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The thorny road to technology legitimation — Institutional work for potable water reuse in California

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ABSTRACT

Technological innovation that is incongruous with established social rules and practices is often confronted with strong skepticism and a lack of societal legitimacy. Yet, how the early actors in a new technological field create legitimacy for new products is not well researched. This paper addresses this gap by proposing an analytical framework for the early technology legitimation phase that combines recent insights from innovation studies and institutional sociology. Both literatures agree that technology legitimation depends on a complex alignment process in which the technology and its institutional context mutually shape each other. Innovation system studies recently proposed to explore these processes in more detail. So far, this literature has mainly treated legitimacy as an outcome of overall system maturation and has not ventured into assessing legitimation as an active process. The framework we put forward in this paper conceptualizes technology legitimation as being enacted by different actors in a technological innovation system through specific forms of institutional work. This framework is illustrated with a case study on potable water reuse, in this case the injection of treated wastewater into drinking water reservoirs — a technology most consumers confront with revulsion. California is among very few regions worldwide where this technology is becoming common practice. Interviews with 20 key stakeholders and content analysis of 124 newspaper articles reveal how technology proponents worked on legitimizing this controversial technology by engaging in system building and institutional work at various levels. We outline how the legitimation process interrelates with other core development processes of a technological innovation system and discuss how our framework informs recent work in innovation and transition studies.
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1. Introduction

Technological innovation and new industries struggle with a crucial problem in their early development phases: the "liability of newness" (Freeman et al., 1983; Suchman, 1995). New technologies that are in conflict with established norms and regulations, incomprehensible to a wider audience, or provide intangible benefits to end users, are likely confronted with major doubts about their utility and reliability (Freeman et al., 1983). The proponents of such innovation have to spend considerable energy in translating and explaining their visionary ideas and in challenging and shaping taken-for-granted beliefs to overcome these barriers. This process can be conceptualized as the creation of technology legitimacy (Markard et al., 2015; Aldrich and Fiol, 1994). Technology legitimation is more complex than simply marketing beneficial qualities of a new product to end users — which is often associated with creating user acceptance (Wuestenhagen et al., 2007; Venkatesh et al., 2003; Dolnicar et al., 2011). Whereas established technologies are strongly aligned with institutional structures to form 'configurations that work' (Rip and Kemp, 1998) or 'socio-technical regimes' (Geels, 2002), new technologies are often incongruous with these structures. The degree of incongruence depends proportionally to how strongly a new technology contradicts established worldviews, norms and societal roles of users, regulators, or engineers.

Proponents of an institutionally incongruous new technology can react to this problem in two ways: either by adapting the technology's characteristics to match existing rules or by attempting to change the rules to fit the requirements of the technolog\y (Smith and Raven, 2012). Technology studies have presented evidence that both processes often take place simultaneously over the course of the development of a new technology. Major innovations in modern history, like bicycles,

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electric lighting, steamships, and cars, were profoundly incongruent with the dominant regimes at their time of introduction. The historical trajectory of these technologies illustrates how legitimacy was gradually established in a long phase of social contestation and collective sensemaking, and how this legitimation process directly influenced the development of the technology (Geels, 2002; Bijker, 1995; Hargadon and Douglas, 2001).

Given legitimacy's key role in the innovation process, innovation studies have increasingly endorsed it as a central explanatory factor for the success or failure of new technologies and industries (Markard et al., 2015; Geels and Verhees, 2011; Bergek et al., 2008a; Hekkert et al., 2007; Bork et al., 2015). Existing accounts broadly characterize legitimacy as a match (or mismatch) of a technology with institutional structures in the relevant societal peer groups (Markard et al., 2015; Aldrich and Fiol, 1994).[1] In innovation studies, the legitimation process has so far mainly been analyzed at a macro-level, e.g. through framing struggles in public discourse (Geels and Verhees, 2011), as the outcome of actor accumulation in a wider innovation system build-up process (Bergek et al., 2008a; Hekkert et al., 2007) or as the interplay of new technological fields with wider institutional 'contexts' (Markard et al., 2015). These approaches provide useful macro-indicators for the existence or absence of legitimacy in new technological fields, but tend to treat legitimacy as an aggregate state variable, which is often almost synonymous with overall success or failure of an innovation. How legitimacy is actively built up through the interplay of different actor groups in the early stage of a new technology and industry, however, is much less analyzed. In the present paper, we attempt to address this gap by developing a more micro-level understanding of technology legitimation. We will accomplish this by specifying the innovation system function 'creation of legitimacy' into several sub-processes that are available to actors in a technological innovation system (TIS). By this we will present an operationalization of this otherwise rather broad process category in TIS research.

The proposed analytical framework builds on recent insights from organizational institutionalism, which has developed detailed conceptual perspectives on how legitimacy is created and maintained for organizations, social structures or individuals (Suchman, 1995; Zelditch, 2001; Jost and Major, 2001; Johnson et al., 2006). We argue in line with this literature that technology legitimation has to be conceptualized as a process in which heterogeneous actor networks fight over, construct and deconstruct alignments between a new technology and prevailing institutional contexts (widely held social norms, preferences and cognitive associations). The relevant actions and strategies can be conceptualized as different forms of institutional work (Lawrence et al., 2009; Fuenfschilling and Truffer, 2016). Combining the practice-focused perspective of institutional work with the more meso-level oriented technological innovation system literature allows us to derive detailed, process-based explanations on how technology legitimacy is constructed during the industry formation process. In contrast to existing TIS studies, which often treat legitimation as synonymous with system maturation, it also enables a more fine-grained analysis on how legitimation impacts other core innovation system build-up processes. In more general terms, this publication is thus a first attempt to explicitly bridge innovation system studies and the literature on institutional work.

Our framework is illustrated with a case study in the field of potable water reuse in California. Potable water reuse can be considered an institutionally highly incongruent innovation that contradicts strongly held social beliefs and norms. Potable water reuse is technically defined as the "augmentation of a drinking water source with reclaimed wastewater" (National Research Council, 2012). The innovation comprises purifying wastewater (including sewage) and introducing it into drinking water supplies like groundwater basins, surface reservoirs or drinking water networks. Especially in arid regions, this technology promises significant environmental and economic benefits compared to more energy-intensive alternatives like seawater desalination or long-distance water transfer (Tchobanoglous et al., 2011; Leverenz et al., 2011; Schroeder et al., 2012). Yet, due in part to the strong social stigma related to sewage (the 'yuck-factor'), potable reuse projects oftentimes raise fervent public opposition (Hurlimann and Dolnicar, 2010a). In a related paper, we analyze the basic conditions that may encourage or hinder organized opposition (Harris-Lovett et al., 2015). In this paper, we focus on the process through which actors in Southern California aimed at establishing purified wastewater as a legitimate source of drinking water. The analysis builds on in-depth interviews with 20 key experts in California's potable water reuse sector, content analysis of 124 local newspaper articles, and a comprehensive review of secondary data sources. The case study examines how the actors in an emerging innovation system engaged in collective system building, as well as long-term and multi-dimensional institutional work to legitimize this innovation.

The remainder of the paper is structured as follows: we first present innovation studies' and institutional theory's take on legitimation and argue why a more elaborate conceptualization of the technology legitimation processes is needed. Section 2 combines these perspectives into a conceptual framework emphasizing system building and institutional work. We then introduce our empirical case study and methods, and scrutinize the legitimation of potable water reuse in California in more detail. Sections 4 and 4.4.3 discuss the proposed framework, outline its contribution to innovation and transition studies, and derive stylized lessons for policy makers.

2. Theoretical background and analytical framework

Legitimacy is a key concept in sociology, political sciences and organization studies (Zelditch, 2001; Jost and Major, 2001). It is commonly defined as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (Suchman, 1995: 574). This definition locates the source of legitimacy beyond the boundaries of individual actors or organization in widely shared social belief systems (Johnson et al., 2006) and institutional contexts (Scott, 2008). Technology legitimation accordingly depends not on single actors, but on collective action among different organizations that "exert major pressures on the normative order by joining together to actively proselytize for a morality in which their outputs, procedures, structures and personnel occupy positions of honor and respect" (Aldrich and Fiol, 1994). Collective action in emerging technological fields has been analyzed in depth by innovation system studies (Bergek et al., 2008b), whereas the processes that lead to change in existing social structures are the hallmark of institutional sociology (Lawrence et al., 2009). In the remainder of this section, we put these two views in dialogue with each other to develop a more comprehensive analytical framework for technology legitimation.

2.1. Technology legitimation in innovation system studies

Innovation studies, socio-technical transition literature, and in particular the literature on technological innovation systems (TIS), recently started scrutinizing technology legitimation in some detail (Markard et al., 2015; Geels and Verhees, 2011; Bergek et al., 2008a; Hekkert et al., 2007; Bergek et al., 2008b).[2] In a TIS conceptualization, an emerging industry's success in diffusing its new products depends on the emergence of a supportive innovation system around the new technology. Especially in radically new technological fields, innovators are confronted with a complex systemic innovation problem: Knowledge about the innovation is not readily available, markets and user groups are not well-articulated, investment and social capital are scarce and the innovation lacks legitimacy. Early entrepreneurs thus have to engage in collective

[1] Institutions are understood not as organizations, but as the regulative, normative and cultural–cognitive 'rules of the game' in social structure (Scott, 2008).

[2] TIS are defined as "a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion, and utilization of technology" (Carlsson and Stankiewicz, 1991).

agency ('system building') to attract other resourceful actors to the field, create new networks, form advocacy groups and system intermediaries (NGOs, associations, etc.) and align their actions to increasingly adapt hindering institutions in favor of the innovation (Bergek et al., 2008a; Hekkert et al., 2007; Musiolik and Markard, 2011).

