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# Enhancing International Technology Cooperation for Climate Change Mitigation

## Lessons from an Electromobility Case Study

*Shikha Bhasin*

*Joint project with:*

IDS Institute of Development Studies

Tsinghua University
School of Public Policy and Management

Indian Institute of Technology Delhi

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## Abstract

As a global agreement on climate mitigation and absolute emissions reductions remains grid-locked, this paper assesses whether the prospects for international technology cooperation in low-carbon sectors can be improved. It analyses the case of international cooperation on electric vehicle technologies to elaborate on the trade-offs that cooperation such as this inherently attempts to balance– national growth objectives of industrial and technology development versus the global goods benefit of reducing greenhouse gas (GHG) emissions. It focuses on bilateral German-Chinese programmes for electric vehicle development, as well as multilateral platforms on low-carbon technology cooperation related to electric vehicles. Based on insights from these cases studies, this paper ultimately provides policy recommendations to address gaps in international technology cooperation at a bilateral level for ongoing German-Chinese engagement on electric vehicles; and at a multilateral level with a focus on the emerging technology cooperation framework of the United Nations Framework Convention on Climate Change (UNFCCC).

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Bonn, September 2014 Shikha Bhasin

# Preface

Mitigating climate change by reducing carbon emissions is one of the biggest and most complex issues the world has ever faced. Technological innovation plays a major role in taking on this challenge. Old and new industrial powers alike are increasingly reforming their policy frameworks to encourage low-carbon investment and innovation.

Evolutionary economics has demonstrated how initial choices of technologies and institutional arrangements preclude certain options at later stages; hence, innovations evolve in an incremental and cumulative way, resulting in context-specific technological pathways. Such path dependency implies that technologies and institutions do not progressively converge toward a unique best practice, as neoclassical equilibrium models might suggest. The historical and social embeddedness of such evolutionary processes instead results in a variety of very different technologies and institutions across countries.

The starting assumption of our research was that low-carbon technologies depend to a high degree on politically negotiated policies, mainly due to the failure of markets to reflect environmental costs. The way national governments and industries deal with the low-carbon challenge varies greatly depending on levels of environmental ambition, technological preferences (such as different attitudes towards nuclear energy, shale gas, carbon capture and storage), the ways markets are structured, and the importance attached to expected co-benefits (such as green jobs or energy security). Consequently, low-carbon technologies are more likely to evolve along diverging pathways than other technologies whose development is more market-driven.

To test this assumption we conducted the international research project "Technological trajectories for low-carbon innovation in China, Europe and India". The project explored to what extent, how and why technological pathways differ across countries. Case studies were conducted in two technological fields, electromobility and wind-power technologies, in China, India and leading European countries. Whether a diversity of pathways emerges or a small number of designs becomes globally dominant has important implications. From an environmental perspective, diversity may help to mobilise a wide range of talents and resources and deliver more context-specific solutions. Convergence, on the other hand, might help to exploit economies of scale and thereby bring about bigger and faster reductions in the cost of new technologies. From an economic perspective, diversity may provide niches for many firms, whereas a globally dominant design is likely to favour concentration in a small number of global firms – which may or may not be the established ones. Comparing European incumbents with Asian newcomers is particularly interesting, because China and India might well become the gamechangers – responsible for most of the increase of $CO_2$ emissions but also leading investors in green technology. In addition, the project explored lessons for international technology cooperation, emphasising ways to navigate the trade-offs between global objectives to mitigate climate change effects and national interests to enhance competitiveness and create green jobs locally.

The project was carried out between 2011 and 2014 as a joint endeavour of four institutions: the German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE), the Institute of Development Studies (IDS) Brighton, the Indian Institute of Technology (IIT) Delhi and the School of Public Policy at Tsinghua University, with additional collaborators from the Universities of Aalborg, London and Frankfurt. The project was truly collaborative, to the extent that international teams jointly conducted interviews in China, India and Europe which helped to build common understanding.

