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Institutional harmonization for spatial integration of renewable energy: Developing an analytical approach

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ABSTRACT

This paper develops an analytical approach to explore institutional barriers to spatial integration between renewable energy (RE) and other land use functions and provides insight into opportunities for institutional harmonization between involved policy domains. Spatial integration of RE with other land use functions provides opportunities to use limited amounts of space more efficiently, allowing for a more fluent roll-out of renewable technologies. However, such integration requires the involvement of various policy domains that are each guided by specific institutional frameworks, which are often tailored to specific sectoral needs. Therefore, spatial integration of RE and other land use functions requires institutional harmonization between involved policy domains. However, there is limited guidance in literature on how such harmonization does or could occur. Moreover, while literature on RE recognizes the merits of institutional approaches, it focuses on institutions as the formal rules of the game, often disregarding the agency component (the 'play of the game'). The analytical approach developed in this paper combines the Institutional Analysis and Development framework with insights from Discursive Institutionalism. The approach enables structured assessment of relationships within and between established institutions (the 'rules of the game') and actors' ideas, interpretations and deliberations regarding these institutions (the 'play of the game'), providing insight in processes of institutional harmonization. This analytical approach is applied to the case of spatial integration of photovoltaics with national transport infrastructure networks in the Netherlands. The findings from the case show that (1) insight in interrelations between institutional barriers is crucial for addressing institutional harmonization; (2) institutional harmonization *within* policy domains is a precondition for harmonization *between* policy domains; and (3) the agency component (play of the game) is key to successful harmonization. In conclusion, the analytical approach provides insight into the co-evolution between the rules of the game and the play of the game, which is pivotal to institutional harmonization.

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1. Introduction

The Paris Agreement on climate change, signed in 2015, shows an increased global sense of urgency to shift towards a low fossil carbon society (Suzuki et al., 2016). This shift involves widespread application of renewable energy (RE) technologies (Mignon and Bergek, 2016). However, RE generation requires extensive amounts of space and is highly visible in the landscape because of the relatively low power density of renewable sources compared to fossil sources (Scheidel and Sorman, 2012; Smil, 2006). Power density (in W/m²) provides insight into the spatial requirements of various energy sources. Whereas fossil fuel sources such as coal or hydrocarbons

have a power density of 10² or 10³ W/m² (Smil, 2006), the power density of renewables is approximately 0.5–1.5 W/m² for wind energy and 4–9 W/m² for solar photovoltaics (PV) (Scheidel and Sorman, 2012). The concept of power density, however, does not take into account the possibility for combining land use functions. To illustrate, wind turbines or solar panels can often be placed upon grounds used primarily for other purposes, such as housing, agriculture or transportation. Such spatial integration of RE production with other land use functions creates integrated energy landscapes which, especially in densely populated regions, appears to be necessary for making the transition towards low fossil carbon societies (De Boer and Zuidema, 2015).

Transport infrastructure is one of the land use functions providing opportunities for spatial integration with RE. The most viable options for such integration include placing wind turbines or solar panels on left-over spaces along highways, highway nodes, and sound screens

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(Frantál et al., 2018; Volpe, 2012; Wadhawan and Pearce, 2017). Areas along infrastructure are suitable for RE production for a number of reasons: (1) these areas are already under environmental pressure due to air and sound pollution and, therefore, offer limited use-value besides the primary function of providing accessibility (van der Horst, 2007); (2) infrastructure networks are usually government-owned, making it easier for governments to develop these areas because they have powers beyond incentivizing development; (3) combinations of RE with infrastructure networks are supported by government ambitions and experimentation, e.g. in the US (Volpe, 2012), the UK (Highways England, 2016; Parker, 2015), Germany (Frantál et al., 2018) and the Netherlands (Ministry of Infrastructure and the Environment, 2016). To illustrate, the Dutch Ministry of Infrastructure and the Environment wrote a letter to parliament in 2016, expressing the ambition to make the national transportation infrastructure networks, managed by its executive organization Rijkswaterstaat, energy neutral by 2030 (Ministry of Infrastructure and the Environment, 2016).

Despite these opportunities and ambitions, few integrated RE and transport infrastructure projects have been implemented so far in the Netherlands and abroad. One of the main challenges appears to be that spatial integration of RE with other land use functions requires the involvement of various policy domains. These domains are each guided by specific institutional frameworks and related practices, which are often tailored to specific sectoral needs. Institutional barriers occur because existing frameworks and practices create an overload of rules which can be contradictory (Grotenbreg and van Buuren, 2018; Negro et al., 2012). Moreover, there appears to be a disconnection between existing (sectoral) institutional frameworks and new ideas and practices that are arising related to RE (Lammers and Heldeweg, 2016). Simultaneously, there are few rules aimed specifically at integrated projects (Grotenbreg and van Buuren, 2018). As a consequence, such integrated projects face a high degree of institutional ambiguity, or even an institutional void, which Hajer (2006) describes as “a situation in which there is no single ‘constitution’ that pre-determines where and how a legitimate decision is to be taken. Actors bring their own assumptions about rules and authority” (p.43).

The above discussion illustrates that the spatial integration of RE and other land use functions appears to be hampered by uncoordinated and ill-adjusted institutions, as well as a lack of specific institutions accommodating the issue at hand. As Suzuki et al. (2016) argue in a special issue of this journal, “harmonization of existing and new policies and institutions is key” (p. 4) if the world is to move towards low fossil carbon societies. However, existing literature does not address how institutional harmonization does or could occur. Therefore, the aim of this paper is to explore institutional barriers that hamper such harmonization efforts, so as to provide insight into how institutional harmonization can be enhanced to improve spatial integration between RE and other land use functions, using the case of transport infrastructure.

The focus on institutions stems from the observation that spatial integration between RE and transport infrastructure has been addressed primarily from a technological perspective (e.g. Debije et al., 2018; Vallati et al., 2015; Wadhawan and Pearce, 2017). These observations are in line with Andrews-Speed (2016), who states that in energy transition literature in general, there appear to be few explicit institutional analyses that draw on insights from institutional theory. Nevertheless, the role of institutions in understanding transition dynamics is academically appreciated. For example, Geels et al. (2016) and Turnheim et al. (2015) position institutional perspectives as essential parts of the analytical approach applied in socio-technical analysis. They perceive institutions primarily as structuring forces on the meso-level, focusing on the importance of national policies and regulations for constraining or stimulating transitions. In addition, Cherp et al.

(2018) emphasize the importance of institutional theory in explaining national energy transitions. However, in line with the observation by Andrews-Speed (2016), neither of these authors explicitly engage with institutional analysis. Instead, they highlight the importance of such analyses in energy transitions literature and emphasize the need to account for the multiple socio-technical sub-systems that co-evolve across spatial and institutional scales. For example, Geels et al. (2016) call for approaches that combine more meso-level socio-technical analysis with insights from micro-level initiatives or practice-based learning. Moreover, while highlighting the energy transition as an encompassing societal transition, these authors focus largely on institutions related to the domain of energy policies. Hence, there is limited attention for policy integration and harmonization between energy policies and other policy domains or land use functions.

Institutions also receive attention in literature on the diffusion of RE technologies. Within this literature (e.g. Mignon and Bergeck, 2016; Negro et al., 2012; Reddy and Painuly, 2004), the focus lies mainly on formal (or hard) institutional barriers, such as a lack of continuity in policies, laws and regulations, the shifting attention of policy makers, misalignment of policies between sectors and government levels, and inadequate support schemes (Negro et al., 2012). Informal (or soft) barriers are mentioned primarily in relation to the active lobby against RE by certain actors and societal resistance against the implementation of RE projects (Negro et al., 2012). Besides barriers categorized as ‘institutional’, a number of other barriers are mentioned including those related to physical infrastructure, interactions, finances, markets, behavior, and capacities (Mignon and Bergeck, 2016; Negro et al., 2012; Reddy and Painuly, 2004). These ‘other’ barriers appear to be conceptualized as non-institutional. However, institutional theory posits that human behavior and interaction are shaped by institutions (North, 1991; Ostrom, 2005) and shape institutions (Mahoney and Thelen, 2010; Schmidt, 2008, 2010). Hence, a part of these ‘other’ barriers can be considered institutional themselves. The above argument illustrates a research gap in literature on RE generation: this literature does not appear to recognize institutions as both shaping and being shaped by actor behavior and interactions. Therefore, a shift in perspective is needed away from understanding institutions as merely formal rules and frameworks on the meso-level to an understanding inclusive of informal institutions and actor behavior and interaction.