In a TIS view, legitimation is considered one of the key system building process which co-evolves with six other system building process that are equally important in the early industry formation phase: Knowledge creation and diffusion, market formation, resource formation, entrepreneurial experimentation, direction of the search as well as development of positive externalities (Hekkert et al., 2007; Bergek et al., 2008b). Legitimacy is "formed through actions by various organizations and individuals in a dynamic process […], which eventually may help the new technology overcome its 'liability of newness'" (Bergek et al., 2008: 407). One often distinguishes between legitimation dynamics in a formative and growth phase of the TIS (Bergek et al., 2008a): In an early stage, the constituent elements of a TIS (actors, networks, institutions) are still embryonic. Legitimation is mainly related to raising expectations and visions about a technology's future potential, often supported by technology assessment studies (Bergek et al., 2008a). In later phases, when several supportive actors have accumulated in the system, they can start to 'run in packs' (Aldrich and Fiol, 1994; Van De Ven, 1993) and influence the institutional context through collective agency (Garud et al., 2007; Garud and Karnoe, 2003).

TIS literature strongly emphasizes the connection between a growing number of actors in the TIS, system-building activities, and legitimation (Bergek et al., 2008a; Hekkert et al., 2007; Bergek et al., 2008b; Negro and Hekkert, 2008; Suurs and Hekkert, 2009). Yet, how these processes interrelate in detail remains underexplored. Empirical TIS studies often assume that legitimacy emerges somewhat automatically from cumulative causation in TIS build-up. For example, Bergek et al. (2008a) cite the solar cell TIS in Sweden in which successful entrepreneurial experimentation, guidance of the search, and market formation led to the installation of the first working photovoltaic systems on rooftops, which ultimately "strengthened legitimation". Legitimacy is thus seen as both input and outcome of the system-building process (Bergek et al., 2008b) and is often conflated with an overall indicator for system development. This aggregate system-level perspective tends to ignore the micro-level determinants of legitimacy, which are based on concrete forms of embedded agency (Fuenfschilling and Truffer, 2016). TIS studies have so far not explicated the different mechanisms and practices through which actors in a new technological field intervene "preemptively in the cultural environment in order to develop bases of support specifically tailored to their distinctive needs" (Aldrich and Fiol, 1994). To better understand the causal determinants of technology legitimation it is necessary to assess how actors construct institutional matches or mismatches and how they interface with relevant institutional frameworks throughout the system build-up process. The next section will elaborate how institutional theory and the literature on institutional work provide useful conceptual building blocks in this venture.

2.2. Legitimation in institutional theory

In lieu of summarizing the broad and rich accounts on legitimacy that exist in sociology, political sciences and organization studies (Zelditch, 2001), we will here exclusively focus on conceptual frameworks that are relevant for technology legitimation processes. Scott (2008) provided a seminal heuristic framework that distinguishes between regulative, normative and cultural–cognitive pillars of legitimacy (Table 1). The regulative pillar is based on accordance to legal or quasi-legal rules. Organizations (and technologies) that operate in accord with existing laws and regulations possess high legitimacy, whereas technologies that require regulative changes appear less legitimate. For example, in its early days, Google Street View received a lot of skepticism from people worrying about an intrusion of personal privacy. The normative pillar relates to a deeper, moral basis of legitimacy: Legitimate organizations follow the moral obligations of a given place and culture. New ideas that are in conflict with existing normative orders in turn likely face public opposition. For example, genetically modified food crops are strongly combatted in many Western European countries that normatively sanction organic farming. The cultural–cognitive pillar, finally, rests on pre-conscious, taken-for-granted understandings of organizations or technologies. A technology that is not related to an audience's prior daily life experience is likely to face strong skepticism as people are unable to connect it to their common cognitive definitions of specific situations, artifacts or social roles. Bijker (1995)provides an illustrative example here with their analysis of how people tried to make sense of the first bicycles that appeared on the market. At first, bicycles were framed as either racing devices, 'macho' status symbols or 'safe transportation devices' by different social groups. Only after the 'safety bike' idea had stabilized and questions about women riding them in skirts (that might be lifted by the wind) were resolved, did the innovation gain broad legitimacy. Suchman (1995) proposes an additional fourth pillar, pragmatic legitimacy. This form of legitimacy derives from the direct utility an artifact provides to a given audience: Innovations with easily understandable benefits to end user groups are more likely to appear legitimate (e.g., smart phones, despite moral and regulative issues related to data protection) whereas ideas with intangible direct benefits will appear less legitimate (e.g., carbon capture and storage, despite potential collective benefits related to climate change mitigation).

Technology legitimacy can accordingly be differentiated into four key dimensions (Table 1) and several sub-dimensions (Suchman, 1995; Harris-Lovett et al., 2015). Innovation that is incongruous to existing regimes usually confronts legitimacy challenges in several (or all) key dimensions which are furthermore often institutionalized to varying degrees (Fuenfschilling and Truffer, 2016). TIS actors that introduce innovation into regime structures with deeply institutionalized norms and beliefs thus face a very complex task: actively aligning the institutional environments to the emerging technology (or vice versa), often thorough multi-dimensional agency (Suchman, 1995; Bergek et al., 2008b; Zucker, 1987).

Institutional sociology also provides differentiated frameworks for the specific forms of action that alter existing institutions, often summarized under the term 'institutional work' (Lawrence and Suddaby, 2006). Purposive action is conceptualized in relation to deeply institutionalized structures (Scott and Meyer, 1994; Powell and DiMaggio, 1991). Actors are embedded in social structures, causing them to unconsciously align their actions to existing institutions. Yet, they are also able to critically reflect on taken-for-granted norms and assumptions and purposefully deviate from them (Giddens, 1984). Such 'embedded agency' (Granovetter, 1985) is the basis of a flourishing field of research that analyzes the different activities aimed at the transformation of institutions, either for maintaining them, purposefully changing them, or establishing new ones (Fuenfschilling and Truffer, 2016; Lawrence and Suddaby, 2006). Several forms of institutional work have been

Table 1
Key dimensions of legitimacy.
Source: adapted from Scott (2008) and Suchman (1995).

	Pragmatic	Regulative	Normative	Cognitive
Motivation	Self-interest	Expedience	Social obligation	Taken-for-grantedness
Affect	Utility/indifference	Fear, Guilt/innocence	Shame/honor	Certainty/confusion
Basis of legitimacy	Personal evaluation	Legally sanctioned	Morally governed	Comprehensible, culturally supported

Table 2
Forms of institutional work.
Source: adapted from Fuenfschilling and Truffer (2015) and Lawrence and Suddaby (2006).

Form of work	Definition	Examples
Advocacy	Mobilizing political and regulatory support through direct and deliberate techniques of social persuasion/mobilizing direct networks to decision-makers	Convincing politicians, the public or investors of the need for an innovation through personal communication, lobbying, meetings, etc.
Political work	Using political power to directly achieve specific goals	Overruling or ignoring democratic processes, diverting issues from their intended meaning to achieve political goals
Changing normative associations	Re-making the connections between sets of practices and the moral and cultural foundations for those practices	Re-interpreting existing practices from an alternative normative perspective, e.g. introducing "business-like" managerial practice into utilities.
Constructing normative networks	Constructing inter-organizational connections through which practices become normatively sanctioned and which form the relevant peer group with respect to compliance, monitoring and evaluation	Creation of expert groups, committees, associations, advocacy groups or NGOs that evaluate and certify the innovation
Mimicry	Associating new practices with existing sets of taken for-granted practices, technologies and rules	Meshing the innovation with daily life experiences, e.g. selling bottled recycled water alongside bottled spring water
Theorizing	Developing and specifying abstract categories and elaborating chains of cause and effect	Creating scientific models and predictions, developing concepts and shared language that build a cognitive map
Educating	Educating actors in skills and knowledge necessary to support the new institution	Public outreach campaigns and information materials, presentations, guided tours to production facilities
Valorizing and demonizing	Providing positive and negative examples that illustrate the normative foundations of an institution	Giving awards to innovative projects and individuals, using celebrities to promote the innovation
Mythologizing	Preserving the normative underpinnings of an institution by creating and sustaining myths regarding its history	Underlining a place's history and experience with the innovation, stories about 'great' men or projects
Imagery	Invoking images that cause fright and worry (or joy and comfort) and associate an issue with danger (or pleasing experiences)	Showing pictures of empty dams, dry farm land, gardens and rivers (or of pristine water, playing children, etc.)

identified in the literature. In this paper, we draw on a selection that has been used earlier for assessing technology legitimation processes (see Table 2).[3] We explicitly focus on the forms of institutional work that are directly related to legitimation, e.g. action that forms new institutions in order to improve a population's trust in an innovation. It is important to note that institutional work often also has other objectives, e.g. mobilizing additional resources for an organizational field (Lawrence and Suddaby, 2006) or at securing favorable societal status for specific actor groups (Johnson et al., 2006).

The list in Table 2 provides a heuristic to the diverse ways in which institutional alignment – and ultimately legitimacy – can be actively constructed. Some forms of work have been associated with constructing new institutions (i.e. advocacy, constructing normative networks, theorizing), while others are more important for maintaining (mythologizing, valorizing and demonizing) or disrupting (undermining assumptions and beliefs) them (Lawrence and Suddaby, 2006). As these forms of work have been detailed in the literature only recently, a coherent theory is still missing on which process will be important in what phase of technology maturation and how their relative importance in the process might be weighted. By use of this typology, the present paper tries to make a first step in identifying specific instances of institutional work that are characteristic for specific phases of industry maturation and in reconstructing how they interrelate with other system building functions in establishing overall technology legitimacy.

