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SPECIAL FEATURE: ORIGINAL ARTICLE

Networks of Action Situations in Social-Ecological Systems Research

From sectoral to integrative action situations: an institutional perspective on the energy transition implementation in the Netherlands

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Abstract

The interlinked nature of today's societal challenges asks for integrative approaches. The energy transition is an especially impactful challenge and presents a compelling opportunity to pursue integration, as it requires changes to space, landscape, infrastructure and organizations at different scales. While the added value of integrative approaches that address the energy transition alongside other societal challenges is widely acknowledged, it is not the status quo. The aim of this study is to uncover the institutional barriers to integration and suggest possibilities for redesign. The paper sheds light on a hitherto relatively understudied phase of integration, namely implementation. Two illustrative cases for energy transition integration are discussed; (i) sustainable residential heating combined with climate adaptation in the urban context, and (ii) biogas production from livestock manure for rural residential heating and nitrogen reduction in the Netherlands. Inspired by the Institutional Analysis and Development framework (IAD) and networks of action situations (NAS) concept, the study shows that in the context of energy transition integration, action situations are pillarized with incidental interactions happening between sectors and across scales. The rules that govern actor interactions stem from sectoral institutional arrangements and produce sectoral action situations. Factors that especially obstruct integration are financial streams, budgeting and designated task responsibilities of actors that favour sectoral, one-dimensional projects. Actors interact in sectoral action situations and struggle to establish links to plan for more integrative outcomes. As a way forward, the study illustrates how rules can be redesigned to create integrative action situations and what mechanisms may help to achieve this in practice.

Keywords Energy transition · Climate adaptation · Sustainable agriculture · Integration · Institutions · Cross-sector

Introduction

The transition towards a low-carbon world, entails the reconfiguring of "geographies" (e.g. space, location, landscape, territoriality and scale) where society produces, lives and works with energy (see Bridge et al. 2013). Because of the energy transition, new claims are made on scarce land resources. These claims come on top of the expanding list of spatial requirements for addressing other societal challenges (e.g. food production, climate adaptation, sustainable agriculture). The additional demands on limited land resources (Lambin and Meyfroidt 2011) restrict the ability to meet existing, already competing demands such as hosting woodlands, pastures, arable lands (Nonhebel 2005), infrastructure, housing or deposition of waste (Smith et al. 2013).

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While the energy transition exacerbates the competition over space, it also comes with integrative potential, i.e. the opportunity to implement solutions that contribute to solving multiple societal challenges at the same time. This integrative potential can manifest itself in various ways. First, integrative potential may occur when societal challenges or solutions to these challenges are interconnected across space. In such cases, integrative potential can be achieved through multifunctional land use or alignment of implementation activities. For example, combining solar PV farms with green infrastructure contributes to the energy transition and improved biodiversity (Semeraro et al. 2020, 2018) and combining the implementation of sustainable heat grids with climate adaptation measures in urban areas avoids double construction works. Second, integrative potential can be achieved by linking value chains (cf. Villamayor-Tomas et al. 2015). This is particularly relevant when energy transition solutions are not economically or otherwise attractive in itself. In such case, implementation may become feasible when an energy transition solution also reduces challenges in other sectors. For example, the production of biogas from livestock manure contributes to more sustainable agriculture by reducing greenhouse gas emissions and benefits the energy transition (Rahaman et al. 2021). Of course, these interacting effects can also be the other way around; energy solutions can worsen other societal challenges or have negative impacts on the possibility to reduce other problems. An example is the construction of renewable energy installations in ecological sensitive areas at the expense of biodiversity in Spain (Serrano et al. 2020). As such, the interacting effects of energy transition solutions can be positive and generate co-benefits (Hennessey et al. 2017; Spencer et al. 2016; Ürge-Vorsatz et al. 2014) or synergies (Hildingsson and Johansson 2016; Sharifi 2021; Shrestha and Dhakal 2019), or negative and give rise to conflicts or trade-offs (Sharifi 2020). Central in this paper is the implementation of energy transition solutions with integrative potential. These are solutions that may provide co-benefits or synergies. Synergies, or "combined or "co-operative" effects, are the effects produced by things that "operate together" (parts, elements or individuals) (Corning 1998, p. 136). Co-benefits arise when additional positive effect on challenge 'B' can be achieved from implementing a measure aimed at challenge 'A' (Grafakos et al. 2019; Sharifi 2021).

Cross-sectoral collaboration is crucial to achieve the integrative potential of energy transition solutions. We define cross-sector collaboration as collaboration by actors "in two or more sectors to achieve jointly an outcome that could not be achieved by actors in one sector separately" (Bryson et al. 2006, p. 44). Compared to solutions that address one societal challenge only, cross-sector collaboration can potentially create more public value. Yet, an integrative approach comes with a price too; additional transaction costs and negative feedback loops due to the interconnectedness of the challenges (Bryson et al. 2006) could be reasons to follow a sectoral approach. While an integrative approach is not a panacea, we consider exploring the potential of integrating different interconnected challenges promising. It provides actors the possibility to avoid negative side effects as well as to exploit opportunities that provide co-benefits or synergies and, hence, to create more public value.

Although an integrative approach that seeks to exploit integrative potential to interconnected societal challenges sounds promising, it is not the status quo (e.g. Fuso Nerini et al. 2017; Grafakos et al. 2020; Larsen et al. 2012; Semeraro 2021). Traditionally, actors have picked up societal challenges in a rather siloed way (Landauer et al. 2018; Larsen et al. 2012; Märker et al. 2018). The persistence of the silo approach stands in the way of exploiting integrative potential (Fuso Nerini et al. 2017). Various studies provide directions where the bottlenecks lie. Issues such as sectoral path dependencies (Landauer et al. 2018), policy mismatches (Clausen and Rudolph 2020), institutional complexities and inconsistencies (Grotenbreg and van Buuren 2018; Spijkerboer et al. 2019), insufficient financial support (Illman et al. 2013), uncertainties in distribution of costs and benefits (van Broekhoven and Vernay 2018), and fragmentation across organizational boundaries (Van Geet et al. 2021) hamper integrative approaches. These barriers are symptoms of an underlying issue: the absence of suitable institutional arrangements to work with integration (Duguma et al. 2014a, b; Göpfert et al. 2020; Nieuwenhuis et al. 2021).

Researchers have looked into various domains through which the integrative potential of interconnected societal challenges can be enacted (Sharifi 2020). Significant attention has been paid to policy integration (Di Gregorio 2016; Jordan and Lenschow 2010) as well as to mainstreaming of policy (Runhaar et al. 2018) and planning (Grafakos et al. 2020; Orsetti et al. 2022; Uittenbroek et al. 2012). Less attention has been paid to the operational level (Chia et al. 2016; Uittenbroek 2016) where actors develop and implement projects and programmes. With regard to energy transition integration, existing studies tend to focus on (eco) system-level interactions (see for instance Hernandez et al. 2019) and hardly examine the role of institutions at the operational level. As a result, how institutional factors influence the implementation of integrative solutions for the energy transition is not well understood.

