Technological Forecasting & Social Change 103 (2016) 298–312

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

The interplay of institutions, actors and technologies in socio-technical systems — An analysis of transformations in the Australian urban water sector

Lea Fuenfschilling [a,*], Bernhard Truffer [b,c]

[a] Lund University, Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), P.O. Box 117, 22100 Lund, Sweden
[b] Eawag, Swiss Federal Institute of Aquatic Science and Technology, Environmental Social Sciences, Ueberlandstrasse 133, 8600 Duebendorf, Switzerland
[c] Faculty of Geosciences, University of Utrecht, Heidelberglaan 2, NL-3584 CS Utrecht, The Netherlands

ARTICLE INFO

Article history:
Received 31 March 2015
Received in revised form 19 November 2015
Accepted 20 November 2015
Available online 7 December 2015

Keywords:
Sustainability transitions
Embedded agency
Socio-technical change
Institutional work
Desalination
Australia

ABSTRACT

Literature on socio-technical transitions has primarily emphasized the co-determination of institutions and technologies. In this paper, we want to focus on how actors play a mediating role between these two pillars of a socio-technical system. By introducing the theoretical concept of institutional work, we contribute to the conceptualization and empirical assessment of agency processes in socio-technical systems. We illustrate this approach by analyzing recent developments in the Australian urban water sector, where seawater desalination technology has experienced an unexpected, but rapid diffusion to all major cities, often interpreted as a reaction to a major multi-year drought. However, the drought broke and left all but one plant unused. This has led many commentators wonder how such a massive investment – which is likely to limit alternative development trajectories in the sector for the coming decades – could have happened so quickly and why other, potentially more sustainable technologies, have not been able to use the momentum of the crisis to break through. A comparative analysis between seawater desalination and its main rival wastewater recycling in regard to processes of institutional work provides valuable insight into how technology, actors and institutions mutually shaped each other.

1. Introduction

The question of how to influence socio-technical systems towards more sustainable consumption and production patterns has become a major focus in many industries and is also gaining increasing importance in politics and society in general. In recent years, literature on sustainability transitions has become influential in the analysis of such long-term change processes, taking up a socio-technical systems perspective (Markard et al., 2012; van den Bergh et al., 2011). One of the central theoretical concepts elaborated in this realm is the socio-technical regime (Dosi, 1982; Geels, 2002; Nelson and Winter, 1982; Rip and Kemp, 1998; Smith et al., 2005). It investigates the co-evolution of institutional and technological elements into a highly institutionalized configuration that enables the fulfillment of specific societal functions (e.g. water and energy provision).

In recent years, the theoretical conceptualization of the socio-technical regime has undergone an institutional turn. Scholars have increasingly drawn on concepts from institutional theory in order to describe the norms and rules that stabilize a socio-technical system (Geels, 2004). Using the three institutional pillars by Scott (2001), the regime has been described as the highly institutionalized regulative, normative and cognitive structures, e.g. norms, standards, values, cultural expectations or regulations, which have evolved in accordance with certain technologies. More recently, the strength of socio-technical regimes, i.e. its structuring effect on actors and technologies, has been analyzed using the concept of institutional logics (Fuenfschilling and Truffer, 2014). As a consequence of the institutional turn in socio-technical regime research, transitions can essentially be interpreted as processes of institutional change with a particular attention to technologies. Formerly dominant regimes are being de-institutionalized and getting gradually replaced by an originally only loosely institutionalized alternative socio-technical configuration.

To date, the focus of many analyses has been on the rigidity and inertia of socio-technical systems that results out of the historically grown co-alignment of technologies and institutions. Radical change, on the other hand, has often been conceptualized as being triggered by extreme events that are expected to lead to an imminent and fundamental destabilization of established structures, which in turn enables the maturation and break-through of alternative technological paradigms (Geels and Schot, 2007; Smith et al., 2005). Recent critical reviews of the transitions literature have suggested that this view is probably only accurate for a few potential transition trajectories. Endogenous and gradual processes taking place within socio-technical systems therefore deserve more attention (Dolata, 2011; Genus and Coles, 2008; Markard and Truffer, 2008; Shove and Gordon, 2007; Smith

* Corresponding author.
E-mail address: lea.fuenfschilling@circle.lu.se (L. Fuenfschilling).

http://dx.doi.org/10.1016/j.techfore.2015.11.023
0040-1625/

et al., 2010). One of the main current theoretical debates in transition studies thus revolves around the question of how to more explicitly conceptualize and integrate actors and agency into the study of socio-technical transitions.

The challenge inherent in conceptualizing agency without ignoring the obvious effects of highly institutionalized system structures (widely known as the problem of embedded agency) can be regarded as one of the fundamental paradoxes in social sciences. Accordingly, much research has been undertaken that shows how processes of embedded agency could be conceptualized and what effect they have on institutional change. In the following, we will draw on insights from institutional theory to tackle these questions.

Since the seminal work by Berger and Luckmann (1966), it is commonly acknowledged that institutions are socially constructed. By looking at the process of how this social construction unfolds, embedded agency and its relevance for institutional change are put forward. One of the central approaches in this regard has been labeled *institutional work*. It analyses and categorizes actions by actors that aim at the creation, maintenance or disruptions of institutions (Lawrence and Suddaby, 2006; Lawrence et al., 2009) and thus shows how processes of (de-)institutionalization unfold. However, the approach explicitly refrains from adopting a methodological individualism with a rational, hyper-muscular entrepreneur (a problem that haunts much of the institutional entrepreneurship literature). Instead, it focuses on how agency is shaped by the institutional environment but nevertheless effective in processes of change and maintenance. We argue that this concept is therefore fruitful to characterize and analyze the endogenous processes in a socio-technical system. In particular, it shows how actors interact with their institutional context and how they deal with the institutional plurality in a socio-technical regime.[1]

By focusing on institutional work, we do not want to state that actors and their actions have so far entirely been neglected in empirical transition studies. Several aspects of embedded agency have been addressed in earlier research. Examples are studies about the role of power or social movements in bringing about change (Avelino and Rotmans, 2011; Ornetzeder and Rohracher, 2013), in work regarding transition management and governance issues (Loorbach and Rotmans, 2010; Smith et al., 2014; Weber and Rohracher, 2012), in the realm of firm strategies that purposefully foster or hinder innovation and change (Musiolik et al., 2012; Turnheim and Geels, 2013) or in the context of influencing sectoral discourses and rationales (Penna and Geels, 2012; Späth and Rohracher, 2010). More fundamentally, many of the theoretical approaches have reiterated constructivist notions of technology development or the idea of a dual structuration cycle à la Giddens (Geels, 2011; Giddens, 1984; Grin et al., 2010). However, so far the different agency processes have not been analyzed regarding their potential to create, change or maintain core institutions of a regime.

The paper illustrates the merits of an institutional work approach with an empirical analysis of the recent 'millennium drought' in Australia and the subsequent diffusion of seawater desalination plants across the country. Triangulating different qualitative methods like expert interviews, document and media analysis, we will show that the rapid diffusion of desalination (and the concomitant standstill of water recycling projects) can only be explained by simultaneously accounting for the interplay of institutions, technologies as well as actors within a system. We will therefore first present an overview of the institutional environment of the sector, i.e. of the prevailing semi-coherent regime. In a second step, we will analyze the different forms of institutional work applied by actors in this environment in order to foster or hinder the diffusion of seawater desalination. We compare these processes to the non-successful institutional work applied in the case of wastewater recycling technology. We explain the success and failure of these two technological alternatives by their respective fit with the prevailing regime and discuss thereof resulting consequences for future sustainability transitions. Our case thus explicitly demonstrates that socio-technical change neither solely depends on technological innovation, regime particularities or actor strategies, but ultimately on the dynamic interplay between all three pillars.

2. Agency as institutional work: creation, maintenance and disruption of institutions

Institutional theory in organization science and sociology has highly contributed to a better understanding of how actors operate in organizational fields[2] by stressing the relevance of higher order structures like norms, values, rules or taken-for-granted assumptions and beliefs (Greenwood et al., 2008; Powell and DiMaggio, 1991). It is assumed that social action is heavily shaped by the institutional context of an actor. The theory thus offers unique insights into the relationship between an actor and its environment (Scott and Meyer, 1994).

The focus of many studies has been on the analysis of the influence and persistence of highly institutionalized regulative, normative and cognitive structures (Scott, 1995).[3] The cause or process of institutional change, on the other hand, was long secondary. Similar to transition studies, the primary explanation for change was mainly based on the disruptive effect of external shocks and jolts (Fligstein, 1993; Greenwood and Hinings, 2006; Meyer, 1982). It was assumed that extreme events break open rigid institutional settings and lead to a reinterpretation of existing belief systems, habits or norms, which subsequently leads to change. However, what constitutes an extreme event and what exactly happens that enables change remained unclear. As a consequence, scholars have started to take up a more process and practice oriented approach that focuses on the social construction of events (Jarzabkowski et al., 2009; Jarzabkowski, 2004). Studies found that also the significance of an event is not objectively given, but decided in a complex social and political process and that actors actively promote or deny the relevance of an event (Munir, 2005; Munir and Phillips, 2005).

The development of a more endogenous approach to institutional change has only recently regained broader attention, which could be described as a 'practice turn' in the studies of institutions (Jarzabkowski et al., 2009; Lawrence et al., 2009; Zietsma and Lawrence, 2010). One approach that focuses explicitly on how actors shape their institutional context is the concept of institutional work (Lawrence and Suddaby, 2006). It can be interpreted as an advancement of the notion of institutional entrepreneurship (Battilana et al., 2009; Garud et al., 2007; Hardy and Maguire, 2008) containing a less pronounced idea of the importance of a "hypermuscular entrepreneur": "*The concept of institutional work highlights the intentional actions taken in relation to institutions, some highly visible and dramatic, as often illustrated in research on institutional entrepreneurship, but much of it nearly invisible and often mundane, as in the day-to-day adjustments, adaptations, and compromises of actors attempting to maintain institutional arrangements*" (Lawrence et al., 2009, p. 1).

The authors do not ignore the effects of institutions on actors, but put their attention on the consequences of actions for institutions. They propose to focus on the different types of actions that actors engage in to construct meaning, beliefs, rules or standards and thereby

[1] This relates to the question of how to assess the "semi-coherence" of a socio-technical regime. Fuenfschilling and Truffer (2014) propose to assess institutional heterogeneity by analyzing dominant discourses in a system. In the present paper, we want to complement this work by assessing the presence and strengths of institutions through the actual practices of actors.

[2] An organizational field describes the institutional setting of an actor that consists of "*those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products*" (DiMaggio and Powell, 1983, p. 148). Transition scholars have defined the level of analysis for socio-technical system to take place on the level of organizational fields (Fuenfschilling and Truffer, 2014, Geels and Schot, 2007).

[3] In this paper institutions are defined as highly institutionalized structures. Structure is used as an umbrella term for things that influence an actor's behavior/cognition or the diffusion of practices (Tolbert and Zucker, 1999).

shape the course of institutional change. One of the most debated issues in this regard concerns the intentionality of actions by actors. We maintain that while actors are capable of engaging in purposeful behavior, the results of those actions do not necessarily coincide with their intentions. Furthermore, what is considered rational and purposeful is shaped by the institutional environment. Not all actions are equally possible, legitimate and probable. Depending on the coherence of the institutional context, there is more or less room for alternative rationalities and actions. Institutional plurality is thought to increase the opportunities for transformative agency, since the presence of different rationalities within an organizational field broadens the scope for legitimate actions, which enhances the potential for innovation and change (Fuenfschilling and Truffer, 2014; Greenwood et al., 2011; Kraatz and Block, 2008; Zietsma and Lawrence, 2010).

