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Making sense of policy for climate technology development and transfer

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1. Introduction

It has been more than 20 years since the United Nations Framework Convention on Climate Change (UNFCCC, 1992) noted the importance of technology development and transfer (hereon referred to as ‘technology transfer’), and almost 15 years after the Intergovernmental Panel on Climate Change (IPCC) published a special report on the topic and defined technology transfer as

encompass[ing] the broad set of processes that cover the flows of knowledge, experience, and equipment for mitigating and adapting to climate change among different stakeholders. These include governments, international organizations, private sector entities, financial institutions, NGOs and research and/or education institutions. It comprises the process of learning to understand, utilize, and replicate the technology, including the capacity to choose it, adapt it to local conditions, and integrate it with indigenous technologies. (IPCC, 2000)

While the issue of technology transfer has continued to receive much attention in the international climate policy domain (and, in fact, even in other policy domains), progress in enhancing our understanding of the various dimensions of technology transfer has been relatively limited. In fact, it would be fair to say that the debate on this issue has often generated more heat than light. At the same time, the role of technology transfer in reducing GHG emissions and adapting to the consequences of climate change is seen as becoming ever more critical, given that we already are in a changed-climate regime (IPCC, 2013), that there is little headroom and time left to avoid dangerous climate change (UNEP, 2013), and that rising emissions in developing countries also requires them to consider significant climate mitigation actions (den Elzen, Beltran, Hof, van Ruijven, & van Vliet, 2013).

The question of how best to undertake technology¹ transfer to address climate change, unfortunately, remains relatively underexplored in the climate policy domain, in part because of its enormous complexity and context-dependence, but also because other policy approaches, in particular market-based mechanisms, have been dominating the discourse around climate policy.

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Technology transfer cannot be a developed- or developing-country issue alone, and is no longer a fully North–South phenomenon either. Both developing and developed countries are key, as in developing countries much new infrastructure is being deployed, while developed countries still possess most of the innovation and financing capabilities (although this is changing). Furthermore, although the states of innovation systems in developed countries vary greatly too, in developing countries technological innovation systems are generally relatively weak in many, if not all, functions. These weak innovation systems constrain the rate of technological change, although this special issue will demonstrate that, over the past decades, several larger developing countries have taken significant steps to strengthen their innovation capabilities in some sectors. Adding to the complexity is the large number of actors – private, public, domestic, international – that are relevant to technology transfer. In any case, successful technology transfer requires an understanding of both the industrialized and the developing-country contexts.

This special issue aims to offer insights to climate policy makers as to the nature of domestic policy in deploying climate mitigation technologies in developing countries, the role of firms in all countries involved in this process, and the linkages between domestic technology approaches and international climate policies. In addition, as a contribution to the policy research literature, the special issue takes forward the interdisciplinary discussion on how to advance technology transfer through better national and international climate policies.

2. Technology policy: a means to simultaneously address development and climate challenges

Technology development and transfer are widely seen as central conditions not only to climate mitigation and resilience, but also to sustainable development more broadly and green growth. Accordingly, it is important to understand the process of the development of technologies and their diffusion – including the roles of knowledge, capabilities, practices, and institutions – across geographical areas, in order to accelerate the movement and deployment of relevant technologies to meet such societal goals. There is broad agreement within both the scholarly and policy communities that if low-carbon and climate-resilient technologies are prioritized globally and if technology development and transfer policies are chosen carefully, developing countries will be better equipped to achieve their economic and social development goals in a more climate-resilient manner. Experiences across a range of developing and newly industrialized countries have also demonstrated that local technological capabilities, including, for example, institutional capacity and the knowledge to innovate on transferred technology, play an important role in enabling technology change and supporting development in a manner that is more locally rooted and more robust. But how these policies have evolved and performed in the case of climate change in developing-country contexts, and what the lessons might be for enhancing local deployment of climate technologies, are not as well understood.

