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The Role of Technology in Policy Dynamics: The Case of Desalination in Israel

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ABSTRACT
This article examines the relationship between technology and policy change, focusing on shifts in Israel's water regime as a case example. Technologies, especially systems of large-scale infrastructures, have offered an explanation for the stability and stagnation of policy regimes in what has been termed "lock-in" and path dependency. Our paper focuses on the reverse phenomenon: on how technology or change in it can induce policy change. Israeli decision-makers have recently embraced desalination technology as a substitute for natural resources, because earlier policies, characterized by a strategy of environmental brinkmanship, have resulted in degradation of natural sources and risk future supply. This analysis is based on extensive document analysis and in-depth interviews. We suggest that technological breakthroughs that rendered desalination economically feasible also undermined long-lasting hydro-ideological support for agriculture, introduced new ideas about water abundance and engendered policy change. Desalination contributed to these shifts because it allowed the displacement of environmental externalities, economic costs and hard political choices to other policy sectors and levels of governance as well as reallocating them between political actors, bureaucrats and professionals. It is important to make displacements like these more visible in order to emphasize more comprehensive and longer-term problem solving rather than problem avoidance or postponement.

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Introduction

This paper contributes to the ongoing discussions on policy regime dynamics by drawing insights from science and technology studies (STS) and the socio-technological transitions literature to demonstrate how technology can spur policy change, and suggesting one important mechanism by which it does so. The role of technology has not been adequately addressed in the literature on policy regime change. Sabatier (1988) did claim early on that the role of technology is similar to that of a crisis as an external pressure on policies and institutions, while Lovell (2007) emphasized the importance of construction material and low-energy technologies in

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the housing sector's policy process in the UK. But much of the policy dynamics literature considers policy a lever for influencing technological trajectories and escaping unsustainable lock-ins (Elzen *et al.*, 2004; Foxon, 2010; Geels, 2005a; Hekkert *et al.*, 2007; Rip and Kemp, 1998), undertheorizing the important reverse causal relationship in which technology has the potential for transforming policy.

We demonstrate how a technological breakthrough can reshape policy paradigms and subsequent policy dynamics by using desalination technology and the Israeli water regime as an example. The regime was static for decades, anchored to a hydro-ideological support of water-intensive agricultural production and characterized by a kind of environmental brinkmanship, and a muddling through punctuated by periods of crises and maintained by strenuous political manoeuvring. While several factors created pressure for incremental change in the Israeli water regime, these were not sufficient to engender a significant socio-technical transition involving changes in existing paradigms, policies and institutional arrangements. Technical advances in desalination, on the other hand, made this an economically, politically and strategically superior alternative, reshaping the Israeli water policy landscape in a remarkably short time.

Techniques for transforming seawater into drinking water had been known and practised in water-scarce regions such as Israel, Australia, the United States and oil-rich countries such as Saudi Arabia for decades. While some actors promoted desalination as a large-scale solution for Israel, this was deemed infeasible by the Ministries of Finance and Agriculture. A parliamentary decision to increase desalination capacity made little progress due to political impasse (Feitelson, 2005). While multiple factors laid the basis for a socio-technical shift as will be discussed below, it was technological advancement that significantly reduced the cost of desalination, which made desalination an apparent panacea for water scarcity. Within a matter of years, the governmental and professional apparatus that had maintained a crisis-ridden status quo for decades realigned around a new vision and its muscular implementation, through which desalination and large-scale water infrastructures will dominate Israel's water management strategy in the next decades and supply all domestic water use (750 million cubic metres) by the year 2020 (Tenne, 2010).

On a theoretical level, this paper examines the relationship between technology and policy change and specifically in the causal power of the former over the latter. Whilst it has been suggested that technological solutions such as desalination do not address entrenched underlying political and social paradigms and arrangements (see for example de Châtel, 2007, or von Medeazza, 2005, 2008), it has not been explained how and why the technology can allow these underlying issues to be bypassed. In this paper, we argue that one key mechanism through which this occurs is the ability of a technology such as desalination to displace costs and tensions into new and less visible realms, helping to avoid direct confrontation with existing power arrangements and offering actors an opportunity to move beyond traditional deadlocked balances of power. We argue that this kind of displacement is a key mechanism by which a technology such as desalination can change policy paradigms, institutional arrangements and constellations of actors, and in our case promote a rapid transition in the socio-technical water system. At the same time, however, we argue that, in order to assure that such changes produce a new socio-technical regime that is genuinely more positive and sustainable, we must be alert to the lure of this kind of displacement and its problematic potential to defer, disguise and shift problems rather than solve them.