Eight reports have been published in, or are currently being finalised for, the DIE Discussion Paper series:

*(1) Altenburg, Tilman* (2014): From combustion engines to electric vehicles: a study of technological path creation and disruption

*(2) Bhasin, Shikha* (2014): Enhancing international technology cooperation for climate change mitigation: lessons from an electromobility case study

*(3) Chaudhary, Ankur* (2014): Electromobility in India: attempts at leadership by businesses in a scant policy space

*(4) Lema, Rasmus / Johan Nordensvärd / Frauke Urban / Wilfried Lütkenhorst* (2014): Innovation paths in wind power: insights from Denmark and Germany

*(5) Schamp, Eike W.* (2014): The formation of a new technological trajectory of electric propulsion in the French automobile industry

*(6) Ling, Chen / Doris Fischer / Shen Qunhong / Yang Wenhui* (forthcoming): Electric vehicles in China: bridging political and market logics

*(7) Dai, Yixin / Yuan Zhou / Di Xia / Mengyu Ding / Lan Xue* (forthcoming): Innovation paths of the Chinese wind power industry

*(8) Narain, Ankita / Ankur Chaudhary / Chetan Krishna* (forthcoming): The wind power industry in India.

On the basis of these case studies, the team is currently working on a series of cross-country comparative analyses to be published in academic journals.

The research team is very grateful for generous funding and the very supportive attitude of the Swedish Riksbankens Jubileumsfond under a joint call with the Volkswagen Foundation and Compagnia de San Paolo.

Bonn, September 2014 Tilman Altenburg

Contents

**Figures and tables**

# Abbreviations

| | |
|---|---|
| AQSIQ | General Administration of Quality Supervision, Inspection and Quarantine, China |
| BMBF | Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research, Germany) |
| BMUB | Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Germany) |
| BMVI | Bundesministerium für Verkehr und digitale Infrastruktur (Federal Ministry of Transport and Digital Infrastructure, Germany) |
| BMWi | Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy, Germany) |
| BMZ | Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (Federal Ministry for Economic Cooperation and Development, Germany) |
| CATARC | China Automotive Technology and Research Centre |
| CDM | Clean Development Mechanism |
| CGIAR | Consultative Group on International Agricultural Research |
| CQCC | China Quality Certification Centre |
| COE | Chief Executive Officer |
| CTC | Climate Technology Network |
| CTCN | Climate Technology Network & Centre |
| EIB | European Investment Bank |
| EU | European Union |
| EV | Electric vehicle |
| EVi | Electric Vehicle Initiative (IEA) |
| GEF | Global Environment Facility |
| GGEMO | Gemeinsame Geschäftsstelle Elektromobilität (Federal Government Joint Unit for Electric Mobility, Germany) |
| GHG | Greenhouse gas |
| GIZ | Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH |
| ICT | Information and communication technologies |
| IEA | International Energy Agency |
| IPCC | Intergovernmental Panel on Climate Change |
| IPR | International property rights |
| LDCF | Least Developed Country Fund |
| MDGs | Millennium Development Goals |
| MIIT | Ministry of Industry and Information Technology, China |
| MoE | Ministry of the Environment, China |
| MoST | Ministry of Science and Technology, China |
| MoU | Memorandum of Understanding |
| NDRC | National Development and Reform Commission, China |
| NGO | Non-governmental organisation |
| NPE | National Platform for Electromobility (Germany) |
| OECD | Organisation for Economic Co-operation and Development |
| OEM | Original equipment manufacturer |
| R&D | Research and development |
| S&T | Science and technology |
| SAC | Standards Administration of China |

| | |
|---|---|
| SCCF | Special Climate Change Fund |
| TEC | Technology Executive Committee (UNFCCC) |
| TUM | Technical University Munich |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WB | World Bank |

# 1 Introduction

Climate change is one of the greatest global challenges facing human civilisation today. To limit its most disastrous effects, global solutions need to be found and spread in a short period of time. The central pillar of the global climate regime, the United Nations Framework Convention on Climate Change (UNFCCC), has so far not been able to trigger sufficient policy responses to reduce greenhouse gas (GHG) emissions.[1] In this paper, we seek to understand whether international cooperation can fare better in the space of low-carbon technology cooperation – a critical input for climate change mitigation (Dechezleprêtre et al., 2010). Thus we ask: **What are the prospects for international technology cooperation in low-carbon sectors**?

