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# Designing the public sector to promote sustainability transitions: Institutional principles and a case study of ARPA-E

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ABSTRACT

Sustainability transition perspectives justify policies tailored to technological innovation systems and socio-technical niches and regimes. These "technology-specific" policies place high demands on the capabilities of the state. This paper examines how public sector institutions can be designed and operated to avoid potential pitfalls and effectively implement technology-specific policies. The paper presents a list of ten institutional design principles and their relation to sustainability transition studies. How the principles are achieved in practice and how they interact within a governance system is then explored through a case study of the Advanced Research Projects Agency-Energy (ARPA-E) in the United States. The case demonstrates that an organization's formal and informal rules can make the design principles mutually reinforcing, while a stronger political consensus is needed to manage tensions between accountability and stability. The institutional design principles can inform future case studies exploring how the state implements technology specific policy in different contexts.



## 1. Introduction

Sustainability transitions perspectives emphasize the need to tailor policies toward the particular challenges found within technological innovation systems (Carlsson and Stankiewicz, 1991; Bergek et al., 2008) or socio-technical regimes and niches (Geels, 2002; Smith and Raven, 2012). These perspectives emphasize the role of policies that are targeted, or "technology-specific," in contrast to those that seek to meet the difficult standard of "technology neutrality" (see Azar and Sandén, 2011; Jacobsson and Bergek, 2011).

However, technology-specific policies place high demands on the state's capability to continuously monitor innovation systems and undertake targeted policy actions. Even if more activist governments following technology-specific policy approaches can be theoretically justified, others warn that such policies can be derailed by "government failures" (Krueger, 1990; Tullock et al., 2002). Advocates of government-directed technological change respond to these concerns by pointing toward "organizational innovation" (Chang, 1994). Given this debate, it is important that sustainability transitions scholars not only outline the theoretical arguments for technology-specific policies, but also explain how such policies can be effectively *implemented*. Indeed, Jacobsson and Bergek (2011) highlight researching the "competence, organisation and integrity

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of public policy bodies" as a key sustainability transitions research priority. This research requires an understanding of the pitfalls that a technology-specific agenda could encounter during implementation, and how institutional design could help avoid these pitfalls.

This paper's first purpose is to propose ten institutional design principles for the effective implementation of technology-specific policies for sustainability transitions. Its second purpose is to demonstrate how these principles are achieved in practice and how they interact through a case study of the Advanced Research Project Agency-Energy (ARPA-E) in the United States. Section 2 briefly reviews arguments on government involvement in technological and industrial development, and asserts that these perspectives reveal the need for a stronger focus on institutional design and democratic decision-making processes, rather than a retreat from state involvement in shaping sustainable technology futures. Section 3 outlines the methodological approach, and Section 4 proposes ten public sector institutional design principles and their relevance for sustainability transitions policy. Section 5 presents a case study of ARPA-E, which demonstrates how these seemingly contradictory principles can co-exist, producing balance and synergy. The case also demonstrates how tensions between principles create management challenges. The paper concludes with lessons from the case study and ideas for future research.

## 2. Technology-specific policies: their rationale and potential pitfalls

The urgent need to transition toward a low-carbon economy has reintroduced the importance of technology-specific policy approaches. These approaches contrast with "technology-neutral" policies that seek to avoid "picking winners" by providing broad signals through mechanisms such as carbon pricing and generalized support for research and development. Sandén and Azar (2005) argue that technology-neutral policies promote the adoption of near-commercial technologies, but fail to produce new technological options. Jacobsson and Bergek (2011) note that sustainability transitions require the development of a large suite of technologies in a limited period of time. They call for "multifaceted and specific" policy interventions because the innovation systems associated with each technology will face different barriers and vary in their development stages.[2] The technological innovation systems (TIS) approach provides a tool to diagnose system weaknesses that require policy attention (Bergek et al., 2008). The multi-level perspective (MLP) on sustainability transitions (Geels, 2011, 2002) also emphasizes the importance of social and technological learning within niche protected spaces (Smith and Raven, 2012), and assesses how these niches evolve to challenge the dominant technological paradigm or "regime." Yet, neither approach offers guidance on how the state can effectively implement the recommended policy actions.

Technology-specific policies require an active role for the state in supporting innovation and guiding economic transformations. The state has played a leading role in technological development throughout history (Block and Keller, 2011; Mazzucato, 2013; O'Riain, 2004; Perez, 2002). However, government attempts to promote technological innovation have also resulted in spectacular failures (Lerner, 2009; Lipsey and Carlaw, 1996). This section will discuss four categories of potential technology-specific policy pitfalls: information failures, political capture, principal-agent problems, and challenges associated with risk aversion stemming from policy ambiguity and complexity. These pitfalls present useful warnings about what could go wrong, and recognition of these problems rules out simplistic views of the state as benevolent or all-knowing. However, this section also argues that these warnings fail to justify avoidance of technology-specific policies. Rather, acknowledging these pitfalls calls for a more careful consideration of how public institutions are designed and operated.

The state's inability to acquire sufficient information to make informed decisions is often presented as an argument against activist government policies. For instance, the Austrian school of economics pointed to information limitations to explain the infeasibility of central planning, and highlighted the role of prices in transmitting information (Hodgson, 1998; Lavoie, 1985). Yet, incomplete information is pervasive across both public and private sectors. Private firms have information deficits, and while market prices transmit valuable information, non-market institutions are critically important for developing new products and processes (Lundvall, 1992). In practice, both firms and governments manage technological change by creating associative structures that enable learning and information exchange (Meadowcroft, 1997; Cooke and Morgan, 1998; Rycroft and Kash, 1999). Removing government from such networks could restrict information flow to both sectors.

Political capture is a second pitfall that occurs when interest groups influence governments to take advantage of policy-induced rents (Buchanan et al., 1980). The rents created by the state entice entrepreneurs to engage in lobbying, and even corruption and bribery, rather than productivity enhancing activities (see Krueger, 1974). The concern over political capture suggests that politics is ubiquitous, yet resorting to "technology-neutral" policies is unlikely to prevent certain groups from gaining undue influence over the state. Azar and Sandén (2011) argue that policies seldom meet the standard of technology-neutrality, and that less targeted policies favour incumbent technologies. The notion of the regime (Kemp, 1994) in sustainability transition studies highlights the lock-in effects of dominant technologies and incumbent players. Non-action by government reinforces status-quo regimes, with the political implication of supporting the interests associated with existing technologies.

Skeptics of government intervention also highlight the prospect for uncontrollable, expanding bureaucracies with little accountability to elected representatives. Tullock (1965) discusses information problems within the state, whereby direc-

[2] See also Acemoglu et al. (2012), who call for a climate policy mix that includes both carbon taxes and more specific measures to influence the direction of technical development.

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