To address this knowledge gap, this study examines how institutions support or hinder actors that seek to capitalize on the integrative potential of energy transition solutions. The research questions that guide this study are: *(1) What institutional barriers are experienced by actors that seek to exploit the integrative potential of energy transition solutions at the operational level? and (2) How can these institutional barriers be addressed?* To answer these questions, we use the

implementation of two promising energy transition solutions in the Netherlands as cases. Drawing from the Institutional Analysis and Development framework (IAD) and networks of action situations (NAS) concept, we show how actors currently address interconnected challenges in silos and what institutional barriers they experience when seeking to exploit integrative potential. Inspired by the cases, IAD and NAS, we introduce the need for and design of "integrative action situations".

By addressing these questions, this paper aims to shed light on what comes after policy integration (Jordan and Lenschow 2010), namely implementation. By providing an institutional understanding of integration, the study particularly contributes to previous studies that draw from IAD and NAS to examine cross-sectoral integration (McGinnis 2011b) and the water–energy–food nexus (Villamayor-Tomas et al. 2015) as well as studies discussing climate mitigation-adaptation synergies (Di Gregorio et al. 2017; Duguma et al. 2014a, b; Locatelli et al. 2015; Reckien et al. 2018), co-benefits (Harlan and Ruddell 2011; Raymond et al. 2017; Spencer et al. 2016; Younger et al. 2008) and the application of NAS to energy transition more generally (Baldwin and Tang 2021; Gritsenko 2018).

The outline of the paper is as follows. "An institutional perspective on integration" introduces our theoretical perspective with a focus on IAD and NAS. We explain our methodology in the following section. In "Energy transition integration in the Netherlands", we illustrate the institutional challenges hindering integration by examining two Dutch cases that show integrative potential. The next section reflects on the presented cases with a focus on redesigning action situations to comprehend and stimulate integration on the ground. In the last section, conclusions and a future research agenda are presented.

An institutional perspective on integration

The role of institutions in exploring integrative potential

The implementation of integrative solutions demands cross-sector collaboration. Such collaboration is, however, not without problems. Civil servants, entrepreneurs and politicians follow their organization's interests and engage in decision-making processes that often concern sectoral projects and policies. Competing institutional logics tend to influence the capacity of actors to agree on process, structure, decision-making and desired outcomes in cross-sector collaborations (Bryson et al. 2006). Along similar lines, Spijkerboer et al. (2019) conclude that pillarized institutional arrangements, or particular sectoral configurations of institutions and actor constellations, hinder integrative approaches (see also García-Martín et al. 2016). Institutions refer here to prescriptions regarding "which actions (or states of the world) are *required*, *prohibited*, or *permitted*" (Ostrom 1986, p. 5). Various studies recognize the pivotal role that institutions play in transitions such as circular economy, bioeconomy, energy transition and climate change adaptation (Adamseged and Grundmann 2020; Agrawal 2008; Maaß and Grundmann 2018; Markard et al. 2016; Warbroek 2019). While institutions reduce uncertainty in human interactions (North 1991), when challenges such as that of climate change urge different behaviour and actions of actors, institutions may negatively affect desirable interactions (Munck af Rosenschöld et al. 2014; Tompkins and Neil Adger 2005). As fragmented institutional arrangements stand in the way of an integrative approach, the potential merits of jointly picking up interconnected societal challenges is often insufficiently explored and exploited. As such, institutional linkages across sectors could support actors that explore integrative potential (compare Huck et al. 2020). Various studies in this sense point at the importance of institutional connectivity across scales and sectors (Ingold et al. 2010; Jaja et al. 2017) and more room for flexibility and agency within institutions (Gupta et al. 2010).

Institutional Analysis and Development framework for integration

To understand how institutions may hamper integration, we draw from the Institutional Analysis and Development framework (IAD). The IAD framework helps to identify the key types of variables across all institutional arrangements, and as such can be applied to examine diverse institutions (Ostrom 2011), which is helpful in studying institutions across sectors. The framework provides a good starting point to uncover (i) how current institutional settings encourage actors to pursue sectoral approaches, (ii) how institutions hamper an integrative approach because of missing institutional linkages and (iii) how to (re)design institutions so that they enable actors to explore and exploit the integrative potential of societal challenges on the ground (compare Vogel et al. 2022).

At the core of the IAD framework is an "*action situation*", i.e. a social space where individuals as (bounded) rational actors can interact and make sound decisions (Ostrom 2011, p. 11). Action situations are influenced by three categories of external variables: (i) *biophysical conditions*; (ii) *attributes of community*; and (iii) *rules in use* (Fig. 1). An ensemble of external and internal variables produces a unique pattern of interaction and outcome for specific resource base(s) at a certain place and at a given time. The internal structure of an action situation can be understood using seven canonical rules that concern: (i) what positions and roles actors have (*position rule)*; (ii) how actors can participate (*boundary*

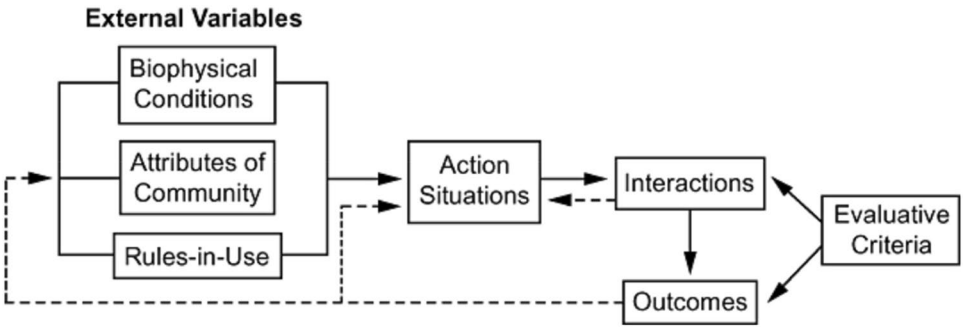

Fig. 1 Basic elements of the IAD framework, adapted from Ostrom (2009)

rule), (iii) what actions they can take (*choice rule*), (iv) how information is shared (*information rule*), (v) what the scope of the outcome is (*scope rule*); (vi) how costs and benefits are distributed (*payoff rule*); and (vii) how decisions are made (*aggregation rule*) (McGinnis 2011a). Rules and action situations can be analysed at three different levels: *the operational level*, which concerns individual actor day-to-day decision-making (focus of this study); *the collective choice level*, which involves groups of actors engaging in policy-making (partly included in this study as this level determines the contextual rules in use at the operational level); and *the constitutional level*, which revolves around actor groups setting rules on how decision-making ensues. Rules made at different levels can impact each other. This implies that outcomes of interactions at different levels are connected (McGinnis 2019; McGinnis and Ostrom 2014).