In order to answer the above question, we studied the ongoing technology cooperation between China and Germany – both strong protagonists in the global climate regime. China has been leading the investment race in clean energy sectors (Pew 2012), but is also the largest emitter of GHGs globally (EIA 2012). Germany has the largest *per capita* investments in clean energy (BMUB 2012), is a leader in low-carbon technology innovations and is amongst the largest propagators of climate change mitigation globally. Moreover, trade relations between the two offer an interesting dynamic to comment on international technology cooperation. Germany is China's biggest trading partner in Europe, while China is Germany's biggest non-EU export market after the United States (Bryant 2013). Despite economic competition in the international market between the two, their bilateral relationship is of strategic importance to both nations.

In this paper, we limit our focus to the unfolding case of electromobility as a low-carbon sector. 20% of global carbon emissions originate from the transportation sector. Electric vehicles (EVs) are a relatively new technology, emerging in varying trajectories around the world (Altenburg / Bhasin / Fischer 2012). EVs are also complex technological products that require comprehensive systemic interventions in order to take off – in terms of research and development (R&D), infrastructural development and new incentive systems. We ultimately aim to offer recommendations that may help expedite the development and diffusion of electric vehicles through cooperation between China and Germany.

Both China and Germany are critical global players. Already, China has emerged as the largest production centre and market for automobiles, despite its car ownership levels (44 cars per 1,000 people) (National Bureau of Statistics China 2011 in Stark 2012) being much below the OECD (Organisation for Economic Co-operation and Development) average (550 cars per 1,000 people) (OECD 2013). This is expectedly on an upward rise – as per the International Energy Agency (IEA), 71% of its transport energy demands will originate from road vehicles by 2015 in a business-as-usual (BAU) scenario (IEA 2011). Studies estimate that (EVs) could save 50% of China's primary energy demand, and 35% of GHG emissions (for example, see Watson et al. 2011). The automobile sector is also amongst

1 The number of member countries at the time of establishment was 41 (Annex I), and now includes 44 countries (http://maps.unfccc.int/di/map). The current pledges made by countries to limit emissions will at best lead to six degrees of warming, 4 degrees higher than the *tipping point* that would lead to disastrous consequences (see http://www.pwc.co.uk/sustainability-climate-change/publications/low-carbon-economy-index-overview.jhtml).

Germany's most strategic, directly employing over seven hundred thousand people (Federal Government of Germany 2012). In keeping with the sectors' strategic nature, as well as the ambition of cutting its GHG emissions by 40 percent[2] by 2020, Germany intends to become the leading *smart mobility* market and provider in the coming years (Germany Trade and Invest 2012).

## 1.1 Trade-offs of international technological cooperation in low-carbon technologies

The global goods perspective suggests that international technological cooperation should be maximised in an effort to decarbonise the global economy. Towards this end, it is desirable that low-carbon technologies be developed and deployed as soon as possible. Unrestricted global diffusion of technological know-how, however, is not in the interest of the owners of low-carbon technologies (in most cases private businesses) who earn innovation rents from their technological advancement. Moreover, mitigation technologies are amongst the fastest growing industries globally – for example, the solar energy sector has grown by over 30% annually in the past twenty years (SolarBuzz 2010). Thus, firms and nations where these firms originate from, want to create and capitalise on their own first-mover advantage and knowledge to maintain competitiveness in the global economy. Technology cooperation is therefore obstructed by the need to protect one's own economic growth.

Future greenhouse gas emissions are expected to emerge predominantly from less-developed economies[3] – their share is set to increase to over 70% of global emissions in the next three decades (IPCC 2013). Whilst these countries have historically contributed less to climate change than developed countries, without their adoption of low-carbon development paths, the stabilisation of atmospheric temperatures is impossible to achieve. However, low-carbon/environment-friendly technologies urgently required to mitigate GHG emissions emerging from fast-growing emerging economies and less-developed countries to avoid further lock-in have been developed primarily in industrialised countries. For example, the Clean Energy Patent Growth Index shows that the United States leads the number of patents gained in clean energy technologies in 2012 accruing more than 14,000 patents, followed by Japan and Germany leading the technical patent race with more margin compared to the rest of the world combined (Heslin Rothenberg Farley and Mesiti Intellectual Property Law 2012). Ensuring their global diffusion thus entails considerable policy and economic challenges because developing countries are unable to do so without adequate knowledge and capacity-building. Moreover, they are reluctant to bear the financial costs of *catching up* through sustainable means, given the environmental costs that the markets do not yet internalise.

