e. the extent to which things can still be (re)negotiated and/or their actual implementation questioned, and the degree of inclusiveness, i.e. the extent to which processes are open to all people, as opposed to for example merely policymakers or technoscientific experts. Through the typology, we find four clusters spanned by these two dimensions, which each call for specific governance strategies and each inform specific connections between the actor base and knowledge base of intervention.

Conclusions: Important potentials for the governance of complex technological problems are currently left untapped, if the actor and knowledge bases are unreflexively mobilized. The proposed framework helps realize more of these potentials, by offering advice for how modes of governance with different degrees of closure and inclusiveness can be mobilized.

Keywords: Governance, Complex sociotechnical problems, Energy transitions, Inclusion, Closure, Cognitive inclusion, Actor inclusion

Background

The governance of complex processes, such as energy transitions, large infrastructural projects or comprehensive spatial planning issues, has hitherto largely been approached along two lines. On the one hand, there have been calls for a broadening of the knowledge base that informs decisions, e.g. by enrolling other types of knowledge than formal expertise, e.g. [1, 2]. On the other hand, there are calls for the enrolment of additional actors than the incumbent policymakers, technocrats and innovators, e.g. [3, 4]. For example, it is argued that interest groups, local communities and practitioners should be involved in decision-making processes. In practice, these two classes are of course conflated. However, it is our argument that this conflation mostly happens in a too unreflexive way. Therefore, we investigate how these two basic approaches can be brought together more systematically, in such a

* Correspondence: g.valkenburg@maastrichtuniversity.nl
[1]Faculty of Arts and Social Sciences, Maastricht University, Grote Gracht 92, 6211, SZ, Maastricht, Netherlands
Full list of author information is available at the end of the article

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way that their potential vis-à-vis specific challenges is maximized.

We first analyse in more detail the sources of complexity underlying these problems and the strategies that existing literatures have offered to tackle them. Then, we put together a conceptual framework that situates modes of governance into an ordered field. This framework builds on two dimensions: the degree to which new actors and new knowledges can be mobilized, or the *level of inclusiveness*, and the degree to which knowledges, technological designs and institutional arrangements become stabilized, or the *level of closure*. These two dimensions span a field in which four basic quadrants can be identified. For each of these quadrants, specific strategies to dealing with the mobilization of both additional actors and additional knowledges emerge as appropriate. Thus, the following argument will contribute to the literature on governance of transitions—and complex problems at large—a further sensitivity for the specific constraints and affordances to which actors and their knowledge are subject.

Methods

This paper presents a conceptual study. First, we offer clarification of how complex problems emerge and face policymaking. Then, we offer a brief literature review of how governance studies have proposed to deal with complex problems. We then point out through further conceptual analysis that the existing approaches unduly conflate epistemic or 'knowledge-driven' and agential or 'action-driven' approaches. At last, the newly explored field is integrated with the knowledge-based part into a single two-dimensional ordering.

Results

The nature of complex problems

Contemporary societies are replete with problems that are complex. Complexity here refers to the fact that the problems defy standard solutions or standard strategies, and they cannot be split into sub-problems for which standard strategies would be available [5].[1] As will become clear, such complexity typically emerges because parts of the problem are not independent, and solving one part of the problem might thus deteriorate another part [6, 7]. As if complex problems are not difficult enough to solve by themselves, it typically does not make things easier if they are to be managed in a democratic or democratically legitimate way [8].

Throughout this paper, we will regularly turn to energy transitions as a specific version, and illustrative example, of complex problems. We understand energy transitions at a conceptual level as a set of structural changes in energy systems [9–11]. These structural changes are needed since the system can no longer accommodate novel elements and subsystems. At this point, the adaptation capacity of the system becomes insufficient. When these novelties are found to be desirable yet fail to fit into the system, an overhaul of the whole system is needed.

As the changes constituting energy transitions concern the system structure, they are highly consequential: other subsystems may become obsolete as they become poorly aligned with new system standards (they become 'reverse salients'; see [12]). For example, a coal-fired power plant takes some time to come online, longer than, for example gas-fired plants. If the energy system comes to incorporate more intermittent sources such as wind and solar power, and if politico-economic circumstances dictate that these intermittent sources should be prioritized over fossil power, then the flexibility required from fossil power might not be possible to deliver by coal-fired plants. This means that coal-fired plants are rendered obsolete, even though they may not have reached their economic life term. Such fundamental changes abound in energy transitions.

