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Shaping the Directionality of Sustainability Transitions:

The Diverging Development Patterns of Solar PV in Two Chinese Provinces

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Abstract

A limited set of studies have addressed how actors shape the directionality of sustainability transitions. Building on recent institutional work literature, this article explores how specific institutional activities developed by both niche and regime actors across spatial levels shape the directions of transition. We examine two cases with contrasting directionalities: solar PV in the provinces of Inner Mongolia and Jiangsu, both located in China. The former developed PV as part of the large-scale centralised power system and the latter focused on PV development as a core element of an alternative distributed form of power generation. We investigate provincial differences as well as the state-provincial dynamics. The article therefore develops a multi-scalar understanding of institutional work. Our research findings suggest three aspects have been key for understanding the divergent patterns: the specific portfolios of enacted institutional work, the type of interactions between niche and regime actors and the selective leveraging of institutional conditions at national by provincial actors. Based on these findings we formulate four propositions and propose a novel conceptual framework to investigate how actors shape the directionality of sustainability transition.

Keywords: Actors; Institutional work; Directionality; Sustainability transition; Solar PV development

Highlights:

- Investigate the proactive role of actors in shaping provincial differences and the state-provincial dynamics of solar PV development in China from 2000 to 2018;
- We develop the concept of multi-scalar institutional work;
- Systematically assess how niche and regime actors adopt a multiplicity of institutional work strategies to shape divergent directions of transition;
- We formulate four propositions and propose a novel conceptual framework;
- Actors adopt institutional work not just across niche and regime boundaries but also across spatial levels (provincial, national, global level).

1. Introduction

The development and scaling of renewable energy technologies is one of the major success stories in terms of decarbonising the electricity sectors. Solar photovoltaics (PV) are a major case in point. Generation costs per KWh decreased by more than 95% since the 1970s (Kavlak et al., 2018), which makes it a cost-competitive alternative in many application contexts today, and has led to a large scale of diffusion of solar PV over the last decade (SolarPower Europe, 2018). However, despite the success

of this technology, the ultimate impact on the structure of the electricity sector remains unclear. Will solar just be an additional source of energy in an otherwise unchanged centralised electricity system or will the diffusion of solar lead to a fundamental restructuring of the sector towards more decentralised power generation with new grids, business models and use patterns? This is a question about the directionality of the transition.

In this article we explore the issue how actors try to shape the directionality of the transition in one of these two ways. Following the Multi-Level- Perspective (MLP) understanding in the sustainability transitions literature we conceptualise the electricity sector as a socio-technical system (Jacobsson and Bergek, 2004), which is characterised by a very clearly elaborated socio-technical regime of rules, such as norms, regulations and cognitive beliefs. Because of this emphasis on rules sustainability transitions can be seen as an institutionalisation process (Rip, 1992; Rip and Kemp, 1998; Geels, 2004; Fünfschilling and Truffer, 2014). New technological alternatives --such as solar PV has to accommodate to these existing rules, this may hamper their development prospects substantially. The MLP assumes that early technological development depends on the availability of “protective spaces” so-called niches in which the necessary learning and alignment processes can be tried out and tested before an alternative can scale up and perhaps challenge the predominant technologies (Hoogma et al., 2002; Schot and Geels, 2008). Essentially, promoters of niches have two options for dealing with prevailing regime rules: they either adapt to the given situation or they proactively try to change the rules in a way that accommodates for the specificities of the new option. Smith and Raven (2012) classified these two approaches as fit-and-conform and stretch-and-transform patterns of transformation. Our research questions are formulated as follows: what kind of strategies do actors enact in order to support either of the two development patterns? What kind of institutional conditions do they have to mobilise and which kind of cooperation do they have to engage in?

Battles over the directionality of transition are not free of conflicts, because unavoidably they will challenge the dominant position of incumbent companies and enable new actors to influence the future development of the socio-technical system. The transition studies literature has accumulated a sizeable stock of evidence on how existing regimes resist transformative pressures and how difficult it is for niches to grow and transform the prevailing rules (Markard et al., 2012). The question of how actors try to shape the directionality of the transition has much less been analysed. Our point of entry for answering this question build on insights from recent studies on “institutional work” (Lawrence and Suddaby, 2006). This literature conceptualises institutional change as the outcome of actors’ attempts to maintain, create or disrupt institutions (Lawrence et al., 2009). Recently, several studies have started to show how concepts of institutional work may be fruitful for analysing sustainability transitions (Brown et al., 2013; Binz et al., 2016; Fünfschilling and Truffer, 2016).

We will build on these recent insights but extend them in important respects in order to address questions of directionality: First, we do not assume that most of the transformative institutional work is carried out by niche actors, leaving regime actors in an essentially defensive position. We therefore adopt an open attitude regarding the portfolios of institutional work different actors employ, irrespective of their degree of incumbency. Second, and as a consequence, we want to explicitly consider the kind of relationships that are established between incumbents and new entrants in support of either of the development patterns. And third, given that institutional structures are defined at different levels of jurisdictions, we propose to analyse institutional work as strategies that may operate at and across different spatial scales.

To answer our research question, we choose a revealing case (Yin, 2014) of the differential deployment of solar PV in two Chinese provinces, Inner Mongolia and Jiangsu. Significant solar development happened in both provinces. But their directions differed substantially. Inner Mongolia implemented a large-scale centralised approach to connect solar power to the electricity grid – thus exemplifying a fit-and-conform pattern, while Jiangsu became a leader in distributed solar PV systems, building on a large range of local experiments and supporting institutions, thus more resembling the stretch-and-transform pattern. This divergence of development patterns occurred despite the seemingly disciplining national framework of Chinese industrial policy that applies to both provinces in an equal manner. We would therefore expect to find substantial and different instances of institutional work employed by local actors in these two provinces that can explain the divergent patterns. Both provinces may have a divergent starting position in terms of urbanisation, industrialisation, population density that may be looked at to explain the divergence. Our assumption is, however, that these factors operate as distinct cause that can be mobilised in different ways through institutional work. It is this work we see as the immediate cause of the divergent patterns.

The paper is structured as follows. Section 2 introduces the literature on institutional work and discusses how questions of directionality can be addressed in the analysis of sustainability transitions. Three core aspects are elaborated: i) portfolios of institutional work; ii) interactions between niche and regime actors; iii) the multi-scalar dimension of institutional work. Section 3 describes the methodology. Section 4 elaborates on the institutional work actors adopted to shape China's solar PV development in the two focal provinces as well as at the national level. Section 5 discusses how local actors performed institutional work to shape the respective development trajectories in the two provinces. Section 6 draws implication of this research for how directionality could be addressed in future transition studies.

2. Institutional work and directionality

There have been different perspectives on why radical socio-technical change occurs. Some have argued that radical change in the socio-technical configuration of sectors can be triggered by extreme events like wars or environmental jolts (Sine and David, 2003). This “punctuated equilibrium” perspective argues that the system generally exists in a relatively static equilibrium (Werbelloff et al., 2016), which can only be changed through a strong and sudden shock (Gersick, 1991). In this view socio-technical change is treated as a black box, it is largely a result of external stimuli (Markard and Truffer, 2006). This view has always been criticised in sustainability transitions studies. It is seen as “probably only accurate for a few potential transition trajectories” (Fünfschilling and Truffer, 2016, p. 298). Most of the system transformation processes are driven by a combination of exogenous and endogenous driving forces (Geels and Schot, 2007).

Moreover, the external shocks “do not mechanically impact niches and regimes, but need to be perceived and translated by actors to exert influence” (Geels and Schot, 2007, p. 404). The actual directions of change are therefore shaped by actors' strategies, which are guided by their specific interests and visions (Smith et al., 2005; Yap and Truffer, 2019). This implies attention needs to be paid to the endogenous and gradual transformation process taking place within the socio-technical system through strategic agency (Markard and Truffer, 2008; Pacheco et al., 2010; Smith et al., 2010; Grillitsch et al., 2018; Yap and Truffer, 2019).

Although a handful of studies have conceptualised how the interaction between exogenous and endogenous change processes produce different transition patterns (Smith et al., 2005; Geels and Schot, 2007), there is still limited understanding on the role of agency in shaping specific socio-technical transformations (Smith and Stirling, 2010; Grin et al., 2011). Farla et al. (2012) and Smith and Raven (2012) suggest to draw upon institutional scholarship to fill this gap.

The criticism that it remains unclear how institutional change happens resonates with developments in neo-institutional studies. Before 1990s, traditional institutional theory predominately treated institutions as relatively passive structures guiding the actions of actors (Meyer, 1982). Hence, they generally treated institutional change as a black box. Neo-institutional scholars, however, regard institutional change as the outcome of actors' attempt to intentionally reproduce, alter or destroy institutions (Battilana et al., 2009). Lawrence and Suddaby (2006) introduced the concept of 'institutional work' to explore the proactive role of actors in shaping institutional change. In our view, institutional work is better suited to study socio-technical transformations compared to the related concept of institutional entrepreneurship (Battilana et al., 2009), because it is less associated with a hyper-muscular view on actors' capabilities and acknowledges that institutional change is always a joint societal process where most actors have only limited effectiveness (Fünfschilling and Truffer, 2016). However, in actual applications to socio-technical transitions (see for instance Yap and Truffer (2019)), there is often only a small difference between the two approaches.

Institutional work conceptualises how actors purposively engage (individually and collectively) in an effort to prevent or generate institutional change. Lawrence and Suddaby (2006) categorise three strategies of institutional work actors can engage in: keep institutions alive (maintenance in the regime), change them (disruption of the regime) or create new ones (built-up niches and reconfiguration of socio-technical elements for new technologies). These three mechanisms are also reflected in sustainability transitions research, where regime actors are conceptualised as primarily busy with reproducing the regime in order to *maintain* their vested interests (Hensmans, 2003; Maguire and Hardy, 2009; Geels, 2014; Hess, 2014; Smink et al., 2015b; Ting and Byrne, 2020). Niche actors in contrast endeavour to *create* new institutions by setting up protective spaces that enable the maturing and scaling of their preferred alternatives (Geels, 2004; Seyfang and Haxeltine, 2012; Geels et al., 2016). Recent transition studies started to articulate the crucial role of *disrupting* institutional work by actors who aim at the destabilisation of the regime in order to shape the direction of transition (Brown et al., 2013; Kivimaa, 2014; Kivimaa and Kern, 2016).

The three type of strategies can be detailed further. Lawrence and Suddaby (2006) proposed a list of eighteen forms of work by which actors can influence institutions. Drawing on the work of Scott (1995) we group them by how prominently they address the regulative, normative or cognitive pillar respectively (see table 1). Regulative pillar refers to formal rules, such as laws, government policies. Normative rules refer to values and social norms. Cognitive rules refer to the beliefs and symbolic meanings (Scott, 2001). We can take from the literature that mechanisms of creating institutions, include advocacy, defining, and vesting. This "reflects overtly political work in which actors reconstruct rules, property rights and boundaries that define access to material resources" (Lawrence and Suddaby, 2006). They therefore contribute primarily to the build-up of regulative rules. Constructing identities, normative networks and changing normative associations emphasises "actions in which actors' belief systems are reconfigured" and therefore address primarily the normative pillar. And finally, mimicry, theorising, educating alter the meanings and things taken for granted, and therefore address primarily cognitive rules. For lack of space, we are not in a position to offer detailed

description of the different forms of institutional work. The reader is referred to Lawrence and Suddaby (2006) and Fünfschilling and Truffer (2016) for further elaborations (see also table 1).