Thus, financing and building up technological capacity needs to be supported by developed countries if climate change concerns are to be tackled (Sauter / Watson 2008).

2 Baseline for emissions: 1990.

3 The Intergovernmental Panel on Climate Change (IPCC) includes all non-Annex I countries in its *developing country* cohort, explained in the following paragraph.

Moreover, the above mentioned countries have a historical responsibility as early industrialised and polluting nations towards less-developed ones, which finds resonance within the United Nations Framework Convention on Climate Change. The historical responsibility is enshrined in the principles of ‘common but differentiated responsibility’ (CBDR) and Firewalls that established the original Annex I and Non-Annex I lists of nations. These lists were based on the fact that 70% of the emissions originated from developed or Annex I countries back in 1990, taken as the base year for emissions reduction when the Kyoto Protocol was negotiated (IPCC 2013). However, while these principles were accepted when the Protocol came into existence, how the burden of such financing and development assistance should be shared amongst the early industrialisers or Annex I countries has not yet been formulated.

The trade-off between national growth objectives based on the increasing value of low-carbon technologies, and the need to make the pertinent technologies affordable and accelerate their diffusion to lower the pace of global warming makes low-carbon technology cooperation inherently conflicting and yet a critical global dilemma that needs to be re-addressed urgently.

## 1.2 Aim and structure of this paper

Finding a way to cut through this trade-off towards a solution is enormously complex. The main question that we wish to address is: **What are the prospects for international technological cooperation in the field of low-carbon technologies?** We look to the case of electromobility to explore how the trade-offs are being managed by different actors undertaking international technological collaboration between Germany and China in this sector. Given the political nature of the trade-off and the focus on different actors, we attempt to answer the above question by framing our empirical findings around three critical points of analysis: (i) agenda-setting of the cooperation initiatives, (ii) sources of finance for cooperation initiatives, and (iii) the final division of ownership/property rights of the knowledge produced.

The next section (Section 2) lays out the conceptual and analytical framework for the remainder of this paper. Section 3 then presents the case of the EV sectors in China and Germany, and analyses the ambitions, anticipated gains and the dominant agents of the technology cooperation currently underway between the two countries. Section 4 presents the multilateral technological cooperation frameworks relating to electromobility in particular, but also highlights the potential of the upcoming “Technology Mechanism” of the UNFCCC as a pillar of climate change mitigation regime. Both Sections 3 and 4 show a lack of internationally coordinated efforts being implemented to accelerate the innovation and deployment of electromobility. Addressing this, Section 5 provides policy recommendations to re-address the gaps in international technology cooperation, such that electromobility as a low-carbon technology may develop rapidly. We do so primarily at a bilateral level of Sino-German engagement, and at the multilateral level through a focus on the emerging technology cooperation framework of the UNFCCC.

## 2 International technology cooperation: conceptual and analytical framework

Answering questions on international technology cooperation's prospects for low-carbon technology diffusion is a formidable challenge. There is no agreed effectiveness model which prescribes conditions and solutions through which to optimise international technology cooperation. Moreover, as indicated above, addressing the needs of global public goods – climate change mitigation in this case – is not just a matter of technical solutions but rather of political ones.

We take the benefit of certain sets of literature to inform us of certain answers, and offer a minimum number of conceptual distinctions in order to unpack the processes and actors that are central to international technological cooperation.[4] This section aims to do so by first defining international technology cooperation. I then elaborate on the central role of national and international policies in promoting the development of and cooperation in low-carbon technologies. Finally, I present our analytical framework that invokes critical issues of collaborative technology development and initiatives: agenda-setting, funding, and international property rights/knowledge gains.