A confusion that often arises around technology policy and more particularly technological innovation is that it mostly focuses on the early phases of technological development, in particular research and development (R&D). Such a limited view of innovation has a number of problems. First, it has been demonstrated since the 1990s that technological development rarely follows a strictly linear path of subsequent research, development, demonstration, deployment, and diffusion. In reality, technologies develop through less-structured processes, often with a low level of predictability and a high
level of chaos (Lundvall, 1992). This is not to say that R&D as an activity is not clearly distinguishable from, for instance, demonstration or diffusion, but to treat the progress of technologies towards wide implementation as a linear process would be to deny the complex reality of technological development and deployment. As an example, in many cases, the technology transfer process requires R&D activity during the deployment phase in order to adapt the technologies to developing-country circumstances, such as raw material quality or scale of production. A second problem is that, while innovation takes place in the hardware (the invention and improvement of new equipment), it also does so in the institutional and social arena. In fact, social innovation and institutional innovation might well be just as important to transformational change and technology transfer as innovations in hardware.

In the linear model of technological development, the focus is on technology as hardware, and only late in the innovation chain do consumers play a role as the ‘market’ for the technology. In such a framing, the social construction of technology plays a very limited role, although historical analysis of technological change has shown that this is not the case (see, e.g., Bijker, Hughes, & Pinch, 1987). To take an even broader perspective, scholars describe technologies as elements of socio-technical systems and acknowledge that there either has to be a fit between the incumbent socio-technical system for a new technology to diffuse, or an opening needs to be created or formed (by intervention or a coincidental combination of circumstances) to provide an opportunity for a technology to emerge (Geels, 2005). Yet others try to design and select interventions that can influence the speed of penetration of a technology into the marketplace and approach the issue on a systemic level (e.g. Hekkert, Suurs, Negro, Smits, & Kuhlmann, 2007; Sagar, Bremner, & Grubb, 2009). The articles in this special issue also take a multifaceted perspective in unpacking and analysing technology policies.

Just as climate change is increasingly seen as a multilevel governance issue, so does technology development and transfer play out at different levels in governments and firms: national strategies are important, but local innovation hubs can be too. At the international level, technology is an issue in UNFCCC negotiations, with a firm place on the agenda since the 13th Conference of the Parties (COP 13) in Bali in 2007 (even if not playing as central a role in the negotiations as the burning issues of national emission commitments or pledges or carbon markets). Local, national, and international governance are all key in technology development and transfer, and, again, the articles in this issue cover these different levels of governance and their interplay.

3. Domestic technology policies and capability development

Domestic policies doubtlessly play the most critical role in advancing the implementation of climate technologies in any country. Yet, not surprisingly, different developing countries have also taken very different approaches to climate technologies (and also specifically to technology transfer). Three articles in this special issue discuss domestic policies around energy-technology-centred mitigation, for three major developing countries – South Africa, China, and India. In particular, the articles examine how these policies balance (or not, as the case might be) developmental aspirations and climate imperatives. The need to balance climate and developmental needs, in fact, goes to the heart of the climate debate in developing countries. Learning from recent experiments and experiences, therefore, is of great value, as policy makers in these countries explore and think through policy options and pathways in the coming years.
Britta Rennkamp discusses the South African strategy for deploying mitigation technologies in the framework of an approach that builds technological capabilities, and contrasts such a capability-building-driven approach to a straightforward sales-driven approach that focuses on the import of technology. She notes that the South African government has the desire to produce the hardware for these technologies locally in line with its industrial policy, as demonstrated by local content requirements in the South African renewable energy subsidy scheme to build local manufacturing capacity as the first step in building technological capabilities. Her investigation of the implementation of four technologies—wind energy, concentrated solar power (CSP), solar photovoltaic (PV), and solar water heating—indicates that South African policies can be seen as taking a technological-capability-building approach, but, in practice, there are elements missing from the enabling environment that are essential for successful achievement of this objective. As a result, the outcome is mixed. For solar water heaters, where a strong focus on building technological capabilities in the technology sector is followed (which Rennkamp calls a high-technological-capability approach), the programme is progressing steadily. For wind energy and CSP, although the government seems to desire otherwise, the dominant outcome seems to be sales-driven. For solar PV, there are elements of high- and low-technological-capability approaches; there is effort on building capabilities for some aspects but not others. Overall, Rennkamp concludes that ‘capability-driven technology transfer can significantly contribute to South Africa’s low-carbon development goals, but the current programmes are not designed to boost local manufacturing capacities.’