In their contribution, Lawrence and Suddaby (2006) have reviewed many articles that empirically analyze how actors engage with institutions. In doing so, they have analyzed similarities and differences between the types of actions described and have created a categorization of actions that have proven especially likely to either maintain, create or disrupt institutions. Two main forms of work can be identified: practices that aim at the *mobilization of resources* and such that target the (*de-*)*construction of rationales*. The former is for instance based on the application of rather tangible resources, such as political power, money, knowledge or social capital. Examples thereof are state interventions through regulations, the patenting of innovations to secure knowledge, the establishment of new relationships with actors to become more powerful or gain legitimacy or the investment in skilled personnel or superior technologies in order to gain competitive advantage. Practices that aim at the (de-)construction of rationales, on the other hand, are characterized by a more cognitive nature, influencing the process of (de-) institutionalization via the shaping of discourse. It concerns the legitimation of an innovation through the development of narratives that establish what is morally right or wrong by means of communication. The development and diffusion of a scientific knowledge base, education, raising awareness by campaigning or the creation of specific meaning for an artifact, problem or solution are instances of this work.

2.1. Creating institutions

From the vast literature that Lawrence and Suddaby (2006) reviewed in their article, they have identified nine practices that actors applied in order to create new institutions. The commonality between those practices is that they have the ability to create rules as well as rewards and sanctions that enforce those rules (Lawrence and Suddaby, 2006, p. 228). This implies that an actor holds a specific position in a field, which legitimates that kind of authority. Traditionally, authority is received via regulative channels, as in the case of official state power, but it can also be based on the resource dependence of other actors (e.g. economic power) as well as through obtaining normative power, as usually seen in professional associations or expert organizations (e.g. Greenpeace, International Labor Organization, United Nations). Accordingly, practices aiming at creating institutions involve a lot of political work that bring about new regulations and policies, change property rights or the access to material resources. But they also aim at reconfiguring prevailing belief and meaning systems in order to change the normative and cognitive environment so that is supports the novelty.

One of the most common forms of institutional work in this regard is *advocacy*. It aims at mobilizing political and regulatory support by using various techniques of persuasion (Lawrence and Suddaby, 2006, p. 221). It can thus be seen as an umbrella term for actions that represent the interests of certain actor groups. The most prominent example is lobbying, e.g. by industry associations or social movements (Clemens, 1993; Holm, 1995). The goal usually is to mobilize financial and political resources or social capital to support one's cause, e.g. influence policy making, create new standards or change regulation that is in place.

Furthermore, practices that reconfigure dominant belief and meaning systems for instance aim at *changing normative associations* by "*re-making the connections between sets of practices and the moral and cultural foundations of those practices*" (Lawrence and Suddaby, 2006, p. 224). An example is the emergence of environmental movements that has changed people's associations with certain technologies (e.g. nuclear energy production), actors (e.g. multi-national companies) or practices (e.g. driving SUVs). Another way of creating institutions is through *mimicry*. Mimicry describes a particular form of work that is used by actors to connect novelty with existing institutions, thereby enhancing chances of its acceptance and adoption (Lawrence and Suddaby, 2006, p. 225). The acceptance of new technologies, for instance, can be increased if the design and functions are very similar to previous, already known devices, since this makes innovations more accessible and understandable (Hargadon and Douglas, 2001).

New institutions are furthermore often based on new knowledge, i.e. novel assumptions of cause and effect. Acquiring new knowledge and diffusing are thus central to the process. *Theorizing*, defined as the "*development and specification of abstract categories and the elaboration of chains of cause and effect*" (Greenwood et al., 2002, p. 60), is the corresponding practice. It is an important step in the creation of institutions, not just regarding innovative knowledge but also the development of specific names, concepts or categories that enable a common language and create a 'cognitive map' (Lawrence and Suddaby, 2006, p. 226). This played an important role in the establishment and legitimation of environmental issues, such as climate change, air pollution or sustainability (Garud et al., 2010; Penna and Geels, 2012). *Educating*, on the other hand, is a crucial practice for the diffusion of knowledge and skills that are necessary to support and sustain the new institution. This concerns for instance scientific training to operate specific technology, but it also encompasses 'softer' forms of knowledge, e.g. environmentally sustainable behavior or hygiene (e.g. hand washing, recycling procedures, etc.). Table 1 provides a list and definition of all the different practices identified by Lawrence and Suddaby (2006) that are likely to be applied if actors aim to create new institutions.

Table 1
Creating institutions (adapted from Lawrence and Suddaby, 2006).

Forms of institutional work	Definition
Advocacy	The mobilization of political and regulatory support through direct and deliberate techniques of social suasion
Defining	The construction of rule systems that confer status or identity, define boundaries of membership or create status hierarchies within a field
Vesting	The creation of rule structures that confer property rights
Constructing identities	Defining the relationship between an actor and the field in which that actor operates
Changing normative associations	Re-making the connections between sets of practices and the moral and cultural foundations for those practices
Constructing normative networks	Construction of interorganizational connections through which practices become normatively sanctioned and which form the relevant peer group with respect to compliance, monitoring and evaluation
Mimicry	Associating new practices with existing sets of taken-for-granted practices, technologies and rules in order to ease adoption
Theorizing	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

2.2. Maintaining institutions

Institutions do not automatically persist. Instead, they need constant maintenance. Although less institutionalized structures need more work to stay in place than highly institutionalized ones, also they need verification and enactment by actors. Actors tend to continuously perpetuate institutions in their daily actions, sometimes as a way of routine and rather unconsciously, but often to specifically counteract ongoing change or destabilization. Lawrence and Suddaby (2006) have identified six distinct practices that actors tend to engage in order to maintain institutions. They all involve the support, repair or recreation of mechanisms that ensure compliance (Lawrence and Suddaby, 2006, p. 230). The question thus is how to get actors to adhere to prevailing rules and regulations and how to keep specific norms or belief systems relevant and binding, maybe even beyond the existence of their inventors.

The corresponding institutional work thus often aims at issues of control. One example is *policing*. It generally aims at maintaining current institutions by "*ensuring compliance through enforcement*, *auditing and monitoring*" (Lawrence and Suddaby, 2006, p. 231). This often includes working through the state by using sanctions or rewards to ensure the appropriate behavior. But also processes of standardization, such as applied by the International Standardization Organization (ISO), can be applied to ensure compliance with certain institutions. Another practice is *deterring*, i.e. the establishment of coercive barriers to change (Lawrence and Suddaby, 2006, p. 232), e.g. via laws and regulations as well as other forms of direct political interventions or overruling. Powerful decision-making actors, such as ministers, may directly intervene in order to stop certain developments by means of legislation, e.g. forbid certain practices or technologies or set specific standards and regulations. An example thereof is the political obstacles that Edison was confronted with when trying to introduce electric lightning, such as a denied operating license or, compared to the gas companies, inflated fees for wiring (Hargadon and Douglas, 2001). Since infrastructure sectors show a particular proximity to public actors and are characterized by high regulation (Markard, 2011), political work is a crucial form of agency that highly determines the development of such sectors.

Less conscious types of institutional work aimed at the maintenance of institutions rather target the reproduction of existing meaning and belief systems. This is for instance done through *mythologizing*, which refers to the deliberate use of myths in order to "*preserve the normative underpinnings of an institution*" (Lawrence and Suddaby, 2006, p.). Very popular are for instance stories about 'great men', ranging from successful entrepreneurs (e.g. Steve Jobs) to footballers (e.g. Maradona) to political and social leaders (e.g. Martin Luther King or Che Guevara) that sustain societal values such as creativity, hard work, social rise, freedom and equality. In addition, also certain widely diffused societal beliefs can be classified as myths, such as the beliefs in markets for achieving efficiency or the belief in technological progress as a way to offset scarcity problems. Keeping such assumptions alive helps to maintain the status quo. Similarly, also "valorizing and demonizing" are used to maintain institutions, e.g. by providing and stressing particularly positive or negative examples of morally appropriate behavior or actors, "*both as en enactment of institutionalized beliefs and as a way of maintaining the power of those beliefs*" (Lawrence and Suddaby, 2006, p. 232). Examples include fostering public recognition by giving out prices for outstanding behaviors or achievements or alternatively engage in public social shaming. Table 2 shows the practices found by Lawrence and Suddaby (2006) to influence the maintenance of institutions.

Table 2
Maintaining institutions (adapted from Lawrence and Suddaby, 2006).

Forms of institutional work	Definition
Enabling work	The creation of rules that facilitate, supplement and support institutions, such as the creation of authorizing agents or diverting resources
Policing	Ensuring compliance through enforcement, auditing and monitoring
Deterring	Establishing coercive barriers to institutional change
Valorizing and demonizing	Providing for public consumption positive and negative examples that illustrates the normative foundations of an institution
Mythologizing	Preserving the normative underpinnings of an institution by creating and sustaining myths regarding its history
Embedding and routinizing	Actively infusing the normative foundations of an institution into the participants day to day routines and organizational practice

2.3. Disrupting institutions

Disrupting institutions is the least well researched form of institutional work. It is often seen as a consequence of the emergence and diffusion of new institutions, which is why de-institutionalization and institutionalization are thought of as complementing processes. However, research shows that the destabilization of an institution can also result out of specific institutional work by actors. This work mainly consists of undermining the compliance of actors with institutions by making the institutions less attractive and delegitimizing them (*disassociating moral foundations*) or relieve punishments associated with nonconformity (*disconnecting sanctions*). Overall, actors tend to disrupt institutions by "*redefining*, *recategorizing*, *reconfiguring*, *abstracting*, *problematizing and*, *generally*, *manipulating the social and symbolic boundaries that constitute institutions*" (Lawrence and Suddaby, 2006, p. 238). Table 3 lists a definition of the three practices identified by the authors as having disruptive effects on institutions.

3. The interplay of institutions, actors and technologies in socio-technical systems

As we have pointed out, institutional theory in transition studies has so far primarily been used to describe and improve the socio-technical regime, i.e. to conceptualize persistence, rigidity and stability in socio-technical systems. However, scholarly work in institutional theory has also dealt with questions of institutional change that involve actors and their actions in the form of embedded agency. We argue that this research, broadly summarized as institutional work, also contributes to the understanding of processes of institutional change in transition studies. Since a transition is described as a shift from one socio-technical regime to another, and the regime is defined as the highly institutionalized socio-technical structures of a system, a transition can ultimately be defined as institutional change with a particular awareness for technologies.

While transition studies have traditionally emphasized the co-evolution of technology and institutions in socio-technical systems, the interplay between institutions and actors has gotten less explicit attention. By introducing conceptual foundations of institutional theory, this paper argues that actors are embedded within more or less institutionalized environments, such as socio-technical regimes, that determine the scope of legitimate, appropriate and possible forms of agency. However, within that range, they play a vital role in keeping

Table 3
Disrupting institutions (adapted from Lawrence and Suddaby, 2006).