Energy transitions epitomize complex governance problems, where complexity derives from many different issues. First, energy transitions involve many different actors, each with different interests, and different interpretations of the transition goals [13]. Their economic and political interests are typically tied up with the specific positions they hold in the socio-economic and technical system. For example, energy producers, for their market position and their influence on policymaking processes, depend on how exactly they have access to the energy infrastructure. Similarly, citizens can only reduce their dependency on big energy producers, if the overall energy infrastructure can accommodate their own small-scale energy production sites, e.g. roof-mounted solar panels. This is at once a technological, regulation and political problem. The dependency of such affordances and constraints on infrastructures entails that competitive positions will change if infrastructures change. This is one important reason why alignment is challenging and why such structural changes are likely to meet resistance.

Second, energy transitions are complex because of the heterogeneity of relevant values [14]. This is of course a general phenomenon in contemporary, technological societies, but energy transitions are no exception. While overall goals might enjoy broad endorsement, their specification into short-term goals and actions is subject to value pluralism and contested prioritization of values. This concerns goods underlying transitions such as energy security and sustainability, as well as a broader range of social goods such as freedom of movement, security of subsistence and the exercise of democratic rights. While these values are each legitimate in their own right, they may each lead to different and conflicting conclusions regarding how the energy infrastructure

should be arranged and inform different and conflicting perspectives on how short-term goals should be set [15].

Third, energy transitions are complex because of uncertainties [11, 13]. On the one hand, this concerns factual and empirical knowledge: knowledge about how energy systems function, especially in connection to their socio-political and geopolitical context, is largely incomplete. What makes things worse is that transitions are an importantly future-oriented affair, and factual knowledge about the future is even more uncertain. It is as yet unknown what kind of energy technologies will be successful in the future, how energy needs will exactly be shaped, etc. Also, the influence of carbon emission on climate change remains swayed by large margins of uncertainty, which determines part of the urgency of energy transitions.[2] [3]

On the other hand, these uncertainties concern normative knowledge about the future. This part is twofold: as the future is unknown, it is not straightforward what we should want for that future (let alone that we agree on that), and it is also unclear what the most important norms and values will look like in the future. This makes the matter more complicated than mere value pluralism. If we only disagree on values and their prioritization, the solution typically consists of a political process through which we arrive at a conclusion that can be accepted by all, even under disagreement to the content. However, in this case, the matter is subject to an epistemic challenge: there are key things we do not *know*. This means that there is uncertainty about the very object of discussion, which means that the aforementioned political processes become futile.

A fourth source of difficulty, also sharing an epistemic nature, is that there is no linear and unambiguous relation between the production of knowledge and processes of decision- and policymaking [16]. Policy choices are based on more than just expert knowledge. They are subject to contingent power relations, to processes of agenda setting, etc. [17]. Also, reality is always more complex than can be captured by knowledge, whether expert knowledge or any other source of knowledge. And finally, knowledge is constantly translated and reframed whenever it circulates. Thus, decisions have an input that is broader than only knowledge, and knowledge itself is often too ambiguous and heterogeneous to inform decisions.

A fifth kind of complexity is a direct consequence of complex social reality: with each and every change in sociotechnical reality, new actors emerge and others disappear from the stage. By consequence, it will similarly differ between situations which knowledge is relevant; no universal principles of knowledge inclusion are likely to be found, beyond some very general principles of democratic account and non-paternalism. Rather than trying to devise democratic principles for the inclusion of knowledge, the issue of mobilization of actors and different sorts of knowledge should be thought of as something that is performed and constructed time and again. More than producing knowledge, it is a matter of positioning people. It is our contention that so far, citizens have been too much addressed as an abstract and unruly 'human factor' [18]. Instead, more attention should be paid to the substance of the roles they play [19] when they act as a consumer, a protester, a voter, a tax-payer and so on.

Thus, energy transitions are complex, heterogeneous, long-term processes. What makes things worse is the fact that such processes are inherently *reflexive* [16, 20, 21]: any intervention made today will change the world of tomorrow. This means that uncertainties do not simply add up but reinforce each other exponentially. We do not know how the future system will behave, since we cannot be entirely sure what system we will build for the future. Given the fundamental levels at which changes in energy transitions take place, we are gradually de facto building new sociotechnical systems, which means that it is not entirely known how these future systems will behave. This holds a fortiori for social reality. In practice, this reflexivity entails that we cannot easily predict the exact social situation in which future technologies will be embedded. This is not only about social and institutional arrangements but also about the whole axiological scale of private moral concerns, habits and life-style-related norms, political ideologies, etc. This reflexivity stands in a dialectic relation to what has been referred to as *recursiveness*: the principle that structure is at once a means and a result of action [22]. While the latter seems to suggest some form of stability, it is through the former intrinsically prone to destabilization.