For the purpose of our analysis, we want to make two points here: i) we expect not all the listed forms of institutional work in table 1 need to be performed during the process of sustainability transition. For the specific directions of sustainability transition, specific combinations of different forms of institutional work may be needed (creating, maintaining and disrupting) across three institutional pillars (cognitive, normative and regulative); ii) these three institutional pillars generally align with each other to maintain resilient social-technical structures (Geels, 2004). However, when shifts occur in one of these institutional pillars, it may create windows of opportunity for changes in other pillars too and thus more radical institutional change is likely to result.

We propose to call specific combination of different forms of institutional work a portfolio. Our assumption is that if actors, through such portfolio of institutional work, shape all three institutional pillars substantially, change will be more radical, e.g. rather support stretch-and-transform patterns. This has been argued by Ghosh and Schot (2019), who differentiate three transition pathways based on the divergent reconfigurations of the socio-technical dimensions and portfolios of changes in the different institutional pillars. They assume more diversified and integrated changes of different institutional pillars led to more fundamental reconfiguration of the socio-technical system, i.e., more radical transition pathways (also indicated by Geels and Schot (2007) and Kemp and van Lente (2011)).

Recently several further empirical studies have been conducted in the sustainability transitions field to explore the relevance of institutional work in order to explore how actors proactively build niches (Brown et al., 2013), or direct the course of socio-technical regime change (Fünfschilling and Truffer, 2016). However, these studies either focus on the historical reconstruction of singular socio-technical system transitions (Brown et al., 2013; Fünfschilling and Truffer, 2016; Novalia et al., 2018) or they focus on institutional work towards specific types of institutional change (for example, towards technology legitimacy (Binz et al., 2016) or policy change (Hess, 2014)). There has been less attention on which actors are doing which type of institutional work, and how this influences the directionality of sustainability transition.

Table 1. mechanisms of how institutional work towards shaping different pillars of institutions (adapted from Lawrence and Suddaby (2006))

<i>Pillars of institutions</i>	<i>Creating institutions</i>		<i>Maintaining institutions</i>		<i>Disrupting institutions</i>	
	Forms of institutional work	Definition	Forms of institutional work	Definition	Forms of institutional work	Definition
<i>Regulative</i>	Advocacy	The mobilisation of political and regulatory support through direct and deliberate techniques of social suasion	Enabling work	The creation of rules that facilitate, supplement and support institutions, such as the creation of authorizing agents or diverting resources;	Disconnecting sanctions	Working through state apparatus to disconnect rewards and sanctions from some set of practices, technologies or rules
	Defining	The construction of rule systems that confer status or identity, define boundaries of membership or create status hierarchies within a field;	Policing	Ensuring compliance through enforcement, auditing and monitoring		
	Vesting	The creation of rule structures that confer property rights	Deterring	Establishing coercive barriers to institutional change		
<i>Normative</i>	Constructing identities	Defining the relationship between an actor and the field in which that actor operates	Valorising and demonizing	Providing for public consumption positive and negative examples that illustrate the normative foundations of an institution	Disassociating moral foundations	Disassociating the practice, rule or technology from its moral foundation as appropriate within a specific cultural context
	Changing normative associations	Re-making the connections between sets of practices and the moral and cultural foundations for those practices	Mythologizing	Preserving the normative underpinnings of an institution by creating and sustaining myths regarding its history		
	Constructing normative networks	Constructing of interorganisational connections through which practices become normatively sanctioned and which form the relevant peer group with respect to compliance, monitoring and evaluation	Embedding and routinizing	Actively infusing the normative foundations of an institution into the participants day to day routines and organizational practice		

Cognitive

Mimicry	Associating new practices with existing sets of taken-for-granted practices, technologies and rules in order to ease adoption	Undermining assumptions and beliefs	Decreasing the perceived risks of innovation and differentiation by undermining core assumptions and beliefs
Theorising	The development and specification of abstract categories and the elaboration of chains of cause and effect		
Educating	The educating of actors in skills and knowledge necessary to support the new institution		

The sustainability transitions research is built on the implicit understanding that a homogenous set of regime actors is challenged by an equally homogenous rival of a clearly defined niche actors. Niche actors are the ones who have generally been recognised to promote radically different future socio-technical system configurations (Geels, 2004; Seyfang and Haxeltine, 2012; Geels et al., 2016), while regime actors, as the more resourceful actors, will aim at watering down sustainability ambitions and push for optimising existing trajectories rather than to explore new (and more sustainable) ones (Coenen et al., 2010; Ting and Byrne, 2020). Moreover, it has been observed that due to cognitive and infrastructural lock-in, regime actors often specifically counteract ongoing change or destabilisation (Fünfschilling and Truffer, 2016). Especially when the niches grow rapidly, regime actors may start to invest in reversing policy support for niches (Hess, 2016) and to undertake defensive institutional work to maintain their dominant positions (Hensmans, 2003; Maguire and Hardy, 2009).

Niche and regime actors thus differ with regard to interests, competencies, values and worldviews and adopt corresponding strategies to promote their specific transition pathways (Coenen et al., 2010). Regime actors tend to prefer fit-and-conform strategies, while niche actors work on stretch-and-transform ones. However, the sustainability transitions literature has shown that the emergence of radical transitions cannot be attributed exclusively to peripheral niche actors (Green, 1991; Kemp et al., 2001; Geels, 2002; Garud and Karnøe, 2003; Schot and Geels, 2008; Brown et al., 2013). Rather it will be the result of interaction among actors with different degrees of incumbency (Jørgensen, 2012; Yap and Truffer, 2019). That is to say, radical institutional change requires collective actions between niche and regime actors. Thus, it begs a key question: how does the interaction process between niche and regime actors unfold, and which types of their interactions shape more or less radical institutional change?

The directionality battle between fit-and-conform and stretch-and-transform is not about whether the new (niche actors) will win over the old (regime actors). In our research we do not want to tie regime actors upfront to a strategy of maintaining institutions (defending the regime) while niche actors do the creating (building niches) and disrupting work (de-stabilising regimes). Rather, battles about the actual course of action may happen equally among regime actors within a prevailing regime as among actors supporting (potentially manifold) niches. Such a view accounts for a situation in which regime actors may operate in the niche, and have an interest building in niches, while niche actors may not want to destroy the regime and prefer to operate on the niche level only. The fact that regime actors are not just defending the status quo has also been recognized in neo-institutional literature. In the seminal work by Leblebici et al. (1991), they emphasized that internal institutional contradictions may emerge as a starting point for dominant actors to engage with institutional change. In transition studies, Fünfschilling and Truffer (2014) elaborated how different institutional logics in a regime may create tensions within and among actors who are incumbents in the prevailing regime. We have therefore to account for a multiplicity of institutional work strategies of a multitude of actors, which are more or less tied to the prevailing regime structures.

To answer the above question about interactions between niche and regime actors, we will have to adopt a more open understanding on how different actors relate to the dominant regime. A specific actor may hold different degrees of incumbency depending on which aspect of the regime is considered (Stirling, 2019). Niche and regime actors may agree on most dimensions of the regime and just differ on very specific aspects. Smink et al. (2015a) have identified that niche and regime actors generally act under divergent institutional logics, which hinder their interactions. However, when they

share institutional logics, they may establish more productive relationships (Smink et al., 2015a). Van Wijk et al. (2013) further argue that niche and regime actors may establish effective collaborations by building up learning network to facilitate their shared understanding of the sense-making and meanings.

Institutional work not only requires actors to work across niche and regime boundaries, but also across spatial boundaries. The recently proposed approach of a “geography of transitions” has started to scrutinize spatial dynamics (Coenen et al., 2012; Hansen and Coenen, 2015; Truffer et al., 2015). Sustainability transitions studies have traditionally focused on national level studies, assuming that niche and regime structures would be essentially uniform within a national territory (Coenen et al., 2012). As argued by Coenen et al. (2012) it is important not to conflate a conventional view on geography with levels in the Multi-Level Perspective (MLP), equating niche with local, regime with national and landscape with global processes and structures (Coenen et al., 2012; Raven et al., 2012; Bridge et al., 2013). A more geographically informed interpretation would see niche-regime interactions as happening at and across multiple scales to generate specific transition pathways (Coenen et al., 2012; Fünfschilling and Binz, 2018). The regional variation was more easily acknowledged in niche processes. Raven et al. (2008) for instance stressed that geographical contextualisation was crucial for niche experiments. They argue local actors reinterpret and reinvent the generic rules, which enable local variations or the emergence of the new niche pathways. However, the regional variation of regime structures found much less resonance (for exceptions see Späth and Rohrer (2012); Binz and Truffer (2017); Fünfschilling and Binz (2018)).

To address how actors mobilize institutional work in the spatially very different contexts, we have to conceptualise the regional specificity of both niche and regime structures. Socio-technical regimes may then be conceptualised as multi-scalar structures with rules that may be interpreted by regional actors for their local contexts (resulting in regional implementation styles of national regulations). Institutional work can also be oriented towards working at different spatial levels. It can either focus on how regional actors try to shape institutions at the national level, or on how national level rules get translated selectively into specific regional contexts (see also Yap and Truffer (2019) for a similar, although not spatially delimited multi-scalar approach to directionality). Not all actors have equal capability to conduct institutional work in such a multi-scalar world. Some actors like big national companies are boundary spanners. They can more easily leverage processes across different scales, while regionally anchored small-medium sized enterprises will be more restricted. A spatial sensitive approach to institutional work is crucial to investigate how and why developments in certain regions move in divergent directions.

These multi-scalar relationships are however not limited to regions in a country. The same applies to different countries in a globally structured sector (Fünfschilling and Binz, 2018). Local actors may mobilise global networks to stabilise local niches (Sengers and Raven, 2015). For example, local actors could translate the global climate change agenda to shape local legitimacy for green technologies (Smith, 2007). It is crucial to recognise that heterogeneous local niche and regime actors may hold different interests and strategies, which enables them to mobilise different types of institutional work to shape the divergent regional visions and pathways (Essletzbichler, 2012). However, Fünfschilling and Binz (2018) remind us about the constraints provided by the global socio-technical regime, they may stifle specific type of changes at the regional and local level, despite the institutional work generated by niche or regime actors.

Based on this selective and focused literature review, we are now in the position to explore what portfolio of institutional work niche and regime actors adopt to shape divergent directions of sustainability transition. We will investigate in the case of solar PV niche development in two Chinese provinces. One case represents a rather ideal type fit-and-conform and the other a stretch-and-transform pattern. To avoid confusion we are not using the notion of transition pathway as used in the literature cited above since we are only interested in making a distinction between two patterns with a particular directionality (or direction): this is the end-shape of the reconfigured system. We will explore whether we can explain the different patterns by looking at the portfolio of institutional work assuming that such a portfolio may be responsible for the divergent patterns. We will investigate the relationships between niche and regime actors and whether and how they work together in performing institutional work. And finally, we will reconstruct how niche and regime actors adopt their institutional work linked with the specific local context conditions and national developments.

3. Methodology

3.1 Case study selection strategy

This study adopts a comparative case study research design (Creswell, 2007; Yin, 2014). To investigate how niche and regime actors adopt institutional work to shape directionality of transition, we select two contrasting cases: solar PV development in two Chinese provinces, Inner Mongolia and Jiangsu, which represent two divergent development patterns, fit-and-conform and stretch-and-transform. Each province is considered a (sub-) case and analysed as such independently, followed by comparison across both (sub-) cases. To develop a geographic sensitive understanding of institutional work, we also elaborate state-provincial dynamics to investigate relevant institutional work across multiple scales.