Forms of institutional work	Definition
Disconnecting sanctions	Working through state apparatus to disconnect rewards and sanctions from some set of practices, technologies or rules
Disassociating moral foundations	Disassociating the practice, rule or technology from its moral foundation as appropriate within a specific cultural context
Undermining assumptions and beliefs	Decreasing the perceived risks of innovation and differentiation by undermining core assumptions and beliefs

those institutions alive (maintenance in the regime), changing them (disruption of the regime) or creating new ones (built-up and alignment of new technologies in niches). It is assumed that practices related to the build-up of new socio-technical configurations around alternative technologies will most likely be aimed at the creation of institutions, while the destabilization of regimes will bring about actions that target the disruption as well as the maintenance of prevailing structural environments. It goes without saying that these processes are often heavily interdependent.

Regarding the creation of new socio-technical structures, literature in the realm of technological innovation systems (TIS) has already identified key processes that contribute to the diffusion of an emerging technology and thus to the establishment of a new socio-technical regime. These key processes include knowledge creation and diffusion, resource mobilization, market formation, legitimation and entrepreneurial experimentation (Bergek et al., 2008; Carlsson and Jacobsson, 2004; Dahmen, 1988; Edquist, 2004; Hekkert et al., 2007; Johnson, 2001). It can thus be assumed that these key processes represent areas where institutional work will be of particularly high relevance regarding the institutionalization of a new socio-technical configuration.

The creation of legitimacy for a new technology may for instance depend on *changing the normative associations* actors have with an artifact and involve intensive *advocacy* like lobbying (Binz et al., submitted for publication). Similarly, the mobilization of resources in order to push the diffusion of a new socio-technical configuration might depend on the *construction of normative networks* with allies or the direct use of political power through *policing*. Furthermore, the creation and diffusion of knowledge through research and development will rely on institutional work like *theorizing* or *educating*, as seen in many instances describing the role of research and development for innovation. Another example concerns the formation of markets for emerging technologies, which also involves a lot of institutional work (Dewald and Truffer, 2012). A crucial precondition for markets are for instance property rights. Hence, activities that change the characteristics of property rights, such as *vesting*, are likely to affect market dynamics in the whole system. The different forms of institutional work discussed above can thus be interpreted as a possible categorization of some of the practices and activities entailed in the key processes of socio-technical systems.

In mature socio-technical systems, it can be expected that a lot of work goes into the maintenance of these key processes, e.g. keep resources mobilized, markets going, knowledge developed along the established pathway and dominant technologies accepted. This is an area of research that has so far rather been neglected in transition studies. The different forms of institutional work discussed aiming at the maintenance of institutions thus offer some insight into how actors keep a socio-technical configuration strong. This includes a lot of *policing* and *deterring*, i.e. compliance management with existing regulations or the establishment of policy bans for potential changes, e.g. alternative technologies or practices. Furthermore, *routines* play a crucial role in maintaining a system. They are often highly embedded within organizational culture and certain knowledge basis and ensure that deviation is kept automatically little. In addition, the status quo is preserved by keeping certain practices, technologies or values accepted. This is often done through *valorizing* or *demonizing* them or by sustaining certain *myths* that underpin the normative foundation of the regime.

Processes of regime destabilization have recently gotten more attention in transition literature. From a governance perspective, a key question is whether the creation and support for a new socio-technical configuration automatically leads to the destabilization of regime structures or whether the disruption process has to be guided separately, e.g. through policies explicitly aiming at the destruction of the status quo (Kemp and Rotmans, 2004; Kivimaa and Kern, 2015). This would involve practices aimed at *disconnecting sanctions*, i.e. officially changing rewards and sanctions associated with certain practices, technologies or standards, e.g. change subsidies. However, most of the research about destabilizing regimes looks at the de-legitimization of regulative, normative and cognitive institutions (Garud et al., 2010; Penna and Geels, 2012; Turnheim and Geels, 2013). Institutional work like *undermining assumptions and beliefs* in regard to the perception of certain technologies or practices as well as *disassociating their moral foundations* are two specific forms of work discussed in the institutional literature. In sum, we argue that the concept of institutional work offers an explicit conceptual framework to look at those various kinds of activities within socio-technical systems and their effects on transformation.

Furthermore, we want to stress the role of materiality, and specifically technology, for the explanation of socio-technical transitions. Institutional theory, however, mainly neglects the meaning and influence of technologies for institutional change and thereby misses a crucial explanatory factor. The materiality of technologies heavily contributes to stability and change in socio-technical systems. Firstly, technologies incorporate and materialize institutions, such as values, cultural expectations, regulations or norms and thus increase their stability. Destabilization is therefore harder to achieve, since it not only involves the disruptions of regulative, normative or cognitive aspects, but of actual material infrastructure.

Secondly, the diffusion of a new technology within a system potentially brings about and accelerates institutional change. Technologies that incorporate a different socio-technical configuration than the dominant regime will have a bigger reconfiguration capacity, i.e. a capacity to alter the underlying socio-technical structures and thus enable institutional change. As Smith and Raven (2012), some technologies, i.e. niches, have the ability to 'fit and conform' with the incumbent logic of a field and others tend to rather 'stretch and transform' the field. We expect that the higher the reconfiguration capacity of a technology is, the more institutional work is required to achieve a diffusion. The diffusion of a technology will thus rely on a combination of the institutional work aimed at fostering it and its institutional fit with the structural environment.

On the other hand, it is also assumed that the technology itself will be affected by the institutional work applied during the diffusion process and thus may alter its design, function, user practices, associated values, etc. over time. In this regard, socio-technical transitions are explicitly conceptualized as an interplay between institutions, actors and technologies. Whereas actors and technologies are embedded within and shaped by institutions, they both also highly contribute to the change or maintenance of these institutions. The diffusion of a technology and its consequences for socio-technical change can thus only be assessed by analyzing the interrelations and effects of all three pillars (institutions, actors, technologies).

In the next section, the interplay of these three pillars is analyzed empirically using the case of the Australian urban water sector. A comparative analysis between seawater desalination technology and its main rival wastewater recycling in regard to processes of institutional work as well as their reconfiguration capacity provides valuable insights into how technology, actors and institutions mutually shape each other.

4. Methodology

We illustrate our approach by analyzing current transformation processes in the urban water sector in Australia. Water sectors worldwide are generally characterized by a highly stable socio-technical regime, which has proven to be very resistant to change (Espeland, 1998; Fuenfschilling and Truffer, 2014; Molle et al., 2009). In recent times, however, the sustainability of water resource management has been questioned and these sectors are put under more pressure to find new organizing principles and technologies (Daigger, 2007). Australia has been considered to be a country where water sector reforms have been rather advanced. This is often related to the extreme weather conditions like droughts and floods, which are believed to make water a more relevant political issue.

During the first decade of the new century, Australia has been hit by an exceptionally severe, multi-year drought, which triggered a range of

reactions by different actors, among others the construction of six large-scale seawater desalination plants. These projects were heavily contested, even more so after the drought broke and left all but one plant unused. This has led many commentators wonder how such a massive investment – which is likely to limit alternative development trajectories in the sector for the coming decades – could have happened so quickly and why other, potentially more sustainable technologies such as wastewater recycling, have not been able to use the momentum of the crisis to break through. These developments make Australia an interesting case to study the impact of institutional work by actors and its interplay with highly institutionalized regime structures as well as the reconfiguration capacity of different technologies.

The empirical analysis is based on the triangulation of different qualitative methods. The cornerstone of the study entails face-to-face expert interviews. Interviews are highly suitable for exploratory as well as explanatory research questions focusing on how certain processes unfold and outcomes are achieved (Creswell, 2009). We conducted 25 semi-structured interviews with water sector experts and industry leaders in Australia, ranging from scientists, government officials, utility representatives to people from associations and multi-national companies, most of them with an explicit knowledge about the subject of desalination in Australia (for a list of interviewees, see Table A.1 in the Appendix A). The sampling strategy targeted senior experts that were directly involved in decision-making processes about desalination or that play a central role in the Australian water sector in general. The first interviewees were chosen based on official data that is publicly available, whereas further experts were sampled based on recommendations from the those experts (snowball method) (Heckathorn, 2002). The interviews lasted between 30 to 120 min, were recorded and transcribed. The transcripts were then subject to a qualitative content analysis based on a coding scheme that was informed by the theoretical assumptions. The coding was conducted with a computer software (MaxQDA), that allowed to allocate exemplary text parts to each category by a bottom up process. Thereby, the coding scheme itself was constantly refined.

The interviews were further complemented by the analysis of secondary data on the topic of the drought, desalination and recycling (e.g. annual reports of utilities and government ministries and company websites) in order to validate the interview data as well as deepen the understanding of the way the drought as well as the different technologies were framed and what kind of storylines, metaphors or myth they represent. In addition, a qualitative analysis of the newspaper coverage on desalination in three Australian newspapers has been undertaken. The Australian (federal newspaper), The Sydney Morning Herald (central newspapers of the East Coast) and The West Australian (main newspaper on the West Coast) have been chosen to represent a data source of the public discourse concerning desalination. This triangulation of data was crucial to a) complement the interview data in regard to institutional work by detecting relevant actors and their actions that were reported on; and b) trace the public discourse about desalination over time.

5. Results

5.1. The Australian urban water sector: institutional context and recent developments

Since the 1980s, Australia's water sector has undergone various institutional changes that can be traced back to the global emergence and institutionalization of economic and environmental principles (Abbott et al., 2011; Cathcart, 2009; Colebatch, 2006; Crase, 2008; McKay, 2005; Tisdell et al., 2002). In a recent study, Fuenfschilling and Truffer (2014) have identified and traced the dominant institutional logics present in the socio-technical regime of Australia's water sector and how they have changed over time (see Fig. 1). Until ca. the 1980s, the rationality of the water sector regime can be described as very stable and rather uncontested. The dominant "hydraulic" logic that had developed over a long period of time was characterized by public actors and engineers building a centralized system of large-scale technical infrastructure (dams) in order to guarantee water security and reliability as well as national welfare. Responsibilities were clear, dominant technologies highly legitimate and values and goals unambiguous and widely accepted.

By the 1980s, this regime rationality came under greater scrutiny due to the rise of neoliberal and environmental ideas. As a consequence, the sector has taken up a more market-oriented approach towards water management, including the corporatization of public water utilities, an increase in water prices to recover the cost through consumers or collaborations with private companies. On the other hand, environmental movements triggered various environmental water regulations, a focus on integrated water resource management (IWRM) and the design of new, potentially more sustainable technologies, such as recycling for waste and storm water. State governments, who have jurisdiction over water supply and sanitation, as well as the federal government had initiated major reforms that targeted the liberalization of the water industry as well as the protection of aquatic ecosystems. The socio-technical regime can thus be described as containing three ideal type institutional logics that coexist and compete for legitimacy within the system: The Hydraulic Logic (technocratic and state-centric), the Water Sensitive Logic (focus on sustainability) and the Water Market Logic (focus on economic efficiency) (see Fig. 1).

The institutionalization of these new principles in the water sector contributed to the destabilization of a once very coherent regime. The subsequent regime can be described as less coherent, since it incorporated elements from different rationalities that are sometimes rather conflicting. Actors within the water sector were thus subject to different guiding principles, which enabled different opportunities for agency and a multifaceted range of institutional work that had an increasing focus on the institutionalization of a new water regime based on principles like economic and environmental sustainability. However, research shows that the degree of institutionalization of these new institutional logics is still lower than the one of the highly sedimented rationality of the historically dominant Hydraulic Logic (Fuenfschilling and Truffer, 2014). As a consequence, it can be expected that the newer regime logics focusing on economic efficiency and environmental sustainability are less powerful in steering the actions of actors within the system.