This paper will contribute to such a new understanding. Specifically, this paper addresses the research gap identified above, by developing an analytical approach that captures the dynamic interplay between various formal and informal rules and how involved actors interpret shape and reshape them in processes of institutional harmonization. The approach developed is based on the Institutional Analysis and Development (IAD) framework by Ostrom (2005), which provides insight into formal and informal institutions that actors abide to (called the ‘rules of the game’ in this paper). The IAD framework is combined with insights from Discursive Institutionalism (DI) as developed by Schmidt (2008, 2010), which applies a more dynamic conceptualization of institutions as simultaneously influencing and being influenced by actors (called the ‘play of the game’ in this paper). As such, the analytical approach is thoroughly grounded in institutional theory. Moreover, in line with the call by Geels et al. (2016), this paper takes into account the co-evolution between the structuring dynamics of policies and regulations at the meso-level and actors’ interpretations, ideas and deliberations at the micro-level. The theoretical background and development of this analytical approach is described in section 2.

This paper explicitly addresses the issues of institutional harmonization between policy domains by applying the analytical approach to the case of spatial integration between solar photovoltaics (PV) and transport infrastructure in the Netherlands. This is a specific type of integration between RE and transport

infrastructure where PV is placed on left-over spaces along highways, highway nodes, or sound screens. As described above, this is currently one of the most viable options for integrated RE and transport infrastructure projects (Volpe, 2012), but due to institutional barriers there are few projects actually realized. This case is further described in section 3. In section 4, the analytical approach is applied to the case. The results first detail the rules of the game that structure the current situation. Second, institutional barriers and opportunities for harmonization are presented, taking into account both the rules and the play of the game. Subsequently, section 5 contains the discussion and conclusion.

2. Theoretical framework

In institutional theory, institutions are commonly referred to as 'rules' (Hodgson, 2006; North, 1990; Ostrom, 2005). North (1990) defines institutions as "the rules of the game in a society or, more formally [...] the humanly devised constraints that shape human interaction" (p.3). Generally, a distinction is made between formal and informal rules (Kingston and Caballero, 2009; North, 1991; Ostrom, 2005). Formal rules are explicit, written down and enforced by actors with specific roles, including constitutions, laws, and policies. Informal rules are implicit, lack clear specification, and are enforced endogenously, including conventions, norms, and codes of conduct (Kingston and Caballero, 2009; North, 1991). Institutional frameworks are formed by interaction between such formal and informal rules (North, 1991), forming multi-layered, nested hierarchies of rules (Ostrom, 2005). Institutional frameworks are often presented as stable, enduring arrangements that structure actors' strategies and actions (North, 1991; Ostrom, 2005).

However, this understanding of institutions is criticized for its static understanding of institutions (Mahoney and Thelen, 2010; Schmidt, 2008, 2010) and the dominance of structure (rules) over agency (action and interaction) (Schmidt, 2008). Discursive institutionalism (DI) emphasizes the importance of acknowledging that institutions encompass both structure and agency (Schmidt, 2008, 2010). The DI perspective on institutions embraces a more dynamic perspective on institutions, in which institutional change is perceived as a constant process in the background, fueled by actors' current behavior. Therefore, this paper develops an analytical approach which allows for institutions to structure actors' behavior through the 'rules of the game', while simultaneously being shaped and changed by this behavior in the 'play of the game'.

This paper applies the Institutional Analysis and Development (IAD) Framework (Ostrom, 2011, 2005, 1990) to systematically analyze the 'rules of the game' that apply to the spatial integration between PV and transport infrastructure. The IAD framework is useful because it is one of the few frameworks that operationalizes institutional analysis in a systematic manner. However, the IAD framework does take a rather static view on institutions as arrangements that structure behavior, and thereby can be subject to the criticism that it focusses primarily on structure, and is "better at explaining continuity than change" (Schmidt, 2010, p. 2). This is problematic, because institutional barriers appear to occur on the boundary between continuity and change, i.e. the moment that institutional frameworks are focusing on continuity, while institutional change is required to encourage the harmonization that is necessary to improve the spatial integration between RE and other land use functions.

Ostrom and Basurto (2011) also acknowledge the importance of "analytical tools for analyzing dynamic situations – particularly institutional change" (p. 317). However, the analytical tool they developed to study "the evolution of rules and norms" (Ostrom and Basurto, 2011, p. 317) maintains a rules-following logic. Their aim is to identify changes in rule-configurations over time. Essentially, this tool aims to record processes of change but does not focus on

the mechanisms behind these changes. By developing an analytical approach for identifying institutional barriers on the boundary between continuity and change, this paper contributes to the discussion on the mechanisms behind institutional change.

The IAD framework focusses on an 'action situation', which is defined as "the social spaces where individuals interact, exchange goods and services, solve problems, dominate one another, or fight" (Ostrom, 2011, p. 11). The IAD framework identifies seven types of rules that structure an action situation (Ostrom, 2005): (1) *Position rules* relate to actors being in certain positions, (2) *Boundary rules* relate to actors entering or leaving positions, (3) *Choice rules* relate to actors doing certain actions, (4) *Aggregation rules* relate to actors (jointly) affecting control over action-outcome linkages, (5) *Information rules* relate to the sending or receiving of information, (6) *Scope rules* relate to the occurrence of outcomes, and (7) *Payoff rules* relate to paying or receiving costs or benefits. The action verbs in these rules (to be, enter or leave, do, jointly affect, send or receive, occur and pay or receive) are important identifiers for the different types of rules. These rules are what Ostrom (2005) calls 'rules-in-use'. Thereby, the IAD framework mainly captures those rules that have been established deliberately and that are applied and enforced in some manner (Kingston and Caballero, 2009). As a consequence, there is no explicit attention to the individual agency of actors in how they interpret, use and also transform these rules through their behavior and interactions. To bring the action situation 'to life', there is a need to present a dynamic action situation in which actors function as agents that are not only rule-following but simultaneously rule-shaping (see Fig. 1). Besides a more traditional analysis of the 'rules of the game', the analytical approach developed here also includes an analysis of the ideas of actors regarding the rules of the game; i.e. how they interpret, reflect on, deliberate or respond to these rules (see Fig. 1). This means that each variable in the IAD framework is operationalized in a manner that allows for an analysis of (1) the 'rules of the game', and (2) actors' ideas, interpretations and deliberations regarding how these rules should be reframed, ignored or abolished in what is called the 'play of the game' (see Table 1).

In its original form, the IAD framework provides insight in who may, must or must not do something, how, when and where. Thereby, it can only provide insight in institutional barriers that are a result of conflicting 'rules of the game'. The addition of the DI perspective broadens the range of institutional barriers and opportunities captured by the IAD framework, through including a more dynamic view on institutions which takes into account the 'play of the game': i.e. actors' ideas, interpretations and deliberations regarding how rules *should* be reframed, ignored or abolished. This analytical approach, which also forms the

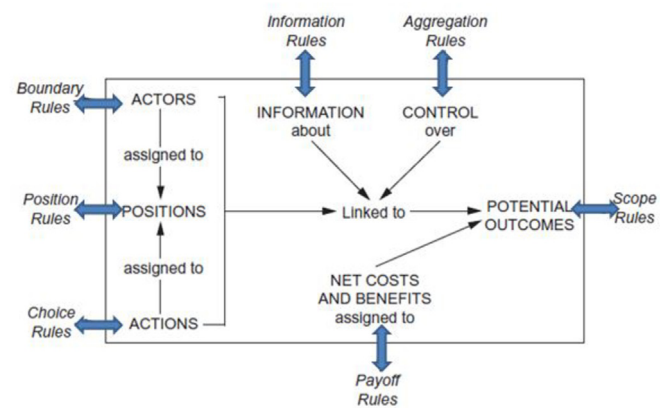


Fig. 1. Interaction between the 'rules of the game' and 'play of the game' through which actors deliberate and change rules, as indicated by the double arrows (adapted from Ostrom, 2011).

conceptual framework for this paper, is provided in [Table 1](#).

The analytical approach developed in this paper helps identify institutional barriers as a result of mismatches within and between the 'rules of the game' and the 'play of the game'. For example, two rules of the game can be contradictory, or rules of the game can be challenged by actors in the play of the game. Moreover, the analytical approach helps identify barriers that are a result of actors' deliberations in situations where there is a lack of rules. As explained by [Hajer \(2006\)](#), a lack of rules can create high institutional ambiguity or even an institutional void. [Ostrom \(2005\)](#) defines default conditions for each variable, which reflect the structure of an action situation in which there are no rules (see [Table 1](#)). High institutional ambiguity or an institutional void can, therefore, be recognized by the approximation of such a default condition. Moreover, by examining relations within and between the 'rules of the game' and the 'play of the game', interrelations between institutional opportunities and barriers can be identified.