To achieve this goal, we finally have to consider how legitimation interacts with a broader innovation system build-up process over time. To accomplish this, we build on Geels and Deuten (2006) and especially Johnson et al. (2006), who provide a phase model that describes legitimation as a non-linear, cumulative process advancing through four generic stages: 1) innovation, 2) local validation, 3) diffusion, and 4) general validation. In the first two phases, an innovation is created to address needs in a specific local context[4]; such as a new organizational procedure for water quality monitoring or a potable water reuse system in a community. To make the innovation appear locally legitimate, actors have to either link it to the existing institutional framework (Zelditch, 2001) or hope that it gets passively validated by not being implicitly or explicitly challenged (Johnson et al., 2006). This first phase relates to pre-formative TISs, in which actors create normative networks, change normative associations and induce theorizing about the innovation, yet without directly attacking deeply institutionalized dimensions of the dominant regime (Geels and Deuten, 2006). If this first phase is successful, the innovation acquires local legitimacy, which is the basis for diffusion to other local contexts (Johnson et al., 2006).

Legitimation processes fundamentally change in the subsequent diffusion phase (Johnson et al., 2006): As the innovation spreads to new contexts, it increasingly interferes with more broadly shared normative, regulative and cognitive rules. The relevant audience is no longer restricted to an isolated project or community, but rather comprises the general public that assesses the legitimacy of both the technology and the 'industry' that emerges in the new field. This phase thus requires more comprehensive legitimation strategies by powerful actor groups that jointly engage in advocacy, political work, mimicry and valorizing/demonizing. These forms of work can often not be provided by single actor groups, but depend on the creation of intermediaries (e.g., trade associations, interest groups, NGOs) that support the innovation from a morally sanctioned position of independence (Aldrich and Fiol, 1994; Geels and Deuten, 2006; Rao, 2004). To the degree that

[3] For a comprehensive discussion see Fuenfschilling and Truffer (2015).

[4] Note that 'local' does not automatically refer to geographic boundaries: Supportive contexts might also develop in a specific department of an organization or in a societal group that is spatially dispersed. 'Local' protected space for experimentation can be created by a wide variety of factors, like strong leadership, natural conditions, technical happenstance and political interventions.

legitimation in this second phase succeeds, adoption in new situations needs gradually less explicit justification and works through self-reinforcing processes like mimetic isomorphism (Haveman, 1993).

Finally, if diffusion succeeds in various local social contexts, actors in a field may take on the assumption that others believe that the innovation is acceptable and thereby generally validate it (Johnson et al., 2006). In this last phase, the innovation becomes part of society's shared culture and is increasingly 'taken-for-granted', meaning that users stop questioning the usefulness and value of the new technology and alternatives become increasingly unthinkable (Suchman, 1995; Tolbert and Zucker, 1983). Once an innovation has reached this level of legitimacy, it is not easily replaced by alternatives. It is perceived as a "configuration that works" and becomes part of the socio-technical regime. After general validation is achieved, actors in the corresponding TIS can turn to forms of institutional work that maintain the achieved legitimacy of the new field (Suchman, 1995; Lawrence and Suddaby, 2006).

2.3. Analytical framework

Summarizing this short discussion, a detailed understanding of the technology legitimation process should relate the innovation system build-up process in a new field of technology to the specific forms of institutional work the actors apply in the three phases of local innovation/validation, diffusion and general validation. Technology legitimation can accordingly be assessed with a four step framework as follows.

First, before examining the legitimation process itself, a 'basic analysis' (Markard et al., 2009) of the TIS in focus is needed to delineate the system boundaries and to identify the relevant actors, networks and institutions emerging around a new technology. One should also specify the degree of incongruence of the specific innovation relative to the prevailing socio-technical regime and collect background data on how aggregate technology legitimacy evolved over time. Newspaper coverage is an often-used aggregate proxy measure for this: High media attention and conflicting perspectives in newspaper articles indicate framing struggles and contested legitimacy in the public, whereas decreasing and/or increasingly positive media coverage indicates increasing legitimacy (Markard et al., 2015; Geels and Verhees, 2011).

In a second step, one can then turn to analyzing how the actors in a pre-formative TIS attempted to locally validate the innovation. These early legitimation efforts will likely be restricted to specific local contexts or 'niches' that protect the innovation from the normal selection environment (Johnson et al., 2006; Geels and Deuten, 2006). The group of actors involved in institutional work in this early phase will be rather small and located in contexts that are particularly amenable to institutional change; e.g. in places or organizations where the local regime structures are less strongly entrenched than elsewhere or because local conditions are particularly favorable for experimentation. Success of the local validation process can be assessed by whether or not opposition appears and is maintained, whether the initiative(s) continue and/or whether other actors in the field consider it a success. For this purpose, one has to assess how key actors try to accommodate institutional structures to support the new technology, and/or how their adversaries try to highlight an institutional mismatch to hinder technology diffusion. Special emphasis in this analytical step lies on the specific types of institutional work that may ultimately lead to local validation, and whether or not and what form of conflicts emerge during this process. Qualitative data based on interviews, focus groups or participant observation may be used for this step.

In a third step, and given that local validation was successful, one can turn to analyzing diffusion efforts and how they co-evolve with formative TIS structures. In the diffusion phase, actor networks and system intermediaries are likely to emerge and expand legitimation activities beyond local contexts to the general public (Bergek et al., 2008a; Geels and Deuten, 2006). Whether or not diffusion succeeds and the technology receives widespread recognition depends on various interconnected elements like the competence of the TIS actors to skillfully address the different dimensions of the legitimation problem, whether or not well-organized groups of skeptics emerge, as well as on whether developments of broader importance come to bear on the issue (e.g. major accidents like Fukushima, in the case of nuclear power or a severe drought in the case of water reuse). The analytic focus in this phase should lie on collective action in the TIS, the specific instances of institutional work, whether organized opposition emerges, and how the actors in the emerging TIS deal with opposition and technology failures. This step will require rich and contextual qualitative data on the actor's strategies and the existing institutional framework.

If diffusion succeeds, one can then turn to analyzing in a fourth step if and how diffusion is further leveraged by TIS actors to generally validate the technology. Here, the focus lies on advocacy groups (industry associations, networks, interest groups, etc.) in the TIS and the way they use (or fail to use) their increasing political influence to address complex and resource-intensive legitimation tasks (like political work, advocacy or mythologizing). This final step should also reveal how legitimation contributes to and co-evolves with wider innovation system build-up and whether and how it supports (or not) the development of other system functions. This final step depends on contextual qualitative data as well, but also on synthesizing the analysis of the previous steps. Table 3 summarizes these different development stages of the legitimation process and relates it to the supposedly dominant forms of institutional work and the prevalent interactions with other system building processes.

In this way, one can retrace how specific attempts to legitimize a new technology evolve over time, identify the specific contributions of legitimation as a core system building process, and assess how it supports (or hinders) other TIS build-up processes and ultimately an innovation's broad public diffusion and acceptance. A core novel contribution of this approach is that it allows disentangling the legitimation process itself from overall system maturation: In some cases, legitimation might be a key prerequisite for TIS build-up and inducing system functions (e.g. entrepreneurial experimentation, market formation and resource mobilization), whereas in other cases legitimacy might become an issue only after a considerable TIS structure and build-up process has already emerged.

3. Case selection and methods

We will now use this framework as an analytical backdrop to analyze the legitimation of an institutionally particularly incongruous innovation: potable water reuse. The innovation comprises either introducing purified wastewater into a surface or underground drinking water reservoir (indirect potable reuse, IPR) or directly adding it to the drinking water supply immediately upstream or downstream of a drinking water treatment plant (direct potable reuse, DPR) (National Research Council, 2012). So far, few places worldwide successfully operate potable reuse systems. In this paper we focus exclusively on California: Utilities in Southern California were early pioneers in the development of indirect potable reuse and an expert panel in the State is currently working to assess the feasibility of widely deploying direct potable reuse (Harris-Lovett and Sedlak, 2015). This particular case thus allows unique insights into a (so far) successful legitimation process in a field of technology that in most places struggles with contested legitimacy in all key dimensions: The general public often questions the benefit of drinking purified wastewater as the practice is morally stigmatized, in conflict with public health-related regulation and incomprehensive for many end-users and even expert groups (for an in-depth discussion see Harris-Lovett et al., 2015). This extreme case was thus expected to illustrate legitimation strategies in all key dimensions of our framework, thus providing comprehensive and (analytically) generalizable insights beyond the particular single case.

3.1. Methods

Following the requirements of our analytical framework, a mixed methods approach was used to reconstruct the empirical case. First, all relevant articles in a prominent Southern Californian newspaper, the Los

Table 3
General characteristics of legitimation processes.