By the year 2000, all the Australian states had set a more or less pronounced water management strategy with a strong focus on IWRM and recycling technologies (Melbourne Water Annual Report, 2000, p. 51). However, between ca. 2002 to 2010, most parts of Australia were affected by a severe drought, now known as the 'millennium drought'. Dam levels in all major cities dropped to an unprecedented low, industries and agriculture were hit hard and the fear of running out of drinking water circulated among politicians and the public. Water was put first on the political agenda and a diverse range of actions were taken by the different governments that were mainly based on two pillars: heavy water restrictions and supply augmentation through large-scale infrastructure, mostly seawater desalination plants. Even though demand management programs achieved a decrease in water use of about 46% (compared to 1997), all major cities decided to additionally invest in desalination plants, despite concerns from expert circles and the public regarding the environmental sustainability of the technology as well as its economic efficiency and necessity. Western Australia (Perth) was the first state to decide on a desalination plant in 2004, followed by Queensland (Brisbane), New South Wales (Sydney), South Australia (Adelaide) and Victoria (Melbourne) within the next few years (see Table 4 for an overview of Australia's desalination plants).

By 2008, the water industry had seen an unprecedented 80% increase in capital expenditure, most of it going back to investments in desalination that were heavily subsidized (WSAA performance report

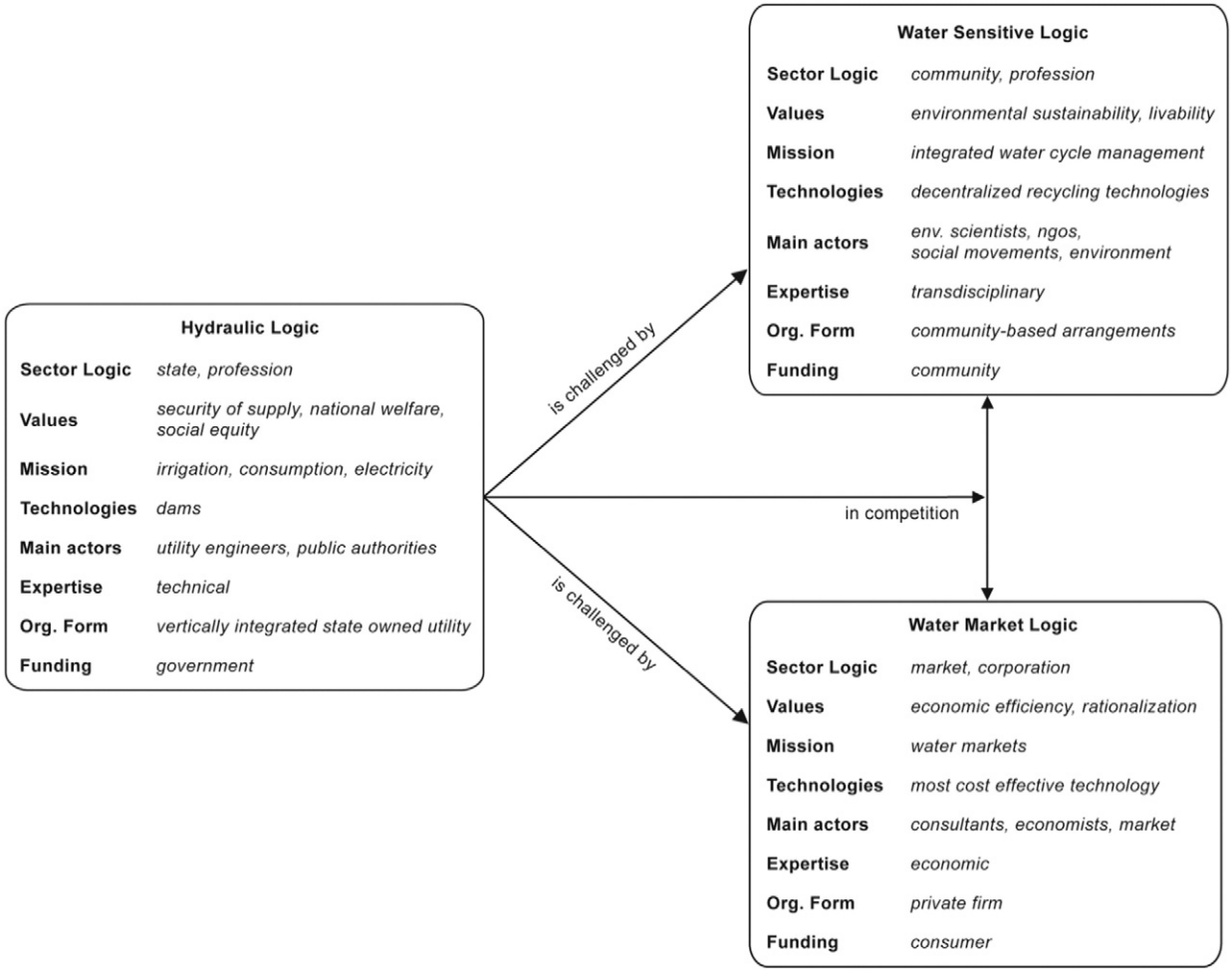

Fig. 1. Institutional logics in the water sector (Fuenfschilling and Truffer, 2014, p. 779).

09/10). Unfortunately, as soon as the construction of the different desalination plants was decided and had begun, the drought on the east coast broke and was followed by heavy rainfalls and flooding, filling the dams up again and therefore rendering the need for additional water sources at least for the coming years obsolete. Consequently, none of the desalination plants on the east coast has ever been

Table 4
Overview of large RO seawater desalination plants in Australia.

Location	Announcement	Construction start	Operation start	Cost	Actors	Size (ML/day)	Current status (August 2013)
Kwinana Desalination Plant, WA	2004	May 2005	Nov 2006	A$387m	*Water Corporation* with *Multiplex-Degrémont JVC*, (separate design/build and operate/maintain contracts for 25 years)	144–250 (ca. 17% of Perth' water supply)	operational
Gold Coast Desalination Plant, QLD	2006	Sep 2006	Feb 2009	A$1.12bn	*Water Secure* with *Gold Coast Desalination Alliance*: Veolia Water, John Holland, SKM and Cardno (design, build and operate contract for 10 years)	125–167 (27% of SEQ's water supply)	Stand-by mode since 2010
Kurnell Desalination Plant, NSW	2006	Aug 2007	Jan 2010	A$1.9bn	*Sydney Water* and *BlueWater* joint venture: John Holland (construction), Veolia Water (operation and maintenance for 20 years) Since 2012: Sydney Water sold the plant to the Ontario Teachers' Pension Plan Board (50%), Utilities Trust of Australia and The Infrastructure Fund (together 50%).	250–500 (ca. 15% of Syndey's water supply)	Stand-by mode since July 2012
Port Stanvac Desalination Plant, SA	2007	April 2009	Dec 2012	A$1.83bn	*SA Water* with *AdelaideAqua*: McConnell Dowell Constructors, Abigroup Contractors, Acciona Agua and Trility (design, build, own, operate contract for 20 years)	270 (ca. 50% of Adelaide's water supply)	Stand-by mode since Oct. 2012
Wonthaggi Desalination Plant, VIC	2007	Sep 2009	Dec 2012	A$3.5bn	*Victoria Dep. of Sustainability and Environment* and *AquaSure*: Degrément, Thiess, Macquarie Capital (30 years contract to finance, design, build, operate, maintain the plant)	410–550 (33% of Melbourne's water supply)	Stand-by mode since Dec. 2012
Binningup Desalination Plant, WA	2007	Jul 2009	Sep 2011	A$955m	*Water corporation*, DBO contract with *Southern SeaWater Alliance*: Tecnicas Reunidas, Valoriza Agua, WorleyParsons and AJ Lucas (25 years)	270 (ca. 30% of WA's water supply)	operational

significantly in use. Instead, they have now been put on standby. The exception is Perth, where the drought is still ongoing and both constructed desalination plants are supplying water to their local drinking water system.

In the next section, we look at how actors dealt with the institutional complexity in the regime described above and how the different rationalities guided their actions in terms of deciding on which technology to invest in.

5.2. Deciding on a technology: institutional work by actors

The search for a solution to the drought became the center of attention not only within the water sector but also within the whole Australian society. The water crisis made more than once front-page news of major newspapers in the country. In general and put simply, two types of solutions existed: saving drinking water to be able to prolong the reserves, e.g. through various water efficiency measures and water restrictions (no car washing or sprinklers, water saving shower appliances etc.) or find new sources of water, either through water recycling or desalination. The question, whether water savings were sufficient to survive the drought without running out of water, was highly contested. So were the opinions about which additional water source would be best, stormwater, rainwater or wastewater recycling or desalination. Although stormwater and rainwater recycling was proposed as one of the most sustainable options, many experts thought it was too expensive and too small-scale to help relieving the tight drinking water situation. In addition, it was often mentioned that these solutions are not efficient in times of no rain or storms. It therefore essentially came down to a 'battle' between large-scale wastewater recycling and desalination.

Being based on highly similar membrane technologies, the main difference between the two applications is the source of water: wastewater or seawater. While wastewater is said to be cheaper to recycle, use less energy in the reverse osmosis process and be environmentally friendlier, seawater is seen as less prone to pollution and more likely to gain public acceptance. However, the arguments used by experts in the media as well as in scientific articles were rather contradictory and opinions varied greatly. Hence, the battle between desalination and recycling was ultimately decided by how successful actors engaged in institutional work. While the next paragraphs take a closer look at institutional work in the realm of recycling, the following sections are dedicated to trace the work that led to the breakthrough of desalination in Australia.

5.2.1. Institutional work regarding wastewater recycling technologies

Wastewater recycling has many different forms. It can be small-scale (household level) or large-scale (big treatment plant for the whole city); there is direct potable reuse (wastewater is treated directly to drinking water quality) or indirect potable reuse (it is treated to a very high quality and then put back into the environment (groundwater, river) to be extracted at a later point in time); or there are different water qualities, e.g. non-potable water quality for outdoor uses or toilet flushing. Australia has explored many of those options in various experimental projects and it can be said that a lobby has developed around many different recycling applications that aims at mobilizing resources and constructing normative networks. In particular, a few research centers have been founded with the goal of advancing know-how of those technologies and come up with a fruitful way for implementation (*theorizing*). Here an excerpt of the homepage from the Centre for Water Sensitive Cities:

> "*The CRC brings together the inter-disciplinary research expertise and thought-leadership to undertake research that will revolutionise water management in Australia and overseas.* (…) *The dissemination and application of research will be facilitated through a number of knowledge sharing and capacity building activities. These include*: (…) *formal education opportunities* (*PhD scholarships and Masters programs*); *developing a National 'Alliance' for transitioning to water sensitive cities and towns.*" CRC for Water Sensitive Cities, http://watersensitivecities.org.au/about-the-crc/, 03.09.2013.