Policy Dynamics and the Role of Technology

Policy dynamics, inception and change have received extensive attention in the academic literature. Although the stability, regularity and persistence of policies and institutions is often emphasized (Lieberman, 2002), they are replaced or changed to a certain degree from time to time. Policy dynamics are depicted as an incremental and evolutionary development of political and social institutions through adaptation and contested processes of restructuring (John, 2003; North, 1991). Incrementalism, however, is limited in its ability to explain cases of abrupt policy change (Wilson, 2000). Seeking to accommodate both stability and change, Baumgartner and Jones (1993) have suggested that public policy-making is characterized by stable periods, which are interrupted by punctuations. Pempel (1998, quoted by Streeck and Thelen, 2005, p. 7) similarly argued that path dependencies – inherited and entrenched systems of governing – are "periodically ruptured by radical change, making for sudden bends in the path of history".

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Several ways to classify policy dynamics and their triggers have been proposed. Jochim and May (2010) distinguish between crisis-driven and coalition-driven triggers of policy change. Policy change and continuity are often explained by the consolidation of an identified problem, solution and political gain, which opens up a "policy window" (Kingdon, 1995), by external crises such as an economic downturn, war or droughts (Jones, 1994; Sabatier and Jenkins-Smith, 1993) or by an endogenous reconsolidation of networks, epistemic communities, interest groups or policy entrepreneurs (Atkinson and Coleman, 1992; Haas, 1992; Hall, 1993). Within an increasingly complex, multi-level system of governing (Meadowcroft, 2008; Paavola and Adger, 2005), the constellation of policy networks can provide an arena for mediation and negotiation of interests of either a single actor or a cluster of actors. Actors are often linked together by ministerial policy sectors and shared world views – or policy paradigms. They embody perceptions about how policy problems are defined and, accordingly, the range of solutions resonating with that world view (Béland, 2005; Wilson, 2000).

Technologies and technological systems are the focus of much interest, as are their interactions with politics, policy-making and governance. A growing body of literature examines changes in and transitions of socio-technological systems. Inspired by neo-institutional traditions, they examine co-evolutionary, multiple and interconnected roles of technologies, institutions and policies (Foxon, 2010; Kemp and Rotmans, 2005; Paavola, 2010) and portray policies and technologies as cogwheels within a complex set of other societal cogwheels such as culture, economy and ecology (Tabara and Ilhan, 2008; van der Brugge *et al.*, 2005). These components reinforce each other to form an interlock, a sign of a completion of a full transitional cycle. According to this literature, a transition is not only a period of abrupt change that follows a crisis, nor does it necessarily take place to solve a pre-identified problem as implied by Kingdon (1995). Socio-technical transitions are better understood as long, multi-stage periods of structural, institutional and organizational change from one system-state to another (Geels and Schot, 2007; Rip and Kemp, 1998), a view that *blurs the distinction* between radical and incremental change. Transition comes about as a result of systematic dynamics at different structural levels (of micro-level technological niche, meso-level institutional regime and macro-level socio-natural landscape). The result is a transformation of a different delivery form of societal functions (Kern and Smith, 2008; Verbong and Geels, 2007).

However, an analysis of entrenched technologies, such as large-scale infrastructure systems, often provides an explanation for the stability or stagnation of institutions and policy at the level of the regime, rather than for their change (cf. Kay, 2005). Notions such as lock-in and path dependency emphasize the link between past occurrences and the limited choices and changes available for present decision-makers (Berkhout, 2002; Cowan and Gunby, 1996; Mahoney, 2000). Socio-technological lock-ins originate from systems of infrastructure, finance, insurance, supplier networks, customer preference, embedded training routines and policy and regulative contexts, which make replacement of incumbent technologies and innovation to breakthrough difficult (Hoogma and Kemp, 2002; Meadowcroft, 2009). Increasing returns from early adoption of a technology often result in that technology, not necessarily the economically, sustainable or technical superior one, dominating the market (Cowan, 1990). These observations underpin the normative view according to which sociotechnical transitions could and should be managed in order to prevent and overcome undesirable lock-ins, and some regimes require regulatory mandates and appropriate government subsidies to stimulate similar adoption (Ashford and Hall, 2011; Meadowcroft, 2009; Voß *et al.*, 2009).

The understanding that technology can cause and has caused substantial material and immaterial changes is, however, in no way new. Technology has often been considered the driving force of human progress and not less than a social agent of institutional and environmental change (Marx, 1994; Murphy, 2007). New technologies may have emerged within existing networks of spare parts, infrastructures, markets and old technologies, but these new technologies also serve as catalysts for social change, patterns of behaviour, preferences and order. In Ellul's (1978, p. 216) words, "technology constitutes a new human environment that is unsuited to human symbolization; technology has turned into its own symbolic transformation".