The country of China is selected because of its rapid and large scale diffusion of solar PV deployment over the last decade and also its divergent regional development, which fits the purpose of this research. China holds the global largest solar PV market (see Fig. 1). The prevailing Chinese electricity regime has been dominated by the model of centralised, large-scale power plants, long distance transmission grids operated by large utility companies over the past decades (Yuan et al., 2012). In recent years, solar PV development showed two different patterns, either promoting solar PV electricity in a form that easily connects to the centralised transmission grid or a form of energy that is produced near the place of consumption and therefore more energy efficient. Inner Mongolia and Jiangsu have been leaders in China in promoting one of these alternatives each. In 2018, the total installed capacity of solar PV in the two provinces contributed 13% of the country's total capacity. The deployment of solar PV in Inner Mongolia is mainly dominated by large-scale centralised solar power plants with long-distance transmission, while Jiangsu is leading in terms of distributed solar PV (see Fig. 2).

The two proposed provinces represent contrasting cases exemplifying different directionalities. The development of solar PV in Inner Mongolia can be characterized as a fit-and-conform pattern, while the case of Jiangsu leans more towards a stretch-and-transform pattern. To elaborate how different actors pushed for institutional change, we focus on the period between 2000 and 2018, which covers the major diverging development phases of solar PV in China (see Fig. 3).

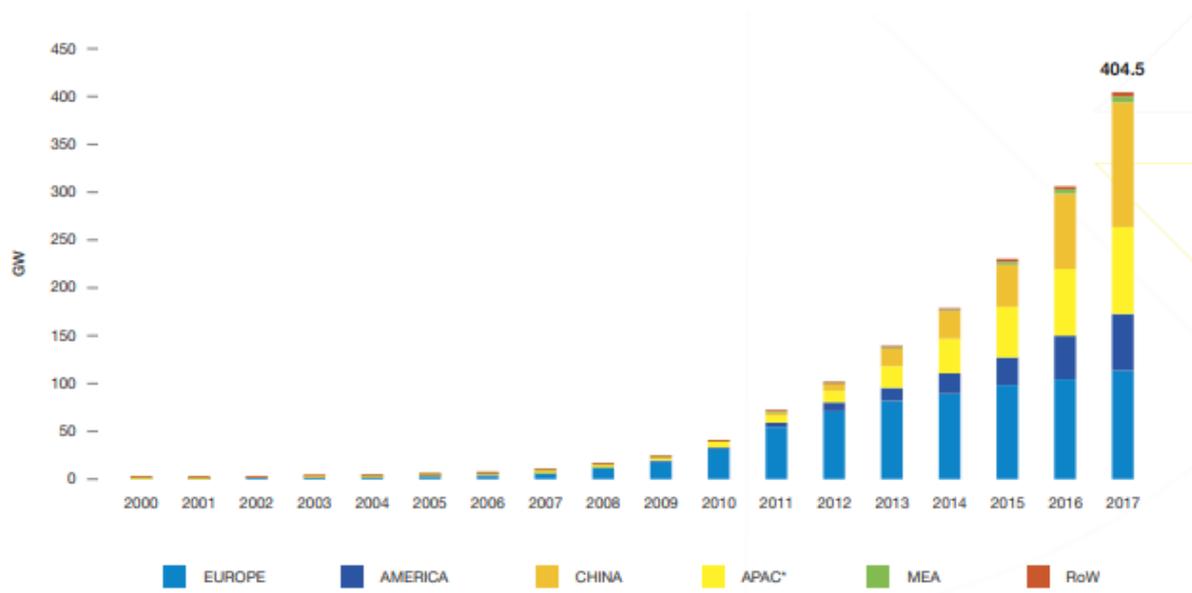


Fig. 1. Evolution of global total solar PV installed capacity 2000-2017.

Source: SolarPower Europe (2018)

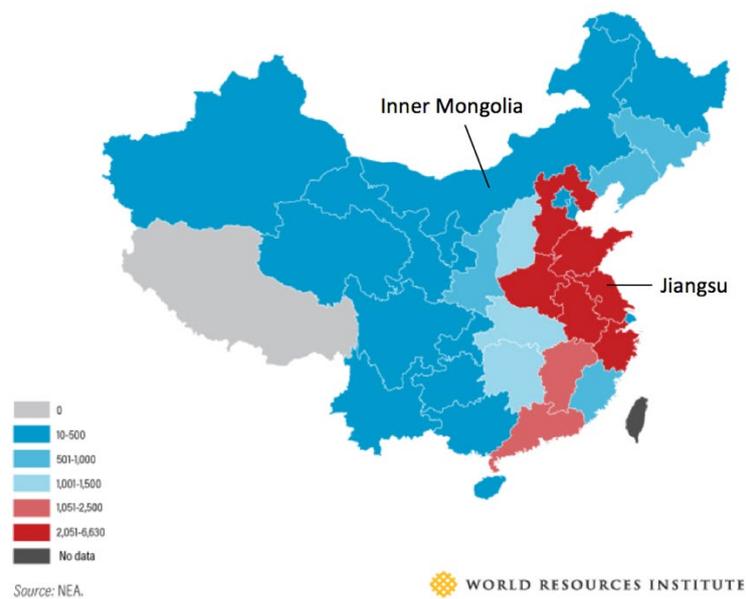


Fig. 2. Installed capacity of distributed solar PV in China- by the end of June 2018

Source: Yuan et al. (2018)

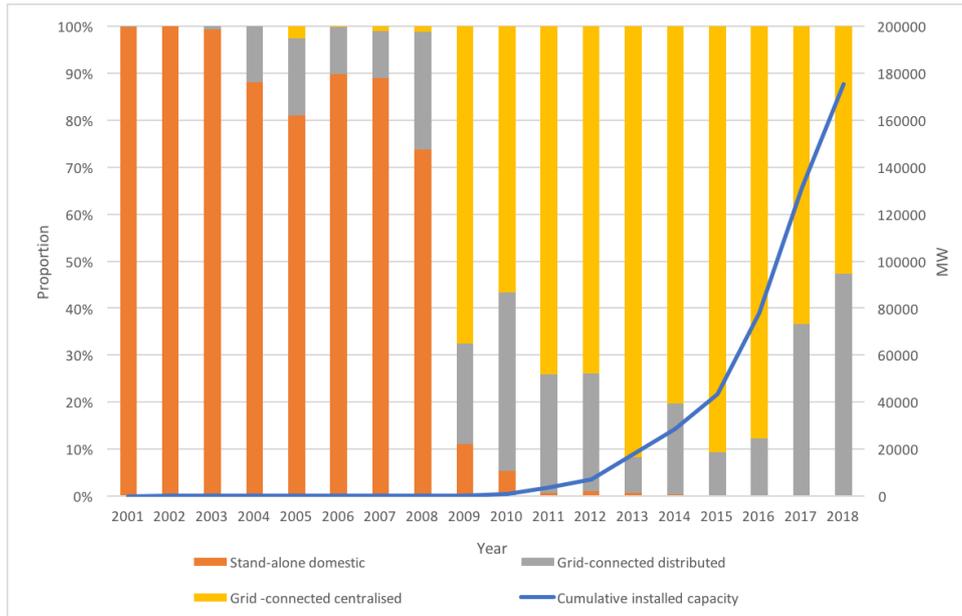


Fig. 3. Cumulative installed solar PV power and various application market in China from 2001 to 2018

Note: the proportion of the various application is based on the proportion of annual new installed market, instead of the cumulative capacity;

Authors own, based on statistic data from Lv et al. (2018);

3.2 Data collection and analysis

To address our research question, we need data about the institutional work of key actors involved in solar PV development in two provinces and at the national level. The study adopts a complex mix of data collection and analysis methods.

Both primary and secondary data were collected and analysed to conduct a longitudinal analysis. Primary data collection included semi-structured interviews, focus groups and workshop from two rounds of fieldwork, conducted from July 2017 to March 2018, and between December 2018 to January 2019. In total forty-two experts were approached covering a wide range of stakeholders (see table A1 in appendix for the list of all the interviewees). Each interview lasted around one hour. All interviews were conducted in Mandarin, recorded with audiotape, transcribed and translated into English. The secondary data covered newspaper articles, policy documents, organisational reports, academic articles etc. Relevant industry conferences were also attended to identify key stakeholders and to collect useful documents (for example, presentation slides and conference proceedings).

During a first round of fieldwork, twenty-six semi-structured interviews and six focus groups were conducted. They served to identify key processes of institutional change, and the role of different stakeholders for solar PV development at the national and provincial level. To be specific, we first operationalised the three institutional pillars as depicted in table 2 so that we could identify the relevant instances of institutional work. Historical changes in national and provincial regulations were identified through secondary data, such as policy documents, newspaper articles, and organisational reports. These documents were complemented and triangulated with individual interview data and workshop insights. Changes in cognitive and normative institutions were derived from the interview data.

Based on the information collected we constructed a timeline of key institutional changes at the national and provincial level at the end of first round of fieldwork. Then we invited stakeholders to a

workshop in March 2018, in order to reflect on the detailed storylines (working with representatives of two provinces separately; hence we did two focus groups). The workshop served as a triangulation for the interview data and also served as an opportunity to specify the role of different stakeholders for solar PV development. In the workshop, the proactive role of local actors became obvious for explaining the diverging development patterns in the two provinces. Phrased by several participants, “the divergent development of solar power in the two provinces is largely promoted by the local actors” (workshop, 8 March 2018, Beijing).

To identify how niche and regime actors adopted different forms of institutional work, we conducted a second round of fieldwork. We ran semi-structured interviews to investigate the specific role of local actors and asked which types of institutional work they mobilized to shape the divergent transition directions. Interview has the advantage to explore the invisible and often mundane dimensions of institutional work (Fünfschilling and Truffer, 2016). In total, nineteen experts from two provinces were approached with three follow up interviews and four focus groups were conducted.

After finishing the interviews, we drew on the theoretical concepts of ‘institutional work’ as identified in table 1 in order to code the interview data. The interview data was complemented and validated with secondary data, such as policy documents, news and organisational reports so that to identify how the institutional changes have been stimulated- through which types of actors, and through which types of activities. These results are presented as storylines in section 4. To highlight the types of institutional work, we numbered creating institutional work as C1-C9, maintaining institutional work as M1-M6, disrupting institutional work as D1-D3 (see appendix table A2 for coding structures). Appendix table A3 presents further evidence of different institutional work adopted by actors at national level and in two provinces. Moreover, we summarised these evidence in three figures (depicted in Fig. 4, 5 and 6).

Table 2. operationalisation of three institutional pillars

Institutional pillar	Definition	Operationalisation
Regulative	Refer to the formal rules, such as laws, government policies	Develop and implement the laws and policies either to support or disrupt regime or contribute to niches. Such as regulations or targets oriented development plans; mandatory quota; subsidy;
Normative	Refer to the values, social norms	Values and social norms, which are mobilized to assess the superiority of either centralised or decentralised forms of power. For example, what is the priority for future energy development? Whether the priority is for economic efficiency or energy efficiency and environment friendly?
Cognitive	Refer to the beliefs and symbolic meanings	What are the local problems; What are actors’ perceptions of energy system/ what is the meaning of energy? For example, whether energy as products or energy as the service?

4. Solar PV development

In this section, we present the historical account of institutional change and different types of institutional work employed by both niche and regime actors for solar PV development from 2000 to 2018 in two focal provinces. To present the national conditions for the two divergent directions, we also briefly introduce the types of institutional work at the national level.

4.1 National level

Solar PV experienced a rapid deployment in China over the last decade (Yang et al., 2020). There was visibly no installed capacity in the country before 2000, while in the year of 2018, its cumulative installed capacity attributes to one third of the global total installed capacity in solar PV (APRICUM, 2019). The deployment of solar PV from 2000 to 2018 can be categorised into three different stages according to different dominant applications (see Fig. 3): before 2009, off-grid stand alone energy system; since 2009, grid connected large-scale centralised power system; and since 2017, the recently boom of grid connected distributed solar PV energy system. As depicted in Fig. 4, this process was shaped by different types of institutional work enacted by both niche and regime actors. The key regime actors involved at the national level include the thermal power generators, grid company, central government, provincial government, and large users. The key niche actors include the solar PV manufacturing industry, solar PV generators, solar PV industry associations.