Uncertainty, occurring in many forms, is a precondition for modern life and any social activity. One specific differentiation between sorts of uncertainty has been dominant in informing a classification of policy problems. This classification takes uncertainty to occur on two possible qualities of an issue. On the one hand, there can be uncertainty with respect to the facts. In this case, expertise could be consulted so as to reduce this uncertainty. On the other hand, uncertainty can be situated at the normative level, if there is no clear position on which value should be realized. In that case, political and moral debate could possibly be conducted to come closer to a consensus. If neither quality is particularly ambiguous, one could speak of 'puzzles': these problems are sufficiently structured and can be approached as implementation problems for which a standard method is available and of which the solution is principally within reach. Quite the contrary, especially difficult or 'wicked' problems occur if uncertainty exists on both qualities.[4] In that case, normative uncertainty renders controversial

or ambiguous what kind of expertise should be enrolled to solve the factual puzzles, and the factual uncertainty renders unclear what the political debate should be conducted about [23–25].

If problems score high on both the normative and the factual qualities, they are unstructured, which means they cannot be approached as puzzles for which standard methodologies are apt. These problems are termed *wicked problems*. In practice, the wickedness of problems may appear as the definition of the problem being ambiguous. Also, there is no clear point at which the problem can be seen as solved nor an unequivocal solution towards which effort can be made. With wicked problems, there is also no test site in which a manageable version of the problem can be tried to solve. Usually, there are no clearly good or bad answers, etc. [7].

This has been sketched in Fig. 1. In the upper right quadrant, many problems have been identified over the past decades that are subject to strong controversy and contestation while uncertainties cannot as yet be reduced by scientific research. This is often the case of uncertainties linked to energy security and transitions, where the weakness of scientific evidence over long-term issues such as peak oil and climate change impacts hampers the reconciliation of opposite political positions on various matters.

As briefly indicated above, complex problems become particularly pressing if they are to be dealt with in a democratically sound way. The notion of *governance* offers a handle to start thinking through complex problems vis-à-vis contemporary, democratic societies. In the following section, we will introduce the notion of governance, particularly focussing on how it relates to complex problems. We then move on to dissect two classes of approaches to the governance of complex problems, namely by enlarging the knowledge base and enlarging the actor base.

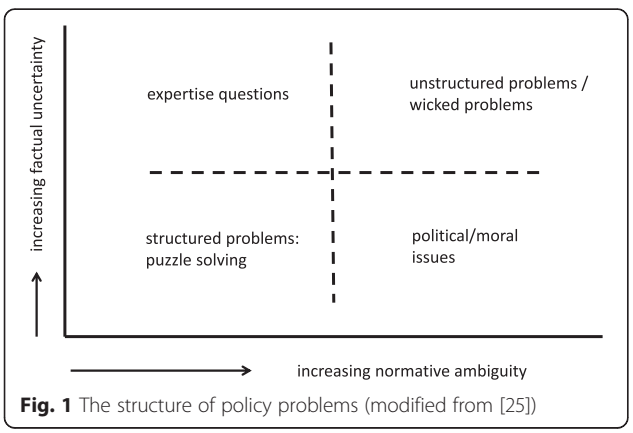


Fig. 1 The structure of policy problems (modified from [25])

Governance

With governance, we refer to the distributed constellations that exercise power throughout society in order to coordinate societal processes [26]. In its broadest sense, governance includes all structuring that has societal consequences and which is supported by some form of legitimation in terms acceptable to the people experiencing those consequences (cf. [27]). It unites all those processes that happen when people start taking control in a collective way, whether through bottom-up or top-down arrangements. We deliberately choose a comparably wide notion of governance and do not restrict it for instance to intentional action (cf. [28]), since that would rule out exactly a number of modes of governance that are essential to our argument.

In a general way, the notion of governance reflects the recognition that bottom-up processes complement conventional top-down modes of command and control, without entirely replacing them [29, 30]. In practice, processes of governance de facto present a balance between maintaining (central) public control over matters and delegating decision and policymaking powers and competences to other agents. These agents might be located at the different territorial scales and both inside and outside the public sector. Where the traditional notion of 'government' referred to the control exercised from within a polity's institutions, 'governance' generalizes this control and also includes all the forms of control that take place outside formal administrative institutions. Straightforward examples of modes of governance—or at least the part that falls outside political and administrative institutions—are public debate, the installation of market incentives, public education, self-regulation of professional groups, etc. At a more philosophical level, it can be argued that governance as an alternative to government offers a reversal of the primacy, from a top-down central government to a bottom-up approach [31].