Latour (2005) also highlights the transformative power of technology. He rejects the traditional view of society and technology as separate systems by his symmetric treatment of both humans and non-humans as actants. He also rejects the idea of a stable 'society', and argues that the social is about artifacts, institutions, procedures and concepts and their reassembly, and the technical embodies social relations. Along similar lines in a study of water technologies in India, Birkenholtz (2009) has stressed the capacity of artifacts to form sweeping, unpredicted new production relations, institutions and social networks – a process he termed "reverse adaptation". Such an analysis follows the well established principles that first technology is too easily dismissed as a tool and its effects are too easily attributed to the good or bad intentions of its users (Weinstein, 1981), and second technology embodies forms of power and authority, and indeed "politics" (Winner, 1986).

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Yet many scholars are reluctant to consider technologies as driving social change. For example, Nye (2006) resists the view that something embedded in technology could make its dominance over society inevitable. Similarly, Geels (2005b, p. 1) argues that "technologies do not fulfil societal functions on their own. Artefacts by themselves have no power". However, contrary to Nye's (2006, p. 28) lament, accepting the possibility of technological causation does not rule out the "importance of particular individuals, accidents, chance, and local circumstances" and does not necessitate "technological determinism". Also, it does not preclude the role of institutions, agency, values, perceptions or social construction. As Marx and Smith (1994, p. xiii) suggest, "...the history of technology is a history of human action"; technology can offer something that enables and promotes change at a certain point of time and in specific circumstances and environments. In this light, concerns about technological inevitability are misplaced. This is especially true if we accept an intermediate view of a "dialectical relationship between the social shaping of technology and the technical shaping of society" (Wyatt, 2008, p. 176), or the view of "technological momentum", which highlights technology's dual role as both cause and effect (Hughes, 1994).

While socio-technical transitions (e.g. from horse carriages to automobiles or from coal to gas) necessarily entail policy changes as part of a wider institutional evolution, the capacity of technical change to directly drive policy shifts has seldom been a focus of research. While research on socio-technical transitions suggests co-evolutionary reproduction and realignment of technologies and policies, it nonetheless primarily aims at reconstructing a narrative of regime change in a way that allows the emergence of new transitional paths. In other words, even when key governance issues are integrated into the analysis, or the transition management model is applied (see Smith *et al.*, 2005; Frantzeskaki *et al.*, 2012), policy change is seen as a tool, rather than as an outcome. Policy-makers shape technology-specific policies, for example (see, e.g., Jacobsson and Bergek, 2011; Kern and Howlett, 2009) or safeguard niche-induced innovations (Lovell, 2007; Smith, 2003). Policy and decision-makers are largely absent from the conceptual language, and transition processes are analysed separately from the policies, management or steering approaches that are to influence them (de Haan and Rotmans, 2011). Yet the literature contributes an important understanding of the power of technological development to form a new sociotechnical regime around that technology (Foxon *et al.*, 2010; Nye *et al.*, 2010).

Other scholars such as public policy researchers and theorists of policy change have not really advanced Sabatier's (1988) early claim that new technology's effect is similar to the role of external crises or a "policy window". The assertion that technological solutions to what are identified by policy-makers as problems can induce significant policy change, and consequently a wider socio-technical transition, is supported by only a few case studies (e.g. Lovell, 2007; see also Paavola, 2010). Exceptions to this are studies that focus on the circular relation between resources, prices and the adoption of technological devices (for a review see Jaffe *et al.*, 2003).

Against this background, our argument here is that a sheer technological breakthrough can play a pivotal role in policy dynamics and socio-technical transitions, although it is usually treated as a dependent variable in the literature, with its development and diffusion aligned or co-evolving with policies and regulations. This is especially true of the research on green technologies and environmental policies (Foxon, 2010; Kemp, 2000). The contribution of this paper is to study technology as an explanatory variable, akin to Dosi's (1982) argument about a "technology push" approach to economic growth and change (see also Cooke, 2010). We treat technology as a punctuation that actively changes paradigms, policy and political power relations, and argue that "displacement" is a key mechanism through which this may occur. While theories of policy change often account for network constellation in favour of a particular technological solution to a perceived problem, this paper shows how the emergence of a new economically and technically feasible solution to the problem of water scarcity in Israel had the capacity to change the water regime, by framing a new shared paradigm and by destabilising existing institutions, networks and actors. In short, we suggest that the usual view of causality (policy → technology) is reversed in our case (to technology → policy); "technology produces policies", to paraphrase Pierson's (1993, p.597) statement that "policies produce politics".

Case Study, Materials and Methods

The Israeli water regime offers a good case study for understanding how technology can influence policy. During the first years of the state's existence (1940s and 1950s), water shortage was perceived as a problem of accessibility, not of quantity, in line with the goals of nation-building, securing food sources and the Zionist vision of "blooming

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the desert" (Tal, 2002; Alatout, 2008). However, what has emerged as water scarcity and later a "crisis" was the result of the high rate of population growth and rapid modernization as well as a long legacy of mismanagement and disregard of continuous droughts, salinization and pollution of groundwater. In addition, the water regime includes multiple actors, responsibilities are distributed among several governmental ministries, and political intervention is significant and frequent (Fischhendler and Heikkila, 2010).