Before 2009, China's solar PV deployment was dominated by off-grid stand-alone energy systems. The majority of cumulative PV capacity was located in rural areas that were lacking access to electricity (Wallace and Wang, 2006; Li et al., 2007; Bhattacharyya and Ohiare, 2012). Developments were mostly supported by the central government's rural electrification programmes, such as the "Brightness programme (光明工程)", "National Township Electrification Programme (送电到乡)" (National Development and Reform Commission, 2002). In 2005, China issued the Renewable Energy Law, which set the legal framework for the renewable energy deployment in China (Zhang and He, 2013). In 2007, the central government implemented the "Medium-Long term Renewable Energy development plan", which mandates the grid company to purchase all of the generated renewable energy, and the large thermal power generators to install a certain proportion of non-hydro renewable energy (3% by 2010, 8% by 2020). This policy defined a new relationship between conventional utilities and renewable energy generators [vesting, C3]. After 2006, the solar PV manufacturing industry took up rapidly in China mainly aiming at serving rapidly growing markets in Europe and the US (Fischer, 2012). The domestic application of solar PV was only marginal. In the year of 2008 for instance, only 1.5% of the country's solar PV cell production ended up serving the domestic market (China Renewable Energy Engineering Institute, 2012). The solar PV manufacturing association articulated that the over reliance on overseas markets represented a high risk for Chinese manufacturers. They therefore lobbied the central government to nurture the domestic market (interview, senior policy researcher, 14 Dec 2017, Beijing) [advocacy, C1]. Especially after the global financial crisis in 2008, when the European solar PV market shrunk massively and imports from China were banned, advocacy for supporting solar PV industry development through indigenous markets became stronger (Huang et al., 2016). In 2009, the central government initiated the "Golden Sun" project and the "Building Integrated PV" project to boost the domestic market for solar PV (Huang et al., 2016).

Since 2009, China encounters a rapid take-up of large-scale centralised solar power plants (Zhang et al., 2014). This was shaped by national solar PV manufacturing industry, together with local governments in the western part of China. They engaged in creating institutional work to address the regulative and normative pillars. To be specific, the types of institutional work that they adopted included: advocacy [C1], vesting [C3], constructed identities [C4], changed normative associations [C5] and constructed normative networks [C6]. The national solar PV industry association constructed that large-scale solar power plants could efficiently prevent desertification of the western provinces of China [C5]. They together with provincial governments lobbied the central government to support

centralised power system, arguing that the build-up of large-scale centralised solar PV power plants is an efficient way to support industry development [C1]. In 2010, the National Development and Reform Commission implemented concession projects to support 280MW large scale centralised power plants in western provinces (Inner Mongolia as one of them). At the same year, the central government denoted solar PV industry as a strategic emerging industry for a low-carbon economy. This set signals for social investors and also for local governments to support the industry [C4]. In the same year, the Chinese solar PV Industry Alliance was established, which reinforced solar PV industry's lobby power to influence national support policy (Huang et al., 2016) [C6]. From 2011, the central government set up national level feed-in tariffs for solar PV generated power [C3]. This further burgeoned the rapid deployment of large-scale power plants.

Since 2017, China witnessed a rapid increase of distributed solar PV (DSPV). This has been a result of both creating and disrupting institutional work entertained by both niche and regime actors especially in provincial level (Zhang, 2016a). This will be elaborated in section 4.3. The central government and niche actors, for example, disconnected market rewards for thermal power plants [D1], dissociated coal power from its moral foundation as the basic power for electricity [D2]. Coal power operators got challenged by the emerging requirement for moving towards a cleaner, greener and low-carbon energy sector. In 2016, the central government implemented the "Energy Supply and Consumption Revolution Strategy" policy, which capped coal power capacity by 2020 [D1]. "Clean and low carbon" have been articulated as the new vision for next generation energy system. In 2017, the National Energy Administration made a clear statement that "with the further transformation of the country's energy system, the future for coal power is to provide dispatching auxiliary service for renewable energy and to make space for renewable energy generation, while previously the function of thermal power was phrased as 'to guarantee the supply of electricity'" (Cableabc.com, 2018) [D2]. Therefore, the strategic position of coal power was fundamentally redefined. Moreover, in 2015, the central government issued "Several Opinions on Deepening Power Sector Reform (Zhongfa [2015] No. 9 document)" policy to launch a new round of liberalisation-oriented reforms of the electricity sector. This reform aims to refine the market mechanism, such as empowering new actors for the retail market, develop inter-regional and provincial trading markets, and building spot markets (Zhang et al., 2018). It thus exerted pressures which undermined the monopoly power of the state grid.

To respond to the challenge, regime actors (thermal power generators and grid companies) also proactively shape institutional change, through valorising and demonizing [M4]. In recent years, coal power regime actors publicly rebuild the good image of thermal power plants to maintain its strategic position in the electricity system. The coal power regime actors valorised the benefits of coal power plants as guaranteeing safety and stability of the electricity system, while, demonising the grid connection of solar PV as causing stability problems. Moreover, they argued that China's coal power plants have been much cleaner in terms of waste emissions compared to the level of 2013 (Lingnengzhe, 2019). Furthermore, coal power plants can offer more jobs compared to renewable energy (Zhao et al., 2013) [M4].

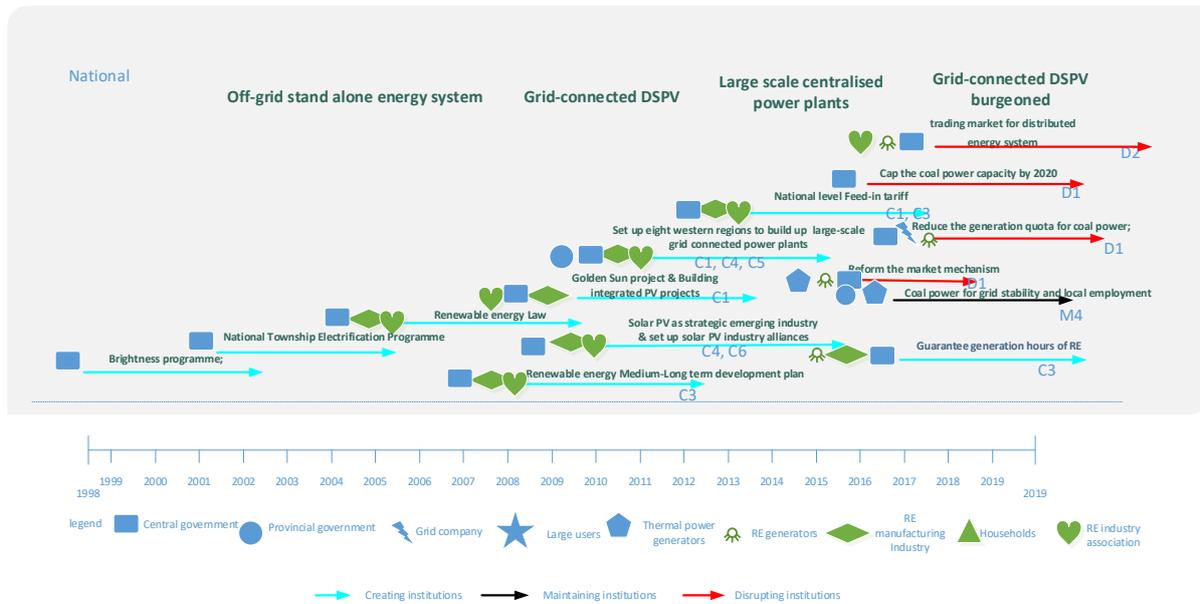


Fig. 4. Institutional work and historical institutional change for solar PV development at national level

4.2 Inner Mongolia: fit-and-conform pattern

Inner Mongolia is leading in China’s renewable energy deployment. By the end of 2017, renewable energy contributed to 15.52% of the province’s total electricity generation mix, of which solar, wind and hydropower contributed 2.55%, 12.45% and 0.53% respectively, while coal power contributed 84.47% (Data from the Inner Mongolia Electric Power Association). Solar PV was predominately installed in the form of large-scale centralised power plants. By the end of 2018, the total installed capacity of solar PV in Inner Mongolia was 9.45GW, of which 9.12GW (i.e. 97%) was in the form of centralised power plants [data from National Energy Administration].

The overall impact of PV on the electricity regime in Inner Mongolia can be characterized as following a fit-and-conform pattern. As depicted in Fig. 5, the deployment of solar PV in Inner Mongolia was shaped from early stage off-grid towards large-scale centralised power system. This has been shaped by different types of institutional work that leveraged by both niche and regime actors across different scales (both provincial and national level). The key regime actors involved in Inner Mongolia include the thermal power generators, the provincial grid companies¹, the provincial government, large users (represented as different shapes in blue colour in Fig. 5). The key niche actors include the solar PV manufacturing industry, solar PV installers and operators, and the solar PV industry association (represented as different shapes in green colour in Fig. 5).

Solar PV was initially targeted in Inner Mongolia to serve remote areas, which lack access to electricity (Li et al., 2007; Huo and Zhang, 2012; Zhang and He, 2013). This has been mainly supported by the central government’s rural electrification programmes (dotted arrow from national level to Inner Mongolia in Fig. 5). These demonstration programmes were predominately off-grid residential solar PV systems.

¹ There are two grid companies operated in Inner Mongolia, the State Grid Inner Mongolia Eastern Power and Inner Mongolia Power Group. They operated independently in the east and west part of Inner Mongolia respectively.

Since 2005, both national solar PV manufacturing industry and provincial government positioned Inner Mongolia as the perfect national site for large-scale solar power plants. They adopted different types of institutional work, such as lobbying [C1], vesting [C3], constructing identities [C4], changing normative associations [C5] and constructing normative networks [C6] to achieve this goal (see Fig. 5). In 2005, Inner Mongolian experts collaborated with national level research institutes in writing a report named “Inner Mongolia Energy Development Strategy Research” (Inner Mongolia local government, 2006). They pointed out that positioning Inner Mongolia as the national energy supply sites was the solution for national energy security concerns [C4]. As further advocated, solar PV was perceived as part of this strategy. The report furthermore argued that Inner Mongolia has decisive resource advantages with good solar incidence and large areas of available land, which is suitable for the installation of large-scale centralised PV power plants. These perceived advantages were mobilised by both the national solar PV industry association and also the Inner Mongolian provincial government to lobby the central government that Inner Mongolia should be prioritised for building large-scale solar power plants (Hu et al., 2004) [C1, C4]. According to the local policy advisory experts, “if we use half of the size of the desert in Inner Mongolia to build solar PV plants, then it can substitute electricity generation of all coal power plants across the country” (Inner Mongolia local government, 2006) [C5]. Moreover, the deployment of large-scale grid connected solar power plants was regarded as one of the key strategies to promote the province’s economic development and environmental benefits (China Economy Informatization, 2014). This fits the purpose of central government’s political agenda to support the economic left behind provinces in the western part of China (dotted arrow from Inner Mongolia to national level). The connection of solar PV with the national political agenda leveraged political legitimacy for central government support. In 2011, the central government identified Inner Mongolia as the national energy supply site as formulated in the policy document “Promote the Inner Mongolia Autonomous Region’s Economic and Social Development” (issued in 2011).