3. Material and methods

3.1. Empirical case

This paper applies the analytical approach to the case of spatial integration between PV and transport infrastructure, referring to the placement of PV on left-over spaces along highways, highway nodes, or (integrated in) sound screens in the Netherlands. The focus lies on highways as *national-level* transport infrastructure. The asset manager for national infrastructure in the Netherlands is Rijkswaterstaat, which is the executive organization for the Ministry of Infrastructure and the Environment. However, developing PV in combination with transport infrastructure requires cooperation and coordination between Rijkswaterstaat and other organizations across multiple scales. The Netherlands has a unitary governmental system with various degrees of decentralization depending on the specific policy field. This means that the national government is the locus of power, but that responsibilities are often delegated to provinces and municipalities ([EC, 1997](#)). Regarding spatial planning many responsibilities have been decentralized to provinces and municipalities, including the responsibility to issue environmental permits for PV installations. Thereby, the case incorporates multi-level and multi-interactive complexity, as suggested by [De Leeuw and Gössling \(2016\)](#) for analysis of institutional change processes.

Spatial integration between PV and transport infrastructure is

gaining prominence in the Netherlands. As a result, rules are shifting from a reactive role towards a more proactive role for Rijkswaterstaat. Until 2015, citizen initiatives, provinces or municipalities could approach Rijkswaterstaat with ideas for solar initiatives and after deliberation Rijkswaterstaat could decide to support these initiatives. Very few initiatives were realized in this manner. In 2015 all applications and discussions were put on hold because a new system was going to be developed in which locations must be auctioned. The rules of the game described in this paper are the rules regarding the system as it is being developed. Therefore, this paper presents the rules of the game of the new situation as it is being implemented, as well as the ideas, deliberations, and negotiations of actors regarding these rules in the play of the game.

3.2. Methods of data collection

This paper is based on qualitative data, gathered using in-depth interviews and a focus group. A total of 14 in-depth, semi-structured interviews were conducted in the second half of 2016 and early 2017. In the design of the interview guides, questions were organized according to the variables of the IAD framework. Respondents included officials from the Ministry of Infrastructure and the Environment, Rijkswaterstaat, the Central Government Real Estate Agency, the regional department of Rijkswaterstaat in the North of the Netherlands, officials from the three Northern provinces, a consultancy firm, an energy company, and an electricity grid operator. A list of interviews is provided in [Table A.1](#) in the [Appendix](#). To triangulate findings from the interviews ([Yin, 2014](#)), a focus group with officials from Rijkswaterstaat, the Central Government Real Estate Agency and the Netherlands Enterprise Organization was held in June 2017.

3.3. Methods of data analysis

Transcripts of the interviews and focus groups were coded using the software Atlas.ti. Codes followed the structure of [Table 1](#), which provides (1) the definitions of the seven variables of the IAD framework to capture the rules of the game, and (2) the adapted definitions of these variables regarding actors' ideas, deliberations and negotiations about these rules to capture the play of the game. Codes were assigned to interview quotes based on their latent content to capture the underlying meaning of the data. Subsequently, manifest coding was used to identify different rules and ideas within each variable ([Babbie, 2010](#)). A consideration was that

Table 1
Analytical approach for studying both the 'rules of the game' and the 'play of the game'.

Variables	Rules	Action verb	Rules of the game based on Ostrom (2005)	Default conditions (Ostrom and Basurto, 2011 , p. 324)	Play of the game
Positions	Position rules	Be	Define the positions that can be held by actors.	Anyone can enter	Ideas regarding the roles actors should uptake and how roles relate to each other.
Actors	Boundary rules	Enter or leave	Define who may enter or leave positions and how.	No formal positions exist	Ideas regarding the actors that should be involved, how and when.
Actions	Choice rules	Do	Define what actors in certain positions may, must or must not do under specific conditions or at certain points.	Each player can take any physically possible action	Ideas regarding responsibilities that actors should have and opportunities they perceive.
Decision-making (control)	Aggregation rules	Jointly affect	Define how actors jointly affect decisions regarding proposed actions and activities and how.	Players act independently [...]	Ideas regarding (criteria for) coordination of decision-making among actors.
Information	Information rules	Send or receive	Define what information is to be send and received by which actors, at what moment, and using which channels.	Each player can communicate any information via any channel available to the player	Ideas regarding information that should be shared between actors and how learning should occur.
Outcomes	Scope rules	Occur	Define which outcomes may, must, or must not occur	Each player can affect any state of the world that is physically possible	Ideas regarding outcomes and targets that should be pursued.
Costs and benefits	Payoff rules	Pay or receive	Define costs and benefits to be payed or received by actors	Any player can obtain any outcome that the player can physically obtain and defend	Ideas regarding the distribution of costs and benefits among actors.

the perception of a single interviewee could bias included ideas. In order to overcome this, only ideas that were mentioned on two separate occasions were included in the results.

In the result section, references are made to the Appendix, where the rules of the game are presented in Table A.2. The ideas related to these rules (the play of the game) are presented in Table A.3. These tables were structured using the seven types of variables defined in the IAD framework. Each variable is assigned a different letter (e.g. B or Ib for boundary rules) and each rule and idea related to the rules is given a number (e.g. B1 or Ib1 respectively).

4. Results of the institutional analysis

4.1. Establishing the action situation: the rules of the game

Before discussing institutional barriers and opportunities, this subsection first describes the action situation for PV on Rijkswaterstaat lands based on the analysis of the rules of the game (Table A.2). A generalized action situation is presented in Fig. 2, while acknowledging that the exact composition of action situations also depends on the specific project (B3).

Rijkswaterstaat is the executive organization of the Ministry of Infrastructure and the Environment and responsible for the management of national transport infrastructure (P3). This means that they receive their assignments from the Ministry (P2) and that the Ministry drafts legislation related to Rijkswaterstaat (P1). Rijkswaterstaat may appoint locations for energy generation for their own purpose of becoming energy neutral and for the purpose of energy generation for third parties on their lands (C2). Rijkswaterstaat may not hold the position of the developer and owner of energy installations (P4); as stated in the ‘Letter to parliament regarding energy neutral networks managed by Rijkswaterstaat, “with renewable energy generation for ‘own’ purposes [...], it is meant that Rijkswaterstaat will become the owner of the associated guarantees of origin” (Ministry of Infrastructure and the Environment, 2016, p. 3). As a result, there is always a third party involved as developer and owner of the installation (P4), while Rijkswaterstaat will become the owner of the guarantee of origin; i.e. the certificates that prove that electricity was produced by renewable

sources. Moreover, Rijkswaterstaat is the licensing authority for the permit on the basis of the Public Works Act (P5).

The Central Government Real Estate Agency is the contract holder for state-owned land (P6) and the party who must organize an auction for the locations appointed by Rijkswaterstaat (C4). The Ministry of Internal Affairs drafts legislation related to the Central Government Real Estate Agency (P1). Potential developers, including both market parties and citizen initiatives, can participate in the auction (P4), with the highest bid gaining rights to develop and operate the PV installation (B4). Subsequently, the developer must apply for an environmental permit with the municipality or the province (C6). Moreover, an agreement must be reached with the local grid operator regarding the grid connection (C9). After receiving the necessary permits, the developer may apply for subsidies with the Netherlands Enterprise Organization (C10), which is part of the Ministry of Economic Affairs (P1). Government organizations are not eligible for subsidies (Y3).

4.2. Identifying institutional barriers and opportunities for harmonization

There is a rich variety of institutional barriers and opportunities for institutional harmonization, as Tables A.2 (rules of the game) and Table A.3 (play of the game) convincingly show. Based on a comparison between the barriers and opportunities mentioned in both tables, it is possible to identify various dominant issues regarding the harmonization between PV and infrastructure policies.

The first of these is the high institutional ambiguity regarding the role and responsibility of Rijkswaterstaat in the broader energy transition. Although Rijkswaterstaat and the Ministry of Infrastructure and the Environment have ambitions related to spatial integration of PV and transport infrastructure for the purpose of making the national infrastructure networks energy neutral (S5), many institutional barriers appear to be the result of a lack of ‘ownership’ of Rijkswaterstaat regarding the general opportunity of placing PV on its lands (Ip4). The Ministry does recognize such an opportunity, expressed in a letter to parliament stating that “the lands managed by Rijkswaterstaat offer considerable potential for the production of renewable energy which reaches further than the ‘own’ use of the organization” (Ministry of Infrastructure and the Environment, 2016, p. 3). Nevertheless, there are no rules defining the role and responsibility of Rijkswaterstaat regarding the energy transition in general (Ip2). In being an executive agency, Rijkswaterstaat is used to being clearly informed by the Ministry of Infrastructure and the Environment about its responsibilities, which are often expressed in clear targets (P3).