Experiments with desalination technology that transform seawater to drinking water had started in Israel already in the 1960s, but large-scale water production was still deemed impossible as long as the technology was seen to be immature and costs too high (Tal, 2002). Meanwhile, a major saving of freshwater was made by reuse of 75% of domestic sewage by farmers (IWA, 2012a). This changed in 2005 when the first large-scale desalination plant entered service, and two others have since been finished. A review of parliament's decisions and future plans prepared by the Israeli Water Authority (IWA) on strategic decisions in water management indicated that a transition from fresh-water supply to desalinated sea-water supply for the urban sector (currently the main water consumer) is projected before the year 2020 (IWA, 2012b). Accordingly, the entire water needs of the country (1750 billion cubic metres) will be produced at water factories near the Mediterranean shore by 2050. This represents a significant, abrupt change in policy regarding water supply, in which desalination plays a key role.

We collected and analysed multiple materials. Our key material consists of the background documents of the national water strategy published between 2008 and 2011. Our materials also include the official minutes of parliamentary committees (including the Interior and Environment Committee, Economic Committee and Science and Technology Committee) on issues related to water policy, regulations and pricing, and the minutes of the IWA and the Israeli Planning Department, in which spatial planning of infrastructures takes place. Our material also included public speeches, press releases and newspaper articles published on-line in the Israeli media after the year 2001, when the policy change of desalinating a non-negligible amount of water was made by the government. We use earlier studies (Feitelson, 2005; Menahem, 2001; Tal, 2002) for insights into the period that preceded the point of change. Although desalination targets have been lowered and raised several times, three large desalination plants have been constructed and integrated into the system since 2007, and policy-makers regard the construction of three additional plants as inevitable in the near future.

The document analysis, sorted and coded using NVivo software, was complemented by 25 in-depth semi-structured interviews with governmental and non-governmental stakeholders in the Israeli water sector. Interviewees included departmental managers in the Water Authority, Mekorot (the national water company), the Ministry of Environment, the Ministry of Energy and Water Resources, the National Planning Committee, the special Planning Committee on Sea Protection, Israel's Society for the Protection of Nature (NGO), Israeli academicians and scientists, TAHAL (water technologies and planning company) and private environmental consultant companies. Participants were chosen on the basis of their integral role in reshaping decisions taken at the highest levels regarding water policy. Interviews and documents were read through, quotations highlighted and coded. The categories revealed the effect of desalination breakthrough as an agent of policy change through the different cases of reframing problems and displacing important issues to other policy sectors and levels of governance as well as between politicians, bureaucrats and water professionals.

In what follows, we discuss this transition in Israel's water regime in greater detail. We begin with a historical background of and context for the recent developments in the water sector and detail the emergence of a new water policy dominated by desalination technology. We then focus in some detail on the displacement mechanism by which this new technology was able to shift the locked-in water policy sector.

Changes in Israel's Water Regime and the Role of Desalination Technology

Continuation and Change in Israel's Water Regime

Studies on Israel's water policy and management emphasize the role of the Zionist–agrarian ideological movement in determining the development of water infrastructure and centralized institutions (Alatout, 2008; Feitelson, 2005; Feitelson *et al.*, 2007), the geo-political situation of both conflict and cooperation between Israel and neighbouring

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nations regarding water resources (Tal and Abed Rabbo, 2010; Wolf, 1995) and the spatial and physical integration of the water system, based on a "national water carrier" that transfers water 130 km from the Sea of Galilee in the north to the south (Fischhendler, 2008). Improper practices, such as over-pumping, neglect and pollution, are highlighted simultaneously with innovation and best practices, which Israel has demonstrated for instance in irrigation and combating desertification (Portnov and Safriel, 2004).

There is wide agreement that water management in Israel has historically been based on hydro-ideological support of agricultural production, and that it has been characterized by "walking on the edge" of water sources, utilizing them to a degree of environmental compromise (Fischhendler, 2008; Parliamentary Investigation Committee, 2010). These two features – the supremacy of agriculture in water allocations and over-pumping of fresh-water resources – shaped a stable though destructive equilibrium in the Israeli water regime for decades. Some authors have suggested that various recent socio-technical developments such as water cuts and price increases, water re-allocations and the weakening of the agricultural coalition have already contributed the following forces and trends that could contribute to a socio-technical transition from this stable configuration.