Since 2012, renewable energy encountered high curtailment issues in Inner Mongolia due to the stand-still of large scale solar and wind power plants, which caused huge economic losses (Zhao et al., 2012; Liu et al., 2018). In 2012, the curtailment rates of renewable energy reached above 10% in Inner Mongolia. This undermines the political legitimacy for central government’s support to the region as the site for instalment of large-scale renewable energy power plants. To relieve this pressure, the local regime actors argued that a strong national transmission grid was a prerequisite for rapidly increasing the clean energy share in the national electricity mix [C5]. When the value of green and low carbon was increasingly shared in society, grid companies mobilised the narrative of transmitting clean energy from Inner Mongolia to other regions to further lobby central government to support the construction of ultra-high voltage grids in order to consolidate the legitimacy of centralised power systems [C1]. The local electric power association expected that electricity demand would continuously grow in the southern part of China. Inner Mongolia could be the clean energy supplier for the country because of its rich renewable energy resource endowment [C6]. Furthermore, the large economies of scale of the massive deployment of PV panels was said to help achieving the cost target of grid parity [C5]. Aligning with national policy to relieve the above accelerated high curtailment problems of renewable energy (dotted arrow from national level to Inner Mongolia), in 2018, the provincial solar PV industry association implemented the “Actions to Reduce the Curtailment of Clean Energy in Inner Mongolia”, which aims to achieve zero curtailment of renewable energy by the end of 2020 [C3]. To achieve this and following the national level electricity sector’s reform (dotted arrow from national level to Inner

Mongolia), the provincial government formulated new policies, such as encouraging direct trade among renewable energy generators and large users to further consolidate the market advantages of the large-scale centralised power system [C6].

At later stage, we observe regime actors proactively mobilised maintaining institutional work to defend the thermal power dominated centralised power regime (black line in Fig. 5). The local regime actors (grid company and thermal power generators) adopted valorising and demonizing [M4] to maintain the legitimacy of large-scale power plants. Furthermore, strategies were adopted to encourage supply side flexibility optimisation, such as flexibility retrofit of coal power plants, and set-up auxiliary service markets [M2]. However, limited attention was given to demand side flexibility.

In summary, all the above referred institutional work mainly addressed regulative and normative pillar while less addressed the cognitive pillar. This has been confirmed by one of the local interviewees, who criticised the lack of cognitive change in the province: “If you treat wind and solar power the same as thermal power plants, and use the idea of managing the big thermal power plants to manage them, then it won’t work. Using the same rules and practices as building the big thermal power plants won’t suit the further development of solar and wind power in China” (workshop participant, 7 March 2018, Beijing).

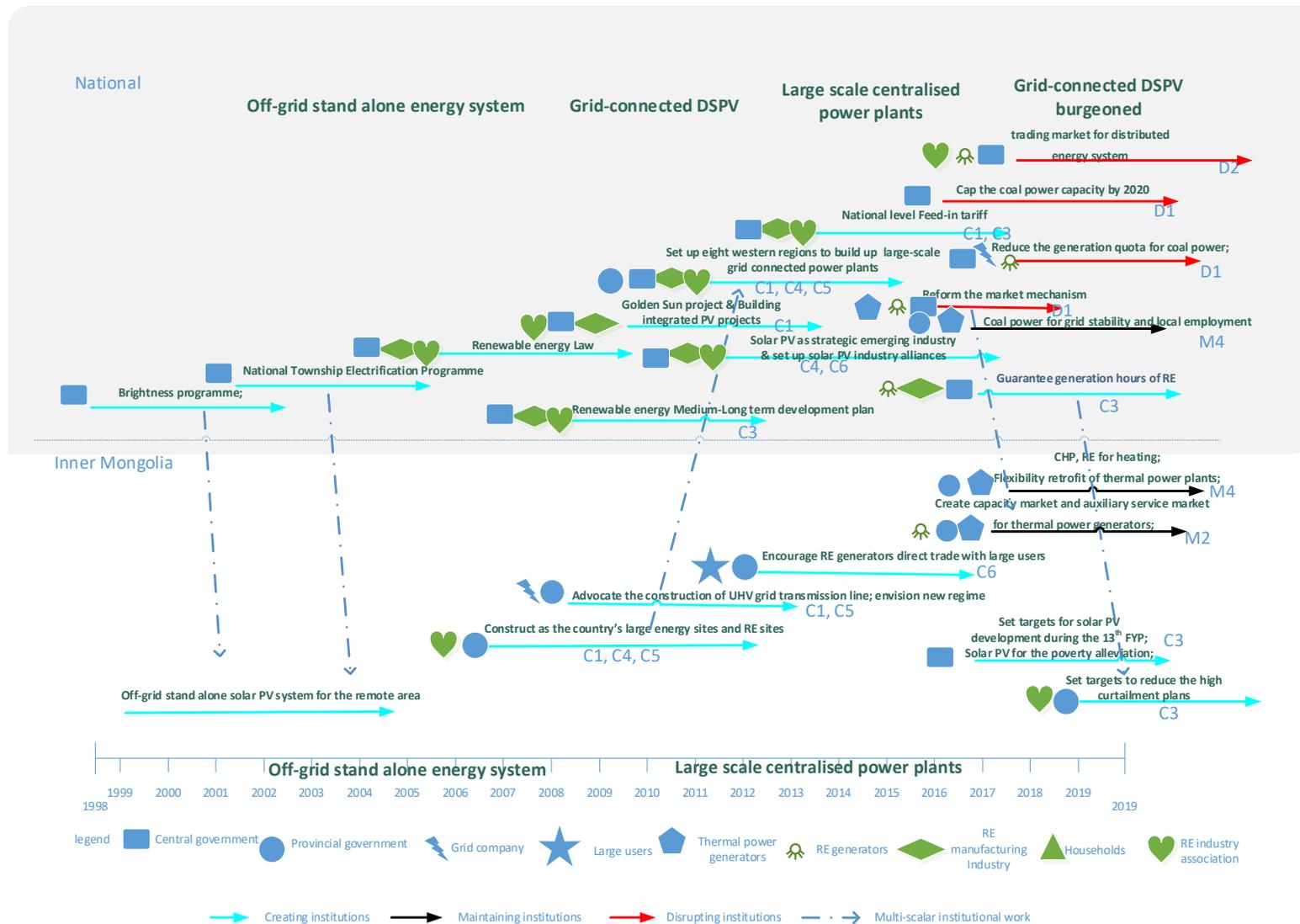


Fig. 5. Institutional work and historical institutional change for solar PV development in Inner Mongolia and national level

4.3 Jiangsu: stretch-and-transform pattern

Jiangsu province has been historically leading the country's installed capacity of DSPV. By the end of 2018, the total installed capacity of solar PV in Jiangsu province was 13.32GW, of which 40.5% is DSPV. The province is a national leader in DSPV as it represents 25.8% of the national DSPV cumulative capacity. Solar PV generation furthermore contributed 0.937%² to the province's electricity mix. Although this market share seems marginal, it has experienced rapid increase in the last decade.

Overall, DSPV has substantially "stretched and transformed" the local centralised power regime in Jiangsu. As presented in Fig.6, this has been shaped by different types of institutional work adopted by niche and regime actors address all three institutional pillars (cognitive, normative and regulative) across both provincial and national level. We observe actors adopted both creating (neon blue line in Fig. 6) and disrupting (red line in Fig. 6) institutional work. These portfolios of institutional work together fundamentally transformed the large-scale centralised power regime, which finally led to a stretch-and-transform pattern. The key regime actors involved in Jiangsu include the thermal power generators, the provincial grid company, and the provincial government (represented as different shapes in blue colour in Fig. 6). The key niche actors include the solar PV manufacturing industry, solar PV generators, small-medium sized solar PV installers, and the solar PV industry association (represented as different shapes in green colour in Fig. 6).

The local niche actors have been very actively shaping the institutions for the deployment of solar PV in the province. The main relevant types of institutional work include: lobby [C1], vesting [C3], constructing identities [C4], changing normative associations [C5], constructing normative networks [C6], theorising [C8] and educating [C9].

In the early 2000s, the local solar PV manufacturing enterprises, which are national leaders of this industry, proactively lobbied the local government to support solar PV deployment in the province (Li et al., 2007). Due to the then increasing electricity shortage problems in the province, solar PV was regarded as one of the solutions to supply clean electricity to the city. Local small and medium sized enterprises played a leading role to invest in PV, which made the region become the leader in the Chinese solar PV market (CIConsulting, 2010). Especially after the global economic crisis in 2008, the local solar PV manufacturing industry association proactively lobbied the provincial government to implement a feed-in tariff to nurture indigenous market so that to prevent large scale bankruptcies in the Chinese industry (Grau et al., 2012; Huo and Zhang, 2012). In 2009 the provincial government followed this advice (interview, president of Jiangsu provincial solar PV industry association, 21 Dec 2017, Nanjing) and set up the country's first provincial level feed-in tariff (see the policy "Opinions to promote solar power in Jiangsu province (江苏省光伏发电推进意见(苏政办发〔2009〕85号))" [C1, C3]. This exemplary provincial level policies also set the moral foundation for the later installed national level supportive policies (dash line with arrow from provincial level to national level in Fig. 6). The implementation of the provincial subsidy policy contributed massively to the rapid increase of installed PV capacity in Jiangsu. By the end of 2011, the province had installed 400MW of

² Calculated by the author= the generation from solar PV/ the provincial's total electric power generation. Note: The size of electricity demand in Jiangsu province is twice the size of Inner Mongolia. Although the market share of solar PV generation in Jiangsu province's electricity mix is smaller than Inner Mongolia, the scale of installed capacity of solar PV in Jiangsu province is larger than Inner Mongolia.

grid-connected solar PV (compared to 40 MW by the end of 2009), which contributed 20% of the country's total installed capacity in this year.

Moreover, the local solar PV investors theorised new futures of the energy system and constructed new identities and values for solar PV. Since 2014, the local solar PV investors, such as small and medium sized enterprises, and the local solar PV manufacturing industry constructed strong narratives that more localised energy should be used because it is more energy efficient [C5]. They argued that the deployment of renewable energy offers opportunities for the province to achieve a higher share of clean and green energy in the local electricity mix [C4, C5]. The deployment of distributed energy was perceived to hold a bright future in Jiangsu province. With limited available land, it has less advantage to deploy large-scale solar PV power plants. On the contrary, with its concentration of large electricity consumers, such as industrial parks, Jiangsu province is the perfect site to adopt distributed solar PV energy (China's Renewable Energy development outlook, 2017) [C8]. As a result, the provincial "13th Five-Year Plan for Energy Development (2016-2020)" portrayed DSPV as the main development pattern for Solar PV deployment in Jiangsu. This led to the local investors developed more diversified business models to promote further DSPV deployment (Zhang, 2016b) [C5]. Apart from rooftop based distributed solar PV, "solar PV +" business models emerged, such as "solar PV+ water-related affairs", "solar PV+ fishing", "solar PV+ agriculture", "solar PV+ transportation" (Statistical bureau of Jiangsu province, 2017).

Furthermore, the local solar PV investors collaborated with the municipal government to further demonstrate local experimentations to connect solar PV with broad social values. For example, in 2015, Yangzhong, one of the cities in Jiangsu province, set the goal to build 'China's Green Energy Island' (Sun, 2017), and set-up a special funding scheme to promote public building integrated and household rooftop based distributed solar PV. It demanded that by 2030, renewable energy should contribute 100% to the local energy consumption [C3, C5]. Another city, Zhenjiang also supported grid-connected building integrated solar PV systems considering it as the crucial strategy for low-carbon city development (Wang et al., 2015). In January 2014, the village located in Donghai County of Lianyungang municipality was the first demonstration programme with rooftop distributed solar PV systems connected to the grid in Jiangsu province. This local experimentation demonstrated the deployment of household solar PV energy systems as being a success case to contribute to an ecological lifestyle. It evaluated this programme to have saved 128 tons of coal and to cut down CO₂ emissions by 341 ton per year. The village soon became a national model for "ecological civilisation" and "beauty China" (Xinhua News Agency, 2014, 2018) [C5, C8].