Facing no explicit targets for RE, taking initiative regarding energy projects is open to individual interpretation of formal and informal rules by Rijkswaterstaat’s managers and employees (Ia5). When asked why Rijkswaterstaat is working on RE issues, many of the interviewees refer to the targets set in the Dutch Energy Agreement and the Paris agreement as the broader scope for action (S4), as well as the aforementioned letter to parliament for the target of becoming energy neutral (S5). However, many of the interviewees also refer to a lack of scope rules that translate this broad ambition (14% RE by 2020 in the Energy Agreement) into specific targets for Rijkswaterstaat (Is4). As a result, there are a number of conflicting ideas regarding the responsibilities and scope for Rijkswaterstaat. First, there are various ideas regarding the approach for reaching energy neutrality. For example, some interviewees emphasize the need to quickly realize a few large wind parks or solar-fields that together cover the energy use of Rijkswaterstaat. Others emphasize that energy neutrality should be pursued by integrating RE in infrastructure projects, thereby slowly realizing many smaller initiatives. Second, there are various ideas

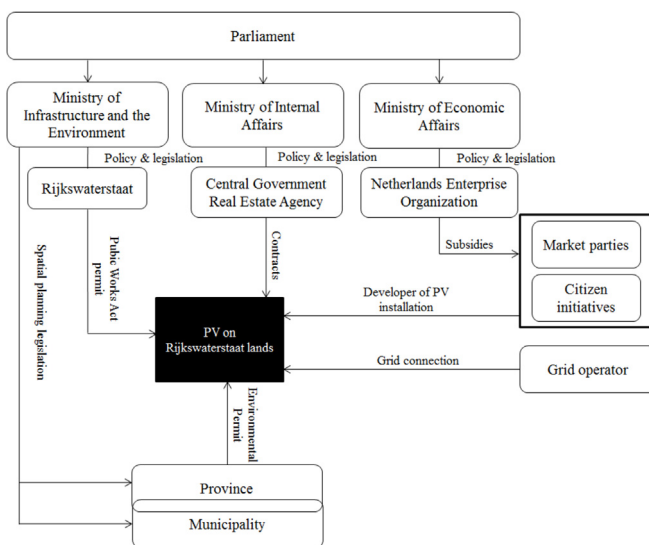


Fig. 2. The action situation for photovoltaics (PV) on Rijkswaterstaat lands. After forming a new cabinet in October 2017 some shifts occurred in the division of responsibilities for the Ministries. The Ministry of Infrastructure and the Environment is now called the Ministry of Infrastructure and Water Management and the Ministry of Economic Affairs has become the Ministry of Economic Affairs and Climate. This figure depicts the situation as it was when the data was gathered.

on whether Rijkswaterstaat should just aim for energy neutrality, or whether they should also support third party initiatives and thus contribute to the national energy ambitions (Is4). In March 2017, Rijkswaterstaat created a new position within the organization for a 'managing director (HID) sustainability and environment', expecting that this new director will make choices regarding the translation of abstract goals into a scope for action (Ip4). Simultaneously, during multiple interviews and the focus group, warnings were outed that a narrow scope which is focused solely on achieving Rijkswaterstaat's ambitions, might limit opportunities for the energy transition in the Netherlands as a whole (Is3). Clearly, for pursuing improved harmonization of RE with infrastructure there is also a need for internal harmonization within Rijkswaterstaat on its ambitions and role.

A second dominant issue relates to the fragmentation of responsibilities for PV on Rijkswaterstaat lands. Rijkswaterstaat must cooperate with other parties to realize PV on their own land (Ia4), but there are no procedures for joint decision-making regarding PV in combination with transport infrastructure; the aggregation rules resemble the default condition that "players act independently" (see Table 1). Because developers are dependent on a succession of decisions regarding permits and contracts with various parties (C2–C10), the lack of rules causes uncertainties and risks. An example of such a barrier is the position rule that either the province or the municipality is the licensing authority responsible for handing out the environmental permit (P6). This lack of clarity on roles can be illustrated using the following citation: *"The locations that came forth do not fit the provincial policy regarding solar parks. But that is a bit of a discussion point. Whether it is a provincial responsibility. Because [...] the municipality gave the environmental permit for these locations. [...] And it fits their perspective perfectly"* (Interview employees Province of Friesland). Without procedures for joint decision making, coordination between provinces and municipalities is crucial, let alone the need to also include the Central Government Real Estate Agency as the contract-holder and grid operators for access to the grid (Ib1). Currently, coordination depends on voluntary action (Ii1). With outcomes being open-ended, developers face serious risks of not being granted a permit. In response, many interviewees consider early involvement of municipalities, provinces, grid operators and the surrounding area in area-based conversations as necessary for coordinating decisions (Ic2) and for broader communication of related interests (Ii1). Ideas such as joint map making are presented by Rijkswaterstaat as a manner of communicating interests in such settings (Ic2). However, the main institutional barrier hindering participation of Rijkswaterstaat and the Central Government Real Estate Agency is the lack of resources in both time and money (Iy2). Moreover, it is unclear who needs to take the initiative in organizing these sessions (Ip4), which illustrates the lack of ownership and urgency regarding the broader opportunity for energy generation on Rijkswaterstaat lands.

Thirdly, interrelations between choice and payoff rules also play a large role in deliberations regarding the division of responsibilities. This can be illustrated using the example of citizen involvement. According to Rijkswaterstaat and the Central Government Real Estate Agency, citizen involvement is the responsibility of municipalities and provinces (Ic6). Due to resource constraints (Iy2), Rijkswaterstaat and the Central Government Real Estate Agency want to keep the process as simple and uniform as possible (Ia3). A simple and uniform process for them means reducing the amount of parties involved in the process (Ia1) and limiting the amount of criteria for assessing bids, thus focusing purely on price (Ia3). Therefore, every interested party, including citizen initiatives, is allowed to submit a bid in potential auctions of Rijkswaterstaat land (C5). However, this focus on auctioning lands to the highest bidder (Y6) creates a number of problems for citizen involvement. First, citizen initiatives are bound to one location and

often lack knowledge, competences and experience to compete with market parties (Ib2). Second, Rijkswaterstaat and the Central Government Real Estate Agency do not create incentives for developers to embed quality criteria, such as citizen involvement, in their bid (Iy5); contrary, involving such criteria might cost developers the bid because citizen involvement requires resources which might result in lower bid prices. Simultaneously, provinces and municipalities often emphasize the importance of citizen involvement in their environmental plans (Is7). Not involving citizens, therefore might lead to problems for developers with obtaining the environmental permit and possibly to resistance of citizens regarding PV on Rijkswaterstaat lands. This is largely an issue of institutional harmonization between different Ministries regarding payoff rules and between different levels, including national, provincial and municipal actors, regarding choice rules.

Barriers are also caused by the interrelation between strict interpretations of position and scope rules in the play of the game, which is related to the lack of clarity on the position of Rijkswaterstaat regarding the energy transition. Since Rijkswaterstaat does not have an explicit task beyond energy generation for its 'own' purposes there appear to be few rules that ensure that employees have an open attitude towards PV initiatives (Ip1). Contrary, employees from both the energy company and the consultancy firm experienced that Rijkswaterstaat staff, particularly specialists and operational staff, often apply strict interpretations of their 'traditional' responsibilities and tasks on PV initiatives, even though the rules of the games do not necessarily prescribe this. Rijkswaterstaat has a 'traditional' focus on safety and accessibility, implying an informal rule encouraging risk-averse attitudes among Rijkswaterstaat staff (Ip1). This can be illustrated using the example of risk-assessment: in the aforementioned letter to parliament, the only condition is that energy facilities must not compromise the safety of infrastructure networks (S2). However, it is unclear when safety is compromised or not (Is2). For example, in the case of transport of hazardous substances, acceptable risk-levels are determined. In the case of PV initiatives it is unclear what risk-levels are considered acceptable (Is2). Static interpretations of tasks and responsibilities combined with a lack of knowledge often result in inertia and rejection. This illustrates that informal rules guiding individual employees can be very influential for the outcomes of PV initiatives, and that positive attitudes at a strategic level within Rijkswaterstaat need to be communicated to specialists and operational staff (Ia6; Ii3).