1. *Innovative irrigation technologies and advanced wastewater reclamation facilities*, which have allowed more efficient water use and released additional water for non-domestic usage.
2. *Reduced contribution of agriculture to the state's economy* – it has fallen below 2% of the country's GDP over the recent decades. Following an economic crisis during the 1980s, a new paradigm supported the shifting of resources from agriculture to other sectors. The "agricultural myth" that established inviolability of agriculture and policies related to that sector (Brown, 1992, in Feindt, 2008), has faded as Israel became more reliant on global food markets on the one hand, and other forms of export, on the other.
3. *Growing public interest in health and environmental matters* has led to the emergence of a new policy network with actors such as environmental NGOs (Menahem, 1998, 2001). The inclusion of environmental values in laws and regulations embedded environmental groups into new "issue networks" or "epistemic communities". Israeli environmental movements have campaigned, for example, for nature's right to water, which was encoded in law in 2004. New ideas such as these have challenged the alleged contribution of agriculture to society and nature, or the view of agriculture as a "public good", and have therefore contributed to shifting the focus away from it.
4. *An easing of geopolitical tensions over water*. Joint meetings of the King of Jordan and leaders of the Israeli government have been conducted in secret since the 1960s. Water was among the contentious issues in these negotiations. In the peace treaty of 1994, Israel committed to allocating a fixed amount of fresh water to Jordan annually. Parallel "water talks" between the Palestinian Authority and Israel took place as part of the Oslo interim agreement in 1995 and resulted in one of the most important parts of the agreement – "Article 40: Water and Sewage", which recognizes immediate Palestinian water needs and lays the foundation for cooperation in developing new sources and protection against water pollution (Kerret, 2010). As a part of geopolitical negotiations with neighbouring nations, these "water talks" have underlined that drinking water demand would increase on both sides of the border (Feitelson, 2002; Kartin, 2000) and have highlighted the concerns over potable water rather than water-intensive crops.
5. *Shifting perceptions of water*, as part of the neo-liberal and globalization trends in Israel more generally. Thus, by means of pricing, water shifted from being an ideological, symbolic scarce resource, to a commodity whose scarcity or abundance would be determined solely by the market and regulatory mechanisms (Bakker, 2003; Fisher and Huber-Lee, 2005). According to Alatout (draft copy available from author), this transition includes the construction of a new Jewish identity as the "citizen of the world", replacing the old identity of "immigrant and settler".

However, while these multiple processes in the technological, economic, environmental and cultural realms laid down the groundwork for incremental transformation of the Israeli water regime, they were not enough to significantly alter the core paradigm, infrastructural system and its spatial distribution, and existing policies of pumping, allocation, treatment and pricing. Decision-makers, mainly in the political (as opposed to the technical) realm, have continued to ignore continuous depletion of water resources and evidence of changes in rainfall quantities and distribution (Feitelson and Fischhendler, 2009; Parliamentary Investigation Committee, 2010; Shuval, unpublished paper based on a report submitted to the National Investigation Committee on the water crisis). It was, therefore, desalination technology that triggered the drastic transition of this regime.

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Desalination did not appear spontaneously. It had been used at experimental and small scales for example in oil-rich countries as well as in the southern region of Israel since the 1960s. However, attempts by water professionals (water commissioners, water engineers or government and academic hydrologists and scientists) to promote desalination during the mid-1990s were rejected by the Ministry of Finance economists (Planning Unit, IWA, personal communication, 25 April 2010), who claimed that postponing desalination was economically and strategically justified (unpublished letter from the Ministry of Finance, 1999).

Nonetheless, in order to compensate for a growing overdraft in the country's main fresh-water reservoirs (two large aquifers and the Sea of Galilee), the Israeli Government adopted an unprecedented target in 2001 to desalinate 400 million cubic metres of water (of a total consumption of about 1.150 billion cubic metres of fresh water). However, implementation lagged behind and it was only in 2005 when the first large desalination plant (120 mcm/yr) was constructed. Delays in meeting the new target have three key reasons. First, Rainy winters in 2002–2003 masked the urgency of desalination for unprofessional eyes. Second, finding suitable land in the already overcrowded coastal strip was a slow and difficult process. Third, the construction of desalination plants involved private companies and capital. The procedure of adapting the water sector to the new era of private–public partnerships (PPPs) required the establishment of new arrangements and institutions, such as the Water Desalination Authority (Planning Department, IWA, personal communication, 25 April 2010). This stasis meant that the cost of supplying water increased, as water shortages required emergency production from marginal water sources.

Concurrent to this halting change, the cost of desalination decreased dramatically from about $2.50 per cubic metre in the 1970s to only $0.53 in 2003 (Becker *et al.*, 2010; Greenlee *et al.*, 2009). This advance triggered a major change in water paradigm, policy and politics. Garb and Lee (2010) suggest that, once decision-makers realized that desalination could free Israel from the constraints of natural water supply and everlasting crises, they shifted their weight to promoting desalination instead of resisting it. As a result, water policy changed dramatically and desalination targets sky-rocketed: the current long-term national plan is to increase the desalination annual capacity target from the current capacity of 300 million cubic metres to 1.5 billion by 2040.