The case study of China’s wind energy industry by Dai and Xue explains in some detail how China, over the past few decades, has laid the basis for its currently thriving wind energy industry through a strategy based on both technological and market developments, which resulted in China not just following, but becoming a leader in wind energy-technology manufacturing and deployment. While the approach can be thought of as ‘capability-driven’, the specific policies were modified as the economic and market context and technological capabilities in China evolved over the three-decade period under examination. The early-stage (1986–1995) implementation policies focused on demonstration, but, subsequently, deployment was slowly ramped up while R&D-centred policies were explicitly pursued to develop the science and technology base, eventually building an innovation system that would enable the Chinese economy to supply wind energy technology locally. It was only after the turn of the century, however, that this strategic approach started paying off, when joint international research and domestic R&D, as well as collaborations in the private-sector sphere, allowed Chinese companies to develop technologies that outperformed foreign wind energy manufacturers.

Dai and Xue also show the importance of co-optimizing sectoral policies with ‘macro’ policies, which define priorities on a higher abstraction level around national innovation systems, climate policy, and a national development strategy. Gallagher (2014), based on extensive empirical work, has shown that China followed a similarly effective pathway in PV and coal gasification, but has been less successful in building local technological capabilities for cutting-edge gas turbines or advanced automotive batteries.

Similarly, Chaudhary and colleagues explore the development of the wind energy and solar PV sectors in India and the evolution of the underlying policies. India has a long and successful history of developing wind energy, initially fuelled by concerns over energy security, but later by a pragmatic combination of industrial development and climate policy. Solar PV policy has picked up much more recently, but, in contrast to wind energy, there is no local firm that has played any significant role in
technology development, as the upfront investment, global competition, and technological sophistication made it unattractive. It seems that for both solar PV and wind energy it was mostly firms that developed the capabilities required to deploy these technologies at a large scale, while government mainly provided what Bergek, Jacobsson, Carlsson, Lindmark, and Rickne (2008) call market formation functions in the technological innovation system. At the same time, as in the Chinese case, flexibility and the evolution of policies, based in part on learning from experience, were key in the attempt to enhance their effectiveness and, more recently, balance developmental and climate considerations.

Although the country studies have different technological and methodological foci, what emerges from all of them is the complexity and difficulty of balancing environmental and various developmental considerations – economic, industrial, and technological – in the implementation of renewable energy technologies, with highly divergent approaches and experiences in different countries. The importance of the development of technological capabilities and of the alignment of various policies to underpin this process also cannot be understated. Also, an evolutionary perspective seems like a requirement: learning based on evolving understandings of the sectors and technological developments, and refining policies accordingly. There are also differences in the degree to which strategic planning on this topic is performed by a central government, and how much countries rely on ‘market pull’. However, it is clear that demand for climate technologies (domestically or internationally) plays a critical role in driving the deployment of these technologies, and the developing countries discussed have been successful, to different degrees, in being able to create this demand.

These emerging economy studies are in line with the views of Tawney and colleagues, who acknowledge the role of the emerging economies in the domain of energy innovation for the poor: ‘look at those emerging economies that have growing innovation capabilities and face significant domestic energy access challenges when thinking about where technical innovations will originate.’ They point out that innovation in energy for the poor is an area that is generally neglected. They also note, however, that many of the relevant innovations may be more in the business model or financial domain to expand access to existing technologies, and that national context and enabling environments are critical aspects of policy approaches in enhancing innovation for energy access. Once again, this reiterates the need to balance and align various kinds of policies for the effective deployment of technologies.

4. International technology interventions

It is key that international technology mechanisms to help address the climate challenge be designed to help domestic innovation systems perform better. The differences among China, India, and South Africa also demonstrate that such international mechanisms will need to be tailor-made.

The role of technological capabilities also plays out in interactions between international interventions to mitigate climate change and domestic policies. In their detailed analysis of technology transfer in the Clean Development Mechanism (CDM), Murphy and colleagues find that the likelihood of projects under the CDM supporting technology transfer is very much dependent on the domestic context. Similarly, Joanna Lewis, in her review of David Ockwell and Alexandra Mallett’s edited book *Low-carbon technology transfer: From rhetoric to reality* (2012), notes that, contrary to what might be expected, the
uptake of low-carbon technologies in developing countries is governed less by cost and more by the domestic context, as also noted by Schmidt (2011).