Using the IAD, the institutional pillarization and fragmentation of societal challenges can be traced back to the variance in rules affecting action situations at different levels and across various resource systems. As McGinnis (2011b) explains: rules behind diverse action situations are developed through different processes at different times. Explanatory elements of variation in rules manifested in action situations at different levels and across the various resource systems are difficult to specify fully. Yet, elements that play a role include: (1) silo-based conceptualization of issues at hand, (2) variation in scales of issues and (3) perceived importance of issues (e.g. prominence in social, economic and political settings).

Networks of action situations

Although the IAD was intended to be dynamic with the presence of feedback loops connecting outcomes of different action situations at different levels to the contextual variables of action situations (McGinnis and Ostrom 2014), this is not clearly represented in the commonly used representation of the IAD framework (McGinnis 2019). In applying IAD, scholars often take one action situation as a snapshot, and assume adjacent action situations that influence this action situation as a given. In response to this, the network of action situations (NAS) concept was introduced to draw more attention to the dynamics between action situations. NAS assists in analysing interrelated action situations and understanding how they jointly produce outcomes (Kimmich et al. 2022). Compared to the IAD, NAS requires more empirical scrutiny as it intends to map all relevant action situations that shape the focal action situation. As described by McGinnis (2011b, p. 54), "[i]n the *focal action situations*, some resources may be extracted from a common pool or services produced for potential customers." In general, identifying focal and adjacent action situations depends on the research question, but can be gained through exploratory field research approaches (e.g. secondary data, interviews, review of the literature) (Srigiri and Dombrowsky 2021). In this study, the focal action situation is where the opportunity to exploit the integrative potential of energy transition solutions occurs (see "Methods"). As integrative potential could arise in different focal action situations, this study understands NAS as the network of *focal* action situations.

The NAS concept is particularly useful in revealing the (missing) institutional linkages between focal action situations, which hinder actors to pursue integrative approaches. Indeed, studies that applied NAS to analyse energy (transition) in conjunction with other challenges show that improved institutional coordination may assist in improving inconsistencies between action situations to enhance cross-sector linkages (Grundmann and Ehlers 2016; Villamayor-Tomas et al. 2015).

Integrative action situations

To enable actors to explore integrative potential, action situations and the institutional elements that they are made of need to be linked more effectively (see also Huck et al. 2020). Here, a distinction can be made between vertical and horizontal linkages among institutional elements. Inspired by this, Ingold et al. (2010) state that *vertical integration* refers to the level of coordination between institutions across spatial scales, and *horizontal integration* refers to the linkages between different sectors (such as actors interactions

and their connections with challenges) (see also Metz et al. 2020).

To allow for the implementation of integrative solutions, it is crucial that actors embrace processes, interactions and rules that facilitate an integrative approach, which ultimately coalesce in what we term as "*integrative action situations*", i.e. action situations in which actors from diverse sectors collaborate to explore and potentially exploit the integrative potential of solutions to interconnected societal challenges. In our understanding, a fundamental characteristic of an integrative action situation is the presence of horizontal integration (cross-sectoral collaboration, (cf. Bryson et al. 2006)). This requires that the seven IAD rules transcend their sectoral configuration; they are integrative so that integrative potential can be explored and exploited. In this process, the reconfiguration of focal action situations by involved actors plays a particularly important role.

To achieve such changes at the operational level, national level institutional redesign (or vertical integration) can play an important role (Shrestha and Dhakal 2019). Yet, this level of policy change (Sabatier 1988) or institutional change (Mahoney and Thelen 2010) usually takes decades. The influence across levels also works the other way around: on the ground changes may be an impetus for more integration at the collective choice level. Lawrence et al. (2002) describe the propensity of such new practices and rules within collaborations to become new institutions as "proto-institutions". Informal patterns of knowledge co-production and collaborations exist within the formal fragmented structures of institutions at the local level. These informal processes, though highly reliant on the individual's motivations and characteristics, present opportunities for re-imagining the formal structures and facilitating institutional redesign (Chen et al. 2018; Faber et al. 2020; van der Graaf et al. 2020).

Methods

Our research strategy encompasses an exploratory, empirical and qualitative approach (Queirós et al. 2017). This strategy was chosen as there is a limited understanding of the institutional factors that support, encourage or hamper the implementation of integrative solutions. Our empirical focus is on the Netherlands. With a population density of more than 500 per km^2, integration seems inescapable. Indeed, an exploratory study commissioned by Rijkswaterstaat (public infrastructure organization) shows that the energy transition, sustainable agriculture, nature conservation, housing, subsidence and climate adaptation would require three times more land resources than available in the Netherlands (van Klaveren et al. 2020). As embedded case, we use the province of Overijssel, located in the east of the Netherlands. Overijssel is predominantly rural, but also houses three mid-sized cities as well as multiple smaller cities and towns. The province faces challenges related to agriculture (especially in rural areas), climate adaptation in both urban and rural areas, and energy transition with urban areas having a high demand for energy and rural areas having space for renewable energy generation. As such, the Overijssel case provides insights into integration in both urban and rural contexts.

Data were collected in the context of the research project "Regional Energy Transition as Systemic Integration (RETSI)". In the RETSI project, the authors collaborated extensively with stakeholders to investigate the potential for integration and the institutional factors that hamper or support integration. Data for this exploratory study were collected through sixteen semi-structured background interviews in the period October 2020 until June 2021. The aim of the interviews was to (i) identify energy transition solutions with integrative potential and integrative projects, (ii) to obtain an overview of actor interactions around interconnected societal challenges to determine the involved action situations and (iii) to uncover institutional factors that hamper integration on the ground. All our interviewees were active at the operational level of the energy transition in Overijssel. They represented energy production firms, the local and provincial government, the regional water authority, network organizations, a housing corporation and a knowledge institute (see Appendix for list of interviewees).

As interviewees mentioned only few examples in which an integrative approach was pursued in project development, the unrealized potential for integration became the focus of the therefore hypothetical cases of integration. From the interviewees, two cases came forward that illustrate how institutional factors hamper or support the implementation of integrative energy transition solutions in the Netherlands. During implementation, actors determine for a specific challenge what resources will be used, when and by whom to address this challenge. The first case involves the opportunity to combine the implementation of heat grids in context of the transition process of urban districts towards sustainable energy sources for residential heating with the climate change adaptation measures (i.e. water retention areas). The second case involves the opportunity to use livestock manure for the production of biogas, effectively contributing to the search for sustainable heat sources and reducing nitrogen and carbon dioxide emissions. The cases show how implementation processes of heat grids, water retention areas, biogas projects and nitrogen reduction are siloed and that current institutional settings hamper actors to explore and exploit integrative potential. As such, siloed implementation processes are discussed in context of their hypothetical potential for integration. The urban and rural character of the cases give

complementary insights into how various types of integration can manifest in different contexts. The analysis of the cases consisted of several steps. First, we analysed interview data and policy documents in-depth to understand which institutional factors hamper actors who seek to exploit the integrative potential of solutions. Here, we specifically looked for 'rules in use' (as outputs of collective choice level action situations) and the configuration of rules within focal action situations. In this analysis, interview data were used to understand barriers from the perspective of actors involved at the operational level. Policy documents were used to understand to what extent formal rules hamper or prohibit integrative action situations. Lastly, IAD and NAS concepts were used to reflect upon the results of the analysis in research team meetings and in stakeholder meetings. These reflections form the basis for our discussion of a way forward, specifically towards what we term "integrative action situations".