This adoption of a policy of large-scale desalination represents a regime shift: policy-makers now consider desalination to address water scarcity in the region, explicitly (though quietly) declaring the end of water scarcity (Garb and Lee, 2010). The goals of the new policy, and the nature of policy problems and their possible instrumental solutions, as discussed below, were changed after a breakthrough in technology. This fits well with Hall's explanation (1993) for a paradigm shift. However, desalination technology did not appear spontaneously, nor is it isolated from broader commitments and trends. Desalination relates to existing networks of known technologies and large-scale integrative systems of water production and distribution. Immaterial structures of technocratic routines and technological optimism are already embodied within it. Moreover, desalination fits and reinforces the traditional view of utilities according to which "bigger is better" when economies of scale are present. Desalination is also compatible with the neo-liberal ideology of privatization. It, thus, represents a "hard path" approach to water (Garb and Lee, 2010). Alternative ways to combat water scarcity, such as conservation, domestic water reuse, recycling or collection, and cleaning of polluted sources require regulative and physical decentralization and greater public investment of funds. There are different reasons why advances in desalination contributed to a major policy change, which will also inevitably result in wider environmental and sociotechnical transition: it was able to realign policy networks around a common paradigm of water abundance with little or no compromise apparent of their positions. This feat was due, in large part, to the subtle ways in which desalination displaced tensions and costs.

"Displacement" as a Mechanism of Technologically Induced Policy Regime Change

While several political and other factors contributed to incremental changes in the Israeli water regime, the role of technology was key, meriting greater theoretical attention than currently awarded in the literature. Desalination provides an example of the potential agency of technological innovations. In what follows, we will explain how a technology such as desalination can exert its agency and transform a locked-in regime, and, in particular, suggest that "displacement" is an important mechanism in this process. Thus, desalination functioned as a "solution" to persistent water problems through *displacing* externalities, costs, tensions and hard choices in a way that aligned with the interests of key actors and embedded institutional structures.

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In public policy studies and political science the term ’displacement’ is sometimes used to describe situations where decision-makers avoid the treatment of messy (or “wicked”) problems, especially when these escape the more technocratic domain of policy-making and involve or require political attention (Dryzek, 1987). Given the relatively short tenures of politicians and the ad hoc nature of political activity (Pierson, 2000), it is not surprising that some problems, tensions or costs are intentionally ignored or reframed as the responsibility of someone else. From an environmental point of view, displacement can have a physical manifestation. Dryzek (1987, p. 428) argued that “any improvement on a single indicator… may mask problem displacement to another medium or location”. That is, environmental problems and impacts can travel spatially and be transferred to other environmental media (e.g. water, air or soil). For Dryzek (2009, p. 4), the combination of short-term political thinking and environmental problem displacement are manifestations of an “ecological irrationality” that characterizes contemporary liberal-democrat states.

There are some good insights in the existing literature on how this kind of policy side-effect or externality could be reduced, or conversely how policy integration might be achieved. Among the strategies of Beck *et al.* (2003) for overcoming side-effects is the suggestion to always expect the unexpected. Grunwald (2007) advises that governments and policy-makers should reflect more about decisions and interactions among actors in order “to gain knowledge about interests, perspectives and capacities and to learn about the character of social/environmental linkages” (Meadowcroft, 2008, p. 309). Researchers often propose that greater cohesion, cooperation and greater integration between sectors and policies could help prevent some of the spillovers, undesirable outcomes of policies, which are otherwise postponed or dislocated (Bammer, 2005; Meijers and Stead, 2004). Policy integration, however, is not easily achieved and transaction costs may be high (Fischhendler and Heikkila, 2010; Geerlings and Stead, 2003).

The terms “externality” “side-effect” or “spillover”, however, ignore the appeal of this displacement, which is why we favour this term. Although problem displacement cannot always be attributed to deliberate intentions of any actor, our case study suggests that the reorganization of outputs, costs, risks and interests engendered by a new technology are a key part of its appeal; indeed, they may be the key to the adoption of a technology and its ability to unsettled locked-in regimes. In our case example, advances in desalination technology allowed an appearance of “water abundance” to emerge as a new water paradigm, replacing the old paradigm of “water scarcity” and repetitive crises, which reinforced a locked-in regime. By offering ‘limitless product whose price and quantity produced are governed by market forces’ (Garb and Lee, 2010), environmental externalities, economic costs and hard political choices were masked (de Châtel, 2007) and displaced. In the paragraphs that follow we delineate several different forms of this kind of displacement in greater detail.