Legitimation phase	Core mechanism	Predominant forms of institutional work	Interactions with other system build-up processes
Innovation and local validation	Establishing 'local' legitimacy in a specific application area (e.g. niches)	*Creating new institutions*: Constructing normative networks, theorizing and changing normative associations	Knowledge creation, entrepreneurial experimentation, and resource mobilization
Diffusion	Interaction with wider institutional structures and broader audiences	*Shaping/aligning institutions*: Advocacy, political work, valorizing/demonizing, educating, mimicry, and imagery	Resource mobilization, guidance of the search, market formation, and entrepreneurial experimentation
General validation	Stabilizing the taken-for-grantedness into a new 'configuration that works'	*Maintaining institutions*: political work, advocacy, and mythologizing	Market formation, resource mobilization, and creation of positive externalities

Angeles Times,[5] were collected[6] and analyzed for their evaluation of and overall tone towards potable reuse (positive, negative, ambivalent).[7] The database, which consisted of 124 retrieved articles, was visualized to identify overall trends and specific peaks in discursive struggles. Second, qualitative data on the legitimation process was collected in a comprehensive literature analysis and in an interview campaign with 20 key experts in California's potable reuse sector (see Appendices A and B, the interview data was also used for related research described in Harris-Lovett et al. (2015)). The sampling strategy targeted senior experts[8] with overview knowledge from all relevant TIS actor groups (water agencies, academia, regulators, engineering consultants and system intermediaries). A first group of 10 experts was sampled based on a literature review, whereas the second group consisted of recommendations from our first interview phase (Heckathorn, 2002). Interviews followed a semi-structured guideline (see Appendix B) that covered the four legitimation dimensions in Table 1 as well as questions about the development of the potable reuse TIS. Interviews lasted 1–2 h, were transcribed verbatim, codified according to the institutional work typology in Table 2, analyzed with code co-occurrence matrices in MaxQDA software and the results triangulated with secondary data sources. Co-occurrence matrixes can be used to analyze how often codes co-occur in the data. Each interview citation was assigned a time code (development phase of the TIS), a type of organization, plus a thematic code (type of institutional work). After aggregating all codes we could reveal which forms of institutional work were most relevant in which development phase and pushed by which actor group.

4. Results: the legitimation of potable water reuse in Southern California

4.1. Basic TIS analysis and aggregate technology legitimacy

Before venturing into a detailed analysis of the legitimation process itself, we provide a short basic analysis of the TIS in focus and evaluate its aggregate technology legitimacy. From a technological point of view, potable water reuse mostly depends on advances in closely related industrial sectors. Reuse systems use key technological components like microfiltration, reverse osmosis membranes, UV disinfection and advanced oxidation systems that are originally developed for application in seawater desalination, water purification or wastewater treatment systems. Technological innovation in the sector is related to creatively recombining these components into treatment trains and adding quality measurement and monitoring systems that guarantee a high level of water quality and operational safety.

Markets for the technology were restricted to niche applications for a long time due to a lack of public acceptance. Up until the year 2000, only a few places worldwide had experimented with the technology. Often cited success cases include Orange County (CA), Windhoek (Namibia), the International Space Station and experimental plants in Denver (CO) and Belgium (Tchobanoglous et al., 2011). During the 2000s, market applications grew quickly with new systems being planned and installed in Singapore, the West Basin Water District (CA), Big Spring (TX), Wichita Falls (TX) and Cloudcroft (NM). Several reports that were published after 2010 project fast future growth for the technology in different parts of the world (Tchobanoglous et al., 2011; Schroeder et al., 2012; National Water Research Institute, 2013) and dozens of additional projects are currently planned in California, Florida, Texas, Australia and Singapore.

A significant share of the key technologies, as well as process and regulative innovation in this field originated from California and in particular the metropolitan regions of Los Angeles and San Diego. At the beginning, key actors were regional utilities, engineering consultant firms, and local universities that cooperated in developing the first purification systems and treatment trains. After first prototypes had been developed and installed, regulators, system intermediaries (industry associations, lobbying groups and research foundations) as well as citizen activist groups also became an important part of the TIS.

In terms of institutional contexts and aggregate technology legitimacy, the potable reuse TIS in Southern California (and worldwide) struggled with persistent resistance stemming from organized opposition groups (Harris-Lovett et al., 2015; Hurlimann and Dolnicar, 2010b). Our media analysis (see Fig. 1) reveals that potable reuse first entered public discourse during the severe drought in the early nineteen-nineties. At that time, newspaper coverage was highly controversial: potable water reuse was seen as a potentially drought-proof new water supply, but also as a threat to public health. Critical newspaper articles reappeared in the mid-nineties, when several new potable reuse projects were halted by public opposition, and again in the year 2000, when the Los Angeles Department of Water and Power presented a potable reuse plan for Los Angeles without first consulting local residents. After the year 2000, media interest gradually declined and the public discourse took on an increasingly positive tone. In 2013, only two articles appeared in the LA Times, both of which were supportive of the technology. These data indicate that aggregate legitimacy of potable reuse in the Los Angeles metropolitan region gradually increased over more than 20 years, in parallel to a continuous innovation system build-up and institutional work process that will now be analyzed in more detail.

[5] The Los Angeles Times is the most influential newspaper in Southern California and has extensively covered potable reuse activities in the region. This outlet was chosen to represent the particular institutional context and public discourse in Southern California which would not be reflected in other, extra-regional outlets.

[6] Search string: ("water recycling" OR "water reuse" OR "toilet to tap" OR "water reclamation" OR "groundwater replenishment" OR "wastewater recycling" OR "wastewater reuse") AND (drink* OR potable OR supply), limited to Los Angeles Times news articles and editorials, then manually filtered to limit to articles about water reused for potable purposes, timeframe covered: 1990–2013, database: ProQuest Newspapers.

[7] Articles classified as positive used descriptive terminology for potable reuse such as "beneficial," "drought-proof," and "favorable," and/or took an angle towards potable water reuse that emphasized the technology's benefits to local communities or society. Articles classified as negative used descriptive terminology such as "dangerous," "concerns," or "wary", and/or took an angle towards potable reuse that underscored its potential risks. Articles classified as ambivalent had the same number of references to positive and negative terminologies with no discernible angle or overall tone to the article, or contained no descriptive terminology and were solely recounting events (i.e. describing the location of an upcoming water board meeting to discuss potable reuse).

[8] Experts are defined in line with the Oxford Advanced Learner's Dictionary as 'persons who have a comprehensive and authoritative knowledge of or skill in a particular area.' Here, we focused on senior experts with comprehensive overview knowledge of the innovation history of potable water reuse.

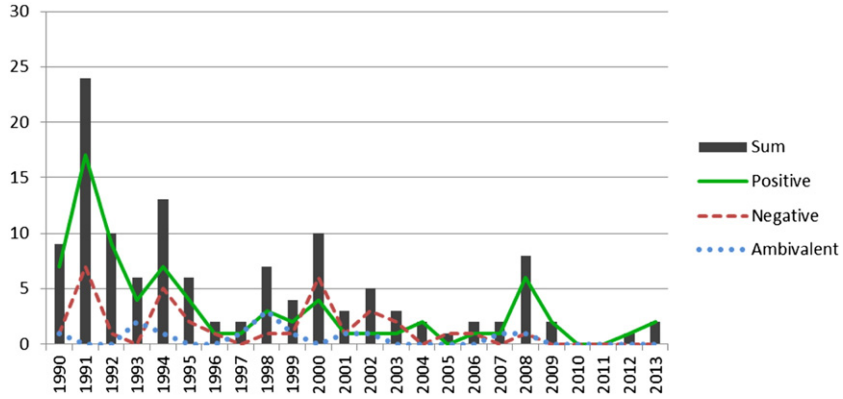

Fig. 1. Media coverage on potable water reuse in the Los Angeles Times, 1990–2013.
Source: own design, based on data from ProQuest Newspapers.

4.2. Local innovation and validation (1960–1990)

4.2.1. Overall TIS development.

The history of potable reuse in California started in the early 1960s in the metropolitan area of Los Angeles, when imported water was first injected into the groundwater aquifer to combat increasing seawater intrusion (Harris-Lovett and Sedlak, 2015). The decisive local innovation happened in the early 1970s, when the Orange County Water District (OCWD) cooperated with local universities to construct a recycling system that would inject purified wastewater into these seawater barriers (Allen and Elser, 1979). The local innovation and validation phase then mostly happened in this specific local context and was strongly dominated by one visionary actor, the Orange County Water District. Their indirect potable reuse system ('Water Factory 21') broke new technological ground. It produced high quality purified water from wastewater in a compact and efficient treatment system, using reverse osmosis membranes that had just been developed for seawater desalination by a local university (Allen and Elser, 1979).

4.2.2. Institutional work.

The institutionally incongruous part of the project was that it would (indirectly) supply the region's drinking water wells with recycled wastewater — a previously unheard of and unregulated practice. Water Factory 21 thus spurred a wave of *theorizing* in the utility and local universities (Interview 19) and forced the State's Department of Public Health (DPH) to officially evaluate the direct injection of recycled wastewater into a drinking water aquifer. To justify the need for this innovation, OCWD, local universities and the Department of Public Health *constructed* a first *normative network* that evaluated the system's performance. After extensive research, reviews and expert consultancy, DPH decided to grant Water Factory approval, and the plant went online in 1976 (Harris-Lovett and Sedlak, 2015). After a few years without serious problems, the project was locally validated in the small involved expert community and at same the time passively validated by the general public:

> "*A lot of the early developments flowed underneath the radar of the general public. In the 1970s, I don't think there was nearly as much insistence on public transparency as there is today.*" (Interview 19)

4.2.3. Summary

As public awareness about the innovation was low, major interventions into existing institutional structures were not yet needed in the local innovation and validation phases. Institutional work was mostly limited to constructing normative networks and theorizing with both activities addressing mostly the local context of Water Factory 21. Still, the – initially rather passive – local validation in Orange County and the build-up of a first embryonic TIS structure (involving networks between utilities, regulators and academia) that induced knowledge creation proved to be vital for later legitimation efforts, especially when public opposition to other projects appeared in the diffusion phase.