Since the notion of governance vastly expands the space in which decisions are taken, compared to conventional notions of politics, both the range and heterogeneity of relevant bodies of knowledge proliferate. One noteworthy kind of knowledge that now becomes salient is knowledge that is generally reckoned to belong to private life.[5] Also, since technologies of many sorts offer affordances and constraints to our lives, decisions underlying the design of those technologies are to be reckoned part of governance.

Some authors present the idea of governance as adding democratic quality to the government of a society [32], or at least a recognition that bottom-up processes are an important factor in the coordination of society. Others contest these pro-democratic claims as being uncritical and point out the blurred criteria of legitimacy

and accountability that the new governance beyond the state often brings about [33–35].

Of course, ways of doing governance, or what we call 'modes', are manifold and heterogeneous. These modes include the activities and institutions subsumed under classical views of politics: political debate, legislation and policymaking, jurisdiction, etc. But they also include practices that are not traditionally reckoned part of politics: education and information, grass-root initiatives, association, etc. The fact that governance thus includes practices that are traditionally outside politics, it is no longer straightforward how political principles function vis-à-vis those generic modes of governance. Looking at public debate and infrastructure specification, to mention just two arbitrary examples, it remains a question how they can be captured under the same denominator.

The notion of governance not only reflects the empirical observation that decision-making is de facto not the prerogative of formal institutions but also reflects that societies are faced with problems that are, as outlined above, too complex to be dealt with within those formal institutions. This has been answered with new normative perspectives on the societal management of complex problems. Addressed challenges have included issues such as value pluralism, uncertainty, contested expertise and the changing role of the state [36–40]. Frameworks such as *post-normal science* [1, 41, 42] and *transition management* [22, 43] have aimed to solve parts of the Gordian knots that puzzle complex, technological societies.

Governing complex problems: knowledge and experimentation

More in detail, for the governance of complex problems, various innovative approaches have been suggested. As we will show, these roughly fall apart in two categories. On the one hand, there is the class of approaches that see the policy problem as a *knowledge deficit*: the issue is difficult, but if we could obtain further knowledge, we would be able to cope with it better. On the other hand, the complex problem can be approached as a *lack of control*: we roughly know what is the case and where we want to go, but we need better means of intervening.

An example of the emphasis on knowledge production is the approach of post-normal science (PNS, [1]). It has prescribed how wicked problems necessitate the expansion of practices of knowledge production beyond traditional forms of expertise. This 'extended peer community' needs to include a broad range of stakeholders, which are needed to bring a sufficiently wide range of perspectives to bear on a particular problem. This increases the democratization of complex problems and their solution. This is to say that, through the extension of the peer community, the problem becomes connected to a broader range of people, and the solution likewise acquires a legitimacy that is carried by a broader public. However, it is a democratization of a specifically *epistemic* sort. While it accommodates the absorption of knowledge put forward by broad ranges of audiences, it does not explicitly engage with how those audiences can be engaged and how these audiences can be made to see themselves as carrying any responsibility for issues on the table.

On the one hand, it is easy to see the value of bringing in many different perspectives. In a most general sense, it enlarges the range of possible solutions that become available. Also, including the perspectives of citizens who are in the end important actors in the effectuation of transitions helps to ascertain that the solution will be adapted to the context of implementation. Inclusion understood as the inclusion of a sufficiently broad range of perspectives on a problem, what could be called *epistemic inclusion*, is important both from the perspective of democratizing decisions and from the perspective of capacitating actors to cope with complex problems. Of course, the inclusion of a broad range of kinds of knowledge brings challenges of its own, and this is exactly where the classification of the modes of governance developed in this paper offers more specified advice.

An approach such as PNS is indeed in principle open to any sort of knowledge, including social and moral aspects. But this openness is at the same time a blind spot: it does not per se help identify problems that are outside the epistemic realm. A lack of knowledge is only part of what makes this class of problems complex. Complexities of geopolitics and markets are neither reduced by expertise nor by debate. Also, as Guston [40] has noted, seeking resolution within a mere epistemic realm would be arrogating to (social) scientists the ability to determine what is good, as they will always be in a prioritized position when it comes to adducing knowledge. Additionally, not all sorts of knowledge can be expected to be equally able to 'speak truth to power' and get their particular truth staged and be heard by those in power. As Adams et al. [17] pointed out, when aiming at influencing policy- and decision-making through the production of knowledge, individuals are more likely to be successful when clustering more or less formally in knowledge communities (may their nature be epistemic, linked to a specific practice or set of values). This hints at a need to further consolidate measures to grant agency to relevant actors. It is our contention that approaching complex policy problems as knowledge problems is thus an incomplete approach, as challenges are not always possible to reduce to a knowledge deficit, whether normative or empirical.