Environmental Problem and Health Risk Displacement

The most obvious displacement involved in our case study was that of problems across environmental media. Environmental risks related to water resources were displaced by transforming them to other risks requiring the attention of planners and policy-makers alike, related to for example to the scarcity of available coastal zones and effects on marine habitats, energy use and vulnerability to climate change (Infrastructures Planning Unit, Ministry of Interior, personal communication, 9 April 2010; Marine and Coastal Environment Unit, SPNI (NGO), personal communication, 31 January 2010). There is no scientific agreement, for example, on the long-term effects of brine and salt discharges from desalination facilities to the marine environment. Environmental externalities and future implications of desalination are sometimes brought up by scientists and environmental groups, but other forms of displacement remain less apparent. Thus, this kind of environmental/media displacement is more tangible than the kinds of political/technical, managerial, economic and geopolitical displacement discussed below.

Displacement of Fundamental Political Choices to Technical Details

Perhaps the greatest tension in the Israeli water regime has been in the political realm. Authority and responsibility over water has been shared by at least five ministries, which has resulted in confrontations over water allocations, quality and pricing (Fischhendler and Heikkila, 2010). The water allocation process was considered lacking democratic representation of affected groups and long-term, strategic thinking (Fischhendler, 2008). Specifically, as Menahem’s (2001) research has shown, a strong agricultural lobby reinforced a prioritization of the agricultural sector in water production, allocation and pricing. It was therefore a political impasse, first and foremost, that postponed desalination by over a decade (Feitelson, 2005; Parliamentary Investigation Committee, 2010). The mainstreaming of desalination became feasible only when innovative development brought about a paradigm shift. The new paradigm

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is centred on the appearance of abundance, rather than entranced scarcity. By creating the impression of water abundance at an acceptable level of cost, the technology has gained support from a broad range of political actors such as environmentalists, ministers of finance and infrastructure, heads of municipalities, the water management authority and even the agricultural sector. Each actor has its own view of potential uses of additional water. A veteran Israeli environmental scientist, for example, considered that

> In some circles there was an almost blind faith that scientific and technological progress was unlimited in its ability and that it was only a matter of a few more years until there would be a dramatic breakthrough in desalination technology and the goal of cheap desalination would be a reality. Thus some agricultural and water planners believed that there would eventually be almost unlimited water supplies available for the vast expansion of agriculture in Israel (Shuval, 1999, p. 8).

It took several years before the awareness of the potential of desalination became ingrained and before the technology was able to offer what policy-makers conceived as a competitive cost compared with natural water pumping. Once this occurred, the technology unravelled the equilibrium of vested interests in water management. Importantly, the new wider coalition favouring desalination did not resolve all political tensions. Rather, these were shifted to technical details, displaced across a new suite of sectors and environmental media and reframed as someone else's problems. For example, decision-makers no longer face the uncertainty of rains, nitrate and pollutant concentrations in aquifers or declining water level in the Sea of Galilee: these uncertainties have been displaced. Instead there are new technical questions, such as who will win the tenders and operate the plants, what would be a sufficient depth for the brine discharge pipes from the plants, and stable sources of natural gas required to power the desalination plants (water expert, advisor to the Water Authority, personal communication, 12 April 2010).

Thus, the responsibility, power and decision-making capacities related to these technical issues have been displaced from politicians to hydro-bureaucrats and professionals. In other words, the hard political choices over the management of scarce water resources seemed to have disappeared, though, in fact, they just rematerialize in other less familiar ways and settings. When water professionals are asked why the future water supply has been pegged on desalination, they express a wish not to have to depend on other countries as sources for water, food or energy because

> It is very easy to build a coalition against us (the State of Israel)... and this can happen in minutes and the water source will disappear, and this is why we cannot trust such sources... (Desalination Department, IWA, personal communication, 24 February 2010).

This political concern trickles down to the managerial level without any governmental policy to guide it. The perception of key actors in the IWA is that

> Israel is a highly political country, which needs to be left with enough water so that politics can play its role (Desalination Department, IWA, personal communication, 2010).

Desalination has therefore allowed the politics of power relations between ministries and geopolitical political negotiation to be modified as a politics of technical details, where water and planning professionals negotiate the needed amounts of desalinated water, the location of the plants, and the source of energy for these plants. However, as Nelkin (1979, in Murphy, 2007) has pointed out, the use of technology to solve problems could sometimes evoke objection aimed less against science and more against the use of scientific rationality and technical expertise to indeed mask political choices.

Displacement of Uncertainties in Water Quality, Quantity and Management

In the agricultural and water sectors it was realized that treated, inexpensive effluent (whose quality would actually be improved by inputs of desalinated drinking water) could be used as an irrigation water substitute. This alleviated conflicts of interest in water resources and avoided the need for painful cuts in water allocations, albeit with an economic dislocation of costs, as further discussed below.