Interestingly, the study in this issue by Murphy and colleagues, as in earlier studies on technology transfer in the CDM (Coninck et al., 2008; Dechezleprêtre, Glachant, & Ménière, 2008; Haites, Duan, & Seres, 2006; Lema & Lema, 2013; Seres, Haites, & Murphy, 2009) notes that according to the project design documents and project developers, only around two-fifths of projects are expected to involve technology transfer. Generic mechanisms like the CDM are prone to only helping those countries that already have the ability to absorb technologies and are, as Lewis also notes, not designed to transfer technology but to reduce GHG emissions as cost-effectively as possible. Not surprisingly, then, the large emerging economies (China, India, and Brazil) dominate the project landscape, but technology transfer is less prevalent in projects here than in many other countries (e.g. Indonesia, Malaysia, and Thailand), where over 90% of projects involve a technology transfer component. Murphy and colleagues hypothesize that this may be explained, in part, by the existing technology base of these latter countries, which have a significant existing knowledge stock and technological base. Elsewhere, Dechezleprêtre et al. (2008) and Lema and Lema (2012) have noted that the kind of technology transfer in CDM projects is dependent on the technological capabilities of the host country, and Phillips, Das, and Newell (2013) note that aspects such as the political economy of the recipient country can also play an important role in defining to what extent the CDM could help build technological capabilities.

Murphy and colleagues have also found a decrease over time in technology transfer occurrence in the CDM in the case of India and China, and attribute this to an increase in domestic technological capabilities within these countries, potentially because of earlier CDM projects, but also because of other technology transfer channels, or the dedicated build-up of capabilities in these host countries. In fact, although most technologies originate predominantly from developed countries (Germany, Japan, the US, and Denmark), China recently joined the group of CDM ‘hard’ technology providers. The finding that technology transfer is no longer exclusively a North–South affair is also noted by Joanna Lewis. Murphy and colleagues highlight that, for a government to successfully promote the deployment of a specific climate technology, sufficient potential for commercial exploitation of the technology needs to be present or developed. The CDM could be part of a strategy to realize the early market potential and enhance existing domestic capabilities, or even lay the groundwork for building such capabilities, if none exist in the country.

While numerous studies on technology-transfer aspects of mitigation technologies exist (although far more are needed to shed light on the complexities of this process), studies on technology transfer for adaptation are rare. In a commentary in this issue, Olhoff points out that in many cases of adaptation technologies, actors seem to have succeeded in finding a balance between ‘hard’ technology on the one hand and ‘softer’ or organizational aspects of technology on the other. At the same time she notes the limited understanding of what technologies for adaptation may be, and, especially given the broad definition of technology, the fact that the distinction between technologies for adaptation and general adaptation policies and measures is blurry. Olhoff cautions against the overlap of work between adaptation bodies under the UNFCCC and its technology bodies. It may be noted that if bilateral cooperation is also unclear about the distinction, there is a challenge there too (not just in international interventions). Indeed, the coordination she calls for in international organizations is (at least formally) implemented within the Advisory Board of the Climate Technology Centre and Network
(CTCN), which contains a representative from the UNFCCC Adaptation Committee, and the meetings of the Technology Executive Committee (TEC) review and discuss the results of the Adaptation Committee meetings. As the CTCN moves forward with its activities, one will be able to assess the effectiveness of this approach.

The issue of intellectual property rights (IPR) has always been a divisive part of international technology discussions, leading often to avoidance of any significant or substantive discussion of the topic. At the same time, there has been a remarkable increase in the patenting of climate technologies, with much of this activity being concentrated in Organisation for Economic Co-operation and Development (OECD) countries (Abdel Latif, 2012). As with the CDM, Abdel Latif (this volume) sees a skewed picture in terms of technology flows through licensing arrangements, with only a few non-OECD countries (China, India, Brazil, and Russia) being the main beneficiaries. While the IP regime is seen as an important consideration for technology licensing, importantly, and once again reflecting the importance of domestic policies and capabilities, other issues such as ‘scientific capabilities, infrastructure and human capital, favourable market conditions, and investment climate were actually considered slightly more important’. However, as with almost any aspect of technology transfer, a number of knowledge gaps remain to be addressed in order to better inform policy making. It also requires experimentation with innovative approaches that find a middle ground to explore ways forward – and there are many emerging examples of such initiatives. Looking ahead, Abdel Latif suggests an incremental and ‘gradual’ approach to untangling this knotty issue; to be honest, we may not have much of a choice anyway.