Local solar PV installers also educated users to further promote the local diffusion of DSPV. For example, Wuxi municipal government worked together with the local solar PV installers to promote "solar PV enter households (光伏进万家-无锡)" activity. These educating activities enabled users to understand better about DSPV [C9]. These local solar PV installers also build heterogenous alignment network with local government and local grid company to explore the institutional support for DSPV deployment. These local networks enabled the local grid company to construct new identities for a next generation of power grids [C4, C5]. New values, flexibility and smartness, have been formulated. With the fast penetration of rapid increase of electric vehicles in the province, the local grid company confronted great challenges. The grid company believed that distributed energy systems could contribute to the resilience of the grid. This motivated them to construct a new identity in the future electricity system [C4]. As phrased by an interviewee from the grid company in Jiangsu: "the utilities need to change the perception of their identities in the electricity market from being CHP

(cooling, heating and power) providers to becoming energy service providers. This requires the grid company to provide more efficient energy services in order to respond to the diversified user demand. The age of the traditional one direction business model, from the grid company to the users, electricity transmission model will become the past” (project manager, 8 January 2019, Nanjing). In 2014, the grid company implemented the national first guidance for solar PV grid connection. This has been a big contrast to the situation in some other provinces where the grid company forbade self-generated solar PV power because they worried that it enables power to be sold to third parties or other consumers which could undermine their benefits. In Jiangsu, heterogenous actors between the local installers, local grid company and the local government have built wide networks for local experimentations which are a result of lobby from the local solar PV enterprises (interview, president of Jiangsu provincial solar PV industry association, 9 January 2019, Nanjing) [C1].

Moreover, we also observe niche actors enacting more visible disruptive institutional work at later stage in Jiangsu, which include disconnecting sanctions [D1], disassociating moral foundations [D2] and undermining assumptions and beliefs [D3]. Jiangsu province has been one of the leading provinces to implement the provincial policy to cap the provincial level coal power plants by 2020 (“263 action plan”, 2016) [D1]. Articulated by the local industry association, with rapidly decreasing panel cost, solar PV became more and more economically competitive. It could finally challenge the thermal power in the market [D2]. The narratives that distributed power generation near place of consumption could be more economic and energy efficient. This undermined the assumptions and beliefs about large-scale power plants and long-distance transmission line being more economically efficient or leading to more stable electricity provision [D3]. Under the background of national electricity sector’s reform (issued in 2015), the province adopted strategies such as peer to peer trading to encourage the deployment of DSPV (see the provincial policy “Market trade Guidance for DSPV generation (分布式发电市场化交易规则)”, 2019) (dash line with arrow from national level to provincial level). This allows the prosumers sell electricity independently to any consumers with a signed contract. It undermined the monopoly power of big utilities in the electricity retail market, which enables to further transform the thermal power dominated centralised power regime.

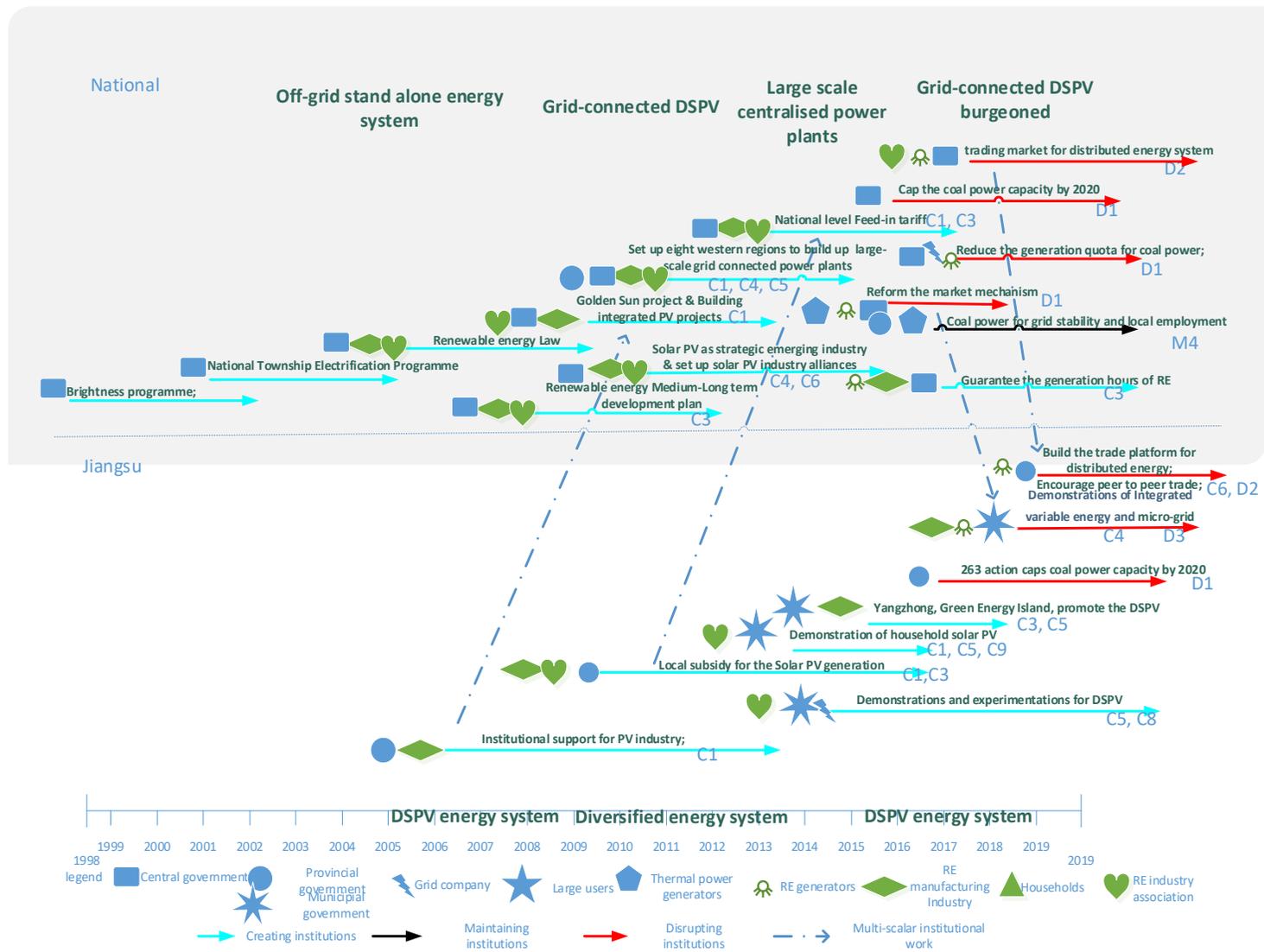


Fig. 6 Institutional work and historical institutional change for solar PV development in Jiangsu and national level

5. Discussion

In this section, we will discuss how niche and regime actors adopted different forms of institutional work by elaborating on three aspects: i) the portfolio of institutional work enacted; ii) the interactions between niche and regime actors; iii) the multi-scalar dimension of institutional work.

5.1 Portfolio of institutional work

Both our cases show that actors engaged in a rich array of institutional work identified in the literature. In other words, the institutional work portfolio differed substantially between the two provinces. In section 2, we categorised institutional work along two axes: institutional pillars (regulative, normative, cognitive ones) and types of institutional work (creating, maintaining and disrupting). In our case analyses presented in section 4, we mapped the portfolio for both provinces (see Fig. 5 and 6). This enables us to compare the portfolios of institutional work across cases. Table 3 summarises the various forms of institutional work presented different pillars by colour code.

Table 3. Divergent portfolio of institutional work in two provinces

	Forms of institutional work	Inner Mongolia	Jiangsu
Creating institutions	Advocacy	√	√
	Vesting	√	√
	Constructing identities	√	√
	Changing normative associations	√	√
	Constructing normative networks	√	√
	Theorising		√
	Educating		√
Maintaining institutions	Enabling	√	
	Policing	√	
	Valorising and demonizing	√	
Disrupting institutions	Disconnecting sanctions		√
	Disassociating moral foundations		√
	Undermining assumptions and beliefs		√

Legend: √ indicates that we observe actors adopt the corresponding form of institutional work.

Light background blue colour corresponds to the regulative pillar;

Light background orange colour corresponds to the normative pillar;

Light background pink colour corresponds to the cognitive pillar.

The Jiangsu case shows that the stretch-and-transform pattern corresponded to actors adopting a portfolio of creating and disrupting institutional work (ignoring maintaining work), while addressing all three institutional pillars. We characterise the portfolio using the three pillars as an entry point. The Jiangsu actors shaped the **cognitive** pillar through theorising and educating (along the creating institutions axis) and through undermining assumptions and beliefs (along the disrupting institutions axis) (see table 3). Niche actors educated users and theorised by voicing expectations on how future solar PV system would fit in a radically transformed electricity system based on more localised and energy efficient distributed generation. This undermined core assumptions and beliefs of the regime, namely that the primary task of the sector is to rely on cost-efficient large-scale centralised power plants, and hence long distance transmission lines. Second, the niche actors were also providing moral and cultural foundations for the de-centralised system (work belonging to the creation of institutions focusing on the **normative** pillar) and disassociated the moral foundations of thermal power plants (disrupting institutions with a strong normative pillar). The local solar PV industry -- especially the small medium sized enterprises -- actively constructed and mobilised normative and positive associations between solar PV and a local low carbon and green energy system while thermal power was criticised as unsustainable. Other work belonging to the normative pillar consisted of mobilizing

support for new business models that defined new identities to regime actors as energy service suppliers and build networks for new institutional support for distributed solar PV energy system. For instance, peer-to-peer trading schemes allowed prosumers sell surplus electricity to other users and therefore encroached on the established business model of the centralised grid company. Finally, we observe that local actors (local government, solar PV generators) also engaged in a mixture of creating and disrupting institutional work to reshape the **regulative pillar**. Local solar PV associations lobbied the provincial government for subsidies and other support resulting in vesting of targets and subsidies by the province (along creating institutions axis). The provincial government also disconnected sanctions for coal power plants, which includes capping coal power plans and reducing their subsidies (along disrupting institutions axis).

The Inner Mongolia case shows that a fit-and-conform transition pattern is more likely when actors adopt a portfolio of creating and maintaining institutional work and privilege the regulative and normative institutional pillar.

Inner Mongolia actors shaped the **normative** pillar through changing normative associations, constructing normative associations and networks (along the creating institutions axis) and valorised the centralised power plants and demonizing decentralised power plants (along the maintaining institutional work axis). Inner Mongolia niche actors constructed normative associations of solar PV to the green and low-carbon values. As green and low-carbon visions became widely shared in society, the local regime actors actively adapted their grid development strategy to accommodate for an increasing share of renewable energy in the electricity mix. However, the Inner Mongolian grid company argued that the integration of solar power in the local grid would undermine the stability to further integrate solar energy to the large-scale centralised system. Moreover, the local regime actors adopted advocacy, vesting (along creating institutional work), enabling and policing (along maintaining institutional work) to address the **regulative** pillar. More specifically, the regional Grid company strongly argued in favour of building more long-distance transmission lines in order to transmit clean energy from Inner Mongolia to other Chinese regions. Also, the local government encouraged the direct trade between large scale renewable energy generators and large-scale electricity users. This established new market relationships further consolidated the large-scale centralised power system. These forms of institutional work forcefully 'fit' the development patterns of solar PV in order to 'conform' to the centralised system logics. Compared to Jiangsu, there has been less institutional work related to the cognitive pillar. Although Inner Mongolia articulated the strategic role of renewable energy for a future green, low-carbon energy system, the local actors were less eager to confront some fundamental problems of the existing centralised energy system. For instance, to address the high curtailment problems of the centralised renewable energy plants in the region, the local solar PV industry association formulated target oriented regulative measures to encourage more integration of solar PV in the centralised power grid, instead of criticising the lacking flexibility of the existing electricity system.