4.3. Diffusion (1990–2010)

4.3.1. Overall TIS development.

Diffusion of potable reuse started in the early nineties, during the drought-induced call for action in California's water sector. With alarming signs of acute water scarcity, new utilities entered the TIS and proposed their own indirect potable reuse projects in San Diego, Los Angeles County, Dublin-Pleasanton and the San Gabriel Valley. These projects heavily relied on OCWD's successful treatment technology and tried to mimic their success case (Interview 20). Nevertheless, most of them soon ran into organized public opposition that ultimately stopped the planning process. Opposition ranged from politicians halting reuse projects for their personal electoral campaign in Los Angeles, (Interview 1) to breweries fearing for their beer's reputation in the Upper San Gabriel Valley (Interview 12), to public opposition groups like the "revolting grandmothers" in San Diego who worried about public health risks of the technology (Interview 1; Royte, 2008). As the managing director of an opposed project put it, the utilities learned the hard way that simply copying the technological concept from Orange County was not sufficient to legitimize potable reuse in other contexts:

> "*Everything that we conceived in that period of the early 1990's is exactly what Orange County Water District did. […] I was naïve in assuming that […] that would succeed. […] But there was all the animosity that came out because [our project] raised all the questions about safety and stuff like that. We tried to prove that it was safe through the technological science basis, but with all the other pressures and all the other things, it just didn't prevail.*" (Interview 20)

It became increasingly evident that the innovation challenges at hand were not merely technical. Instead, they included influencing deeply institutionalized beliefs to such a degree that key stakeholders and the general public, beyond Orange County, would begin to perceive drinking purified sewage an appropriate social practice. A more coherent and collective legitimation strategy was needed that would include actors from various relevant stakeholder groups, like industry, academia, health authorities and community organizations (Interviews 2, 11, 19). This realization and the drought-induced urge for action triggered a first round of system building and subsequent institutional work in the early nineties.

Two intermediary organizations (the WateReuse Association and National Water Research Institute, NWRI) were founded after the drought in the early 1990s and quickly became key actors in the potable reuse TIS. NWRI was founded by a private donor and six Southern Californian water agencies. It was located inside the Orange County Water District's

office building, next to their water recycling plant and was working in close cooperation with several Southern Californian water utilities. Initially, this organization funded research on non-conventional water sources. The WateReuse Association and WateReuse Research Foundation in turn were founded in the early nineties by Southern California water agencies. The Association was intended to be a direct advocacy organization for (potable) water reuse. Its mandate included breaking barriers to water recycling, making people aware of recycling opportunities and increasing research and lobbying for potable reuse (Interview 13). It was financed by the utilities and therefore strongly influenced by the water agencies' increasing push for potable reuse (Interviews 8, 10, 13). Both organizations' initial missions were to help develop new solutions to California's pressing water challenges, but they soon also became an integral part of more direct legitimation work.

4.3.2. Institutional work.

At the outset, NWRI and WateReuse mostly contributed to *theorizing* the feasibility of potable reuse. They published a series of highly influential white papers and reports that provided key basic vocabulary and arguments for the necessity and feasibility of potable reuse (Tchobanoglous et al., 2011; Leverenz et al., 2011; Schroeder et al., 2012; National Water Research Institute, 2013; National Water Research Institute, 2010; Leverenz and Tchobanoglous, 2002). Yet, from the mid-nineties, they also became engaged in other forms of institutional work.

First, NWRI played a key role in *constructing* a highly relevant new *normative network* through the facilitation of 'Independent Expert Panels'. These panels were created to provide a relevant peer group with respect to compliance, monitoring and evaluation of potable reuse: Throughout the history of potable reuse (and up until 2015), California's Department of Public Health had only formulated a provisional regulative environment for potable water reuse, and approved potable reuse projects on a case-by-case basis (Interviews 6, 14). This situation created mistrust in the relevant expert groups and community organizations (Interviews 2, 6). In the early 2000s, NWRI thus developed the idea to form expert panels in which specialists from academia, engineering consultants and utilities would evaluate reuse projects and give technical recommendations to the utility managers and regulators. The panels were created from a small, well-connected (and generally supportive) group of experts who would jointly assess new water reuse projects, give recommendations to utilities in public meetings and ultimately label them as 'OK' if all the requirements were met. Composition of the panels was not left to chance. Often, the panel consisted of an intentional combination of a core group of professionals with local experts in order to maximize trust from local communities and the regulators (Interview 12):

> "*A lot of times we used retired folks, academics, former regulators. We used people that are viewed as credible […]. When people on the outside saw who's on the panel and who they are, they go, "Wow. I can trust them.*" (Interview 9).

The utilities soon realized that the evaluation from these prestigious expert panels could be instrumental to other forms of institutional work, like basic forms of *advocacy*. For example, the city of San Diego Water Department put the expert panel's evaluation into their report to the city council to underline the cutting-edge expertise involved in the project (Interview 9).

> "*This worked very well. The panel gives confidence to the regulators and it also gives confidence to the community.*" (Interview 12)

Overall, even though the original intent of the expert panels was to answer technical questions, this newly constructed normative network soon became instrumental in:

> "*helping the regulators work through [DPR projects], it's helping with utilities' public outreach. So it has these other benefits that are kind of layered over on top.*" (Interview 9)

The second and similarly important form of institutional work induced by NWRI and the WateReuse Association was *valorizing* potable reuse and its proponents through the establishment of prizes like NWRI's Clarke Water Prize or the WateReuse Association's Annual Awards. Both prizes were introduced in the late 90s/early 2000s to honor outstanding projects and individuals in the water sector and thereby provide positive normative examples for other people working in the field. A considerable share of these prizes was awarded to key individuals and projects related to potable reuse,[9] which helped DPR experts improve their prestige and mobilize additional resources for research projects in later TIS development stages (Interviews 9, 15).

These forms of work successfully construed normative (and to some degree regulative) legitimacy of potable reuse, but major problems persisted with the pragmatic and cognitive dimensions. Our media analysis revealed that in the early 2000s potable reuse was still highly contested in public discourse. When OCWD's management started planning a large expansion project to Water Factory 21 in the early 2000s,[10] they thus embarked on additional forms of institutional work that would directly target the pragmatic dimension. A specialized communication company was commissioned to develop an outreach plan to create and maintain public support for the project (Interview 17). The communication specialists encouraged OCWD to set out for a massive *education* campaign that would focus on establishing pragmatic legitimacy in particular. The utility embarked on a 10-year outreach effort comprising more than 1200 talks, speeches and presentations (Interview 17). OCWD staff, directors or board members strategically educated the local community (and in particular highly-regarded community leaders) about the project and explained how it would serve people's personal interests:

> "*What's most important [are] the community leaders– the leaders of the Kiwanis group, the leaders of religious groups, the leaders of medical groups. You want those people to have a good understanding of the project, first and foremost, because they're the ones that everybody else relies on.*" (Interview 19)

To guarantee ongoing support, OCWD's outreach activities adopted a long-term perspective. Local politicians were regularly targeted and urged to sign letters of support for the project (Interviews 10, 17). This pro-active outreach campaign effectively stalled organized opposition in OCWD jurisdiction and due to its success, became an unofficial industry standard that is now replicated in several other potable reuse projects (Interviews 4, 7, 10, 16, 17).

4.3.3. Summary

The diffusion phase was characterized by a wave of system building in which several new utilities and two intermediary actors entered the TIS. Activities in the TIS still mostly focused on knowledge creation, direction of the search and entrepreneurial experimentation in several new reuse projects. Collective legitimation strategies emerged only in the mid-nineties after fervent and organized public opposition had stopped several new potable reuse projects. System intermediaries started influencing the normative and regulative bases of legitimacy mostly through constructing a normative network (independent expert panels) and valorizing potable reuse through the allocation of high-prestige water prizes. In addition, OCWD actively addressed the pragmatic legitimacy dimension with a massive education and public outreach campaign. These increasingly coordinated legitimation strategies of NWRI, WateReuse, OCWD and other utilities allowed California's potable reuse TIS to reestablish a basis of legitimacy by the early 2000s. As a result, the TIS continued expanding at a time when similar initiatives

[9] See the webpages of both prizes: http://www.nwri-usa.org/ClarkePrize.htm and https//www.watereuse.org/information-resources/press-room/awards-program.

[10] Their new $480-million "Groundwater Replenishment System" would produce much more recycled water (up to 100MGD) and inject it into the groundwater aquifer, providing enough recycled water for nearly 600,000 residents (Interviews 8, 19, http://www.water-technology.net/projects/groundwaterreplenish/ (accessed on 10/16/2014)).

collapsed elsewhere, e.g. in Australia after massive public opposition emerged to potable water reuse in the town of Toowoomba (Hurlimann and Dolnicar, 2010a). Later in the 2000s, several utilities successfully built indirect potable reuse systems: West Basin Water District introduced potable reuse into its service portfolio, OCWD inaugurated the Groundwater Replenishment System in 2008, new reuse projects got planned in California, Texas and New Mexico and Singapore built a successful potable reuse plant in close interaction with California experts (Interviews 16 and 19).

4.4. Towards general validation (starting from 2010)

4.4.1. Overall TIS development.

With increasing technology diffusion, activities in California's potable reuse TIS gained additional momentum and led to another expansion of the actor base: In 2012, a new powerful advocacy group (the 'DPR Research Initiative'[11]) was founded by leading water utilities and the WateReuse Association and raised considerable resources for further knowledge creation and lobbying activities. Several private engineering consulting companies now entered the TIS and donated money to support research projects on this potential future multi-billion dollar business. Regional universities got increasingly integrated in the system mainly by applying for research grants funded through the donations raised by the DPR research initiative. In that phase, the discourse in the TIS started shifting from indirect groundwater replenishment to (even more controversial) direct potable reuse (DPR). Several meetings, conferences and research reports directly addressed this new topic, including a very influential report by the National Research Council (2012) (Tchobanoglous et al., 2011; Leverenz et al., 2011; National Water Research Institute, 2010; Nellor and Millan, 2010). NWRI, WateReuse and the members of the DPR initiative became key actors in integrating and directing the agenda of the emerging potable reuse sector and further strengthened the legitimation work in the system.