Besides the actual theorization of what recycling is and can or cannot do, one of the central forms of institutional work applied by recycling proponents is *changing normative associations*. Recycling turns the way people think and have thought about water provision for hundreds of years upside down. Especially in terms of direct potable reuse, where drinking water is made out of wastewater without any further step in between, such as flow down or rest in a river for a while, challenges not only the perception of many laypeople:

> "*Their idea of what standard water supply was, was very natural. Going from a pristine catchment to supply their water to taking the sewage and turning it into drinking water was just too big a step. And I don't just mean for the people of Melbourne, I mean the people that ran the water business, the people that have got PhDs.*" (Interview 16)

Wastewater is clearly not seen as a source for drinking water, no matter what the sciences say. Therefore, many activities of recycling proponents have engaged in various *advocacy* activities to change how people think about the use of waste water: "*We spent a lot of trouble, a lot of time talking to the community, reassuring them that's the big thing, you know, basically getting community gradually acclimatized, their education facilities and lots of research*" (Interview 16).

The biggest concern in the community was seen to be water safety. Nevertheless, the pressures put on water supply during the drought was strong and governments started to see recycling as a potential option for supply augmentation, even though there were various policy bans in place that forbade the use of indirect and direct potable reuse as a safety precaution (*deterring*). However, even though recycling slowly got on the radar of some politicians and many experts argued for the use of recycling technologies, resistance to it was extensive. There was a lot of *demonizing* involved, putting up public campaigns against 'drinking poo water' or 'shit water' and establishing the metaphor 'from toilet to tap'. People were seen as guinea pigs for new technologies and there was a fear of being kept in the dark regarding the negative impacts of drinking recycled water. No matter what all the scientific studies said, trust in science or in scientists was not granted:

> "*The government in New South Wales really snubbed their noses at it, so much so that they actually made it harder I think, for future governments to make that decision. The water minister at the time, he was on the news one night saying, we're not going to make Sydney drink they're own sewage, or their own shit. I can't remember exactly what he said, but it was a pretty crude comment and it presents all of the images that you don't want people to associate it with, if you're trying to convince them, this is a safe way to supply drinking water.*" (Interview 10)

The development of this rather negative image of recycling culminated in a plebiscite in Toowoomba, a small town in Queensland. Running almost out of water, the government wanted to introduce wastewater recycling. In the last minute, however, a huge campaign, started by a rich citizen of Toowoomba who refused to drink 'poo water', resulted in a tight public vote with the majority saying no to the implementation of the recycling scheme (*deterring*, *advocacy*). This event set the political climate regarding recycling: from then on, wastewater recycling was considered politically unfeasible.

Nevertheless, one large-scale indirect potable reuse scheme was built. Together with a small group of experts, the Premier of Queensland decided on building the scheme without public consultation (*policing*): no plebiscite, no referendum. This decision was built on a lot of *advocacy* from certain water sector experts:

> "*We built a group of credible scientists that governments had a level of confidence about their capability and their expert advice. And so when we came into looking at options, one of the options you look at*

obviously is recycling and one of the issues is, can we be confident that recycled water is safe for consumption and all that sort of things. And so there was work done to show that is was." (Interview 18)

However, the Premier retired and soon thereafter the rain came and filled up the dams before the building of the recycling scheme was completed. The new Premier did not want to take on any political risks, which is why she decided not to pursue the same course and only put the recycled water into the dam if dam levels drop below 40% (Interview 20). To date, this has not yet happened. Hence, the recycled water is only used for non-potable purposes, such as cooling power plants. The frustration among the recycling proponents was huge and many of them believe that if Queensland would have taken the step to introduce recycled water into their dams, then it could have become feasible for all of Australia:

"*Even if Toowoomba had gone the way it did, but Queensland had turned on its recycling scheme, that would have made the difference across the country. It's almost unquestionable that that would have been the case.*" (Interview 20)

Although many forms of institutional work were applied to institutionalize wastewater recycling as a feasible technological and political option, the institutional work that was aimed at preventing this from happening seems to have been more powerful: "*Private recycling enterprises don't currently have a strong voice. We're trying to get them to have that voice, and if they had had that voice back in 2003, 2004, (…) maybe they would have added their weight of voice to the government about how this* [*the supply augmentation*] *could be done*" (Interview 20). However, the 'failing' of recycled water can only be explained by looking at the success of the alternative: desalination. The next sections thus trace the diffusion of desalination worldwide and particularly in Australia. For a summary of forms of institutional work regarding wastewater recycling see Table 5.

5.2.2. Institutional work regarding desalination technologies

The diffusion of desalination plants across Australia can only be understood if we take a look at the global development of the technology. Since more than 97% of all water on earth is saltwater, the idea of turning it into freshwater has a long global history and ancient roots (Birkett, 1984; Delyannis and Belessiotis, 2010; Glater, 1998). The first international symposium took place in 1957 in the US, followed by a European one in Athens in 1962. A journal specifically created to promote research on desalination was launched in 1966. The framing of desalination found in the first editorial has remained highly similar until today:

"*As lack of usable water in many parts of the world causes increasing concern, more and more people become involved in water desalination. Scientists and engineers, encouraged by Governments and international organizations, have tackled the many challenges presented by the need to make saline water usable at an economically bearable cost.*" (Editorial, Desalination 1, 1966, p. 3)

Two different technologies for desalinating seawater became prominent: thermal and membrane desalination. Membrane based technologies, such as todays most used reverse osmosis (RO), experienced a significant boost since the 1960, partly due to innovative firms from different industries who discovered the potential of water desalination (Glater, 1998). Between 1995 and 2006, the world wide capacity of desalination doubled, with RO being the most popular technology (see Fig. 2). Among other things, this can be related to technological improvements and the thereof resulting drop in costs, e.g. a decrease of 80% in energy cost for RO technologies (Shortell and Maggs, 2012; Zhou and Tol, 2005). However, seawater desalination is still significantly more expensive than conventional water provision. According to the Global Water Intelligence (GWI), the biggest market for desalination in 2010 was in Saudi Arabia, followed by the US, the United Arab Emirates and Australia.

The global diffusion of seawater desalination, however, and especially also the diffusion of RO plants across Australia, can only be fully comprehended if we look at the strategies of actors aimed at framing desalination as the panacea of water scarce regions. By now, expertise on desalination has become a domain of multi-national companies, such as Veolia, Doosan and GE (see Fig. 3). Especially large-scale desalination projects require a contractual financial security that often only multi-national companies are able to provide (Interview 1). Governments usually invite tenders for the building and operating of desalination plants and contenders are typically consortia consisting of an EPC (engineering, procurement, construction) company, an investment bank as well as further engineering and management consultants (see Table 4 for actors involved in Australia's desalination plants). Recently, also accounting firms signaled interest in desalination, such as PricewaterhouseCoopers who started a desalination division: "*I think the world is realizing that water is going to be the one*" (Interview 3). Therefore, these actors can be assumed to have a special interest in bringing desalination to the market, which involves different forms of institutional work.

All the multi-national companies, even though competitors, have worked and are working towards the same goal: establishing seawater

Table 5
Institutional work regarding wastewater recycling.

Work for recycling	Work against recycling
Constructing normative networks and mobilization of resources: e.g. Urban Water Security Research Alliance 2007 (SEQ), Australian Water Recycling Centre of Excellence 2009, CRC for Water Sensitive Cities	*Deterring and policing*: policy ban for indirect/direct potable reuse, Toowoomba plebiscite, decision not to use water from the recycling scheme in SEQ
Advocacy: e.g. scientific advisory boards as consultants for governments; political campaigns	*Demonizing*: campaign against drinking 'poo-water', 'toilet to tap' metaphor
Changing normative associations: distribution of information, demonstration of technology	*Advocacy*: political campaigns against it
Theorizing development of fit-for-purpose water categories, concept of water sensitive urban design (WSUD), experimental recycling projects like Rouse Hill, Salisbury	
Policing: decision to build recycling scheme in SEQ without democratic process	

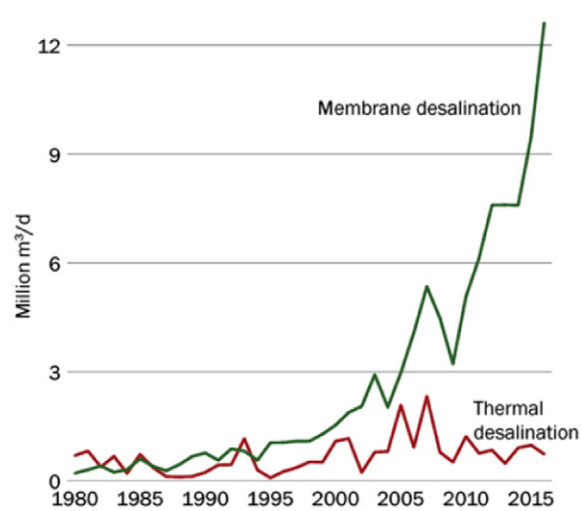

Fig. 2. Annual new contracted capacity: thermal vs. membrane (source: DesalData.com).

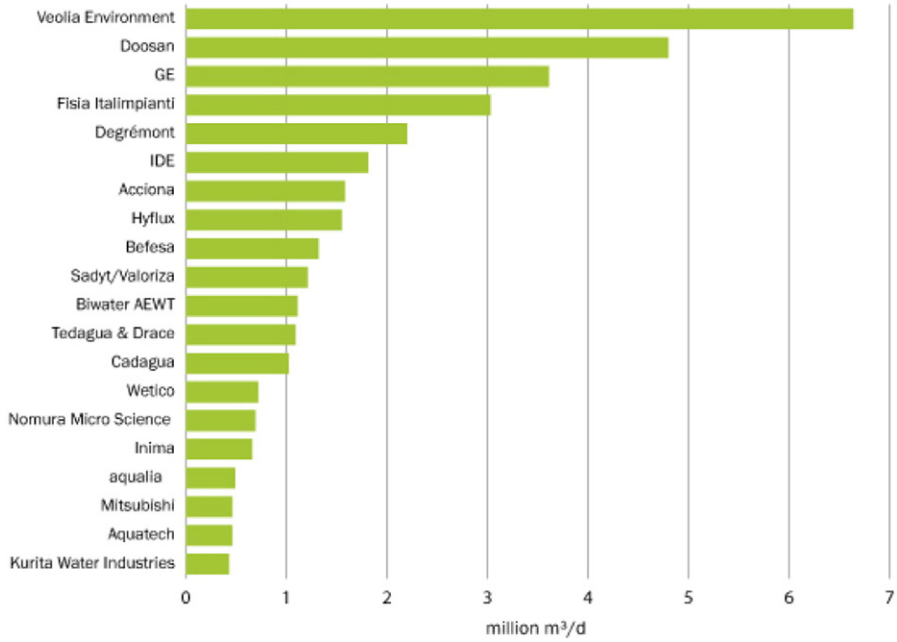

Fig. 3. Top 20 EPC contractors since 2000 (source: DesalData.com).

desalination as the perfect global solution to water scarcity. They work towards this by becoming "desalination's advocates": They make extensive use of *mimicry*, i.e. associating the technology with existing values and beliefs, such as appealing to the importance of water security for the wellbeing of a country or comparing the technical process of desalination with the natural process of evaporation (Interview 5). Making desalination sound more familiar and genuine leads to the impression that it is the logical way to go. But also issues such as environmental sustainability or social equity are picked up by framing desalination as the only way to provide enough water for everybody without destroying the environment (as opposed to dams or groundwater).