Two differences between two cases stand out. We have formulated them in terms of propositions about generalised relationships that we would expect to find also in other cases:

P1: The directionality of a transition will more likely follow a stretch-and-transform pattern if niche and regime actors adopt a portfolio of institutional work that consists of both creating and disrupting institutional work (while ignoring maintaining institutional work) and address all three institutional pillars.

P2: The directionality of a transition will more likely follow a fit-and-conform pattern if actors focus on creating and maintaining institutional work (while neglecting disrupting institutional work) and address both regulative and normative institutional pillars.

In both propositions we do not make a distinction between niche and regime actors, in fact in section 4 we have shown they both engage in various types of institutional work. This begs the questions about their identities and relationships.

5.2 Niche-regime interactions

Remarkably both our cases show that niche and regime actors can adopt very diverse types of institutional work: creating, maintaining, disrupting (see Fig. 5 and Fig. 6). For example, in the case of Inner Mongolia, we saw that regime actors (the local government and the local grid company) engaged in creating institutional work, contributing to the development of solar PV, while they also developed maintaining institutional work to further consolidate the legitimacy of centralised power plants. This contrasts with the conventional understanding in transition studies where niche actors are mostly supposed to focus on niche creation and regime actors prefer to maintain the prevailing rule systems. The conventional view sees the fit-and-conform and stretch-and-transform as essentially unidirectional processes, which suppose niche actors to either 'fit' to or 'stretch' the regime. We conclude from our study that the directionality should better be understood as a bidirectional process shaped by both niche and regime actors (this resonates by recent studies (Mylan, Morris et al., 2019)).

However, in our cases there is still a difference in terms of outcome. In Inner Mongolia regime actors were leading the institutional work that led to a fit-and-conform pattern, while in Jiangsu the institutional work was dominated by niche actors and resulted in a stretch-and-transform pattern. This dominance of either regime or niche actor is rather obvious in our cases. In general, we argue however that we have to look beyond the dominance of either niche or regime actors. Instead we should focus on niche-regime interactions.

In the case of Jiangsu province, we observe substantial local experimentations developed in networks of niche and regime actors. Niche actors are large solar panel manufacturers, and a large numbers of local solar PV installers. These local small and medium sized enterprises held close interactions with the local municipal government, which enabled them to gain local government support for experimenting with distributed solar PV. Moreover, the provincial industry association was able to communicate with the provincial government about the needs of the PV industry, which led to the adaptation of local institutions to the needs of solar PV. In Inner Mongolia, the niche-regime interaction was happening as well, but was not leading to any positive synergies in terms of institutional work. Some local niche actors (local solar PV generators) initiated disruptive institutional work. But they were unable to collaborate with regime actors who perceived limited promise to engage proactively in decentralised PV. This lack of niche-regime interactions shaped the movement towards a fit-and-conform pattern. In more general terms, we propose the following proposition:

P3: Stretch-and-transform patterns are more likely if niche actors play a leading role in shaping institutional change working with regime actors, while fit-and-conform patterns are more likely when regime actors play a leading role, and are in the position to ignore the disruptive institutional work of niche actors.

5.3 The multi-scalar dimension of institutional work

As a third aspect of conceptual refinement of the institutional work perspective, we identified the need to look at the multi-scalar dimensions. In our case, this relates mostly to the way actors selectively interpret or intentionally shape institutions at national level in order to support the respective transition directions at the provincial level. Two key insights can be generated from our analysis.

First, local actors proactively leveraged opportunities that resulted from the different niche and regime structures in the two regions (see dotted arrow from national level to provincial level in Fig. 5 and Fig. 6). We observe that local actors selectively mobilised national context conditions (policies, visions, infrastructures) to achieve their preferred regional transition directions. For example, Jiangsu intentionally emphasized the liberalisation-oriented electricity reform in order to open windows of opportunity for small medium sized enterprises, while Inner Mongolia mobilised the national development strategy for the western provinces to position itself as the leading clean energy supplier in China. This created the legitimacy for Inner Mongolia to build up the ultra-high voltage infrastructure for more centralised large-scale power plants.

Moreover, the two provinces interpreted national policies differently in order to encourage experimentation with different forms of solar PV integration into the grid. In the new round electricity sector's reform (No.9 document), different provinces adopted divergent local experimentations. Jiangsu actors chose more disruptive market mechanisms, for example, encouraging peer-to-peer trading mechanisms, to support the deployment of distributed solar PV. Inner Mongolia mainly aimed for market mechanisms to maintain the centralised power system, such as those required for cross-regional trade, which imply long distance transmission of electricity. Moreover, it encouraged direct trade of renewable energy with large users, and build-up auxiliary service markets for thermal power plants to further protect the market advantages of large-scale power plants (Liu and Tan, 2016).

Secondly, provincial actors not only proactively mobilised external resources to fulfil the local energy vision, they also enacted different forms of institutional work to shape conditions at the national level, in order to support their preferred transition directions (see dotted arrow from provincial level to national level in Fig. 5 and Fig. 6). For example, Inner Mongolian actors directly lobbied the central government to position the region as the country's predominant energy producer. The close network between the central and the local government of the western part of China enabled the mobilisation of national resources to achieve the regional targets. This is in line with similar strategies observed for the case of wind power (Hu, 2014).

Moreover, large manufacturing enterprises shaped institutional change across different scales. For example, the large solar panel manufacturers in Jiangsu province, such as Trina Solar, Xiexin, Suntech, have been actively shaping both the provincial but also the national level policies. In 2010, these big players together with other partners built up the Chinese solar PV Industry Alliance, which reinforced their power to lobby for national solar PV supportive policy, such as domestic feed-in tariffs (Huang et al., 2016). The strong capability of these local actors in Jiangsu province enables the region to adopt a preference for distributed solar PV energy system even before the central government opens up to this priority before 2013.

The importance of multi-scalar institutional work in these two provinces challenges the conventional understanding of China's renewable energy development as a process steered by central government.

Most existing studies portray China’s rapid renewable energy deployment as resulting from central authorities’ active intervention to nurture domestic market and domestic industry (Lewis, 2013; Harrison and Kostka, 2014; Mathews, 2014; Hochstetler and Kostka, 2015; Chen and Lees, 2016; Korsnes, 2019). However, our two cases indicate that the two provinces’ divergent transition patterns are the outcome of interactive process between niche and regime actors across multiple scales (provincial and national level) to intentionally shape socio-technical development. We translate this finding into our final general proposition:

P4: Institutional work has a multi-scalar dimension that should be taken into consideration, it will influence the directionality of the transition in terms of emergence of a fit-and-conform or stretch-and-transform pattern.

5.4 Towards a potential conceptual framework: co-evolve process among three key aspects

The above research findings suggest the three aspects we have selected to focus on in our research on the role of institutional work in shaping the directionality of transitions all matters. We have summarized this finding in 4 propositions (see table 4).

Table 4. Propositions on how portfolios of institutional work adopted by niche and regime actors across spatial boundaries shapes the direction of sustainability transition in terms of fit-and-conform and stretch-and-transform pattern.

Three aspects	Propositions
Portfolio of institutional work	<p>P1: The directionality of a transition pattern will more likely follow a stretch-and-transform pattern if niche and regime actors adopt a portfolio of institutional work that consists of both creating and disrupting institutional work (while ignoring maintaining institutional work) and address all three institutional pillars.</p> <p>P2: The directionality of a transition pattern will more likely follow a fit-and-conform pattern if actors focus on creating and maintaining institutional work (while neglecting disrupting institutional work) and address both regulative and normative institutional pillars.</p>
Niche and regime interactions	<p>P3: Stretch-and-transform patterns are more likely if niche actors play a leading role in shaping institutional change working with regime actors, while fit-and-conform patterns are more likely when regime actors play a leading role, and are in the position to ignore the disruptive institutional work of niche actors.</p>
Multi-scalar of institutional work	<p>P4: Institutional work has a multi-scalar dimension that should be taken into consideration, it will influence the directionality of the transition in terms of emergence of a fit-and-conform or stretch-and-transform pattern.</p>

We suggest that these propositions covering three key aspects can be seen as a new conceptual framework to be used in other studies when to understand how actors adopt institutional work to shape divergent directions of sustainability transitions. The portfolios of institutional work adopted by niche and regime actors matters, taking into account how they cross both spatial and niche and regime boundaries. The relationship between these aspects co-evolve during the process. In other words, it can be formulated as follows (see Fig. 7): the directionality of a sustainability transition in terms of fit-and-conform and stretch-and-transform need a portfolio of institutional work executed by both niche and regime actors, who mobilise not only regional and local contexts but also national developments. We can add global ones, although they were not studied by us.

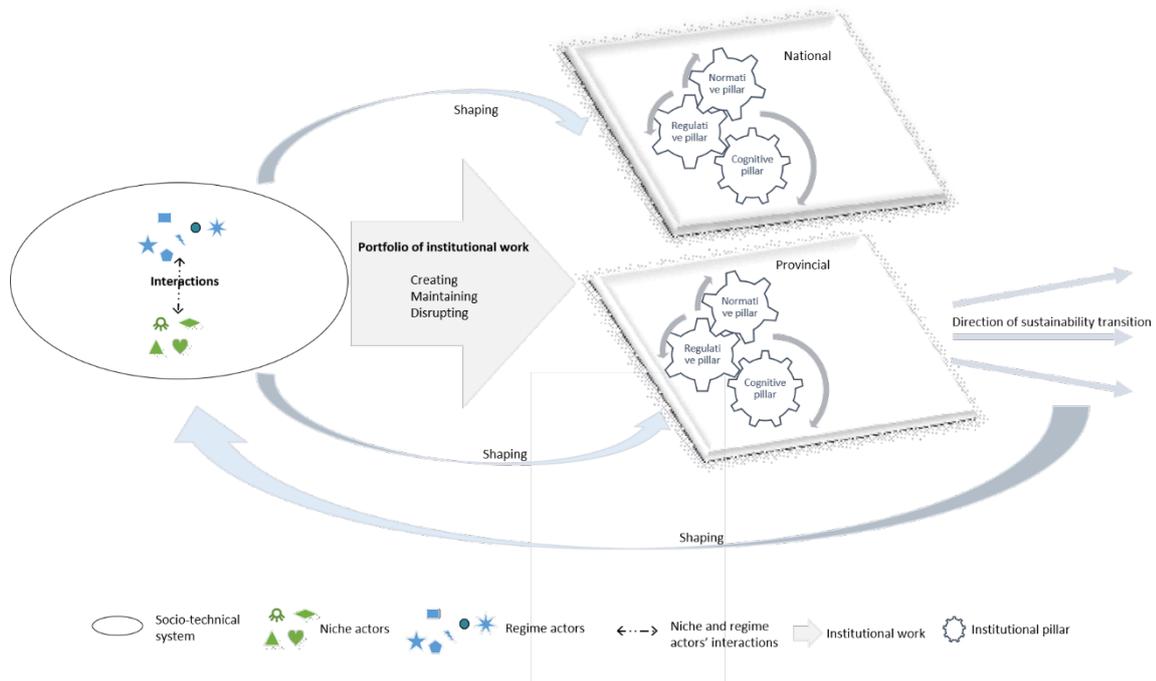


Fig. 7. Actors adopt portfolio of institutional work shaping directionality of sustainability transitions

6. Conclusion

This paper aims to investigate how institutional work adopted by niche and regime actors shapes the directionality of sustainability transitions in terms of fit-and-conform and stretch-and-transform patterns. Based on two strands of literature, sustainability transitions and institutional work studies, we have developed a more symmetrical analysis of niche and regime actors' interactions. Instead of assuming the conventional niche actors oriented niche development and regime actors resist to change, we trace how niche and regime actors adopt different portfolios of institutional work to shape the process of socio-technical change. Moreover, we develop a more spatially sensitive concept of multi-scalar institutional work to capture how niche and regime actors shape regional divergent directions of sustainability transition. The article led to the formulation of four general propositions that have crucial policy implications. The policies aiming for more transformative change should nurture more heterogenous actors to work collectively to shape institutional change across all three institutional pillars. Especially our studies indicate the build-up of shared visions across niche and regime actors is key, and when these shared visions allow for a leading role of niche actors combined with openings for new roles and identities of core regime actors, the emergence of a stretch-and-transform pattern is more likely.