4.4.2. Forms of institutional work.

In this last phase, the portfolio of legitimation-related institutional work in the system strongly expanded. First and foremost, by integrating the voice of resourceful companies, utilities and universities in the DPR research initiative, an even more inclusive *normative network* to morally sanction potable reuse was *constructed*. The main goal of this initiative was identifying and addressing the unresolved research questions on DPR, including 'fail-safe' treatment and monitoring technology, substitution for natural buffers, and public acceptance (WateReuse Association, 2014). At the same time, the network gave the WateReuse Association backing in direct *advocacy* work for potable reuse. In 2010, WateReuse helped introduce several bills[12] into California's legislation that would cause the State to formulate definitive regulation for indirect potable reuse by 2014, assess the feasibility of direct potable reuse by 2016[13] and allocate the regulatory responsibility for recycled water to the drinking water regulatory bodies.[14] One of the Bills ran into considerable opposition in the State Assembly. WateReuse's legislative experts thus decided to embark on direct *advocacy* with members of the Assembly and the Senator's office:

> "*The Department of Public Health, the day before the Senate was to vote on it, they opposed the bill […]. So we told them, "you oppose it if you want. If you think you can get the governor to veto the bill, go for it." But we didn't think they could. We were talking to the governor's office. We thought they wouldn't prevail, and they didn't. The governor signed our bill and he had a signing statement saying "DPR study is not happening fast enough. Move it along faster." […] We get a lot of support now. It's just fantastic.*" (Interview 13)

The enactment of this Bill[15] and the signing statement of the governor set a new pace for the further validation of potable reuse in California, but it also created a new problem: together with the enactment of the bill, the governor (for unrelated reasons) also transferred the Drinking Water Division of DPH into the SWRQCB. This undermined the recycling community's plan to keep potable reuse under drinking water regulation. The legislative staff of WateReuse subsequently engaged in direct *political work* to resolve this problem:

> "*I'm pretty involved in a task force that the governor's office established to advice on this change. One of the things that I appear to have gotten agreement from the State on, is that when they move the Drinking Water Division from DPH over to the State Board, they will put potable reuse permitting in that Drinking Water Division, which is exactly what we were trying to accomplish [with one of our Bills]. So we appear to have gotten there by a different pathway.*" (Interview 13)

With the potable reuse community gaining political influence and access to financial resources, technology proponents could now also turn to addressing the very persistent cognitive "yuck-factor" problem. WateReuse, the DPR initiative, NWRI and several utilities developed a broad set of projects that aimed at making the innovation more comprehensible for the general public. Experiences made in OCWD, West Basin and even Singapore provided general lessons that could inform institutional work in this field (Nellor and Millan, 2010). First, actors realized that *education* campaigns had to address a deep cognitive level and provide people with very basic knowledge and a storyline that would enable them to support the new practice:

> "*What we found […] was that people at the time didn't know where their water came from. They took it for granted. […] So we changed our presentation. Almost every presentation first started with the overall big picture. So that the people could appreciate what it takes to get their water. And then, we'd go into what we do and what water we provide to them.*" (Interview 17)

The resulting education programs strongly relied on *imagery*: A webpage and YouTube video[16] were created that explained in simple language that all water on Earth is recycled in the natural water cycle. Potable water reuse was framed in the context of taken-for-granted water supplies and *existing assumptions and beliefs* were strategically *undermined*:

> "*It worked very well. People who saw [the video] said things like "you know, I never thought of it that way before, but it makes so much sense". And a lot of people said this should be in schools. It should be on TV […] because it causes people to change their mental mindset.*" (Interview 7)

This storyline used *mimicry* of a discussion on de facto potable reuse, showing people that much of the water that is currently supplied to Southern California from the Colorado River is de facto recycled water that has passed through several wastewater treatment plants upstream of their drinking water intakes (Harris-Lovett et al., 2015). Once people were educated about this context, potable reuse could be framed as a superior solution:

> "*I can show that [our potable reuse project] has better quality water than any other source. That's a really good message to be able to give the public. I can compare […] a number of choices. Which one is my best? It's the recycled water. It's a pretty good story.*" (Interview 19)

In addition, another project coordinated by WateReuse's 'Public Education and Outreach Committee' related to *changing normative associations*. It aimed at defining a vocabulary and a more standardized

[11] More detailed information: http://www.watereuse.org/foundation/research/DPR-Initiative.
[12] SB 918, AB 2398, SB 322
[13] CA Senate Bill 918, http://legiscan.com/CA/bill/SB918/2013
[14] CA Assembly Bill AB 2398
[15] SB322.
[16] Video available at http://www.athirstyplanet.com/your_h20/downstream.

communication strategy for potable reuse projects (Interview 16). Psychologists were funded to assess what words would make people associate potable reuse with more positive mental pictures than drinking wastewater 'toilet-to-tap' (Nellor and Millan, 2010; Haddad et al., 2009).

> "*When we first started, it was 'wastewater purification' or 'wastewater treatment'. Now, […], it's 'purification'. And it's not a wastewater purification facility. It's a 'water purification facility'.*" (Interview 17)

This strategy was further supported with strong *imagery*. In a YouTube clip a famous Hollywood actor can be seen drinking 'purified water' in a paradise-like setting, saying: "don't think about what it was, […] don't think sewer. Recycled. It's recycled. This is pure, natural, regular water and I can do this [drink this]!"[17] Finally, most utilities that do potable reuse also included visitor centers, organized guided tours and let people taste freshly purified wastewater from a small tap, all in an attempt to make people cognitively associate purified wastewater with their daily routine of drinking tap water (Harris-Lovett et al., 2015).

4.4.3. Summary

In this last phase, the TIS further expanded to include new actors from the private sector and academia and intensified its internal networking activities. Resource mobilization and market formation strongly increased while knowledge creation and guidance got better coordinated among system actors. Growing resources and political influence also meant that the key TIS actors were able to develop a comprehensive portfolio of legitimation strategies. WateReuse leveraged their reputation in speeding up institutional work in the regulatory dimension (advocacy, political work), the DPR initiative formed a new normative network that framed potable reuse not only as a necessity, but as a superior source of drinking water (undermining normative assumptions and beliefs), and several utilities and consultants developed strategies to further increase pragmatic and cognitive legitimacy (education, mimicry, imagery, changing normative associations). The depth and breadth of the forms of institutional work applied in this phase was unmatched in previous development stages. In addition, the TIS now also started to provide positive externalities to its members, mostly in the form of member-only events, publications and training workshops.

Through consecutive episodes of system building and institutional work, Californian actors were able to overcome the legitimacy-related blocking mechanism that persistently hinders this innovation's development in other regions (Hurlimann and Dolnicar, 2010a). The comprehensive and coordinated portfolio of institutional work that developed in California after the mid-90s increasingly aligned the innovation with relevant institutional contexts and ultimately allowed the TIS to enter a growth stage; several large potable reuse projects are currently planned and built throughout the State, the governor is pushing for the fast formulation of regulations and standards, and even the direct injection of purified wastewater into the drinking water system is not a taboo topic anymore. Even though reliable predictions are impossible, California's potable reuse TIS seems poised for continued rapid growth and increasing general validation.

5. Discussion

Figs. 2 and 3 further summarize the TIS formation and legitimacy related institutional work processes outlined above. The TIS itself experienced two waves of expansion, one in the early nineties and one in the late 2000s. Before 1990, most activities were mainly related to knowledge creation and confined to OCWD and its immediate local context. This situation changed between 1987 and 1991, when a serious drought hit California and activities in the water recycling field suddenly skyrocketed (Harris-Lovett and Sedlak, 2015).

Several utilities entered the field to experiment with new potable reuse projects and two intermediary actors started supporting knowledge creation and direction of the search. The second major structural expansion of the TIS happened after 2010, when a diversified advocacy group including actors from utilities, academia, the private sector and regulators (the 'DPR research initiative') was able to mobilize considerable additional resources, further focus the direction of the search and provide positive externalities to its members.

Legitimacy-related institutional work did not automatically result from actor accumulation in the TIS, but co-evolved with system expansion and other system building processes in complex ways. At the outset, local innovation and validation were largely managed by a single organization (here: OCWD) with local legitimation strategies as described by Suchman (1995). This first phase overlapped with the embryonic TIS development stage. Here, a small network among experts from utilities, regulators and universities worked on legitimacy matters by inducing normative networks and theorizing to justify experimentation and collective learning. As the general public was mostly unaware of their activities, the TIS actors did not yet have to embark on collective institutional work to influence social norms and assumptions beyond the immediate regional context.

When the TIS entered an expansion stage in the early nineties, proponents of potable reuse underestimated the complexity involved in translating an institutionally incongruous innovation to new contexts. Several new potable reuse projects that tried to copy the technological 'success case' of OCWD (mimetic isomorphism) became highly controversial and were confronted with fervent public opposition. To overcome a looming legitimacy crisis in the TIS, the technology's advocates were forced to embark on a broader set of institutional work that directly addressed the parts of the wider institutional framework that were not aligned to the innovation's needs. Starting from the mid-nineties, intermediary actors took over a key role: They successfully engaged in normatively charged forms of institutional work like valorizing and the construction of normative networks from a seemingly independent (and therefore more credible) position than early innovators. NWRI's 'independent expert panels' and WateReuse's water prizes are two successful examples of this emerging collective legitimation strategy. These efforts (together with OCWDs extensive education campaign) represented an important precondition for overcoming a major barrier for the TIS to move from one development stage to the next.