Energy transition integration in the Netherlands

Underlying all efforts in the Dutch energy transition is the 2019 climate agreement, which has the ambition of 49% CO_2 reduction in 2030 compared to 1990 (Climate Agreement 2019). The climate agreement outlines several key themes, such as industry, mobility and agriculture. The built environment is one of the themes and has as primary challenge the replacing of natural gas by sustainable alternatives in residential heating. In general, there are three ways of making this so-called 'heat transition' happen: the construction of collective heat grids, the replacing of natural gas by biogas while making use of the existing grid, or the installation of heat pumps at the household level (see Table 1). This study focuses on two energy transition solutions with integrative potential: heat grids and biogas. The (unrealized) integrative potential, rules in use and action situations that are relevant to both solutions are discussed in the context of the energy transition in Overijssel. First, the case of the urban heat transition (heat grid) and climate change adaptation measures is presented. Second, the case of using livestock manure to produce biogas and reduce nitrogen emissions is presented.

Integration of the urban heat transition and climate change adaptation

Integrative potential

The installation of heat grids in urban areas implies considerable infrastructural and construction works. As such, interviewees and policy documents underscore that the heat transition provides opportunities to improve the climate resilience of urban areas. Measures such as installing water retention areas to alleviate pluvial flooding in case of heavy rainfall, or installing green and blue infrastructure (e.g. trees, green strips or urban creeks) to address heat stress and water nuisance can be combined with the construction work for heat grids. The focal action situations in this case involve the implementation of a heat grid and of a water retention area. For heat grids, actors interact over the heat source, supply and demand, project scale, technological installations, stakeholder involvement, planning and organization, permits, business case and financing. For water retention areas, actors interact over design and project scale, costs and financing, planning and organization, and stakeholder involvement. Capitalizing on the integrative potential of heat transition and climate change adaptation presupposes a move away from traditional, sectoral implementation and requires actors from both sectors to start collaborating and agreeing around issues such as project scope and budgeting.

Sectoral rules in use

The status quo is that heat transition and climate change adaptation solutions are implemented in sectoral ways with the rules in use for the action situations coming from the respective national level policy frameworks. In case of the heat transition, the national government's Program Natural Gas Free Districts is an important policy framework that supports local governments in the journey towards sustainable residential heating in their jurisdiction. The scale

Table 1 The energy source, physical implications and context of application of heat transition solutions

Solution	Energy source	Physical implications	Context
Heat grids	Residual heat from wastewater treatment facilities, industry, surface water	Digging up streets, installing heat grid, building renovations	Densely populated areas, collective solution
Biogas	Biomass, manure, sludge	Limited, existing gas infrastructure can be used	Densely populated and rural areas, individual and collective solution
Heat pumps	(solar/wind) electricity	Reinforcing and expanding electricity grid	Densely populated and rural areas, individual household-level solution

on which the heat transition takes place ranges from the municipal level (i.e. policy and vision making) to the neighbourhood level (i.e. sustainable residential heating projects, typically involving around 300–700 houses). The latter is the focus of this case. Whilst the point of departure of the program is the energy transition, policy makers urge practitioners to actively look for and capitalize on integrative opportunities. Climate adaptation is an opportunity that is often mentioned in this context, specifically in grant application documents, implementation-level policy documents and by interviewees.

In case of climate adaptation, the main policy framework is the Delta Plan on Spatial Adaptation. One of the seven ambitions of this policy specifically addresses integration of climate adaptation with other spatial challenges, such as the energy transition, sustainable agriculture and biodiversity (National Delta Programme 2021 2020). The National Climate Adaptation Strategy (2018) pays specific attention to creating synergies between the implementation of climate adaptation and the energy transition. In the evaluation of the climate adaptation implementation programme, the energy transition is raised as one of the most important transitions to connect with (*Nationaal perspectief klimaatadaptatie, Rapportage NAS 2017–2019* 2020).

The above shows that national level policy makers of both energy transition and climate adaptation sectors underscore the importance of, and encourage more integration. As such, horizontal institutional linkages are present at the policy level. Yet, further analysis shows that these linkages are rather superficial. There are no regulatory or economic policy instruments in place to coordinate integration on the ground, neither are there any strict requirements or rules that incite integration. As two interviewees explained, various financial streams (budgets, grants, loans) need to be applied for and integrated in order for integration to be pursued. In practice, this is especially challenging for government actors as budgets are earmarked and allocated for the local administration's terms of office. The interaction processes of budgeting take place in adjacent (both collective choice and operational level) action situations and are not part of the focal action situation, but have a significant impact. Sectoral budgets and grants therefore stand in the way of exploiting integrative potential. As a result, for focal action situations involving the implementation of heat grids and climate adaptation measures, sectoral implementation is the status quo, leading to sectoral outcomes.

This institutional disconnection is visualized in the upper half of Fig. 2. The figure shows how operational level focal action situations on heat transition and climate change adaption implementation are guided by sectoral rules in use. There are no vertical institutional linkages that accompany the policy makers' ambitions for integration to actors at the operational level to exploit the integrative potential of the heat transition and climate change adaptation. Vertical linkages in shape of integrative budgets and grants would provide a supportive context for actors to explore integrative potential, as it would take away the complex process of integrating financial streams.