In addition, they are heavily engaged in research and development activities, i.e. *theorizing* about what desalination can and cannot do, where it is appropriate to build plants, which technology to use, how to assess associated risks etc. In general, they build up a certain monopoly situation of scientific expertise. This process gets enhanced by selectively *educating* people that can bring back the knowledge into their home organization. This was also a crucial aspect of the story of desalination in Australia, as one of the most prominent desalination engineers, who first worked for a utility and afterwards for a multi-national EPC company, explains:

> "*So then I got sent to Scotland for a year to go and learn more about desalination at* (*big EPC*). (…) *some of our bosses flew across to go and look at that* [*desal plant in Trinidad*], *and I would bring in a lot of these experts around the world.* (…) *So, yes, and then I sort of became a desalination evangelist.*" (Interview 3)

This monopoly situation of expertise thus provides a strong position for *advocacy*, e.g. by lobbying or consulting politicians and utilities. This played a major role in Australia in terms of considering desalination as a solution to the drought:

> "*We had probably the biggest range of individuals, consultancies, both nationally and internationally here, that we've ever seen. So we had large companies like Veolia, Black and Veatch, all the large consulting firms, GHD, you know, Acom, all here with their experts helping out to do this process.*" (Interview 24).

Table 6 presents an overview of the institutional work applied by multi-national companies in regard to the institutionalization of desalination.

But not only the institutional work by multi-national companies fostered the diffusion of desalination in Australia. Looking at annual reports of Australian water utilities, it is evident that desalination was not on the radar of most actors until the drought was qualified as a crisis. In March 2006, for instance, a utility report states that the future strategy foresees the development of a total desalination capacity of 41–55 ML per day starting in 2031 (Gold Coast Waterfuture Strategy, p. 12). Later the same year, due to a state intervention, construction started for a plant that delivers 125–167 ML per day, potentially providing around 27% of Southeast Queensland's (Brisbane) water supply. How can such a momentous change in strategy happen so quickly?

Western Australia (Perth) was the first state to decide on augmenting its supply by building a desalination plant. Announced in 2004, the plant was operational in 2006, i.e. long before the states on the eastern seaboard had desalination on their agenda. The data suggests that the reason for this frontrunner role was that the local, public water utility, Water Corporation, and in particular its CEO, Jim Gill, identified that Perth was affected by a declining rainfall pattern and that desalination could be an interesting option:

> "*We actually held a big seminar in 1996 with experts from North America and CSIRO and we realized that the climate was changing and that this could well be a permanent trend and that we better get our skates on.* (…) *In 1999 we decided to have a closer look at desalination to see if it really was something that would not happen until 2050.* (…) *We did a deal with a Scottish desalination company, we did a staff exchange* (…). *We actually produced a report in the year 2000*

Table 6
Desalination's Advocates: Institutional work by multi-national companies.

Type of institutional work	Description
Theorizing	Creating a monopoly of scientific expertise, develop scenarios of global water needs and scarcities, describe the technological efficiency of desalination and develop studies that prove its environmental soundness
Educating	Education of people around the world in order to run local divisions or distribute knowledge into a utility
Advocacy	Extensive lobbying and consulting of politicians and utilities
Mimicry	Appealing to the importance of water security for drinking water, industry and agriculture, i.e. for the wellbeing of the country

regarding the prospects of desalination in WA. So that was actually a good study that recalibrated our thinking, made us more aware." (Presentation Jim Gill 2012)

This quote shows that there were interactions between the utility and the international level before the decision was made to invest in desalination. By the end of 2001, Water Corporation had developed the desalination tender, by mid-2002 they had proposals from international companies that were ready to be implemented (Presentation Jim Gill 2012). As soon as the drought was considered severe enough, they went ahead with the construction of the plant. The CEO of Water Corporation emphasized that the monopoly position of the utility helped to get political influence, i.e. to engage in *advocacy*: "*Political trust, you had to be trusted, that was fundamental. So in July 2004, Geoff Gallop* [*the premier of WA*] *and I were talking and I was briefing him on the situation and he said, well Jim, let's do it. So there we are, we hit the button on building the Kwinana Desalination Plant.*" (Presentation Jim Gill 2012)

Besides that, Water Corporation and the politicians agreed that it would be best not to advertise the decision to build desalination in order to avoid a hindering controversy with desalination opponents or the public, i.e. leave out a democratic process (*policing*):

"*One thing that we did was keep it under wraps. It was being built exactly at the same time like the major railway line and this railway line has been hit by all sorts of industrial strikes and I did not want to happen the same thing here.* (…) *So what we did is, we kept it out of sight. We did not let any of the media go to it, we did not have a sod turning ceremony, and I actually didn't go to see the thing myself to only a couple of month before we opened.*" (Presentation Jim Gill 2012)

The Kwinana Desalination Plant opened in 2006 and has ever since been an important contribution to the water supply in Perth. Unlike the east coast, Western Australia is still suffering from drought conditions, which is why they decided to build a second desalination plant in 2007. Both decisions have been well received in the public and both plants are still operational.

The story of the desalination plants in the Eastern states, on the other hand, reads differently. Many of them have been heavily criticized by experts and in the media for being an unnecessary, political panic reaction caused by the drought as well as for being environmentally and financially unsustainable (*demonizing*). However, many interviewees mentioned that resistance to desalination was not organized or vocal enough (*advocacy*): "*Somebody could have organized opposition, and there was pockets of opposition, but there wasn't anything systematic. There were people who said, you know, the energy costs, all those issues were raised, but they didn't supervene the actual building of it, as you can see*" (Interview 4).

Some statements even suggested that the drought crisis has been exploited by politicians as an opportunity to legitimize a billion dollar investment into infrastructure that would otherwise never have been politically feasible. In Sydney, for instance, the recommendations of the experts assigned to evaluate the water supply situation for the government have clearly stated that a contingency planning approach would be most efficient that will first explore all other options (e.g. water saving and efficiency measures) and then step by step go in the direction of desalination, i.e. buy the land, call for tenders, get proposals and only if dam levels drop below 30% proceed with building the plant. However, despite these recommendations, the government autonomously decided to build the desalination plant when dam levels were ca. 34%:

"*In 2005 the premier retired and a new premier came in and he made an announcement, which said we're going to build a desal plant, drought or no drought.* (…) *And that changed everything. I mean that's essentially a preemptive build of something which was prior to that considered to be a drought or contingency option.*" (Interview 12)

Interview statements also suggest that governments were overstrained with the idea of running out of water, which led them to take over power in a very centralized manner, ignore critical voices and quickly decide on a large-scale solution behind closed doors, which altogether is an indicator for extensive *policing*:

"*Melbourne ended up agreeing to put in the largest desalination plant in Australia. But there was no public document released to discuss the options, and even today, the reasoning behind it is kept in confidence, so there was no, there was no transparent decision making process*" (Interview 16)

"*The state government said* (…) *we need to take charge. So the next thing was a political move* (…). *They created the Queensland water commission* (…) *and that's where it all kicked off, so very, very quickly. And I'm talking as fast as we've ever seen. The water restrictions were made consistent, the water grid, that's the new water supply, was designed over a weekend.*" (Interview 24)

The extreme political relevance of finding a solution to the drought as well as the similarity of the reactions by all the state governments despite the different preconditions indicates that desalination on the east coast became more than a functional, technological solution. Instead, the interviewees often described it as having a symbolic meaning that signaled political activity:

"*The politicians of the day saw themselves as a bit of a white knight in providing a solution, by building these expensive plant and getting federal money as a subsidy.*" (Interview 4)

This symbolic dimension indicates that desalination developed into a politically legitimate 'best practice' against the drought independently of local conditions. Data suggests that the diffusion of the technology went from East to West in the form of a 'domino effect', whereby governments on the East Coast imitated the successful story of the West Coast (Perth) to signal strength and responsibility.

Table 7 summarizes the different forms of institutional work regarding desalination in Australia.

5.3. Reconfiguration capacity of recycling and desalination technologies

The analysis of the fit of an emerging technology with its structural environment is crucial to assess the reconfiguration potential of a technology, i.e. the likelihood that a diffusion of a technology would bring about radical institutional change. Technology is seen as a structural element of the rationality of a regime. The institutional logics develop in relation to material structures. In the water sector, for instance, dams became the dominant technology to fulfill functions like drinking water provision, flood control or energy generation. But the technology did not just fulfill a function, it also coined and shaped these functions in the first place. Only because the dam is a large-scale technology that

Table 7
Institutional work regarding seawater desalination.

Work for desalination	Work against desalination
Advocacy: lobbying by multi-national water companies, but also by farming and mining industries as well as some utilities	*Demonizing*: NGOs and green parties establish desalination as environmentally problematic and economists as financially unsustainable. Also media coverage rather negative
Policing: decision to build desalination plants without democratic process	*Advocacy*: expert and consultancy groups that distinctly advised against desalination

enables the generation of electricity or the storing of water in huge amounts, values such as water reliability or missions like energy production developed. In short, the technology shapes the institutional environment and the other way around.

In regard to wastewater recycling and desalination, the following matches and mismatches with the structuration of the socio-technical regime have been identified.

5.3.1. Desalination

Desalination has become very popular during the drought, because it suggests the infinity of water supply, i.e. water security, which is the basic value of the Hydraulic Logic. This argument was so strong that it survived all the criticism in other areas, such as water quality, economic efficiency, environmental sustainability or social equity. In addition, it is a large-scale technology built by engineers and often subsidized by the state, just like the dams always were. In that regard, they are highly compatible with the once dominant and still highly institutionalized rationality. But desalination also brings some disruptions, e.g. the involvement of new actors like multi-national water firms, investment banks or consultancies or the lack of expertise to operate and maintain the plants. The plants are sometimes also operated separately from the utility, which means that the traditional supply chain needs to be rearranged (e.g. new actors like bulkwater suppliers). In regard to the newer regime rationalities, it is important to mention that desalination is considered economically inefficient, since it is very expensive compared to traditional water sources. In addition, desalination has been criticized for being environmentally unsustainable, mainly regarding its high energy consumption as well as impacts on the ecosystem stemming from the high concentrations of salty water put back in the ocean. However, in sum, desalination plants fit with the regime core of the current institutional structure very well and only cause manageable frictions.

5.3.2. Wastewater recycling

Recycling shows some good matches with the structuration, but also very problematic features. A good fit is achieved regarding environmental sustainability, especially in terms of the idea of water conservation and ecosystem health. Water quality, however, in particular regarding health and safety issues, causes major frictions with the current structuration: public perception is bad and policy bans for direct/indirect potable reuse have been launched in many states. The distrust regarding water quality furthermore requires an extensive regulatory framework, since public authorities fear a potential contamination scandal. Recycling is thus not yet regarded as a source of drinking water, which lowers its performance in terms of security of supply. A further challenge concerns the supply chain: who 'owns' wastewater and who is allowed to treat it and make a business out of it? In some states, first attempts of third party access have failed. Still, academia advances the knowledge about recycling technologies and many firms are interested in delivering technologies and services. Overall, recycling schemes have a positive fit with the Water Sensitive Logic, but cause various frictions in regard to the Hydraulic Logic, which is still institutionalized to a higher degree and thus considered more legitimate. It can thus be stated that wastewater recycling has currently a bigger reconfiguration capacity than desalination and would thus most likely need more institutional work to diffuse widely. However, a potential diffusion can be expected to enhance radical institutional change in the system. See Table 8 for a summary of the institutional fit of both technologies.

Table 8
Institutional fit of technologies.