On the other hand, there is the class of approaches to complex problems that avow the inclusion of a broad

range of actors and aim to attain a strategy by experimentation. An example of such an experimentation style of approaching complex problems is provided by transition management [16, 20, 21]. The approach is by no means void of knowledge production, but emphasis is on learning by doing, exactly because much relevant knowledge is unattainable ex ante [13]. So-called (on a side-note, poorly specified) frontrunners are to be enrolled [22, 44], and iteration in the sense of revising short-term and mid-term goals in view of newly acquired experiences is key. In a more general sense, this type of approach is about activating people.

Both categories of approaches to complex problems presented above, i.e. those focussing on their epistemic nature and those more specifically concerning with actors' inclusion, inform as to how specific governance arrangements—modes of governance in our wording—may be more effective than others in achieving specific outcomes. As Treib et al. [45] review, modes of governance can be classified with respect to the degree of coercion, the degree of openness of implementation of decisions, the presence of sanctions, their involvement of actors, their dependence on market mechanisms and some more.

Similarly, it has been suggested elsewhere that modes of governance can be classified on a scale between 'deliberative' and 'hierarchical' [31]. While deliberative refers to the further production of knowledges, and hierarchical refers to a potential to determine action, we contend that it is by no means given that these are opposed. (Even if the authors have meant this scale to refer to governance more broadly without splitting so radically between knowledge production and intervention, it still remains non-trivial why deliberative knowledge production cannot go together in any way with centralized management.) Rather, as we further argue in the following sections, it is exactly the relation between them that merits further development.

From experimenting and knowledge production to inclusion and closure

It is worth noting that in most literature on governance of complex problems, core notions are not always clearly specified. For example, actors, stakeholders and frontrunners appear in theories without specifying who is to be enrolled there. The high-school teacher? The mayor? The utility contractor? It is hardly at this level that actors are specified. Exceptions are found in concrete case studies, where relevant players are staged and labelled as such, e.g. the two case studies by Rotmans and Loorbach [22]. It appears though that in such case studies, the classification of actors happens in hindsight, and it remains unclear why exactly *this* actor is to play a particular role.

To a large extent, this is of course owing to exactly the experimental nature of transitions and, more generally, of the governance of complex problems: ambiguity about who the relevant actors are is part of what makes things complex. It is for this reason that we are just as much fundamentally unable to specify ex ante how actors are to be positioned and enrolled. What our framework aims at though is offering a classification of modes of governance that entails particular actor roles. While it remains impossible to identify actors beforehand, it at least further sharpens the view by pointing out what is to be expected from them.

Before we can further develop this in the next section, we need to argue the same here for the inclusion of a broader range of knowledge. It is clear that scientific knowledge, or even in a more general sense expert knowledge which is predominantly modelled after the criteria for natural-scientific knowledge [46], provides an insufficient knowledge base to address all the intricacies of complex problems. However, hardly any substantive criterion for which knowledge is relevant is ever given. Of course, ideas include that it is necessary for problem definitions to resonate with the knowledge people hold about an issue, for those people to feel responsible for the issue. Hence, those people should be included in defining the problem in the first place [18].

Again, this is hardly fair to criticize. Also, here, it is at the basis of the very definition of complex problems that it is impossible to tell ex ante which kinds of knowledge need to be roped in. What is needed here is a specification of what kind of role knowledge should play in a particular mode of governance.

In the following section, we further specify how specific roles can be expected from both actors and knowledges. The conceptual move we make is in recognition of the fact that specific modes of governance always come with specific constraints and potentials.

Arranging governance

Our prior definition of governance, chiefly all those processes through which control over the arrangement of society is exercised, leaves unspecified what these processes look like. We have already mentioned some classifications of modes of governance, which have been suggested along various dimensions. In this light, we propose to put together a classification of modes of governance along two dimensions that allow for both an epistemic and an agential specification: their level of inclusiveness and their level of closure.

The first dimension is to capture the extent to which modes of governance are socio-spatially distributed and mobilize agency of a broad variety of actors. This *level of inclusiveness* is low if only institutional and political actors matter and high if the general audience and market

players etc. matter as well. Political debate in parliament is a fairly exclusive, centralized affair. So are taxes, since there is only one authority that executes them. In contrast, grassroot initiatives, interest groups and public information are much more distributed and hence inclusive. They are accessible to many or all citizens, and their execution or effectuation is importantly done by many. (Note that these are not empirical claims, but just conceptual explications, or tautologies if one likes—we just recite what is generally meant with parliamentary debate, interest groups, etc.)