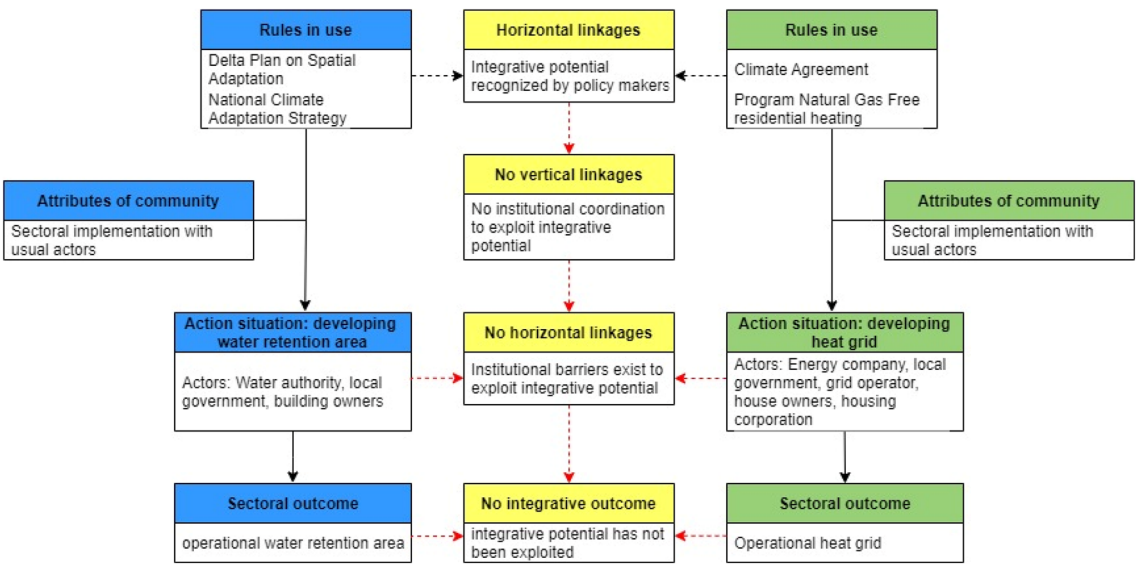

Fig. 2 Limited institutional links between sectoral action situations of heat transition and climate change adaptation. Source: authors' own elaboration

Within action situations: sectoral interactions and rules

The lack of vertical institutional linkages stemming from the rules in use gives rise to various institutional barriers (or an absence of horizontal linkages, lower half of Fig. 2) that actors experience when they seek to exploit integrative potential. From the outset, interactions occur between usual actors in sectoral heat transition and climate change adaptation action situations (*attributes of community*). Actors that are typically involved in the implementation of a heat grid are local government, energy company, grid operator, house owners and housing corporation. For climate change adaptation measures, these are the water authority, local government and house/building owners. According to three interviewees, existing sectoral action situations are complex in themselves as they integrate a diversity of interests. Especially energy transition projects are perceived as being already complex when pursuing the sole goal of CO_2 emission reduction. Making combinations with other goals makes these projects even more complex. The choice rules involved are often not equipped to cope with different goals as procedures and protocols that assign actions to actors are provided by the sectoral rules in use and the organization's own institutional logic (see also Neef et al. 2022). As water nuisance is typically the driver of installing water retention areas, exploring the integrative potential of energy transition solutions is not within the scope of such an action situation, and not within the realm of actions of the involved actors. In other words, expanding the *scope* of project outcomes, and by that indirectly the *choice* and *boundary rules* (to invite other types of actors), is perceived as undesirable and not straightforward by actors. This implies that the boundary and choice rules of sectoral action situations are primarily determined by the responsibilities and tasks of actors, instead of inspired by the integrative potential of the interconnected challenges.

In a similar vein, the sectoral interpretation of roles and responsibilities (*position rule*) permeates action situations. The sectoral goals of policy frameworks facilitate a myopic interpretation of responsibilities and roles by actors, and thus a sectoral interpretation of envisioned project outcomes which hinders integration. Housing corporations evaluate heat transition projects on how they perform in terms of affordability and the potential for scaling up the involved energy solutions. Since the core responsibility of housing corporations is affordable housing, working in public areas—as is often the case with climate adaptation measures—is not their responsibility. As such, this position rule directly impedes on exploring integrative opportunities. Collaborating with other actors in heat transition projects to implement climate adaptation measures is therefore not institutionally supported and depends on the ambition of the involved housing corporation.

Energy suppliers predominantly evaluate integrative potential on its impact on the *payoff rule* as their main concern is a feasible business case. Specifically, one of their main worries is to minimize the risk of delay during construction work. The process of installing a heat grid involves an intensive stakeholder management process in the construction area as streets are being demolished. When such construction work is combined with constructing water retention areas, the risk of delays increases which may lead to higher costs (contractors cannot perform their work in case of delay, but they still charge the energy supplier). Furthermore, if climate adaptation measures would lead to a lower demand for energy (e.g. green roofs used to insulate houses reducing energy demand), this would negatively affect the financial result for the energy supplier, even though more public value is produced. As such, the incentive for exploiting integrative potential is limited for energy suppliers.

The primary task of regional water authorities is water quality and quantity management (inter alia governed by EU directives). As such, water authorities have substantial responsibilities for climate change adaptation. Their involvement in heat grids is therefore not evident. However, water authorities can also have the position as energy supplier as waste water treatment plants discharge warm water and have sludge as waste material, which both can be used as energy sources for heat grids. Still each of these integrative opportunities is evaluated whether it impedes on their core tasks. Risks associated with energy supply are therefore important considerations for water authorities.

Although local government is involved in both action situations for heat grids and climate adaptation measures, these sectors are governed by different departments. This means that different civil servants, budgets and policy ambitions are involved. Even within local government organizations, it is challenging to overcome internal silos. Thus, sectoral interaction patterns and sectoral interpretations of roles and responsibilities imply that, despite integrative potential, energy transition and climate adaptation solutions tend to be discussed and implemented in a sectoral way.

Integration of the rural heat transition and nitrogen reduction for sustainable agriculture

Integrative potential

In the rural parts of Overijssel, heat grids are not a suitable solution as they require large concentrations of houses. Yet, as the natural gas grid in the countryside is as well developed and as dense as in urban areas, biogas is considered a promising solution. When the potentially significant reservoir of manure from intensive livestock farming would be converted into biogas, this solution could have high integrative

potential across the value chain. Exploiting this reservoir of methane in the manure would reduce hazardous emissions caused by agricultural activities, in particular intensive livestock farming producing proteins such as milk, pork, beef, eggs and poultry.

Currently, the agricultural sector is predominantly governed by cost efficiency and production increase which lead to economies of scale (Ministry of Agriculture 2018). The downside of this economic gain are environmental hazards due to the scale and intensity of Dutch farming. Intensive livestock farming in particular is hold accountable for 46% of the nitrogen (N) emissions in the Netherlands (Advisory Board Nitrogen Challenge 2020). The N- emissions in agriculture are predominantly ammonia (NH_3, 87%) and less nitrogen oxides (NO_x, 13%). The NH_3 emissions are related to imported feed and fertilizer, while the CO_2 equivalents are related to the digestion of feed by the animals. Manure digestion could contribute to emission reduction in agriculture under certain conditions (Gollenbeek et al. 2021; Reijers 2021). It could also reduce the CO_2 footprint of natural gas based fertilizers and would not be in conflict with soil management in agriculture (no additional manure is produced, but manure surplus is used to produce biogas). The focal action situations in this case involve the production of biogas and an area-based approach to nitrogen reduction. For biogas projects, actors interact over supply and demand, project scale, technological installations, planning and organization, permits, business case and financing. For nitrogen, actors interact in area-based fashion over different measures to reduce nitrogen emissions. Producing biogas through manure digestion would therefore not only provide a more sustainable alternative for natural gas but also contribute to reducing nitrogen and other emissions and sustaining agricultural activities.