5. Firms play a key role – everywhere

The discussions on domestic and international policies for technology transfer have revolved around managing development aspirations and climate aims. Many aspects of development aspirations, however, are also closely connected to the role of the private sector – not only how local industries can be developed, but also how favourable and enabling environments can be created for foreign investors to finance climate-resilient technologies and industries rather than conventional ones. Fortunately, a literature base is emerging to address this question from the viewpoint of the private sector (Kolk & van den Buuse, 2012; Lanoie, Laurent-Lucchetti, Johnstone, & Ambec, 2011) in addition to the historically already extensively covered public sector (see, e.g., IPCC, 2000, for a wise assessment that was perhaps ahead of its time).

A better understanding is emerging of the need for (and the kind of) government technology policies to orient firm activities towards more sustainable, resilient, or low-carbon practices. The diversity in the private sector is huge. There are myriad companies in different sectors with different roles, varying from renewable energy equipment manufacturers to coal or oil companies, and from carbon market consultants to engineering companies in the field of water management and infrastructure development. What all firms have in common is the profit motive, but there can be large differences in how their business interests intersect with the climate arena; the interests of some are fully aligned with strong climate policies, but those of others are at odds with a transformation to a low-carbon system and are fully entrenched in the fossil-fuel system.

Essentially, technology policies to advance climate objectives aim to discourage undesired activities and promote the development and deployment of climate-friendly technologies. Technology policies
take a less hands-off approach than market mechanisms; they are generally more directive and, unavoidably, somewhat prescriptive. The million-dollar question, of course, is how to get these policies right. To enhance the chance of success, it is helpful to be able to get ‘under the skin’ of firms and understand what drives them to invest in climate innovation (and avoid investments in conventional technology) as well as the conditions that can make companies invest abroad to launch climate-resilient technologies in new markets.

Ans Kolk highlights this need for a better understanding of corporate decision making around climate change, and links it to three broad ‘peculiarities’: sectoral characteristics, company peculiarities, and country circumstances. Country circumstances can be summarized as the enabling environment, which is also the topic of the articles by Chaudhary et al., Xue and Dai, and Rennkamp. The sectoral characteristics can differ greatly, between ‘high-salience’ companies, climate-invested companies, and companies with low emission profiles, which are oblivious to climate change concerns except for the possibility that they profile themselves on corporate social responsibility-related aspects of climate change.

Aliza Belman Inbal and Asaf Tzachor note that scant attention has been paid to the question of whether industrialized countries create enabling environments for their companies to transfer climate technology to developing countries, even though industrialized countries could benefit from greater activity of their firms within these international markets. Barriers emerge particularly for small and medium enterprises which have limited experience with international markets, limited means to gain information on new, uncertain markets in order to invest there, and a low awareness of the opportunities. Belman and Tzachor illuminate this through the case of Israel, arguing that industrialized countries could do more in funding R&D aimed at technology transfer, insuring risk and providing matchmaking services to overcome difficulties in identifying private-sector partners in the South and funding demonstration sites. This suggestion complements those made by other scholars about ways through which to support the advancement of low-carbon technologies in developing countries (see, e.g., Gallagher, 2014; Ockwell & Byrne, 2014).

6. Conclusions

Drawing on empirical work and insights from the more generic innovation literature, the articles in this special issue have highlighted openings for a more effective role for technology policies in advancing technology development and transfer. There are three broad conclusions.

First, domestic policies matter tremendously. Reducing the costs of technology helps, but the premium on transferring climate technologies has to do with the enabling environment in developing countries. Domestic policies can contribute to building this enabling environment, which is akin to a national technological innovation system. We observe that many indeed do so, but to varying degrees and with varying success.

Second, domestic policies in developed countries, as well as international mechanisms, can contribute. The CDM is an example of an international mechanism that can play a useful role in market formation if demand for CDM credits is maintained in developed countries. Such a mechanism, combined with domestic or international instruments for capability development, can be a powerful channel for change. Much analysis has demonstrated that a market-based mechanism
alone would not result in transformational changes in developed or developing countries (Grubb, with Hourcade, & Neuhoff, 2014), and cannot be realistically expected to singlehandedly build all capacity needed for low-carbon and climate-resilient development in developing countries. Tailor-made international support for domestic policies, as is potentially foreseen in the CTCN, provides a much-needed supporting pillar for a viable approach to meeting the objectives of the UNFCCC.