In the further structural expansion of the TIS at the end of the 2000s, key system building activities asked for new forms of institutional work that led towards "general validation" of the technology. Much of the advocacy and political work induced by the DPR research initiative, for instance, was only possible after backing and significant donations were raised from powerful regime actors. Resourceful private actors in turn entered the TIS only when they saw a potential multi-billion market and after they had sensed that their open engagement would not be detrimental to their business reputation. Improved access to resources and increasing political influence in turn meant that system intermediaries could start to address more challenging legitimation activities: they engaged in direct advocacy and political work with the State government and started undermining the general public's deeply held normative and cognitive assumptions related to drinking wastewater.

These results have relevant conceptual implications. First, they show in contrast to existing TIS studies that actor accumulation in an emerging industry is a necessary, but far from sufficient condition for successful technology legitimation. More generally, TIS formation and the different phases of legitimation are not always perfectly synchronized. In the potable reuse case, a first system expansion episode in the early 90s did not lead to increased trust in the innovation, but rather to organized opposition and a broad legitimacy crisis which put future TIS development in danger.[18] The decisive factor for legitimation appears not to be actor

[17] Video available at http://www.youtube.com/watch?v=ll_YlUDAv3c.

[18] A similar process might be happening at the moment with potable reuse projects being operated in Texas without clear regulatory guidance or comprehensive legitimation strategies in place.

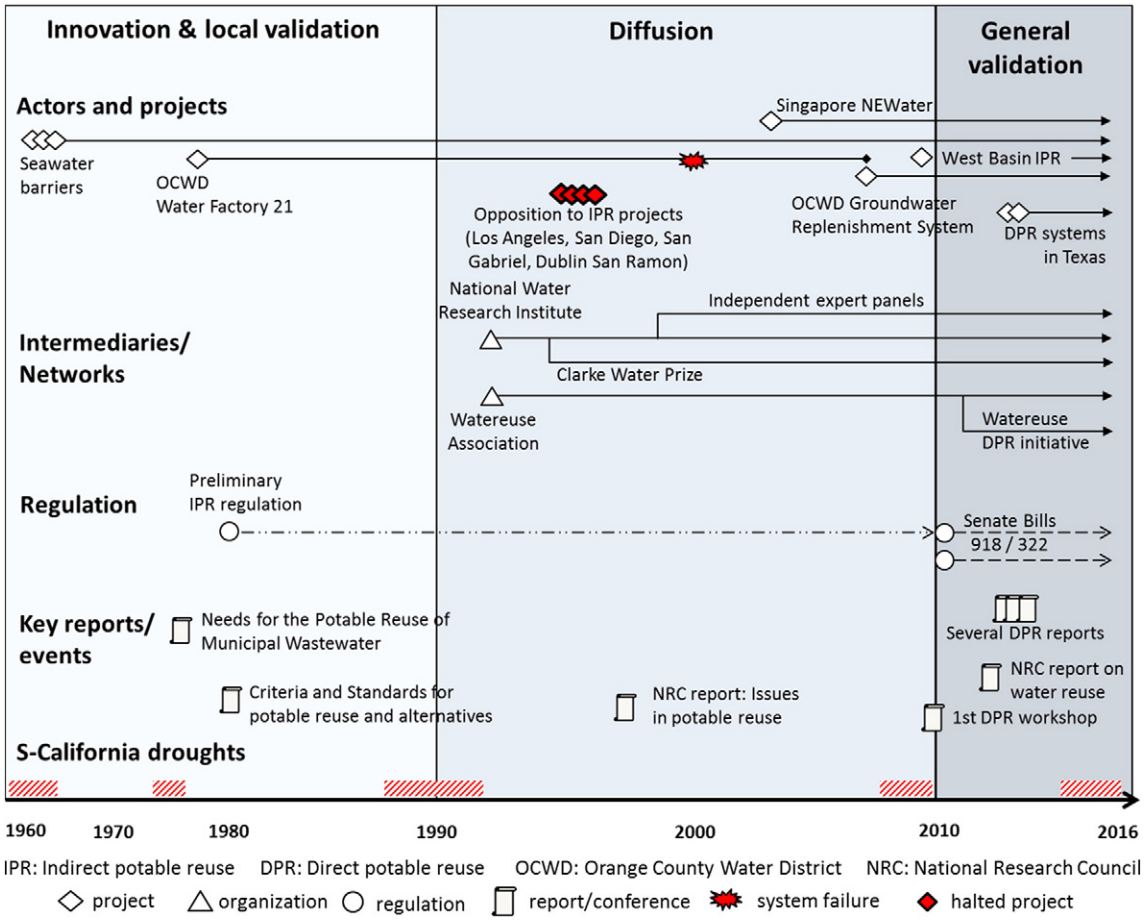

Fig. 2. Development of the potable reuse TIS in California.

accumulation per se, but the specific ways in which technology advocates organize their institutional work strategies at a more micro-level.

On the other hand, our results also show that the forms of institutional work available to technology proponents are not completely independent from the structural preconditions that emerge over the course of TIS maturation. As long as an innovation is promoted only by an embryonic TIS structure, its proponents will likely not be able to mobilize the resources and develop the political prestige to influence deeply held societal beliefs or key regulations. Here, our results emphasize in line with organizational sociology the particularly important role that intermediary actors play in expanding an innovation beyond local validation (Rao, 2004). Among others, intermediaries' crucial impact can be related to coordinating various actor groups, vesting potential conflicts of interest and valorizing technology advocates from a position of (seeming) independence.

Clarifying the complex relationship between legitimation activities and TIS development enables us to move beyond the simple distinction between a formative and a growth stage of the TIS (Bergek et al., 2008a): In the local innovation and validation phase, pre-formative TIS structures and functions will limit the possible forms of institutional work to actions directed at some specific local context. Once the locally validated technology enters the diffusion phase, it will depend on a system structure containing intermediary actors that construct new normative networks and coordinate collective institutional work to align the innovation with the relevant institutional contexts. To achieve general validation, even more complex forms of institutional work like advocacy, political work or changing normative assumptions will require the build-up of a more complex system structure which is able to mobilize significant resources and coerce powerful regime actors into supporting the innovation.

Overall, combining institutional work with the TIS perspective thus creates a nuanced analytical framework to work on the question why institutionally incongruous innovation gets successfully embedded in some regions (e.g. potable reuse in California), while it remains highly contested in other places (e.g. potable reuse in Australia). Our results show that Californian actors continuously worked on a diverse set of institutional conditions to legitimize potable reuse in a 40-year-long system-building process. 'Acceptance' of radically new technologies has to be understood on the basis of this complex socio-technical development process and not – as is often assumed – as a direct outcome of education and information campaigns that only target pragmatic dimensions of legitimacy (Harris-Lovett et al., 2015).

6. Conclusions

This study aimed at extending the prevailing conceptual perspectives on legitimation processes for innovations that are incongruous with a dominant socio-technical regime. Our analytical framework and results show the usefulness of combining institutional sociology with innovation studies for assessing how actors in embryonic sectors influence extant institutions to such a degree that widespread trust in a new technology is created. We conceptualize technology legitimation as a long-term, cumulative construction process that depends on embedded agency of TIS actors through institutional work. In contrast to existing literature, our case study shows that legitimation does not