Another consequence of the large role of informal rules in guiding individual employees is that information sharing occurs on an ad hoc basis, without clear learning objectives (Ii1; Ii2). Besides standard procedures for auctions and permits, information rules resemble the default condition that "each player can communicate any information via any channel available to the player" (Ostrom and Basurto, 2011, p. 324). As a result, essential information for projects is sometimes shared late, or not at all (Ii5). Moreover, there is no obligation for early consulting with other actors regarding initiatives (Ii1). This is problematic because e.g. the financial feasibility of an initiative depends heavily on the proximity and capacity of network stations, and therefore on early cooperation with grid operators (Ib1). In addition, internal communication about initiatives within Rijkswaterstaat only takes place in loosely structured meetings that do not necessarily focus on energy, or are organized on an ad hoc basis (Ii1). There is no structure for learning from experiences, whether they are successful or not, of past initiatives regarding how to improve coordination between actors (Ii2). This hampers both internal and external harmonization efforts.

Finally, institutional barriers can also be the result of strong political discourses forming an undercurrent in the play of the game. This can be illustrated using the example of the position rule that Rijkswaterstaat is not allowed to be the developer who operates RE installations (P5). The following quote illustrates that this

rule is based on the discourse of the leading political party regarding the relation between the State and the market (Ia8): “*The position of the State and the market is essentially a political choice. With the current coalition [government] the role of Rijkswaterstaat will not be changed, but if other parties came to power there might be opportunities.*” (Interview employee Rijkswaterstaat). In the current political context, therefore, these rules are difficult to change. Moreover, the perception of Rijkswaterstaat employees that a rule is difficult to change prevents proactive searches for improved harmonization in this regard, with many parties accepting and following rules without questioning them.

Action at a higher political level, including the Ministry of Infrastructure and the Environment and the parliament, might be crucial in clarifying the responsibilities of Rijkswaterstaat (Ic5; Ia6). However, even at this level some key barriers seem to exist. For example, interviewees indicated that it is unlikely that the minister will set a target for Rijkswaterstaat regarding RE, because the Ministry of Economic Affairs is responsible for RE (Ic4). This illustrates that improving institutional harmonization for spatial integration of PV on Rijkswaterstaat lands also requires a political choice with more pro-active policy on the level of the ministry, including coordination of both internal harmonization within the policy domain of infrastructure (Rijkswaterstaat), and external harmonization between policy domains, specifically, between RE and infrastructure.

5. Discussion and conclusion

This paper develops an analytical approach to explore institutional barriers to spatial integration between renewable energy (RE) and other land use functions and provides insight into opportunities for institutional harmonization between involved policy domains. Existing literature does recognize the importance of institutional perspectives in research on the energy transition (Andrews-Speed, 2016; Cherp et al., 2018; Geels et al., 2016; Suzuki et al., 2016; Turnheim et al., 2015). In the introduction it was noted that ill-adjusted and uncoordinated policies and regulations are positioned as causes of institutional ambiguity and a lack of institutional harmonization (Grotenbreg and van Buuren, 2018; Lammers and Heldeweg, 2016; Negro et al., 2012). However, these studies rarely apply explicit institutional analyses, understand institutions mainly as formal rules, and do not provide much insight in how harmonization does or could occur. Responding to these research gaps, the analytical approach developed in this paper is thoroughly grounded in institutional theory and focuses on the dynamic interaction between established ‘rules of the game’ and ideas of actors regarding these rules in the ‘play of the game’. As such, the approach moves beyond formal and static aspects of institutions and includes opportunities for analyzing the co-evolution between formal and informal institutions in a more dynamic fashion. Generally, it can be concluded that the approach illustrates the importance of ideas, routines and interpretations (i.e. the play of the game), which largely occur on the micro-level, and how these interact with the more formal, structuring rules on the meso-level.

The application of the analytical approach to the case of integrating PV with transport infrastructure also provides substantive insights in the process of institutional harmonization that add to existing literature. First, the results show that institutional barriers experienced by various actors are often interrelated. It can therefore be concluded that, when pursuing institutional harmonization, it is important to take into account these interrelations because they can help determine the level at which action is required, by whom, and the potential influence of these actions on other experienced barriers and rules for efficient action. Secondly, although spatial integration requires external harmonization between policy domains, this paper

shows that internal harmonization within the respective policy domains is a crucial first step. This is related to the third conclusion that the agency component (the play of the game) is key to successful harmonization, because this is the part of the arena where actors are often dealing with a lack of knowledge and experience. Hence, institutional harmonization is more than merely improving the coordination and coherence of formal policies and regulations. Within a context of institutional fragmentation and substantive ambiguity of key actors upon their exact roles and responsibilities, institutional harmonization becomes dependent on organizational cultures and individual characteristics. Whether and how existing and new rules are being applied in practice is dependent on ideas, interpretations and deliberations of individuals that are embedded in organizational cultures and practices and that are simultaneously shaping these cultures and practices. Therefore, it can be concluded that it is of crucial importance to ensure the co-evolution between the rules of the game and the play of the game.

The analytical approach and the conclusions presented here provide interesting avenues for further research. First, it would be interesting to compare and add to these insights by exposing the analytical approach presented in this paper, to cases exploring integration of RE with different sectors or in different contexts. The analytical approach presented can easily be adopted in contexts other than the Dutch. There is much room for application of this approach in other contexts with further possibilities for fine-tuning it, as the spatial integration of renewable energy and the development of more coherent policies surrounding energy transition are at least European if not global issues (Solorio, 2011). Second, this study’s approach is a first step in exploring a broader role for institutional approaches that are inclusive of informal institutions and actor behavior and interaction in research on the energy transition. This paper demonstrates that institutional theory offers opportunities for ‘bridging’ various approaches to studying the energy transition as called for by Geels et al. (2016) and Turnheim et al. (2015). Following the call by (Andrews-Speed, 2016), a recommendation would therefore be to further explore the role of institutional analyses in research regarding the energy transition, including RE generation but also issues of energy efficiency and carbon mitigation. Third, it is important to gain more insight into the agency of key actors, including the roles and activities these actors perform to navigate circumstances of institutional ambiguity and to achieve internal harmonization. Existing theories containing such agency perspectives, such as actor-network theory or boundary spanning, can provide valuable insights here.

This paper illustrates that opportunities for institutional harmonization consist of an interplay of mutually coordinated *creation* of new formal and informal rules, *abandonment* of certain rules, and *adaptation* or re-interpretation of existing rules within and between policy domains. By pursuing institutional harmonization, space can be organized within and among the various institutional frameworks involved to enable the spatial integration of RE with other land use functions. In other words, when looking for physical space for RE generation it is important to also consider its institutional counterpart, which can be coined institutional space.

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APPENDIX

Table A.1
Interviews.

Code	Interviewees and discussion sessions
I1	Interview employee Rijkswaterstaat WVL 1
I2	Interview employee Rijkswaterstaat WVL 2
I3	Interview employee Rijkswaterstaat WVL 3
I4	Interview employee Rijkswaterstaat corporate staff
I5	Interview employee Rijkswaterstaat regional department
I6	Interview employee Rijkswaterstaat regional department
I7	Interview employee ministry of Infrastructure and the Environment
I8	Interview employee grid operator
I9	Interview employee Central Government Real Estate Agency
I10	Interview employees consultancy firm
I11	Interview employee energy company
I12	Interview employee Groningen Province
I13	Interview employee Drenthe Province
I14	Interview employees Friesland Province
F1	Focus group with employees from Rijkswaterstaat (9), the Central Government Real Estate Agency (2) and the Netherlands Enterprise Organization (1)

Table A.2
Results 'Rules of the game'.