Sectoral rules in use

At the national and regional level, policy makers and practitioners acknowledge the integrative potential of nitrogen reduction and biogas production. However, according to interviewees, this integrative potential is not supported by any resources, regulations or policy frameworks. The Ministry of Agriculture promotes sustainable farming, but neglects the contribution of manure digestion to sustainable agriculture (Ministry of Agriculture 2018). The recently rectified Dutch Nitrogen law covers the nitrogen challenge for agriculture as an isolated technical challenge of the individual farm. In the nitrogen policy there is no single reference to the N-reduction potential of manure digestion. In the national energy production support scheme, the potential of manure digestion is solely recognized as a source of sustainable electricity production, not as a source for sustainable heat. As a result, an integrative approach for biogas and nitrogen faces a highly pillarized and fragmented institutional environment at the regional and national level. Interviewees mentioned that from the outset, manure digestion for biogas production is governed by different regulations than soil management (relevant for manure and nitrogen). This frustrates actors that seek to exploit integrative potential in sustaining agriculture (by reducing nitrogen) and effectuating the heat transition (by producing biogas).

Another institutional disconnection arises from EU regulations. Consider how the EU's Nitrates Directive and the Water Framework Directives (which amongst others regulate nitrogen emission by agriculture) impacted the development of the Dutch manure regulations (RVO 2020). The directives influence rules that complicate achieving a good business case for installing manure digesters in small farms that do not produce enough manure onsite. What plays a role here is that collective choice rules are shaped by old directives that were developed in the 1990s and 2000s with different goals (e.g. reduction of water pollution). The pillarization of the rules in use is visualized in Fig. 3.

The lack of institutional linkages, both horizontally and vertically, directly determine the way in which challenges are addressed at the operational level. Specifically, the interconnected challenges come to the farm separately. According to an interviewee, multiple fragmented public law and rule systems govern individual elements of farming and frustrate innovation at the farm level. Farmers face segmented rules and regulations for manure, fertiliser, water and environment, which quite often frustrate innovative and more integrative farming practices as they face inconsistencies with regulations (see for instance Raven 2004; Teesing 2019; Wolters and Schuite 2002). Moreover, the expertise and competence of the farmer is neglected by the high level of detail in regulation, forcing farmers to apply generally prescribed means (such as which type of stable to use), instead of appealing to their professionalism by prescribing targets and goals. As such, regulations that define the *choice rules* for farmers substantially restrict their possibilities for integration.

Within action situations: sectoral interactions and rules

At the operational level, the integrative potential of biogas from manure is acknowledged by actors who are working either on the energy transition or on nitrogen reduction and sustainable agriculture (lower half of Fig. 3). As actors and action situations are separated, both action situations are far from mutually reinforcing. While the potential contribution of biogas production by manure digestion is acknowledged by actors, this has not yet resulted in a systematic and structured integrative approach. Biogas production initiatives are still ad hoc initiatives of individual farmers. In the

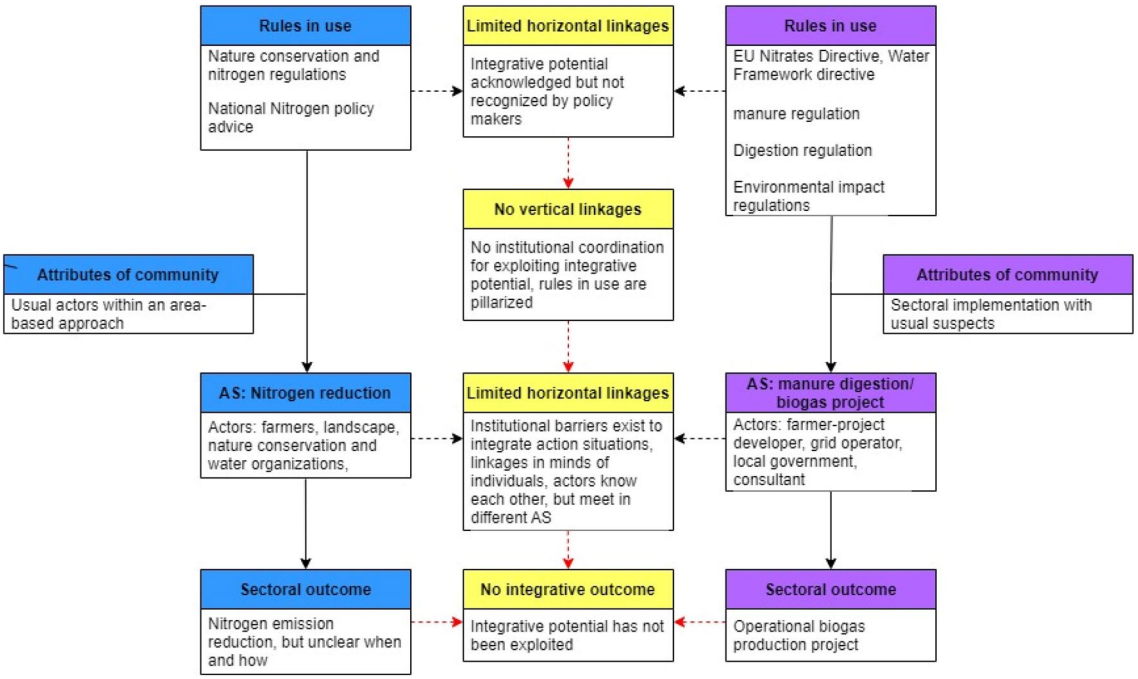

Fig. 3 Limited institutional links between sectoral action situations of biogas and nitrogen, source: authors' own elaboration

action situation of such initiatives, the individual farmer, the network company, consultants and the municipality work together to realize the project technically and financially, without taking into account the integrative potential of biogas production and nitrogen reduction and enhancing sustainable agriculture. The financial part of projects is particularly challenging because of the lack of public financial support of manure digestion. The driver of those initiatives, and thus the involved *scope rule*, is not so much the energy transition in the country side, but rather sustaining farming activities and financially exploiting the farm's manure surplus. The nitrogen reduction potential is completely neglected by these initiatives. Another reason for this is that nitrogen reduction has no monetary value (which points to the *payoff rule)* that can be added to the business case. According to interviewees, developing a biogas project is already highly complicated in itself and including the N-reduction potential in project development would increase complexities and would require additional expertise to the existing action arena.

Part of the complexity stems from an inconsistecy in the municipal responsibility regarding manure digestion. The municipal responsibility for the heat transition appreciates manure digestion as a sustainable energy resource. From the perspective of the municipal responsibility for environmental quality, manure digestion is considered an environmental hazard. Both responsibilities have advocates in the municipal politics and organization, which incorporates potential for inert municipal decision-making on licensing (complicating the *aggregation rule*), as stressed by several interviewees. Finally, a profitable business case for biogas production suffers from the strict separation between commercial and regulated activities in the gas and electricity market, acting as a rigid *boundary rule*. Regulations forbid network companies to financially participate in biogas projects to facilitate the upgrade of the produced methane to green gas. Upgrading produced methane to green gas is considered an energy production activity by energy market regulation. Grid operators are, however, only allowed to invest in energy distribution projects. While the financial participation of grid operators would positively add to a feasible business case, it is prohibited by gas market regulation.