Note that this level of inclusiveness is at once epistemic and agential. Also, there is a correlation (but not a strict identity) between the two domains: practices that are inclusive in terms of participation are also likely to be inclusive of a broader range of knowledge than less inclusive practices [47, 48]. Similarly, if exclusion is exercised, it is very conceivable that unfitness of specific knowledges is mobilized as a justification (there is of course a large literature on such forms of 'boundary work', starting with Gieryn [49]). This correlation is not conclusive. This somewhat fuzzy mapping and conflation of the epistemic and agential dimensions of governance is done deliberately so as to leave some flexibility in its use. We find it unproblematic for the current argument, but further specification might be an interesting avenue for follow-up research.

If a mode of governance scores higher on the dimension of inclusion, it may count as more democratic—though this of course depends on the exact criteria for democracy one holds dear [50]. The idea of inclusion involves the enrolment of citizens in effectuation of a policy, as well as their knowledges pertinent to that policy. It involves citizens' access to the institutions where the policy is created and implemented, and their possibilities to get their voices heard. It includes the extent to which something pertains to all members of society. And it includes the degree to which things are physically distributed and pervasive through society. Thus, this distribution is comparably intuitive and leaves intact some underlying heterogeneities and ambiguities. (Also, again, the explanation is largely conceptual and tautological, not empirical.)

The second dimension by which we group modes of governance is the level of closure. This captures the extent to which propositions, in terms of their (re)definition and/or implementation, are open to negotiation or instead have closed down and become inevitable. This level of closure is high if things are settled, when arrangements become institutionalized, and decisions are binding. It is low if decisions can still be debated and contested and for example when the effectuation of decisions remains dependent on voluntary action. Closure can occur in the discursive sphere [51], as well as in institutional arrangements [52] and in technological design [53].

Political debate, conducted within the confines of political institutions, has in itself a low degree of closure, but closure may occur the moment political debate leads to the production of laws and other authoritative policies and ultimately the coercion of decisions taken. In comparison, public debate has the same low degree of closure, but getting from public debate to closed-down decisions is far less straightforward. It may generate new ideas and perspective, it may generate support for a particular case, and it may in the end breed acceptance for laws to be adopted, but in itself, it is not able to issue binding rules. This difference not least relates to the difference between the two on the other dimensions: the two modes differ greatly on the level of inclusiveness.

The level of closure is largely antonymous to the agency people and institutions have: the more things are fixed and closed down, the less there is to choose and change to effectuate. The concern underlying this paper was that agency was largely underdeveloped in the governance approaches we discussed. The arrangement of modes of governance in Fig. 2 shows that this two-dimensional approach is indeed necessary to do justice to the orthogonality between inclusion and closure: one cannot be reduced to the other, and a mode scoring high on one dimension does not necessarily score high on the other.

Following distinctions along these two dimensions, a collection of modes of governance—by no means intended to be comprehensive—was arranged in Fig. 2. In tandem, these two dimensions produce a field in which the complete range of modes of governance can be charted. As will become clear onwards, this classification allows for engaging at once with how agency of individual actors is arranged and with the inclusion of heterogeneous forms of knowledge.

This classification of modes of governance helps to chart the territory in which agential and epistemic inclusion are to be pursued. With different modes come different levels of inclusiveness and closure, which importantly determines how issues are circulated, how actors show agency, how actors are positioned in power relations and how outcomes are never merely determined by knowledge positions. Only with sufficient sensitivity towards these constraints and affordances can it be possible for the citizen to be incorporated and mobilized in dealing with complex problems, as for instance energy transitions.

If we divide the field in four quadrants, and realize that the main challenges of achieving energy transition are both epistemic and agential, then the following four strategies can be devised (see Fig. 3). In the lower left corner, we find chiefly those modes of governance that are closely related to institutional politics in its conventional sense. We have termed it 'government' here