Boundary rules define who may enter or leave positions	Sources
B1: <i>Location</i> : Ownership, governance or management of land or infrastructure assets within a specified area determines which actors are involved (e.g. province, municipality, grid operator, and regional department of Rijkswaterstaat).	I2; I6; I8
B2: <i>Legal</i> : Legal obligations determine that a party needs to be involved (e.g. ministries and Central Government Real Estate Agency).	I2; I9; I14
B3: <i>Project</i> : Based on the specific project, additional parties may enter or leave the arena (e.g. advisory bureaus, experts from national departments of Rijkswaterstaat, or market parties).	I1; I5; I10
B4: <i>Competition</i> : Developers enter the arena based on competition on price. The developer with the highest bid may enter the arena.	I1; I2; I9
Position rules define the positions held by actors	Sources
P1: <i>Legislators</i> : <ul style="list-style-type: none"> The ministry of Infrastructure and the Environment is the legislator for i.a. policy regarding infrastructure, environment and spatial policy related to renewable energy. The Ministry of Economic Affairs is the legislator for i.a. energy ambitions and policy. The Ministry of Internal Affairs is the legislator for i.a. central government real estate policy. 	I1; I2; I14; F1
P2: <i>Commissioner</i> : The ministry of Infrastructure and the Environment provides assignments to their executive organization Rijkswaterstaat.	I6; I7; F1
P3: <i>Executive organization</i> : Rijkswaterstaat is the executive organization of the Ministry of Infrastructure and the Environment and responsible for design, construction and maintenance of the main infrastructure networks in the Netherlands for the purpose of safety, accessibility and livability, which is laid down in assignments set by the Ministry.	I4; I6; I14; F1
P4: <i>Developer</i> : A market party or citizen initiative is allowed to develop and exploit solar panels along a highway. Rijkswaterstaat is not allowed to hold this position.	I1; I2; I3; I4; I5; I6; F1
P5: <i>Licensing authorities</i> : <ul style="list-style-type: none"> Rijkswaterstaat is the licensing authority for the permit on the basis of the Public Works Act (Wbr-permit); Municipality or provinces are the licensing authority for the environmental permit. 	I1; I2; I7; I9; I14
P6: <i>Contract-holder</i> : The Central Government Real Estate Agency is the contract-holder for state-owned land.	I2; I3; I6; I9; I14
P7: <i>Grid operator</i> : The grid operator is responsible for realizing the grid connection.	I2; I8; I12; I14
Choice rules specify what actors in certain positions may, must or must not do at certain points	Sources
C1: <i>Draft policy and regulation</i> : The ministries may draft policy and regulations for their legislative domains (see P1).	I1; I2; F1
C2: <i>Provide locations</i> : Rijkswaterstaat may designate locations that are available for energy production.	I1; I2; I3; I4; I9
C3: <i>Set permit conditions</i> : Rijkswaterstaat may set conditions connected to the Wbr-permit only to ensure safety, accessibility and livability of their networks.	I4; I9
C4: <i>Organize the auction</i> : The Central Government Real Estate Agency must organize an auction after a location is approved for energy generation by Rijkswaterstaat	I2; I3; I5; I6; I7; I9; I10; I14
C5: <i>Submit bid</i> : Every potential developer may submit a bid in the auction procedure.	I2; I3; I5; I9; F1
C6: <i>Apply for permits</i> : The developer must apply to the municipality or the province for an environmental permit.	I2; I7;
C7: <i>Set permit conditions</i> : Provinces and municipalities may set conditions connected to the environmental permit, only to ensure the spatial quality of their territory.	I12; F1
C8: <i>Sign the contract</i> : The Central Government Real Estate Agency must sign the private-law agreement for surface-rights over the respective area with the developer who submits the highest bid.	I2; I3; I7; I9; I10; I14
C9: <i>Arrange grid connection</i> : Rijkswaterstaat or the developer may contact the grid operator. The grid operator checks whether there is space available on the grid for a new PV park and provides a price estimate based on standard rate structures.	I8;
C10: <i>Apply for subsidies</i> : After winning the auction, the developer may apply for SDE + subsidy with the Netherlands Enterprise Organization. Government organizations are not eligible for SDE + subsidies.	I2; I14
C11: <i>Involve citizens</i> : A developer may include citizens participation in the project.	I2; I11
Aggregation rules determine how actors jointly affect decisions regarding proposed actions and activities and in what manner.	Sources
A1: <i>Permit decision</i> : A province or municipality must decide whether to provide an environmental permit based on compatibility with the area vision.	I2; I5; I12; I13; I14
A2: <i>Subsidies</i> : The Ministry of Economic Affairs (or Finances) must decide whether to appoint subsidies to developers after they have won the bid and have the necessary permits.	I2; I10;
A3: <i>Termination rights</i> : the Central Government Real Estate Agency always includes a clause for 'termination in the public interest' in contracts to safeguard the executive organization's interests.	I9
Information rules determine what information is to be send and received by which actors at what moment	Sources
I1:	I2; I9

Table A.2 (continued)

<i>Publishing locations:</i> The Central Government Real Estate Agency must publish locations that are going to be auctioned in an open and transparent manner.	
I2: <i>Regular consultation:</i> The Central Government Real Estate Agency and Rijkswaterstaat have regular consultations (once per 4–6 weeks) regarding concrete energy-projects. If discussions have financial consequences the ministries are involved as well.	I2; I9;
Scope rules determine which outcomes may occur	
S1: <i>Infrastructure expansion:</i> Solar panels must not be realized on grounds reserved for expansion of infrastructure networks	Sources I2; I3; I7
S2: <i>Safety:</i> Solar panels must not compromise the safety of the infrastructure networks.	I1; I4; I5;
S3: <i>Maintenance:</i> Panels must be accessible to maintenance, and must not hinder maintenance of networks	I5; I9; I10
S4: <i>General agreements:</i> Goals set in the Dutch Energy Agreement (connected to EU targets) and the Paris Agreement	I3; I1; I4; I7
S5: <i>Target:</i> target stating that Rijkswaterstaat must become energy neutral by 2030.	I1; I4; I6; I7; I9; I10; I9; F1; I14
S6: <i>Environmental vision:</i> Provinces may indicate preferred locations for solar parks in their area vision (e.g. adjacent to build-up areas); they may not indicate who needs to be involved (e.g. participation).	I2; I12; I13; I14
Payoff rules assign costs and benefits to actors	
Sources	
Y1: <i>Lease:</i> Developers must pay Rijkswaterstaat for the use of the grounds, which is laid down in the contract with the R Central Government Real Estate Agency VB and is paid per MWh. A minimum price is laid down by the Central Government Real Estate Agency	I2; I10; I9
Y2: <i>Earn money:</i> Rijkswaterstaat may use its lands to earn money	I3; I6; I7; I11; F1
Y3: <i>Subsidies:</i> Rijkswaterstaat is not eligible for SDE + subsidies.	I2; I10; I4
Y4: <i>Project funding:</i> Major construction and renewal projects (>€30 mln.) are laid down in the MIRT and funds must not be used for other purposes than Rijkswaterstaat's primary tasks.	I2; I3; I4; I7
Y5: <i>Performance funding:</i> General maintenance and management of infrastructure networks is laid down in the SLA, which includes commitments regarding financial and human resource for four years.	I2; I3; I5; I7
Y6: <i>Highest bid:</i> Rijkswaterstaat land is granted to the party issuing the highest bid.	I2; I3; I7; I9; I10; I14

Table A.3

Results 'Play of the game'.

Ideas related to boundary rules	Sources
Ib1: <i>Early involvement:</i> Partners (neighbors and municipalities) should be involved early to create more certainty regarding permits and grid connection.	I2; I3; I5; I7; I8; I12; F1
Ib2: <i>Citizen involvement:</i> Citizen initiatives should compete in auctions according to Rijkswaterstaat and the Central Government Real Estate Agency, but they are bound to one location and often lack knowledge, competences and experience.	I2; I5; F1
Ib3: <i>Reduce fragmentation:</i> Boundary rules related to renewable energy within the organizations of Rijkswaterstaat and Infrastructure and the Environment should be clarified to reduce the fragmentation of departments and people working on topics related to renewable energy from their own position and interest with little coordination.	I1; I4; I5; I10; I11; I14
Ib4: <i>Province or municipality:</i> Rijkswaterstaat should identify when provinces or municipalities should be involved regarding PV at specific locations, because this can differ per province and municipalities - if it regulated at all - depending on e.g. the size of the initiative or the procedure.	I2; I12; I13;
Ideas related to position rules	
Sources	
Ip1: <i>Open attitude:</i> Civil servants, especially experts and regular employees (within Rijkswaterstaat and the Central Government Real Estate Agency in particular, but provinces, municipalities and grid operators are also mentioned), should have a more open and less risk-averse attitude towards renewable initiatives. Higher level managers, who are more used to dealing with new ideas, should encourage such an attitude.	I1; I2; I5; I6; I7; I8; I10; I11; I14; F1
Ip2: <i>Position of Rijkswaterstaat regarding RE:</i> The position of Rijkswaterstaat regarding the energy transition should be clarified; despite statements regarding far-reaching opportunities for PV on Rijkswaterstaat lands, Rijkswaterstaat only received the assignment to make the infrastructure networks energy neutral, leaving the position regarding the energy transition in general and the accompanying role as either facilitator or puller in the middle.	I1; I4; I5; I6; I7; F1;
Ip3: <i>Contradictory positions within Rijkswaterstaat:</i> Citizen involvement should be a point of attention in PV projects, because the ambition of Rijkswaterstaat to make as much money as possible with auctioning lands is at odds with the importance of citizen involvement in infrastructure projects where quality criteria are always required in bids.	I5; I6; I11; I14; F1
Ip4: <i>Create problem-owner:</i> There should be a 'problem-' or 'opportunity-owner', to pull the initiatives, create commitment within organizations, address barriers, and reduce the inertia that currently characterizes PV on Rijkswaterstaat lands. The creation of the position of 'HID sustainability and environment' is considered a step in this direction by Rijkswaterstaat.	I4; I6; I8; I9; I10; I11; I12; F1
Ip5: <i>Adapt organizational culture:</i> Rijkswaterstaat should adapt the culture of the organization so employees are aware of the fact that you can have a role in PV projects even if you are not fully responsible for the whole project (contrary to the current culture where you are either responsible or you are not).	I6; I14; F1
Ideas related to choice rules	
Sources	
Ic1: <i>Joint map-making:</i> Rijkswaterstaat should participate in joint-map-making to create insight in overlapping interests and opportunities for PV, in relation to other land owners, provinces, municipalities and grid-operators.	I2; I6; I7; I8; F1
Ic2: <i>Area-agenda's:</i> Strategic cooperation should take place between various parties involved to coordinate actions and ideas for future use of space in e.g. area-agenda's.	I2; I3; I5; I7; I8; I12; F1
Ic3: <i>Assignment for RE:</i> Rijkswaterstaat is used to acting when given an assignment connected to a resource allocation. If more PV need to be realized, Rijkswaterstaat should be given a specific assignment in this regard by the Ministry of Infrastructure and the Environment.	I5; I10; F1
Ic4: <i>No assignment:</i> Rijkswaterstaat wants an assignments from the ministry of Infrastructure and the Environment, but the ministry does not want to give this assignment because the Ministry of Economic Affairs is responsible for RE.	I1; I7; F1
Ic5: <i>Fragmentation up to the highest level:</i> Cooperation should be initiated at the highest level to deal with the division of responsibilities for infrastructure and (renewable) energy up to the highest level, between ministries.	I1; I7; I14
Ic6: <i>Responsibility:</i> According to Rijkswaterstaat, municipalities should safeguard citizen interests and participation in PV projects on Rijkswaterstaat lands..	I2; F1
Ic7: <i>Exception for citizen involvement:</i> Rijkswaterstaat and the Central Government Real Estate Agency should allow exceptions from the rule that locations must be auctioned for citizen initiatives for projects below a certain size.	I2; I6; I9; F1
Ic8: <i>Structured assessment of Rijkswaterstaat lands:</i> There should be a structured (method for) assessment of locations that Rijkswaterstaat deems feasible.	I5; I7; I10; F1