We suggest these four propositions can be tested in follow-up studies. More comparative case studies could be conducted to be able to build a comprehensive overview of types of institutional work that are mobilised for a variety of contexts and systems. This study focused on the specific Chinese solar PV case. In general, the type of institutional work, the role of niche and regime actors and how the multi-scalar works out may be different in other socio-technical systems and contexts. Moreover, our

studies indicated that sustainability transitions literature could also contribute substantially to the institutional work literature. Future studies could develop a systematic review of institutional work employed by actors in the field of sustainability transition studies. This could complement the listed institutional work identified in the field of institutional theory in organisational studies, on which this article is based.

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Appendix

Table A.1. List of interviewees' organisations and interview date

Date	Organisations
16 Oct 2017	Greenpeace (2experts)
18 Oct 2017	North China Electric Power University
22 Oct 2017	Longyuan, Guodian Corp.(one of the big 5 generators) Focus group with three experts
4 Nov 2017	China Guangdong Nuclear Power Company, (SOE, power generator)
10 Nov 2017	Research institute of NDRC (government affiliated)
14 Nov 2017	Renewable Energy research centre, Research institute of NDRC
18 Nov 2017	Energy research institute of National grid company
18 Nov 2017	Chinese Academy of Sciences (decentralised energy system researcher & policy consultancy and directly involved into policy making)
1 Dec 2017	National Energy Investment Corp. (the merge of Guodian and Shenhua- the biggest coal power company in China)
14 Dec 2017	Renewable Energy research centre, Research institute of NDRC
20 Dec 2017	(S&T) Local government of Jiangsu
21 Dec 2017	Solar power industry association of Jiangsu province
22 Dec 2017	Renewable Energy association of Jiangsu province (focus group with 4 experts)
27 Dec 2017	National Laboratory of Trina Solar (S&T and innovation)
31 Dec 2017	Xi'an Jiaotong-Liverpool University (researcher)
7 Jan 2018	Renewable Energy research institute of National Grid company
10 Jan 2018	Electric power industry association of Jiangsu province
12 Jan 2018	CAS (decentralised energy system researcher & policy consultancy)
23 Jan 2018	Solar PV manufacturing firm on Micro-inverter for Solar PV
23 Jan 2018	Vice Secretary in General of solar PV industry association
3 Feb 2018	Renewable Energy research institute of National Grid company
7 Mar 2018	Workshop at CASTED
16 Mar 2018	Workshop at CASTED (largely focus on role of climate change for China's Renewable Energy development, and the role of China's Renewable Energy development for the mitigation of climate change)
27 Dec 2018	North China Electric Power University
29 Dec 2018	Tsinghua University

	(researchers who have conducted different initiatives for solar PV development)
8 Jan 2019	Solar power industry association of Jiangsu province; (Follow-up interview)
8 Jan 2019	Jiangsu Grid company;
8 Jan 2019	Decentralised energy system and storage company and experts (solar PV and Renewable Energy in general) from the Renewable Energy industry association of Jiangsu province (focus group with three experts)
9 Jan 2019	Solar PV generator; Distributed solar PV investor and storage company; Big data and Internet of Things- company; (focus group with three experts)
10 Jan 2019	Local installer company; Local government official from Changzhou, Jiangsu province; (focus group with two experts)
10 Jan 2019	Trina Solar- strategic development experts
11 Jan 2019	Micro-inverter for solar power system
11 Jan 2019	Trina Solar- leader on the distributed energy system and storage group;
17 Jan 2019	Trina Solar- expert on the company's strategic plans;
22 Jan 2019	Renewable Energy industry association of Inner Mongolia
23 Jan 2019	focus group (4 experts, local government, solar PV manufacturing industry association; solar PV investor, Grid company from Inner Mongolia)

Table A.2. Coding structures of institutional work

	Forms of institutional work	Codes
Creating	Advocacy	C1
	Defining	C2
	Vesting	C3
	Constructing identities	C4
	Changing normative associations	C5
	Constructing normative networks	C6
	Mimicry	C7
	Theorizing	C8
	Educating	C9
Maintaining	Enabling work	M1
	Policing	M2
	Deterring	M3
	Valorising and demonizing	M4
	Mythologizing	M5
	Embedding and routinizing	M6
Disrupting	Disconnecting sanctions	D1
	Disassociating moral foundations	D2
	Undermining assumptions and beliefs	D3

Table A.3. Portfolios of institutional work adopted by actors shaping solar PV development at national and two provincial level

	Forms of institutional work	National level	Inner Mongolia	Jiangsu
Creating institutions	<p>Advocacy: The mobilisation of political and regulatory support through direct and deliberate techniques of social suasion</p>	Solar PV associations lobby central government to support the industry development;	<p>Provincial government and national solar PV industry association, local grid company, lobby central government to support large-scale centralised power plants deployed in the province.</p> <p>In 2016- when the central government put stringent policy which cancel the construction of new coal power plants in Inner Mongolia, provincial government and thermal power companies lobby the central government to cancel the regulation of thermal power in the region.</p>	Local solar PV industry association lobby provincial government to set up subsidy and other support for the local solar PV deployment.
	<p>Defining The construction of rule systems that confer status or identity, define boundaries of membership or create status hierarchies within a field;</p>	Not present	Not present	Not present
	<p>Vesting The creation of rule structures that confer property rights</p>	In 2007 the medium-long term renewable development plan- set up mandatory quota which requires the conventional utilities to install certain proportion of renewable energy in their capacity portfolio, also requires the grid company to purchase all the renewable energy generation.	Provincial government set targets for solar PV deployment; provincial solar PV industry association set targets to encourage the integration of solar PV into grid to solve the high curtailment issues;)	Apart from setting up targets for solar PV deployment, the province set up the provincial level subsidy for solar PV deployment.
	<p>Normative pillar Constructing identities (defining the relationship between an actor and the field in which an actor operates)</p>	In 2010, central government denoted the solar PV industry as the strategic emerging industry.	Inner Mongolia -was constructed as the country's large clean energy sites which offers to supply clean energy to other provinces - this helps to re-define their relations between the other provinces.	Provincial grid company construct their new identities as the service supplier instead of energy products supplier in the envisioned future energy system;

<p>Changing normative associations (re-making the connections between sets of practices and the moral and cultural foundations of these practices)</p>	<p>Solar PV manufacturing and local governments reconnected the normative associations between the deployment of large-scale solar PV power plants with the desertification prevention.</p>	<p>Provincial government reconstructed the region as the national clean energy supplier- instead of just the large energy supplier- this fits the increasing environmental concerns and the legitimacy of the clean and low-carbon in the society. Regime actors, for example, the grid company and the provincial government advocating the national government to support the construction of UHV which could help the transmission of clean renewable energy from the province to other regions. Niche actors also construct the normative association of solar PV for clean and low-carbon development with the environmental concerns, and later on re-construct new value- solar PV for poverty alleviation.</p>	<p>Local solar PV association changed the normative association of the distributed solar PV system from improving the green and low carbon energy system to also improve the grid resilience to respond to the fluctuating demand.</p>
<p>Constructing normative networks (Constructing of interorganisational connections through which practices become normatively sanctioned and which form the relevant peer group with respect to compliance, monitoring and evaluation) [for example, construct the new business model;]</p>	<p>National solar PV manufacturing industry constructed different business models to promote solar PV deployment, for example, solar PV + model- which refers to the solar PV together with agriculture/ fishing etc. business models</p>	<p>Provincial government encouraged direct trade of large generators with the large users, this construct new networks between generators and users, this undermines the conventional monopoly power of grid company, but also encourage the incentives for the power generators to build more economic efficient large scale centralised power plants.)</p>	<p>The province experimented peer to peer trading which is also based on the legitimacy that encourages the liberalisation-oriented electricity sector reform.</p>
<p>Cognitive Mimicry (Associating new practices with existing sets of taken-for-granted practices, technologies and rules in order to ease adoption)</p>		<p>Not present</p>	<p>Not present</p>
<p>Theorising (The development and specification of abstract categories and the elaboration of chains of cause and effect)</p>		<p>Not present</p>	<p>Demonstrating the village with the installation of the distributed solar PV system as the national model for the ecological development, connect with the broad value of 'ecological civilisation' and 'beauty China'.</p>

	Educating (The educating of actors in skills and knowledge necessary to support the new institution)		Not present	Local EPC (engineering, procurement and construction (EPC)) solar PV companies educate users what DSPV is to promote the local diffusion. These EPC companies together with local government and also the local grid company to manage the risks of grid connections with distributed solar PV system through doing experimentations.
Maintaining institutions	Enabling work (The creation of rules that facilitate, supplement and support institutions, such as the creation of authorizing agents or diverting resources;)	The grid company introduced the grid connection standards for solar PV integration.	Local provincial government encourages capacity market and auxiliary service for thermal power to further enforce the centralised power system. This enables the coal power plants get motivation to provide the auxiliary service for renewable energy. This also build the new moral connections between thermal power plants and renewable energy- that thermal power can provide auxiliary service for renewable energy to keep grid stability.	Not present
	Policing (ensuring compliance through enforcement, auditing and monitoring)		Both the central government and the local solar PV industry association set up the targets-oriented policy to guarantee the renewable energy integration.	Not present
	Deterring (Establishing coercive barriers to institutional change)		Not present	Not present
	Valorising and demonizing (Providing for public consumption positive and negative examples that illustrate the normative foundations of an institution)		The provincial grid company demonised the integration of solar PV into the grid which will cause less stability problems. The coal power regime actors valorised the benefits of coal power plants which is clean with technology improvement and can attribute to the safety and stability of electricity system and also the local employment.	Not present
	Mythologizing (Preserving the normative underpinnings of an institution by creating and sustaining myths regarding its history)		Not present	Not present

	Embedding and routinizing (Actively infusing the normative foundations of an institution into the participants day to day routines and organizational practice)		Not present	Not present
Disrupting institutions	Regulative pillar Disconnecting sanctions (Working through state apparatus to disconnect rewards and sanctions from some set of practices, technologies or rules)	Central government capped the coal power capacity by 2020; Central government implemented the policy to gradually cancel the annual generation quote of thermal power.	Not present	Provincial government implemented such as the 263 policy to cap the coal power plants in 2020.
	Disassociating moral foundations (Disassociating the practice, rule or technology from its moral foundation as appropriate within a specific cultural context)	Disassociating the dominate position of coal power in the future energy system with the environmental concern; Central government reform the electricity market- based on the legitimacy of introducing the competition in the retailing market. – this undermines the monopoly power of the grid company;	Not present	The local solar PV investors disassociated moral foundation of coal power plants for the stability of grid- while encouraged the integration of clean and low-carbon energy towards more local energy efficient and environment friendly distributed energy system.
	Undermining assumptions and beliefs (Decreasing the perceived risks of innovation and differentiation by undermining core assumptions and beliefs)		Not present	Provincial solar PV association and local solar PV investors encouraged deployment of more distributed energy system and undermined the assumption and beliefs of the economic efficiency of large-scale long-distance transmission line.

Legend: Light background blue colour corresponds to the regulative pillar;

Light background orange colour corresponds to the normative pillar;

Light background pink colour corresponds to the cognitive pillar.

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