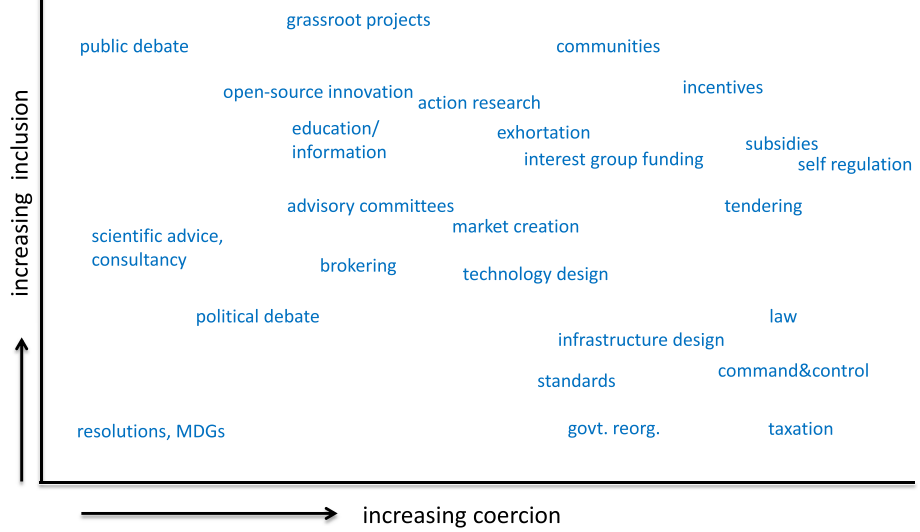


Fig. 2 A two-dimensional classification of conventional modes of governance (original)

because that most exemplarily catches the character, but of course, it is slightly broader than what government literally refers to. While inclusiveness in the sense of getting citizens to participate is not directly relevant here, all the more attention could be paid to having the process epistemologically inclusive, as this is not self-evidently the case. That is to say, mainstream politics could aspire to mobilize the methods from policy studies discussed above, so as to curate a richer knowledge base upon which decisions are to be made. It is a known complaint [54] that in these spheres, discourses are too much limited to economic and technological/technocratic vocabularies. In this corner, the earlier lessons learned from post-normal science could be deployed.

In the upper left corner, inclusiveness is high and closure is low. We have termed it 'crowd sourcing', referring to practices where many supporters each contribute a small bit to a common goal. For the purpose of this argument, such contributions must be thought to include both knowledge and action. In this quadrant, epistemological inclusiveness is not very problematic: different sorts of knowledge can in principle be adopted or at least to the extent that a given society is able to perform such inclusion. Similarly, no fundamental hurdles may stand in the way for agential inclusion. It is more likely that agential inclusion will take place if the epistemic inclusiveness is more emphasized: if people are explicitly invited to voice their definitions of problems and the opportunities they see for solution. This all is not to say though that inclusion is straightforward or would not require work. It just says that the low level of closure poses few or no limits to it.

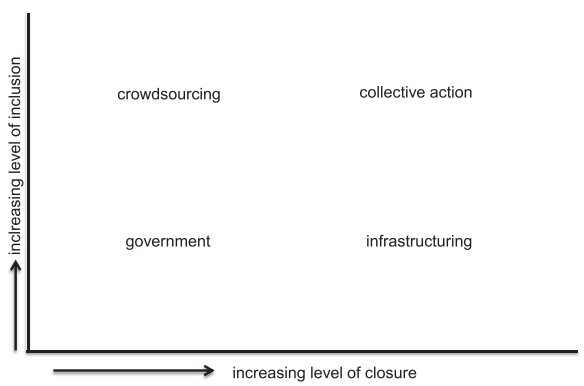


Fig. 3 Four types of modes of governance (original)

The upper right corner is termed collective action. In this corner, both inclusiveness and closure are high. Here, things really depend a bit more on where the closure has taken place. If it is largely epistemic, then mobilizing further knowledge production might not that productive, and more action-oriented inclusion might be prioritized. Conversely, if closure has taken place in the technical and action domain, then inclusion into knowledge production might help to create common ground. It is not self-evident that this will happen, and Caiati et al. [55] show that particularly, those projects are successful that actually pay attention to the work that needs to be done to align new practices and cognitive frameworks with existing frames held by citizens.

In the lower right corner, finally, we find the activity of 'infrastructuring'. The notion of infrastructure has of course many meanings across a vast range of literatures and even within this article, but here, we refer to those

elements that organize interactions in society over a longer time and in doing so go by unnoticed. These elements might not only be technological structures but also practices that are fixed in place and institutions of various sorts. In building such infrastructures, inclusiveness is low but closure is high. In other words, it is not granted that citizens will have access to these particular processes of governance, and if they have access, it is not given that they can exert any substantial influence, since the course of affairs is already largely determined—whether in the allowable repertoire of action or in the possible contestation of knowledge. In some natural sense, these modes of governance are therefore not so relevant for citizens. They are just there, hence the term 'infrastructuring'. However, as both high closure and low inclusiveness render these modes of governance highly influential for the organization of society, they provide an important site where arrangements can be made that engender both epistemological and agential inclusiveness in the other quadrants. Examples are developing infrastructures such that they remain open to sociotechnical experimentation (agential inclusiveness) and organizing governmental institutions such that a wide array of knowledge can be incorporated (epistemic inclusiveness).