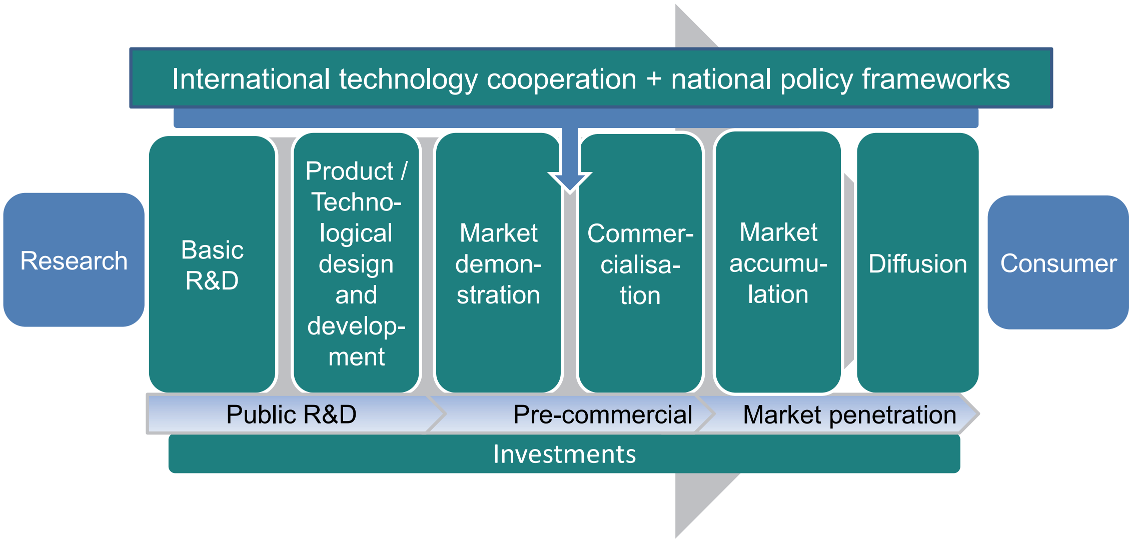
### 2.1 What is *international technology cooperation*?

Access to and mastery of technology are widely accepted as being the basis of *catching up* with industrial and economic development; and international technological cooperation, as a means to this catch up, is a central factor in global development cooperation (Sampath / Roffe 2012; OECD 2012). However, the processes of technological *transfers* and cooperation, and which actors it should directly address, remain less certain (Sampath / Roffe 2012). Since its inception as a term 50 years ago, the idea of *technology transfer* is moving away from implying the transfer of *hardware* or *external technologies*. Consensus is emerging for international technological cooperation to signify technological capacity-building in developing countries that seeks to cater to the entire technology cycle and its development. This stems from the understanding that technology is "*too complex to be fully encompassed by either codified information or physical capital*" (Bell / Pavitt 1996; in Huenteler / Schmidt 2012, 13).

The UNFCCC remains the central pillar of the climate change regime, and the Cancun Agreements that emerged from its meeting there define *technology development and transfer* through the entire technology cycle. The UNFCCC recognises research and development, demonstration, deployment, diffusion and transfer of technologies as being a part of it (UNFCCC 2010). However, as Grubb (2008), Gallagher (2012) and others have pointed out, although these different *"phases"* in the technology cycle can be seen as distinctive activities, a purely linear interpretation of the innovation activities is *"too simplistic"*, and requires concerted linkages between different actors and contextual factors (Climate Strategies 2012, 1) (see Figure 1). As Sagar elaborates, *"successful technological innovation is underpinned by 'systems of innovation' that comprise a range of actors and institutions that support various activities along the innovation chain"* (Sagar 2010, 3).

4 These are taken from analytical insights available in the literature about international relations, the global public goods perspective, innovation systems, and technology transfer. If one were to review the literature from these schools of thought it would only provide limited added value to our discussion as it does not sufficiently highlight the relevance of the political nature of our questions.

**Figure 1: Technology cycle for low-carbon technologies**




Source: Author 2013 (based on Grubb 2004; Sagar 2010)

It is widely acknowledged that national innovation systems in developing economies are weak (Sagar 2010). In addition to the capacities of firms to adapt technologies to local contexts, there is a need to create networks of local suppliers, users, and research institutions to enable the dynamic growth and improvements in learning and sustaining a technological sector (Bell / Figueiredo 2012; Lundvall 2005). Thus, technological sophistication, innovation systems, and the competitiveness of firms in developing economies is dependent on much more than just their ability to access intellectual property rights and import technology (Bell / Pavitt 1996).