(continued on next page)

Table A.3 (continued)

Ideas related to boundary rules	Sources
Ideas related to aggregation rules	Sources
la1: <i>Control</i> : Rijkswaterstaat wants to be the single 'owner' of a project because this reduces the complexity	I2; I4; F1
la2: <i>Safeguard control over public lands</i> : The Central Government Real Estate Agency and Rijkswaterstaat want to keep as much control as possible over grounds which is not compatible with third-party ownership over (parts of) Rijkswaterstaat lands.	I10; F1
la3: <i>Simple, uniform procedures</i> : Rijkswaterstaat and the Central Government Real Estate Agency want to keep procedures as simple and uniform as possible because of limited resources, using an auction based on price with limited criteria.	I2; F1
la4: <i>Interdependence</i> : Rijkswaterstaat should coordinate actions with other actors (e.g. developers, grid operators, municipalities and provinces) municipalities because, contrary to traditional infrastructure projects, Rijkswaterstaat depends on these parties for the realization of energy ambitions.	I1; I2; I5; I6; I7; I9; F1
la5: <i>Individual persuasion power</i> : The success of initiatives should be less dependent on the right people at the right level pulling their weight, thereby making initiatives less ad hoc.	I1; I10; I14; F1
la6: <i>Control within the policy domain</i> : Higher level managers within Rijkswaterstaat or the Ministry of Infrastructure and the Environment should more often use their power in the hierarchy of the organization to enable PV initiatives.	I1; I5; I10; I14; F1
la7: <i>Province or municipality</i> : It should be clarified when provinces and when municipalities must decide on environmental permits and municipal and provincial environmental plans should be aligned.	I2; I12; I13; I14
la8: <i>Political dimension</i> : Parties involved in PV on Rijkswaterstaat lands should be aware of the large political dimension of certain decisions (e.g. regarding Rijkswaterstaat role and responsibility in the energy transition), especially at the ministerial level which is colored by party-politics.	I2; I4; I6; I10; F1
Ideas related to information rules	Sources
li1: <i>Platforms for communication</i> : Platforms should be established to enable structured communication within Rijkswaterstaat, between Rijkswaterstaat and the Ministries, and between Rijkswaterstaat and other parties at early stages, to function beside current, loosely structured meetings regarding these topics.	I5; I7; I10; I12; I13; F1
li2: <i>Learning</i> : Structures should be installed that stimulate learning from initiatives and communication of this knowledge to various parts of the organization.	I6; I10; F1
li3: <i>Lack of connection between policy and practice</i> : Both within Rijkswaterstaat and between Rijkswaterstaat and the Ministry, connections between people working on projects (and their experiences) and the people involved in policy-making and regulations should be improved.	I7; I10; I14; F1
li4: <i>Contact persons</i> : Rijkswaterstaat should clarify responsibilities for PV within the organization and avoid changes in contact persons over the course of projects as much as possible.	I10; I11; I14
li5: <i>No communication of essential information</i> : Essential information affecting projects should be communicated to project-partners immediately.	I5; I11
Ideas related to scope rules	Sources
Is1: <i>Infrastructure expansion</i> : It should be clarified when potential future expansion of infrastructure networks is a valid argument for blocking PV projects.	I7; I11
Is2: <i>Risk assessment</i> : It should be clarified how and when PV compromises the safety of infrastructure networks.	I5; I10; I11
Is3: <i>Too narrow focus</i> : Rijkswaterstaat should watch out for a very narrow focus on energy neutrality for themselves, which might hinder (future) opportunities that are beneficial to the energy transition in the Netherlands.	I6; I7; I8; F1
Is4: <i>Operationalization</i> : Rijkswaterstaat and the Ministry should translate high level ambitions into an implementation agenda, with clear goals which should be connected resource allocations, to reduce current confusion regarding approaches about: <ul style="list-style-type: none"> Rijkswaterstaat should become energy neutral or Rijkswaterstaat should contribute to energy transition in the Netherlands Rijkswaterstaat should realize a few large scale projects, or Rijkswaterstaat should realize many smaller projects 	I1; I4; I5; I7; F1
Is5: <i>Environmental visions</i> : Provinces and municipalities should reach agreements on scope rules for environmental permits for PV along infrastructure.	I2; I12; I14
Is6: <i>Place-based assessment</i> : The provinces want to assess per project, in the context of the location what fits the landscape for solar projects, so exceptions from the rule may be possible but have to be assessed on a case-by-case basis.	I12; I13
Is7: <i>Spatial quality and participation</i> : Provinces want to safeguard spatial quality and participation, but unlike spatial quality, participation cannot be safeguarded in the environmental permit.	I5; I10; I12; I13; F1
Ideas related to payoff rules	Sources
ly1: <i>Subsidies</i> : The ministry of EZ however wants to limit the flow of government funds to government parties. This is a conflict of interests which may in the future limit the possibilities for PV on Rijkswaterstaat lands.	I1; F1
ly2: <i>Resources</i> : It should be clarified how many resources (time and money) Rijkswaterstaat is allowed to spend, since there is no assignment with clear resource allocations (also because there are barely any resources programmed in the MIRT or SLA for sustainability, let alone renewable energy).	I3; I5; I7; I11; F1
ly3: <i>Assignment with resource allocation</i> : Rijkswaterstaat is an executive organization focused on executing assignments given by the Ministry and should therefore be given an assignment with clear resource allocations and consequences for not meeting the assignment.	I1; I2; I3; I5; I10; F1
ly4: <i>Energy as a primary task</i> : RE should become a primary task of Rijkswaterstaat to deal with the fact that the parliament (particularly with the current leading political party being liberal) disapproves of project costs that are not directly related to the primary tasks of Rijkswaterstaat.	I2; I4; F1
ly5: <i>Include quality criteria in the bid</i> : Quality criteria regarding e.g. citizen involvement should be part of the bid to enable developers to use experiences with citizen participation and reduce possible resistance.	I11; I14; F1
ly6: <i>Resource competition</i> : it should be clarified who pays for what between the Ministries of Infrastructure and the Environment and Economic Affairs, e.g. who's employees will execute which tasks and how these employees are financed	I7; I9; I14
ly7: <i>Clarity on costs and benefits of options</i> : Rijkswaterstaat should clarify the costs and benefits of the various options that are discussion among ideas regarding scope rules, not only for Rijkswaterstaat itself but for the Netherlands as a whole.	I1; I10; F1