Technology	Desalination			Wastewater Recycling		
Institutional logic	Hydraulic logic	Water Sensitive logic	Market logic	Hydraulic logic	Water Sensitive logic	Market logic
Values	+++	−	−	−	++	++
Mission	+++	−	−	+	+++	+
Actors	+++	−	+	+	+	+
Expertise	++	−	−	+	++	+
Org. form	+++	−	+	+	−	+
Funding	+++	−	−	+++	−	−

6. Discussion

The analysis of the transformations in the Australian water sector entailed three specific aspects: the identification of the current socio-technical regime of the sector, i.e. its institutional setting; the identification of institutional work by actors regarding technology choice; the assessment of the reconfiguration capacity of the technologies in discussion. Looking at the case from these three angles, it becomes clear that transformation can only be explained by similarly accounting for the interplay between institutions, actors and technologies.

First, the change in institutional logics within the sector since the 1980s has broadened the scope for actions that are considered legitimate. The rise of environmental and economic principles as guiding rationalities within the regime enabled different thinking and actions, changing how problems and solutions are identified and framed, what values are pursued and what means are appropriate. The spectrum for agency has thus opened up. As a consequence, actors engaged in new research and practices, which caused some of the transformations mentioned above, such as a focus on new recycling technologies, organizational forms or regulations. However, within that scope for agency, actors can apply different forms of institutional work and thereby contribute to the maintenance of a status quo or the promotion of new regime rationalities.

While some of the institutional work applied was very successful in creating, maintaining or disrupting structures, others failed or was insufficient. The desalination lobby, for instance, was highly effective in its advocacy, using strategies such as mimicry to connect to the deeply rooted values and perceptions of the sector (e.g. water security and quality). They were also much more successful in demonizing the competing technology through campaigns (no 'poo water') as well as engaging in a lot of deterring and policing, e.g. through putting a policy ban to water reuse, thus enforcing compliance with traditional water sources. The lobby for wastewater recycling, on the other hand, was less organized and had less impact on policy makers and the public, despite various efforts.

This can partly be related to the argument that recycling technologies have a much higher reconfiguration capacity than desalination and thus need more institutional work to diffuse. Implementing desalination does not lead to much change in the current system, which is why it can be assumed that resistance to it is generally lower. It could even be argued that desalination is highly compatible with the Hydraulic Logic of the regime, e.g. by enforcing values like water security, large scale engineering solutions as well as state control and financing. In this regard, the diffusion of desalination can be interpreted as an entrenchment of the historically dominant regime. The heavy financial investments alone will have an effect on future actions. Some interviewees suggested that opportunities for research around alternative technologies for water supply, such as recycling, have dropped significantly (Interviews 10, 12, 17, 19, 20). The financial debt caused by desalination is remarkable, not enabling any other investments for the next years (Interview 10, 11, 15). Furthermore, it is generally questionable if there will be a need for alternative technologies at all, since desalination represents an abundant source of water. In that regard, the diffusion of desalination can be interpreted as potentially hindering a transition.

Recycling, on the other hand, incorporates new values, such as environmental sustainability, and depends on some major changes

in the perception of how water is supplied as well as organized. However, to date, there was not enough institutional work put in the translation of values like economic efficiency or environmental sustainability into concrete practices within the sector. How are environmental benefits really measured? How would you price recycled water? These insecurities and ambiguities suggest that the newer institutional logics have not been developed and institutionalized to the same degree as the once dominant Hydraulic Logic, which made them overall less legitimate. Due to its reconfiguration capacity, it can be expected that the diffusion of recycling could have had the potential to push the institutionalization of the alternative rationalities and thus foster a more radical transition of the sector.

This can for instance be observed in the case of California's water sector. Despite experiencing very similar climatic conditions as Australia, the sector has gone down a different pathway, focusing increasingly on potable recycling technologies. This can be interpreted as being a consequence from having a different regime setting in combination with highly specific institutional work applied in the area of reuse technologies (Binz et al., submitted for publication). The reconfiguration capacity of a technology is thus not the only argument why desalination diffused more easily than recycling. The transformation of a sector is always a result of the specific interplay of institutions, actors and technologies.

From such a perspective, the development in Australia is not as surprising as many commentators thought. Desalination technology not only shows a better fit with the historically dominant regime configuration, but also experienced a lot of institutional work by actors that maintained and strengthened prevailing system rationality. It can be argued that albeit the newer rationalities have found their way into the regime and triggered different actions that led to significant changes, they were not yet institutionalized highly enough to withstand a crisis. The drought seems to have revoked the most sedimented institutional logic in the system. At the end of the day, politicians needed to account for water security and the most trustworthy way of achieving this was by relying on the best known means: large-scale technologies with a reliable water source.

Newer values, such as economic efficiency or environmental sustainability were thereby eclipsed. The taken-for-granted status of these values seems to be less guaranteed than the discourse suggests. While the degree of institutionalization of different regime structures could already be assessed through a discourse analysis as well as through indicative developments in practice (Fuenfschilling and Truffer, 2014), this paper now shows how actors' actions are affected by the institutional environment and how they work towards changing or maintaining this specific setting. As such, the strength of a socio-technical regime, i.e. its impact on actors, as well as its gradual transformation was additionally evaluated by focusing on agency processes.

The paper thus has some general theoretical implications for transition studies. The introduction of the concept of institutional work shows that institutional theory not just offers insights into stability and persistence of regime structures, but also on how institutional change can be conceptualized by focusing on a more endogenous type of socio-technical change that not only accounts for extreme events, but also for agency. By linking this agency to the structuration of the regime of a system, a perspective on agency as embedded within structures becomes possible. We showed that the scope of agency growth with the increase of institutional plurality within the regime. However, how actors engage in agency and what the effects on the regime are, is highly dependent on the type of institutional work applied. To stress the importance of materiality for processes of (de-)institutionalization, we furthermore introduced the notion of reconfiguration capacity, which shows that materiality itself contributes to the maintenance or change of the regime and thereby plays a crucial role in transitions. Overall, the study is an example of how to address socio-technical transitions as an interplay between institutions, actors and technologies.

7. Conclusion

This paper contributed to an advancement of the micro-foundation of transition processes by introducing the concept of institutional work. Such a practice-oriented perspective enabled a more diversified analysis of the internal dynamics of socio-technical systems. Research on institutional work has identified a series of actions that are likely to influence the creation, maintenance or disruption of institutions. Since socio-technical transitions can be characterized as processes of institutional change, it is crucial to focus on how structures become (de-)institutionalized and what role actors play in such processes.

The concept of institutional work is particularly suitable for the analysis of agency in transition processes because it conceptualizes agency in interrelation with structures, such as the regime. Agency is thus seen as being shaped by a current regime that enables certain behaviors and actions while hindering others. Our analysis revealed that the creation and diffusion of a technological innovation is influenced by highly institutionalized regime structures that lay out a certain scope for legitimate actions. But within that range, actors are able to behave purposefully.

By empirically analyzing actions that contributed to the rapid diffusion of desalination technology, we showed how actors play a mediating role regarding the co-evolution of institutions (i.e. the regime) and technologies. Actors actively contribute to the (de-)institutionalization of certain regime structures and thus influence the transition process. However, their efforts are always understood as being guided by prevailing rationalities as well as material manifestations. As such, we showed an approach to the study of transitions that is inherently socio-technical in nature and similarly accounting for structural as well as agentive arguments of change.

Appendix A

Table A.1
List of interviewees and their role in the urban water sector in Australia.

Position	Interviewee
CEO of a research center	1
Director of educational division of a research center	2
Global business leader desalination, multi-national company	3
Professor	4
Professor	5
Professor	6
Professor	7
Senior lecturer	8
Project manager industry association	9
Senior lecturer	10
Professor	11
Professor	12
National manager industry association	13
Associate professor	14
Professor	15
Project leader government department, senior research fellow	16
Senior leader research institute	17
Assistant director research institute, prior: senior management government department	18
Senior researcher	19
CEO research center, prior: director government department	20
Senior fellow research institute, prior: general manager policy government department	21
Senior audit office	22
Executive leader utility	23
CEO utility, prior: executive director policy government department	24
Member of utility	25

References

Abbott, M., Wang, W.C., Cohen, B., 2011. The long-term reform of the water and wastewater industry: the case of Melbourne in Australia. Util. Policy 19 (2), 115–122.

Avelino, F., Rotmans, J., 2011. A dynamic conceptualization of power for sustainability research. J. Clean. Prod. 19 (8), 796–804.

Battilana, J., Leca, B., Boxenbaum, E., 2009. How actors change institutions: towards a theory of institutional entrepreneurship. Acad. Manag. Ann. 3, 65–107.

Bergek, A., Hekkert, M., Jacobsson, S., 2008. Functions in innovation systems: a framework for analysing energy system dynamics and identifying goals for system-building activities by entrepreneurs and policy makers. In: Foxon, T., Köhler, J., Oughton, C. (Eds.), Innovation for a Low Carbon Economy: Economic, Institutional and Management Approaches 4. Edward Elgar, Cheltenham, pp. 79–111.

Berger, P.L., Luckmann, T., 1966. The Social Construction of Reality. Doubleday, New York.

Binz, C., Sedlak, D., Harris-Lovett, S., Kiparsky, M., Truffer, B., 2015. The thorny road to technology legitimation – Institutional work for potable water reuse in California. Technol. Forecast. Soc. Chang. http://dx.doi.org/10.1016/j.techfore.2015.10.005 (in press).

Birkett, J.D., 1984. A brief illustrated history of desalination: from the bible to 1940. Desalination 50 (0), 17–52.

Carlsson, B., Jacobsson, S., 2004. Dynamics of Innovation Systems — Policy-making in a Complex and Non-deterministic World.

Cathcart, M., 2009. The Water Dreamers. The Remarkable History of Our Dry Continent. The Text Publishing Company, Melbourne.

Clemens, E., 1993. Organizational repertoires and institutional change: women's groups and the transformation of U.S. politics, 1890–1920. Adm. Sci. Q. 98 (4), 755–798.

Colebatch, H.K., 2006. Governing the use of water: the institutional context. Desalination 187 (1–3), 17–27.

Crase, L. (Ed.), 2008. Water Policy in Australia. Resources for the Future, United States of America.

Creswell, J.W., 2009. Research Design - Qualitative, Quantitative and Mixed Methods Approaches (3rd). Sage Publications, Thousand Oaks, CA.

Dahmen, E., 1988. 'Development blocks' in industrial economics. Scand. Econ. Hist. Rev. 36 (1), 3–14.

Daigger, G.T., 2007. Wastewater management in the 21st century. J. Environ. Eng. 133 (7), 671–680.

Delyannis, E., Belessiotis, V., 2010. Desalination: the recent development path. Desalination 264 (3), 206–213.

Dewald, U., Truffer, B., 2012. The Local Sources of Market Formation: explaining regional growth differentials in German photovoltaic markets. Eur. Plan. Stud. (3), 397–420.

DiMaggio, P.J., Powell, W.W., 1983. The iron cage revisited - institutional isomorphism and collective rationality in organizational fields. Am. Sociol. Rev. 48 (2), 147–160.

Dolata, U., 2011. Radical change as gradual transformation: characteristics and variants of socio-technical transitions. SOI Discussion Paper (03).

Dosi, G., 1982. Technological paradigms and technological trajectories. Res. Policy 11 (3), 147–162.

Edquist, C., 2004. Reflections on the systems of innovation approach. Sci. Public Policy 31 (6), 485–489.