In light of the above discussion, we propose that *international technological cooperation implies financial and technical assistance that support and undertake joint actions with actors and institutions across national borders directly looking to impact a technology's innovation cycle.* We deliberately attempt to make use of the term *technology cooperation* over *technology transfers* for two reasons: one, the use *technology transfer* is often misinterpreted to signify the transfer of hardware or codified knowledge from one country to another; and two, *cooperation* highlights the implicit political nature of balancing trade-offs that these endeavours seek to bridge through agenda-setting, financing, and the eventual knowledge ownership and impact.

As mentioned earlier, this paper looks at the technological cooperation underway in the electromobility sector as a basis for understanding the prospects of international technology cooperation, with a special focus on China and Germany as bilateral partners and countries interested in gaining competitiveness in this sector. Since electromobility as a technology is in its early stages of development, we focus our attention on the pre-market stages of cooperation, that is, R&D, product design, standardisation, testing, and the market demonstration stages of EV development. Given the range of activities involved in an innovation cycle's initial stages of technology development, many actors are involved in international technology cooperation, including different ministries and their agencies, international organisations, universities, research labs and epistemological communities, non-governmental organisations and, last but not least, private enterprises and industrial associations. All of these are increasingly operating and cooperating at multiple levels – global, regional, national and local (Altenburg / Pegels 2012). The linkages between them, and the resultant technical cooperation, thus depend greatly on institutional and regulatory environments (BIAC / OECD 1996). We highlight this role of policy frameworks further in the following subsection.

## 2.2 International technology cooperation: a policy imperative

As discussed above, climate change mitigation requires a wide range of activities, actors and institutions to partake in international technology cooperation – and that too under considerable time pressure. Research estimates that current ambitions to mitigate climate change are a far cry from the reductions in GHG emission levels required to limit global warming to a two-degree target, set as the tipping point if the catastrophic impacts of climate change are to be avoided. Widespread mitigation efforts are required to meet this mammoth challenge in a short period of time. Since many countries are still grappling with industrialisation and economic development, and given the uncertainties that accompany technology choices and market opportunities, a mix of international and national frameworks are needed to encourage further experimentation, development and adoption of low-carbon technologies so that they can detract from the locked-in paths of carbon-dependent economic development that are dominant today. To mobilise capacity and ambition within various different developed and less-developed countries to do so, international cooperation initiatives, both bilateral and multilateral, have the potential to play a critical role in transitioning to low-carbon development globally.

Although the private sector remains the dominant protagonist within technology development and deployment globally[5], for low-carbon technologies to be diffused and for technological cooperation to occur at an optimal pace for the protection of global goods, a strong policy imperative at the domestic, bilateral and multilateral level is required as a first. This is mainly for two reasons: one, the externalisation of environmental costs makes low-carbon technology products un-competitive compared to the conventional carbon-intensive counterparts. Secondly, the *social benefits* or the global goods advantages of low-carbon technology innovations cannot be fully realised by individual firms (United Nations Economic and Social Council 2010). Thus, the pace at which investments are needed to optimise low-carbon development to curtail climate change needs to be incentivised.

As Altenburg and Pegels (2012) affirm, the timely transition to low-carbon technological pathways being adopted and adapted requires that concerted policy transitions and frameworks be developed throughout the entire innovation systems. The spread of low-carbon technology cooperation requires such an approach of *sustainability-oriented innovation systems*, where various dimensions of tackling market failures, differing trade-offs, and embedded institutional characteristics are coordinated through policies. This works at multiple levels of governance, and requires coordination between national and international frameworks as well (Altenburg / Pegels 2012).

5 Two-thirds of the investment in low-carbon technology comes from the private sector (see OECD 2013).

These factors ring especially true for electromobility which is in need of a concerted public policy push throughout its innovation cycle. The transition to electric vehicles requires simultaneous development and changes in product design, production processes, infrastructure, consumer behaviour, incumbent institutional and industrial actors, and a combination of different subsystems therein. Thus, the challenge of simultaneous technological breakthroughs (in batteries, chargers, consumer interfaces, and infrastructure, for example) as well as encouraging organisational innovations in order to accelerate a transition to EVs as a mobility concept remains to be met (Altenburg / Bhasin / Fischer 2012).