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Fiscal Costs and Subsidy Displacement

A fourth major displacement relates to the cost of water production. In principle, desalination can ease the tensions related to historical subsidization of water for agricultural uses because it creates additional water for domestic use. This leaves more natural – that is, 'cheaper' – water available to the agricultural sector. Domestic water can also be recycled as cheaper water (treated sewage) for agriculture. Thus, to a large degree, the costs and politics of agricultural water subsidies have been displaced to the sewage regime, where pricing and ownership of grey and black water will have to be renegotiated and clarified. Policies that prioritized agricultural water use in the past will not need to change because 'governmental subsidies would reappear in one way or another', as suggested by the former Head of the Water Authority (Uri Shani, public talk, 2010). Therefore, 'cheap water for agriculture' remains an underlying directive of water policy, with the full cost of both desalinated water and sewage treatment being gradually displaced onto the general public. Prices of domestic affluent treatment for households have already undergone an accumulative increase of 32% between January 2010 and January 2011 (Water Authority website, 2012).

Displacement of Geopolitical Strategic and Economic Tensions

The fifth displacement takes place in the geopolitical realm. Actors have also embraced desalination on the basis of its promise to solve regional tensions over water resources. Interestingly, early on, desalination was opposed as undermining Israeli claims to water resources such as the Eastern Mountain Aquifer underneath the West Bank (unpublished letter from the Ministry of Finance, 1999). However, the official Israeli standpoint has changed. Now water abundance is seen to allow more flexibility in geopolitical negotiations with the Palestinian Authority and neighbouring countries (Garb, 2010), easing what has been termed 'hydro-hysteria'. There is Israeli support for the construction of a desalination plant on the Israeli coast to provide 150 million cubic metres of water to the Palestinian population in the West Bank (Ynet, 2008), though Palestinians expressed reservations about this plan: desalination displaces security risks (as large plants of strategic importance are vulnerable to sabotage) from Israel to Palestinians, making the latter dependent on Israel and international donors for water sources as well as in their limited ability to pay for desalinated water for domestic and particularly agricultural activities (Ghbn, 2010). Having a desalination plant under Israeli control as a solution to the Palestinian water scarcity problems also displaces the familiar Israeli–Palestinian disagreement on 'water rights' onto more technical lines. Having plenty of water with no recognition of rights to specific sources for either party may move the negotiations forward, but may still be considered strategically unwise by both sides.

These kinds of displacement reflect the appeal of desalination and its ability to reconfigure the Israeli water sector. More broadly, we suggest that it altered the balance and tradeoffs between issues, actors and driving forces that had been deadlocked. The ability of technological advances to transform regimes might, however come at the expense of less visible sites and configurations.

Concluding Remarks

We have suggested in the paper that technological change can be a key driver that contributes to changes in policy paradigms, political frictions and consequently the transition of the sociotechnical regime. We have also explained how technology exerts its agency through displacement mechanisms, illustrating these claims with the case of water production by desalination technology in Israel. Desalination dislocated environmental externalities across sectors and environmental media; political choices were displaced as water came to be seen as a neutral product that can be governed by scientific, technocratic and market rationality, and water-related economic costs and subsidies were displaced to the sewage subsector. Finally, geopolitical tensions over limited water resources in the region were shifted to less visible and prominent economic and strategic tensions such as the Palestinians' ability to pay for water, and whose hand is on the tap.

Our case study suggests that a considerable component of the appeal of a new technology and its ability to dislodge locked-in regimes (via the socio-technical systems that underline them) is the way in which the new system may offer opportunities for displacing and hiding long-standing tension and worrying costs. This finding has considerable importance for evaluating policy changes and the adoption of new technologies. One result of the

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complexity facing analytical decision-making (Dryzek, 1987) is that the problem in question and the range of possible solutions can rarely be analysed holistically. Empirical evidence suggests that policy changes in governing systems are to a great extent 'sources of causation, feedback, and the sheer complexity of what is going on' (John, 2003, p. 483). This means that any sectoral regime often spans its own 'sectorial' boundaries and encounters horizontal and vertical interdependencies (Jochim and May, 2010; Pierson, 1993; Rayner *et al.*, 2001). If new technical/policy regimes are adopted precisely through their ability to utilize yet ignore these interdependencies, it would be wise to focus strongly on these aspects as we evaluate these technologies and the shifts they engender. These displacements of physical, social and economic consequences should be made more visible so as to avoid a transition from one inferior socio-technical regime to another, and to encourage new regimes built on genuinely sustainable solutions to problems, in terms of environmental performance, economic affordability and social acceptance.

Displacement is not a problem per se but rather an indicator of the unresolved edges of public policies, especially but not only of environmental ones. Indeed, the isolation of sectors in policy-making arenas should be questioned, especially when borders between policy levels and policy areas are transcended by cross-sectorial challenges. Further examination of policy coherence and linking up is needed to reduce the risk that new technologies are adopted as a result of their ability to displace – rather than to solve – hard problems.

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