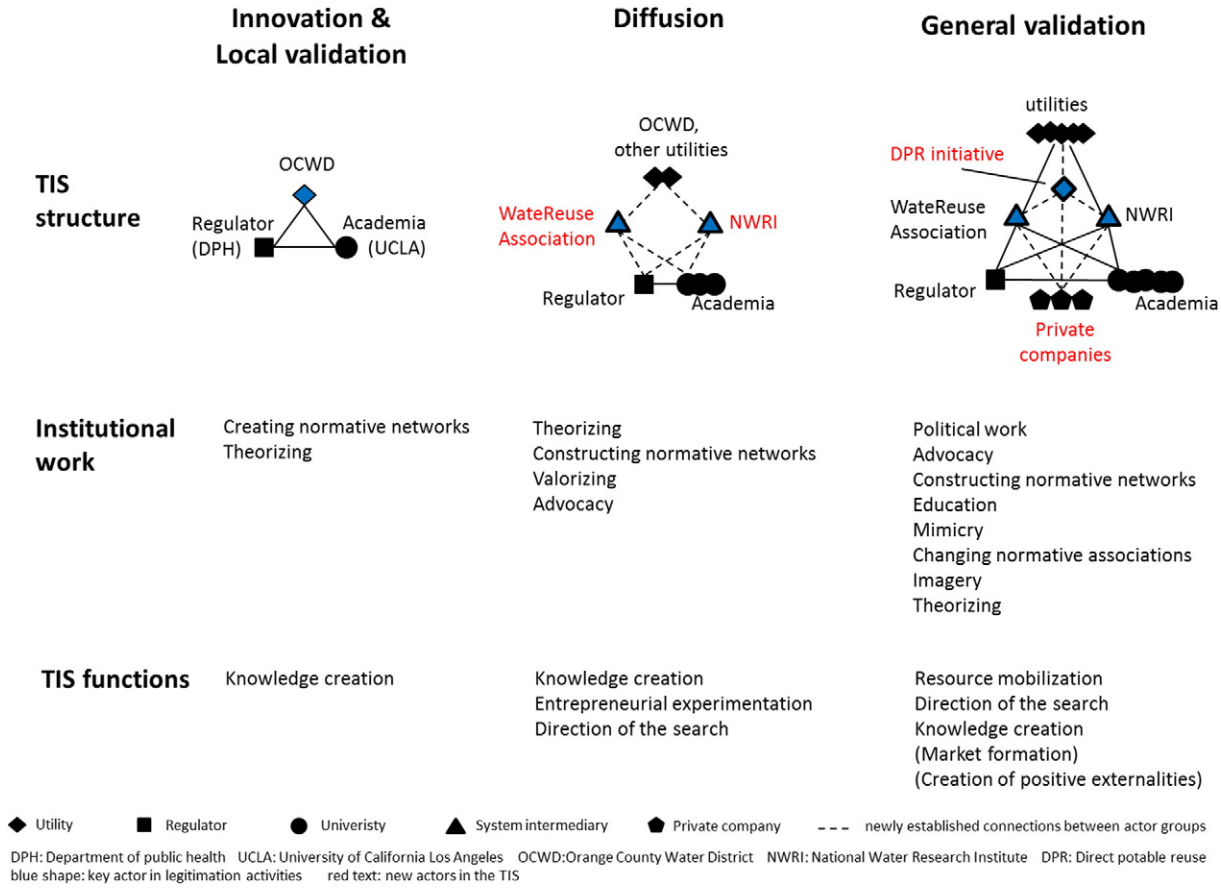

Fig. 3. TIS formation and legitimacy-related institutional work.

automatically result from the accumulation of actors and the build-up of formal advocacy groups in a technological innovation system. It is rather related to a wider set of system-building processes and interacts with these in complex ways. An explicit consideration of specific forms of institutional work that actors embark on and their cumulative outcome over long time periods enables a more differentiated account compared to the prevailing meso-level perspective in innovation and transition studies which emphasize framing struggles and the cumulative causation between different system functions.

The presented insights open ground for conceptual improvements in innovation and transition studies as well as for related policy advice. First and foremost, our framework enables a more detailed processual account of the 'creation of legitimacy' function in TIS research. TIS scholars so far proposed to assess legitimation by "mapping the rise and growth of interest groups and their lobby actions" [15: 425]. The framework outlined in this paper embraces this basic idea, but provides a more nuanced mapping tool which differentiates legitimation into specific dimensions, development phases and sub-processes. The proposed micro-level analysis also clarifies how legitimation relates to overall system maturation and provides a new set of indicators to operationalize and empirically assess technology legitimation.

Conceptually, combining innovation studies and institutional sociology furthermore offers a potential link between TIS development and niche upscaling processes as developed in the context of the multi-level perspective on technological transitions (Geels, 2002; Smith and Raven, 2012). By specifying the relation between viable forms of institutional work and overall innovation system maturation and by adopting an actor-based analytical perspective, our framework explicitly conceptualizes the institutional misalignments of an emerging TIS with the dominant socio-technical regime and allows tracing the agency of early technology proponents in overcoming the hindering (institutional) regime dimensions.

Finally, our results have direct implications for policy making. As specific legitimation strategies seem to be viable only in TIS contexts that have matured to some degree, policy interventions to support emerging sectors should be reflective of the specific phases of the legitimation process in critical periods of innovation system maturation: Supporting knowledge creation and entrepreneurial experimentation during the local innovation and validation phase might need very targeted niche management strategies, while in the diffusion and general validation phase, identifying and eliminating key system failures and bottlenecks (e.g. a lack of credible intermediary actors) should move center stage.

It goes without saying that our results have limitations that warrant further research. First, our approach downplayed issues of interest and power. In the DPR case, legitimation depended on a relatively small group of experts that occupied positions of power in the involved utilities, industries and regulatory agencies. While their favorable social position enabled them to quickly push their agenda into the legislative process and coordinate the sector-wide legitimation strategy, their close interpersonal connections might also undermine the emerging sector's credibility in the long run, especially if people's attention will shift from specific projects to the broader emerging sector and ask whether the involved actors are applying the "right structures and processes for the job" (Suchman, 1995; Harris-Lovett et al., 2015). Detailed work from a political ecology perspective might identify critical power issues and sketch out how the system could be reconfigured to guarantee independent and inclusive supervision and quality management for potable reuse operations in the future.

Second, this paper emphasized how legitimacy was created in the public domain. One could also differentiate between legitimation processes within specific actor groups. Academicians, regulators and the

general public likely differ significantly in their assessment of a new technology's legitimacy. Doing a differentiated analysis for each actor group could reveal important additional insight on how legitimacy diffuses from expert communities to the general public (or not). Third and finally, due to the single case study design, we only claim analytical generalizability for our results. Legitimation processes in other contexts would likely depend on different actor configurations and sequences of institutional work. Comparative case studies in other industrial and regional contexts would be needed to further elaborate and validate the analytical framework presented in this paper and to develop a generalizable life-cycle theory on the forms of institutional work that enable or hinder radical technological innovation.

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Appendix A. Interviewees.

Professional role	Type of organization	Interview
Company president and consultant	Water engineering and policy consulting company	1
Water engineering consultant	Water engineering consulting company	2
Senior Vice President and Chief Technology Officer	Engineering consulting company	3
Assistant General Manager	Municipal water district	4
Professor, expert panel member	University	5
Environmental engineering consultant	Public health regulatory agency	6
Company founder and consultant	Public relations and communications consulting company	7
General Manager	Municipal groundwater management district	8
Executive Director	Research and advocacy non-profit	9
General Manager	Municipal water district	10
Director and founder	Water engineering consulting company	11
Water Reuse Chief Technologist and Associate Vice President	Engineering consulting company	12
Managing Director of a regional section	Water reuse advocacy organization	13
Former Principal Engineer	Public Health regulatory agency	14
Professor emeritus	University	15
Executive Vice President	Strategic communications consulting company	16
Head of Public Relations	Municipal groundwater management district	17
Founder and General Manager	Environmental engineering company	18
Assistant General Manager	Municipal groundwater management district	19
Retired director	Municipal water and wastewater district	20

Appendix B. Interview guideline.

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Interview with: _____
Date: _____
Type of organization: (i.e. utility, regulator, consultant) _____
Introduction

- Introduction of interviewer(s) and explanation of aim of the interview: 1.) Reconstructing the process leading up to implementation of direct potable reuse in California's water code, 2.) Understanding current challenges to potable reuse, 3.) Understanding advocates' and critics' arguments and actions.
- Definition of 'direct potable water reuse' (from the California water code/Senate Bill 918): injection of treated wastewater effluent directly into a drinking water distribution system or directly upstream of drinking water plant, with no natural buffer.
- Permission for audio recording

Introduction

- From your perspective, how did the story of water reuse in California unfold? What were important steps between 'not considering this technology at all' towards 'implementing it as a goal in California's water code'?

Follow-ups

- o What were the different phases of development? How can they be characterized?
- o Was the advance of potable water reuse ever particularly endangered? What happened? When?
- o Was there competition between potable water reuse and alternatives like desalination, water transfers, or non-potable water reuse?

Organization's role

- o When did your organization get involved in potable water reuse? Why? Who was advocating for it?
- o What were crucial milestones in the internal discussions on potable water reuse? When? Why?

Other actors

- o Which other actors were important in pushing potable water reuse? What did they do specifically? Did you cooperate with or try to influence them?
- o Who is actively opposing potable water reuse? Why?

Network formation

- o Did you team up with partners in pushing potable water reuse? Who? Why? What joint projects were formulated?
- o Are existing networks effective in developing solutions for the sector? Why (not)?
- o Did your organization create potable water reuse-specific networks? Why (not)? With whom?

Regulatory legitimation

- o What kind of policies pushed/hindered potable water reuse? Regional differences across the state?

- How does the process for defining potable water reuse standards/regulation work? Who is involved? Is standardization also pushed at a federal level? Why (not)?
- Did your organization influence regulation/policies (e.g. Senate Bill 918)? How?

Cognitive legitimation

- How did your organization influence the public perception of potable water reuse? What were your organization's core strategies? Based on what key arguments? Did your organization have success/failure? Why?
- Does your organization have a specific communication strategy on potable water reuse?

Pragmatic legitimation

- What prejudices exist about potable water reuse in the public? Does your organization address them? How? Does anyone else address them?
- Does anyone show/showed resistance to potable water reuse? What did they do and say specifically? How did your organization address public resistance/fear?
- Were there moments of concentrated media attention on potable water reuse? How did your organization react? How did others react? With what effect?
- Are standardized public involvement/participation programs developed in California's potable water reuse scene?

Procedural legitimation

- Have you experienced emergencies in the past with your potable water reuse system? Were problems communicated to the public? Why or why not?
- Do people trust your organization's potable water reuse activities? Did you create new management tools for potable water reuse? What exactly? Why?
- What contaminants do recycling plants test for? How? How often?
- How are the operators of potable reuse plants trained?

Financing potable reuse

- Where does the money for potable water reuse projects come from?
- What problems exist in finding financial resources for potable water reuse? How could the situation improve?

Influence from outside California

- Did best practices from outside CA/the US play a role in developing CA's potable water reuse (Windhoek, Singapore, Big Springs TX, Cloudcroft NM)? When, in what project?
- Did failure stories from other projects influence California's potable water reuse story? (Toowoomba AUS, others?) How exactly?

Final questions

- From your perspective, what are currently key challenges for the further development of potable water reuse? How could they be overcome?
- Did we miss an important topic that is relevant?
- Is there further documentation or sources of information that might be useful?
- Are there other people you suggest we should interview?

Do you want to comment on the interview transcripts?

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