Espeland, W., 1998. The Struggle for Water: Politics, Rationality and Identity in the American Southwest. 1. University of Chicago Press, Chicago.

Fligstein, N., 1993. The Transformation of Corporate Control. Harvard University Press, Cambridge.

Fuenfschilling, L., Truffer, B., 2014. The structuration of socio-technical regimes — conceptual foundations from institutional theory. Res. Policy 43 (4), 772–791.

Garud, R., Gehman, J., Karnoe, P., 2010. Categorization by association: nuclear technology and emission-free electricity. In: Sine, W., David, R., Keister, L. (Eds.), Institutions and Entrepreneurship. Emerald Group Publishing Limited, pp. 51–93.

Garud, R., Hardy, C., Maguire, S., 2007. Institutional entrepreneurship as embedded agency: an introduction to the special issue. Organ. Stud. 28 (7), 957–969.

Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Res. Policy 31, 1257–1274.

Geels, F.W., 2004. From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory. Res. Policy 33 (6–7), 897–920.

Geels, F.W., 2011. The multi-level perspective on sustainability transitions: responses to seven criticisms. Environ. Innov. Soc. Transit. 1 (1), 24–40.

Geels, F.W., Schot, J., 2007. Typology of sociotechnical transition pathways. Res. Policy 36, 399–417.

Genus, A., Coles, A., 2008. Rethinking the multi-level perspective of technological transitions. Res. Policy 37 (9), 1436–1445.

Giddens, A.T., 1984. The Constitution of Society. Outline of the Theory of Structuration. Polity Press, Cambridge.

Glater, J., 1998. The early history of reverse osmosis membrane development. Desalination 117 (1–3), 297–309.

Greenwood, R., Hinings, C.R., 2006. Radical organizational change. In: Clegg, S., Hardy, C., Nord, W., Lawrence, T. (Eds.), Handbook of Organization Studies. Sage Publications, London.

Greenwood, R., Oliver, C., Sahlin, K., Suddaby, R. (Eds.), 2008. The Sage Handbook of Organizational Institutionalism. Sage Publications, London (822 pp.).

Greenwood, R., Raynard, M., Kodeih, F., Micelotta, E.R., Lounsbury, M., 2011. Institutional complexity and organizational responses. Acad. Manag. Ann. 5 (1), 317–371.

Greenwood, R., Suddaby, R., Hinings, C.R., 2002. Theorizing change: the role of professional associations in the transformation of institutionalized fields. Acad. Manag. J. 45 (1), 58–80.

Grin, J., Rotmans, J., Schot, J. (Eds.), 2010. Transitions to Sustainable Development. New Directions in the Study of Long Term Transformative Change. Routledge, New York.

Hardy, C., Maguire, S., 2008. Institutional entrepreuneurship. In: Greenwood, R., Oliver, C., Sahlin, K., Suddaby, R. (Eds.), Organizational Institutionalism. Sage Publications, London, pp. 198–217.

Hargadon, A.B., Douglas, Y., 2001. When innovations meet institutions: Edison and the design of the electric light. Adm. Sci. Q. 46 (3), 476–501.

Heckathorn, D.D., 2002. Respondent-Driven Sampling II: Deriving Valid Estimates from Chain-Referrel Samples of Hidden Populations. Social Problems 49, 11–34.

Hekkert, M., Suurs, R., Negro, S., Kuhlmann, S., Smits, R., 2007. Functions of innovation systems: a new approach for analysing technological change. Technol. Forecast. Soc. Chang. 74 (4), 413–432.

Holm, P., 1995. The dynamics of institutionalization: transformation processes in Norwegian fisheries. Adm. Sci. Q. 40, 398–422.

Jarzabkowski, P., 2004. Strategy as practice: recursiveness, adaptation, and practices-in-use. Organ. Stud. 25 (4), 529–560.

Jarzabkowski, P., Matthiesen, J., Van de Ven, A., 2009. Doing which work? A practice approach to institutional pluralism. In: Lawrence, T., Suddaby, R., Leca, B. (Eds.), Institutional Work: Actors and Agency in Institutional Studies of Organization. Cambridge University Press, Cambridge, UK, pp. 284–316.

Johnson, A., 2001. Functions in Innovation System Approaches.

Kemp, R., Rotmans, J., 2004. The management of the co-evolution of technical, environmental and social systems. In: Weber, K.M., Hemmelskamp, J. (Eds.), Towards Environmental Innovation Systems. Springer, Heidelberg, pp. 33–56.

Kivimaa, P., Kern, F., 2015. Creative destruction or mere niche creation? Innovation policy mixes for sustainability transitions. SPRU Working Paper Series.

Kraatz, M., Block, E., 2008. Organizational implications of institutional pluralism. In: Greenwood, R., Oliver, C., Sahlin, K., Suddaby, R. (Eds.), Organizational Institutionalism. Sage, London, pp. 243–275.

Lawrence, T.B., Suddaby, R., 2006. Institutions and institutional work. In: Clegg, S., Hardy, C., Lawrence, T.B., Nord, W. (Eds.), The Sage Handbook of Organizational Studies. Sage Publications, London, pp. 215–254.

Lawrence, T.B., Suddaby, R., Leca, B., 2009. Institutional Work. Actors and Agency in Institutional Studies or Organizations. Cambridge University Press, Cambridge.

Loorbach, D., Rotmans, J., 2010. The practice of transition management: examples and lessons from four distinct cases. Futures 42 (3), 237–246.

Markard, J., 2011. Transformation of infrastructures: sector characteristics and implications for fundamental change. J. Infrastruct. Syst. 17 (3), 107–117.

Markard, J., Truffer, B., 2008. Technological innovation systems and the multi-level perspective: towards an integrated framework. Res. Policy 37, 596–615.

Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: an emerging field of research and its prospects. Res. Policy 41 (6), 955–967.

McKay, J., 2005. Water institutional reforms in Australia. Water Policy 7, 35–52.

Melbourne Water Corporation, 2000. Melbourne Water Corporation Annual Report 1999/2000. Melbourne Water, Melbourne.

Meyer, A.D., 1982. Adapting to environmental jolts. Adm. Sci. Q. 27 (4), 515–537.

Molle, F., Mollinga, P.P., Wester, P., 2009. Hydraulic bureaucracies and the hydraulic mission: flows of water, flows of power. Water Altern. 2 (3), 328–349.

Munir, K.A., 2005. The social construction of events: a study of institutional change in the photographic field. Organ. Stud. 26 (1), 93–112.

Munir, K.A., Phillips, N., 2005. The birth of the 'Kodak moment': institutional entrepreneurship and the adoption of new technologies. Organ. Stud. 26 (11), 1665–1687.

Musiolik, J., Markard, J., Hekkert, M., 2012. Networks and network resources in technological innovation systems: towards a conceptual framework for system building. Technol. Forecast. Soc. Chang. 79 (6), 1032–1048.

Nelson, R.R., Winter, S.G., 1982. An Evolutionary Theory of Economic Change. Belknap Press of Harvard University Press, Cambridge, Massachusetts, and London, England.

Ornetzeder, M., Rohracher, H., 2013. Of solar collectors, wind power, and car sharing: comparing and understanding successful cases of grassroots innovations. Glob. Environ. Chang. 23 (5), 856–867.

Penna, C.C.R., Geels, F.W., 2012. Multi-dimensional struggles in the greening of industry: a dialectic issue lifecycle model and case study. Technol. Forecast. Soc. Chang. 79 (6), 999–1020.

Powell, W.W., DiMaggio, P.J. (Eds.), 1991. The New Institutionalism in Organizational Analysis. The University of Chicago Press, Chicago.

Rip, A., Kemp, R., 1998. Technological change. In: Rayner, S., Malone, E.L. (Eds.), Human Choice and Climate Change — Resources and Technology. Battelle Press, Columbus, pp. 327–399.

Scott, W.R., 1995. Institutions and Organizations. Sage Publications, Thousand Oaks.

Scott, W.R., 2001. Institutions and Organizations. Sage Publications, Thousand Oaks.

Scott, W.R., Meyer, J.W. (Eds.), 1994. Institutional Environments and Organizations. Structural Complexity and Individualism. Sage Publications, United States of America.

Shortell, A., Maggs, D., 2012. Water Desalination — Deep Enough to Dive In? GP Bullhound, United Kingdom

Shove, E., Gordon, W., 2007. Caution! Transition ahead: politics, practice, and sustainable transition management. Environ. Plan. A 39, 763–770.

Smith, A., Raven, R., 2012. What is protective space? Reconsidering niches in transitions to sustainability. Res. Policy 41 (6), 1025–1036.

Smith, A., Kern, F., Raven, R., Verhees, B., 2014. Spaces for sustainable innovation: solar photovoltaic electricity in the UK. Technol. Forecast. Soc. Chang. 81 (0), 115–130.

Smith, A., Stirling, A., Berkhout, F., 2005. The governance of sustainable socio-technical transitions. Res. Policy 34 (10), 1491–1510.

Smith, A., Voss, J., Grin, J., 2010. Innovation studies and sustainability transitions: the allure of the multi-level perspective, and its challenges. Res. Policy 39 (4), 435–448.

Späth, P., Rohracher, H., 2010. 'Energy regions': the transformative power of regional discourses on socio-technical futures. Res. Policy 39 (4), 449–458.
Tisdell, J., Ward, J., Grudzinski, T., 2002. The Development of Water Reform in Australia. Cooperative Research Center for Catchment Hydrology, Australia.
Tolbert, P.S., Zucker, L.G., 1999. The institutionalization of institutional theory. In: Clegg, S., Hardy, C. (Eds.), Studying OrganizationTheory and Method. Sage, London, pp. 169–184.
Turnheim, B., Geels, F.W., 2013. The destabilisation of existing regimes: confronting a multi-dimensional framework with a case study of the British coal industry (1913–1967). Res. Policy 42 (10), 1749–1767.
van den Bergh, J., Truffer, B., Kallis, G., 2011. Environmental innovation and societal transitions: introduction and overview. Environ. Innov. Soc. Transit. 1 (1), 1–23.
Weber, K.M., Rohracher, H., 2012. Legitimizing research, technology and innovation policies for transformative change: combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework. Res. Policy 41 (6), 1037–1047.
Zhou, Y., Tol, R.S.J., 2005. Evaluating the costs of desalination and water transport. Water Resour. Res. 41 (3), W03003.
Zietsma, C., Lawrence, T.B., 2010. Institutional work in the transformation of an organizational field: the interplay of boundary work and practice work. Adm. Sci. Q. 55 (2), 189–221.

Lea Fuenfschilling is a postdoctoral researcher at CIRCLE, Lund University as well as a lecturer at the Department of Sociology, University of Lucerne. She holds a PhD in Sociology from the University of Basel.

Bernhard Truffer is heading the Environmental Social Science Department at Eawag (the Swiss Federal Institute of Aquatic Science and Technology) in Zürich area in Switzerland and holds a chair in the Geography of Transitions in Urban Infrastructures at Utrecht University. He has a long track record in sustainability transitions research. He is a founding co-editor of a new Elsevier journal Environmental Innovation and Sustainability Transitions (EIST) dedicated to transitions research. A number of his original contributions relate to "geography in sustainability transitions" research. He has published review papers on the lack of a spatial perspective in transition studies and presented a constructive research agenda for economic geographers and regional studies scholars willing to engage in this field.