References

- Andrews-Speed, P., 2016. Applying institutional theory to the low-carbon energy transition. *Energy Res. Soc. Sci.* 13, 216–225. <https://doi.org/10.1016/j.erss.2015.12.011>.
- Babbie, E., 2010. *The Practice of Social Research*, twelfth ed. Wadsworth, Belmont.
- Cherp, A., Vinichenko, V., Jewell, J., Brutschin, E., Sovacool, B., 2018. Integrating techno-economic, socio-technical and political perspectives on national energy transitions: a meta-theoretical framework. *Energy Res. Soc. Sci.* 37, 175–190. <https://doi.org/10.1016/j.erss.2017.09.015>.
- De Boer, J., Zuidema, C., 2015. Towards an integrated energy landscape. *Urban Des. Plan.* 1–16. <https://doi.org/10.1680/udap.14.00041>.
- De Leeuw, T., Gössling, T., 2016. Theorizing change revisited: an amended process model of institutional innovations and changes in institutional fields. *J. Clean. Prod.* 135, 435–448. <https://doi.org/10.1016/j.jclepro.2016.06.119>.
- Debijs, M.G., Tzikas, C., de Jong, M.M., Kanellis, M., Slooff, L.H., 2018. The solar noise barrier project: 3. The effects of seasonal spectral variation, cloud cover and heat distribution on the performance of full-scale luminescent solar concentrator panels. *Renew. Energy* 116, 335–343. <https://doi.org/10.1016/j.renene.2017.09.079>.
- EC, 1997. *The Compendium of European Spatial Planning Systems*. Luxembourg. <https://doi.org/10.1080/09654319508720313>.
- England, Highways, 2016. M40 Photovoltaic Noise Barrier Project - Stakeholder Q&A [WWW Document]. Highw. Engl. URL. <http://www.m40-chilterns.org.uk/docs/m40-noise-barrier-scheme.pdf> (accessed 6.11.17).
- Frantál, B., Van der Horst, D., Martinát, S., Schmitz, S., Teschner, N., Silva, L.,

- Golobic, M., Roth, M., 2018. Spatial targeting, synergies and scale: exploring the criteria of smart practices for siting renewable energy projects. *Energy Pol.* 120, 85–93. <https://doi.org/10.1016/j.enpol.2018.05.031>.
- Geels, F.W., Berkhout, F., van Vuuren, D.P., 2016. Bridging analytical approaches for low-carbon transitions. *Nat. Clim. Change* 6, 576–583. <https://doi.org/10.1038/nclimate2980>.
- Grotbreg, S., van Buuren, A., 2018. Realizing innovative public waterworks: aligning administrative capacities in collaborative innovation processes. *J. Clean. Prod.* 171, S45–S55. <https://doi.org/10.1016/j.jclepro.2016.08.128>.
- Hajer, M. a., 2006. The living institutions of the EU: analysing governance as performance. *Perspect. Eur. Polit. Soc.* 7, 41–55. <https://doi.org/10.1080/15705850600839546>.
- Hodgson, G.M., 2006. What are institutions? *J. Econ. Issues* XL 1–25 doi:Article).
- Kingston, C., Caballero, G., 2009. Comparing theories of institutional change. *J. Inst. Econ.* 5, 151. <https://doi.org/10.1017/S1744137409001283>.
- Lammers, I., Heldeweg, M.A., 2016. Smart design rules for smart grids: analysing local smart grid development through an empirico-legal institutional lens. *Energy Sustain. Soc.* 6, 36. <https://doi.org/10.1186/s13705-016-0102-z>.
- Mahoney, J., Thelen, K., 2010. *Explaining Institutional Change: Ambiguity, Agency and Power*. Cambridge University Press, Cambridge.
- Mignon, I., Bergek, A., 2016. System- and actor-level challenges for diffusion of renewable electricity technologies: an international comparison. *J. Clean. Prod.* 128, 105–115. <https://doi.org/10.1016/j.jclepro.2015.09.048>.
- Ministry of Infrastructure and the Environment, 2016. Kamerbrief over Voornemen Energieneutrale Netwerken in Beheer Van Rijkswaterstaat [Letter to Parliament] [WWW Document]. URL <https://www.rijksoverheid.nl/documenten/kamerstukken/2016/06/05/energieneutrale-netwerken-in-beheer-van-rijkswaterstaat> (accessed 6.11.17).
- Negro, S.O., Alkemade, F., Hekkert, M.P., 2012. Why does renewable energy diffuse so slowly? A review of innovation system problems. *Renew. Sustain. Energy Rev.* 16, 3836–3846. <https://doi.org/10.1016/j.rser.2012.03.043>.
- North, D.C., 1990. *Institutions, Institutional Change and Economic Performance*. Cambridge University Press, Cambridge.
- North, D.C., 1991. *Institutions*. *J. Econ. Perspect.* 5, 97–112.
- Ostrom, E., 1990. *Governing the Commons. The Evolution of Institutions for Collective Action*. PDF. Cambridge University Press, New York.
- Ostrom, E., 2005. *Understanding Institutional Diversity*. Princeton University Press, Princeton.
- Ostrom, E., 2011. Background on the institutional analysis and. *Pol. Stud. J.* 39, 7–27. <https://doi.org/10.1111/j.1541-0072.2010.00394.x>.
- Ostrom, E., Basurto, X., 2011. Crafting analytical tools to study institutional change. *J. Inst. Econ.* 7, 317–343. <https://doi.org/10.1017/s1744137410000305>.
- Parker, G., 2015. *The Application of Solar-Noise Barriers for UK highways and their combined benefits for local government , developers and the wider community*. In: *EuroNoise Conference Proceedings*. 31 May - 3 Juni, Maastricht, pp. 63–68.
- Reddy, S., Painuly, J.P., 2004. Diffusion of renewable energy technologies—barriers and stakeholders' perspectives. *Renew. Energy* 29, 1431–1447. <https://doi.org/10.1016/j.renene.2003.12.003>.
- Scheidel, A., Sorman, A.H., 2012. Energy transitions and the global land rush: ultimate drivers and persistent consequences. *Glob. Environ. Change* 22, 588–595. <https://doi.org/10.1016/j.gloenvcha.2011.12.005>.
- Schmidt, V.A., 2008. Discursive institutionalism: the explanatory power of ideas and discourse. *Annu. Rev. Pol. Sci.* 11, 303–326. <https://doi.org/10.1146/annurev.polisci.11.060606.135342>.
- Schmidt, V.A., 2010. Taking ideas and discourse seriously: explaining change through discursive institutionalism as the fourth “new institutionalism”. *Eur. Polit. Sci. Rev.* 2, 1–25. <https://doi.org/10.1017/S175577390999021X>.
- Smil, V., 2006. 21st century energy - some sobering thoughts. *OECD Obs.* 258 (259), 22–23.
- Solorio, I., 2011. Bridging the gap between environmental policy integration and the EU's energy policy: mapping out the “green europeanisation” of energy governance. *J. Contemp. Eur. Res.* 7, 396–415.
- Suzuki, M., Kanie, N., Iguchi, M., 2016. New approaches for transitions to low fossil carbon societies: promoting opportunities for effective development, diffusion and implementation of technologies, policies and strategies. *J. Clean. Prod.* 128, 1–5. <https://doi.org/10.1016/j.jclepro.2016.04.087>.
- Turnheim, B., Berkhout, F., Geels, F.W., Hof, A., Mcmeekin, A., Nykvist, B., van Vuuren, D.P., 2015. Evaluating sustainability transitions pathways: bridging analytical approaches to address governance challenges. *Glob. Environ. Change* 35, 239–253.
- Vallati, A., De Lieto Vollaro, R., Tallini, A., Cedola, L., 2015. Photovoltaics noise barrier: acoustic and energetic study. *Energy Procedia* 82, 716–723. <https://doi.org/10.1016/j.egypro.2015.11.797>.
- van der Horst, D., 2007. NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Pol.* 35, 2705–2714. <https://doi.org/10.1016/j.enpol.2006.12.012>.
- Volpe, J.A., 2012. Alternative uses of highway right-of-way: accommodating renewable energy technologies and alternative fuel facilities [WWW document]. U.S. Dep. Transp. URL https://www.fhwa.dot.gov/real_estate/publications/alternative_uses_of_highway_right-of-way/ (accessed 6.11.17).
- Wadhawan, S.R., Pearce, J.M., 2017. Power and energy potential of mass-scale photovoltaic noise barrier deployment: a case study for the U.S. *Renew. Sustain. Energy Rev.* 80, 125–132. <https://doi.org/10.1016/j.rser.2017.05.223>.
- Yin, R.K., 2014. *Case Study Research: Design and Methods*, fifth ed. SAGE publications, Thousand Oaks.