The action situations for N-reduction are generally area based. While they are broad, they also follow five different, specific routes to reduce nitrogen. Route one is reduction of nitrogen at the source in intensive livestock farming by means of technical measures, such as better stables and cleaning technologies. Source measures also address other sectors like traffic and infrastructure, industry and housing construction. This means that the action situations are inhabited by a very wide range of actors representing a diverse mixture of societal and economic activities. These widely composed action situations with flexible *boundary rules* are organized in six different areas in the Province of Overijssel. This area-based organization of policy implementation is the second route of the provincial nitrogen policy implementation. The third route is the recovery of initial qualities of nature areas in the province, in particular Nature 2000 areas.

The fourth route is licensing and enforcement of nitrogen emitting activities in accordance with nature conservation laws and regulations. The fifth and final route is the division of newly available nitrogen emission quotas, resulting from the finalization of nitrogen emitting economic activities. The N-reduction potential of biogas production from manure is completely dissolved in the N-reduction action arenas. Termination of livestock farming activities is the favored outcome and overshadows the option of high quality manure processing. Thus, sectoral interpretations by actors of challenges at hand imply that despite integrative potential, manure-based biogas production and nitrogen reduction are implemented in a sectoral way. Sectoral regulations and interests substantially influence how action situations are configured, and pushes actors towards sectoral solutions and outcomes leaving integrative potential unexploited.

Discussion: institutions supporting integration

In this section, we reflect upon the cases of integrative potential and draw lessons to suggest a way forward, specifically underscoring the role of integrative action situations.

Existing sectoral action situations

In both urban and rural cases, sectoral rules in use profoundly influence the actors involved, their interactions and the outcomes of action situations. The lack of institutional coordination, or vertical linkages (observed in sectoral rules and regulations) vexes operational level action situations in which actors seek to exploit integrative potential (see also Kimmich and Tomas 2017). Challenges are picked up in a sectoral way and actors' tasks and responsibilities are directly translated into envisioned outcomes. Ultimately, actors bring their own sectoral position, choice, boundary, aggregation, payoff and scope rules to the action situation effectuating sectoral outcomes. The status quo is that actors focus on addressing challenges in a siloed fashion, as the institutional settings steer them to do so. Despite actors' familiarity with each other in both urban and rural cases, policy frameworks and regulations withhold them from jointly addressing interconnected challenges. Actors struggle to overcome these institutional hurdles themselves and look at policy makers to start supporting integration. In the existing situation, integrative potential remains largely unexplored and unexploited. While setting up integrative action situations (which implies institutional redesign) involves transaction costs, actors do not assess whether the additional public value that integration may produce outweighs these costs. It is important that actors start making this consideration.

Redesign of action situations

Actors are inclined to point to the policies and regulations that underlie the barriers to exploit integrative potential (e.g. earmarked budgets, unfeasible business case, siloed responsibilities). Fortunately there are possibilities for operational level actors to overcome these obstacles when they turn to reinterpreting the rules of the action situations to come to more integrative configurations.

Both cases show that actor responsibilities and tasks profoundly influenced the action situation and its envisioned outcomes. Hence, increased flexibility regarding *position rules* can be a fruitful adjustment to enhance integrative outcomes. Currently, sectoral responsibilities limit actors in their flexibility to pursue integration, as well as the actions that they can take. In the urban case, the responsibilities of housing corporations, water authorities, energy companies and municipalities push these actors to develop solutions that help achieving the goals they are tasked with. Within this context, an energy company is likely to perceive the combined implementation of heat grids and climate adaptation measures as an unwanted risk. Important here is that position rules move towards a shared sense of responsibilities (van Tulder and Keen 2018). In similar vein, more flexible *choice rules* will help actors to engage with integration more effectively, instead of sectoral, rigid choice rules (Neef et al. 2022). In existing settings, actors take action based on their own sectoral, institutional logic. When actors take the interconnected challenge as a starting point, they could engage in other, sector-transcending types of action. The operational level *boundary rules* stem from the policy frameworks made at the collective choice level. This came forward in both urban and rural cases where usual suspects interact, but do so in sectoral action situations. An example is that grid operators are not allowed to financially participate in biogas projects to facilitate the upgrade of the produced methane to green gas. Boundary rules that are inspired by a profound stakeholder analysis (Kimmich et al. 2022) could provide a more open interaction process (see also Neef et al. 2022). For example, interactions directed at integrative potential could compel involving actors who are usually excluded but who require or have interest in the available resources for achieving their goal. For instance, a regional water authority with control over large water retention areas may benefit by interacting and collaborating with bioenergy producers who can grow and collect biomass in some sections of water retention areas. This way, the regional water authority may increase its income while a bioenergy producer secures a feedstock supply.

Furthermore, the current sectoral *scope rules* steer for one-dimensional projects (e.g. heat grids without considering climate adaptation, manure management without biogas production). In the rural case, the different routes

for nitrogen reduction have a predefined scope, effectively leaving out the potential of biogas production from manure as a solution pathway. In the urban case, the national policy framework primarily steers for heat transition measures and the involved grant solely supports energy-related measures. Instead of taking policy targets as point of departure, scope rules inspired by area-based challenges can provide a starting point for exploring integration. In both cases, *payoff rules* push for business case optimization and risk averse behaviour. Energy companies in the heat transition focus on optimizing the business case and minimizing risks during implementation. In the rural case, nitrogen reduction has no monetary value and therefore actors ignore the integrative potential. Instead, payoff rules capturing public, societal and ecological values may alternatively produce more integrative outcomes. Value capturing across projects paves the way to implement integrative projects that individually may show insufficient financial feasibility but may boost project portfolios of involved actors (Bos-de Vos et al. 2019). Although not mentioned as a barrier by the interviewees, sharing information on maintenance, investment plans, project plans is key for integrative action situations. Indeed, in the context of cross-sector collaborations, the importance of information flow between actors is commonly underscored (Bryson et al. 2006; Lawrence et al. 2002; Meadows 1999). As such, *information rules* should be configured in such way as to promote information sharing and organized with intention to promote joint fact finding (Matsuura and Schenk 2017). In the rural case, the difficulty of decision-making in exploiting integrative potential became apparent as the municipality has ambitions both in energy transition (advocating for manure-based biogas) and environmental quality (advocating against manure-based biogas) (*aggregation rule*). In this sense, consensus-based decision-making is key in keeping different actors committed to the process (Vangen et al. 2015).