Third, the international debate around IPR is making progress as more independent evidence is becoming available on the actual role of IPR in climate technology diffusion. The debate might now be ready for, and would benefit from, a gradual move towards a more constructive and pragmatic dialogue based on agreed evidence and possible ways forward. The UNFCCC Technology Mechanism’s TEC could play a constructive role in facilitating progress.

7. Gaps in knowledge

This special issue has also highlighted many gaps in the literature. For example, how can climate technology policy create opportunities for companies to develop and transfer relevant technologies? It seems likely that questions regarding the finance of technology (public loans to cover the risky part of sustainable technology investments in developing countries, for instance) can be part of such an exploration, but this remains largely unexplored, including in this special issue. The role of not just commercial finance and mainstream banks and investors, but also multilateral banks, needs to be further illuminated.

Finding creative ways to go beyond the stale and stalled IPR debate is another topic that needs analysis. Under which circumstances do existing arrangements around IPR (e.g. the World Trade Organisation or World Intellectual Property Organisation) serve as an incentive for climate technology innovation or a barrier? To what extent will proposals such as ‘technology banks’ or pools advance a climate-compatible technological transformation in developing countries?

Within the technology policy field, the UNFCCC Technology Mechanism could be a powerful force for positive change in developing countries, but policy research in this field is in its infancy. Lewis’s review of the Ockwell and Mallett (2012) book notes that the emerging literature is beginning to fill some gaps, but much remains to be done. For technology policies, the policy research community is a long way removed from the level of policy analysis in topics such as the field of carbon markets or renewable energy policy instruments, such as feed-in tariffs or subsidies. The complexity of technology policies, given the systemic nature and absence of a single comprehensive and comprehensible metric, does not make this an easy feat, but policymakers may be helped by a ‘technology policy menu’ from which to pick and choose.

One main focus of this special issue is on developing-country policies to enhance the development and/or adoption of climate-friendly technologies (an increasing number of studies along these lines are appearing in the literature). However, the relative lack of analysis of the role of industrialized-country policies for enhancing the development and transfer of climate technologies in developing countries limits our understanding of this crucial point. In general, it is assumed that industrialized countries do not need a policy, or that such a policy would be deleterious to the interests of the developing-country concerned. This assumption may reflect engrained thinking of the past. Currently, many actors in
developing countries and industrialized countries have in practice reoriented their positions and policies, but the results of the interaction of such technology, innovation, and trade policies has not been the subject of much analysis. This is an important gap in policy analysis and practice that needs further attention.

Last, but not least, what are effective mechanisms for the generation of technological capabilities in developing countries, and which lead to failure? Such capabilities seem to develop autonomously in larger emerging economies with growing government budgets, diversifying economies, and an increasingly educated workforce, but this is deceptive. This special issue has shown how, in India and China, deliberate government intervention has led to greater innovation capabilities.

The challenges are greater in the smaller low- and middle-income countries that are less likely to appear on the radar of donors and the international community, because their cumulative annual emissions are low and seemingly insignificant at the global level. Yet, interesting innovations could also take place in these countries, for instance in the area of low-carbon energy access, which could propel local sustainable economic development, and provide better and cheaper technological alternatives on the world market. It is therefore important for the policy research community to also focus on these countries and not follow the path taken by the CDM, where most attention is lavished on the major emitters.

**Notes**

1. There is often confusion about the term ‘technology’. On hearing the term, the first thought that most people have is about the hardware – the nuts and bolts, the wind turbine, the boiler, or the motor in a car – but the academic literature and many UN policy documents treat technology as encompassing not just the hardware but also the software (such as knowledge, capabilities, and know-how) and the orgware (in particular institutions, policies, culture, rules, and legislation), reflecting the relevance of all these dimensions in the successful application of scientific and technical knowledge to address problems. In this special issue, we assign this broader meaning to the term ‘technology’.

2. An ‘innovation system’ can be thought of as the set of interlinked actors embedded in (and shaped by, and shaping) the institutional context (‘institutions’ here being ‘rules of the game’, following North, 1990), which is often very location-specific. A technological innovation system comprises the innovation system for a specific technology, which, according to Hekkert et al. (2007) and Bergek et al. (2008), needs to fulfil functions such as entrepreneurial experimentation, knowledge development, and market formation.

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