Discussion

Energy transitions are pervasive phenomena that entrench societies both along technological and along socio-political and economic lines. Consequently, an utterly heterogeneous range of kinds of knowledge is salient to the problematics, as is the broadest range of relevant actors. The above argument has offered a systematic way to classify the substantive ways in which the relevance of these kinds of knowledge and relevant actors can play out. It thus fleshes out more of the 'learning' strategy that is often taken too much at face value in dealing with the management of transitions. Such a systematic approach is a necessary addition to the hitherto uncritical conflation of actor and knowledge.

The argument has been largely conceptual, which means it could be further corroborated with empirical study. Such a study could for example investigate, through anthropological and other qualitative methods, how both closure and inclusiveness (or their counterparts, contestation and exclusion) are achieved in practices of governance. Also, further policy analysis could be conducted into how the trajectory of issues, from problem definition to implementation of a solution (or failure thereof) maps onto the field sketched above.

Conclusions

Lessons for governing complex issues

Underlying the proposed argument is a recognition that the inclusion of knowledges as well as actors, when it comes to governance of complex problems such as energy transitions and others, has hitherto been assumed too uncritically. By consequence, the conflation of epistemic and agential inclusion has merited further attention. The field of modes of governance we proposed above helps operationalize the idea that the solution of complex problems requires that multiple perspectives are brought to bear on the very problem. We solve the problem indirectly: not by making more specific which actors and knowledges should be included and how, but by articulating what might be realistic expectations given the relative position of a mode of governance vis-à-vis other modes.

Also, how these two dimensions of inclusion and closure play out has been differentiated for modes of governance.

Further research

It is to be hoped that this approach, of arranging modes of governance in the field spanned by the level of inclusion and the level of closure, can be developed further. Underlying the whole approach to the mobilization of citizens is that attention must be paid not only to epistemic and agential inclusion but also to the extent to which these are facilitated or constrained by the particular mode of governance. This also sheds a particular light on issues of legitimacy and accountability. One follow-up question would be how each of the four quadrants should be more explicitly related to the production of legitimacy of decision-making and of accountability for the decision taken.

Finally, this production of engagement, legitimacy and accountability must be connected more explicitly to the ideas of learning that are central to existing approaches to governance of complex issues, which in turn are strongly connected to the notion that such processes are highly reflexive processes. If reflexive systems (whether technical or social) indeed change their own fundamentals, they render the prediction of their future behaviour unpredictable. The production of engagement, legitimacy and accountability are themselves interventions in the sociotechnical system and reflexive at that. The current article aims at mobilizing learning processes to deal with this reflexivity.

Endnotes

[1]As one reviewer rightly pointed out, a distinction is often found in the literature between 'complicated' and 'complex' problems (see, e.g. [56]). The former refers to problems where scale and heterogeneity necessitate the involvement of, and coordination between, different types of expertise. Despite these difficulties, such problems are ultimately reducible to smaller sub-problems, and solutions are repeatable between similar cases. Complex problems, on the other hand, are not reducible, and solutions are not reproducible. These problems emerge in evolving

and adaptive systems. While we think this distinction should not be at the core of our argument, we will explicate relevant aspects when needed.

[2]This claim is of course not meant to represent a 'climate-sceptic' stance but just to emphasize that the future is fundamentally uncertain.

[3]At this point, it could be argued, in line with endnote 1, that these are largely coordination issues that make transitions a complicated problem, not a complex problem. However, we contend that these interactions between parts of the process make the process importantly irreducible, which makes the process complex, not only complicated.

[4]Prior definitions of wicked problems by, e.g. Rittel and Webber [7] and Termeer, Dewulf, and Breeman [36] use different specifications, but the overall characteristics of the current class of problems are much alike.

[5]For a further discussion of the relation between knowledge and power, check the 'Territorial knowledge channels' framework developed by Adams, Cotella and Nunes [17].

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Authors' contributions
GV devised the conceptual framework. GC contributed to fine-tune it and to substantiate the connection between the framework and the empirical data. Both authors read and approved the final manuscript.

Authors' information
GV writes from a perspective of constructivist social studies of science, technology and society. GC writes from a spatial planning and policy perspective.

Competing interests
The authors declare that they have no competing interests.

Author details
[1]Faculty of Arts and Social Sciences, Maastricht University, Grote Gracht 92, 6211, SZ, Maastricht, Netherlands. [2]Interuniversity Department of Regional and Urban Studies and Planning (DIST), Politecnico di Torino, 39 Viale Mattioli, 10125 Torino, Italy.

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