Setting up and embedding integrative action situations

The redesign of rules for integrative action situations does not happen by itself. Coalitions and partnerships (Srigiri and Dombrowsky 2021) amongst actors need to be built. They should include actors that are able to grasp the complexity of the interrelatedness of the societal challenges, and willing to think and act across the boundaries that have been erected in light of sectoral efficiency. The cases show that despite the fact that actors are familiar with the integrative potential and one another, this has not led to integrative action situations. A key explanation is that actors fail to adapt and flexibly deal with rules. In our understanding, what is needed to make cross-sector collaboration happen is the building of trust (Getha-Taylor 2012) and new relational skills, knowledge and competencies (Loosemore et al. 2021). A wide range of open-source, participatory, spatial and interactive tools are available to actors to support them in this process. Tools that are designed to promote collaboration and learning include open-data initiatives (Pilemalm et al. 2016; Susha et al. 2017) and cross-sector platforms (Chang et al. 2021; Ladu 2020; Marsal-Llacuna 2020; Young et al. 2020). Interactive simulations (Li et al. 2015) can be used not only to make various actors aware of the potential environmental impacts but also to simulate feedback loops.

Achieving integration also asks for the mediation of an independent intermediary (van Lente et al. 2003) or boundary spanner to foster deliberative interactions between actors (Williams 2002). Indeed, the involvement of an impartial third actor led to a more integrative approach in a specific bioenergy value chain (Grundmann and Ehlers 2016). In the urban case, the importance of an independent actor mediating such integrative processes was also acknowledged by interviewees. Intermediaries create "spaces and opportunities" for others (Stewart and Hyysalo 2008, p. 296) and create "new possibilities and dynamism within a system" (Howells 2006, p. 726). In these spaces (or integrative action situations), they make connections between different actors or things (Hodson et al. 2013). A key function of intermediaries lies in this realm of aggregating knowledge (lessons learned, experiences) and de-contextualizing it to be applied to other contexts (Geels and Deuten 2006; Hargreaves et al. 2013). Furthermore, they work to embed individual, isolated interventions (or in our case, integrative action situations), and assist in building and reshaping institutions, and therefore ultimately add to systemic change (Horne and Moloney 2018). Ample evidence exists for the pivotal role of boundary spanners in cross-sector collaborations (Loosemore et al. 2021; Manning and Roessler 2013; Ryan and O'Malley 2016).

In light of embedding interventions, positive feedback loops can assist in developing new rules in use and attributes of community ultimately strengthening the propensity of new integrative action situations being enacted. Learning processes will serve as the lubricant within feedback loops that over time build up to foster integration at system level. In sustainability transitions research, learning is widely regarded as an important facet of governing for sustainability transitions (Smith 2007; van Mierlo et al. 2020). Importantly, learning not only needs to occur in terms of project-internal learning, but also become embedded in policy networks, procedures and the like (Vinke-de Kruijf et al. 2020). Such wider learning outcomes are difficult to achieve when projects are not in line with the wider policy context (ibid.). In this sense, both horizontal interactions between integrative action situations, as well as vertical interactions between action situations at operational and collective choice level need to facilitate the embedding of integrative

action situations. We argue that this process of embedding should be facilitated by both bottom-up processes (e.g. disseminating processes of internal-project learning ensuing in integrative action situations, establishing communities of practice that assert new attributes of community) as well as top-down processes (e.g. facilitating integration with policy instruments (i.e. grants) and institutional elements such as a civil servant assessing the extent of integration of proposed or pilot projects) (compare Reed et al. 2010). As such, strategies and measures that foster social learning amongst actors and networks, as well as policy-oriented learning will benefit the creation and entrenchment of integrative action situations.

Conclusions

The interlinked nature of today's societal challenges asks for integrative approaches. As the energy transition creates new geographies and involves significant infrastructural and organizational changes on different scales, it presents a compelling opportunity to pursue integration. While the value of integration is commonly acknowledged, it is not the status quo. As such, this study set out to explore what institutional barriers actors experience when venturing to exploit the integrative potential of energy transition solutions and how these barriers can be addressed. Our analysis and discussion are largely based on two case studies that are illustrative of how energy transition projects are currently implemented in the densely populated country of the Netherlands: (i) sustainable residential heating (i.e. heat grids) combined with climate adaptation (i.e. water retention areas) in the urban context and (ii) biogas production from livestock manure for rural residential heating and nitrogen reduction. Using IAD and NAS, the study showed that in the context of energy transition integration, action situations are pillarized with incidental interactions happening between sectors and across scales. Siloed rules in use hinder actors that seek to exploit integrative potential on the ground. The internal rules that govern their interactions stem from sectoral institutional arrangements and produce sectoral action situations. Actors that would like to exploit integrative potential are left to sectoral devices that aim to achieve sectoral operational level solutions to interlinked societal challenges. While actors commonly know each other from their interactions in sectoral action situations, they struggle to bring the diverse societal challenges that they work on separately into a setting where the potential for integration is collectively explored. Factors that especially obstruct integration are financial streams and designated tasks and responsibilities of actors that favour sectoral, one-dimensional projects. These in turn determine to a great extent the rules for who participates and what actions actors typically take within action situations. Actors bring their own sectoral (position, choice, boundary, aggregation, payoff, scope) rules to the action situation. Ultimately, the cases revealed a need for alternative institutional designs that are supportive of integration.

As a way forward, this study proposes that actors configure so-called integrative action situations, where the potential for integration is acknowledged from the outset and integrative solutions are actively explored. Following terminology from the IAD framework and NAS, the process of designing integrative action situations requires actors to adjust the existing internal rules. As such, actors play a key role in redesigning the action situations. This study contributes to the body of literature by gaining a better understanding of how institutions affect actor interactions in the context of operational level integration.

To further the understanding of integrative action situations, future research should look into and unpack the actual mechanisms and conditions for creating integrative action situations. More research using an actor-centred perspective on institutions and institutional change is an important starting point. Here, theories and concepts of social learning, boundary spanning and intermediation, coalition building, network management, and adaptive capacities of actors present opportunities for researchers and practitioners to configure integrative action situations. Progression towards integrative action situations could provide new insights to studies looking into interactive and participatory planning, the acceptance of renewable energy developments, the water–energy–food nexus, policy integration and climate adaptation mainstreaming.

Appendix

List of interviewed organizations and the sectors in which they operate.

#	Type of organization	Sector
1	Network and knowledge	Built environment, construction
2	Network and knowledge	Soil and food production chain
3	Network/branch representative	Bioenergy
4	Knowledge Institute	Energy systems
5	Project developer, energy producer and consultancy	Bioenergy
6	Energy producer	Bio energy
7	Energy supplier, project developer	Sustainable heat

#	Type of organization	Sector
8	Citizen energy co-operative	Solar PV, citizen participation
9	Housing cooperation	Social housing, housing renovation
10	Municipality	Renewable energy, sustainable heat, agriculture
11	Municipality	Renewable energy, sustainable heat, agriculture
12	Self-employed advisor for municipalities	Sustainability and agriculture
13	Regional water authority	Water management, renewable energy, sustainable heat
14	Province	Renewable energy, sustainable heat
15	Province	Energy transition, Environment
16	Province	Energy transition, solar PV

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