As the central institutional pillar governing the international climate change regime, the UNFCCC has a very important role to play in accelerating the transition to low-carbon sustainable development as a global norm. According to Abbott and Snidal

> *states consciously use international organisations both to reduce transaction costs in the narrow sense and, more broadly, to create information, ideas, norms, and expectations; to carry out and encourage specific activities; to legitimate or delegitimate particular ideas and practices; and to enhance their capacities and power. These functions constitute IOs [international organisations] as agents, which, in turn, influence the interests, intersubjective understandings, and environment of states* (Abbott / Snidal 1998, 7).

Despite not being able to elicit enough ambition from countries to reduce their absolute emissions, as an international organisation the UNFCCC has successfully created various mechanisms and instruments to bring the issue of climate change mitigation and adaptation to the fore. It has also constitutionalised the protection of weaker states, labelled as Non-Annex I countries, with support from the Annex I countries.[6] As its Technology Mechanism emerges, there is potential for it to create a global norm on international technology cooperation such that it aides comprehensive capability building across the innovation cycle in less-developed countries.

While the Technology Mechanism could become transformational in accelerating international technology cooperation, bilateral and domestic initiatives are just as critical. The implementation of international treaties and norms depends on domestic capacities and regulatory frameworks. Bilateral and national initiatives urgently need to underscore goals to develop and deploy low-carbon technologies such that this leads countries away from fossil fuel-based economic structures. Research has affirmed that even when international treaties do not bind countries to commitments, they may act as a soft power tool for states not to go against their agreed objectives (Yang 2012; Townshend / Matthews 2013). For example, soon after the drawing up of the Montreal Protocol, seen as amongst the most successful environmental agreements to have been implemented, the EU and the United States (collectively responsible for emitting over 80% of ozone-depleting substances at the time) brought out regulations that validated and helped achieve the goals of the Protocol. Currently, the lack of mitigation ambition in most countries across the globe is undermining the prioritisation of addressing and curbing climate change. For low-carbon technological cooperation to find more success regardless of a global deal on climate change, domestic and bilateral cooperation initiatives that bring together relevant actors and institutions for low-carbon technological development and deployment can significantly encourage setting the stage for a global norm towards this end. At the same time, the multilateral framework

6 A deeper discussion of the role and potential of the UNFCCC is addressed in Section 4.

must facilitate and establish procedures for norm creation, elaboration and coordination amongst different countries, thereby enhancing cooperation.

Thus, it is a mix of multilateral, bilateral and domestic frameworks, as well as public- and private-sector actors, that establish and partake of these frameworks which align and enable a low-carbon technology and sector to develop successfully. Literature from the innovations systems approach recognises that no one actor (individual/firm/government) has the ability to transform technological development and diffusion (Foxon / Pearson 2008). Thus, the need for different actors to come together – cutting through the public and private divide – in order to stimulate technological development is a critical basis for technological development and cooperation.

## 2.3 Managing the trade-offs, financing and international property rights (IPR) protection: analytical framework

Given the multitude of actors and spheres of interaction that need to be coordinated through policy interventions to drive a transition to electromobility, a spurt of alliances have been formed, cutting through the public- and private-sector divide, as will be shown in the next section. However, despite having encouraged alliance-building to research, develop and cooperate on electromobility, the underlying differing motivations behind these actions still remain. These differing motivations of participating agents of cooperation create trade-offs that impact the cooperation-initiatives' funding structures, their ambitions, and their implementation. We attempt to understand how these *trade-offs* are managed in bilateral and multilateral spheres of electromobility cooperation; and how they impact the climate mitigation efforts through electromobility development.

Keeping the above in mind, we suggest the following dimensions to understand the prospect of international technological cooperation in Germany's and China's electric vehicle sectors. The most relevant aspect underlying these dimensions stems from the fact that it is not distinct institutions and actors that undertake technology cooperation but rather alliances formed through public spending and engaging across national borders. Thus, we identify three aspects of cooperative design and ask

i. **Who sets the agenda?** This relates directly to the management of ambitions and trade-offs inherent in international technology cooperation across differing actors, firms, and institutions.

ii. **Who funds the cooperation activities?** This addresses how the cases of international cooperation are financed, and whether the financing actors have a greater leeway in agenda-setting over the other practitioners.

iii. **Who gains the ownership of knowledge and intellectual property rights?** This seeks to understand how different cooperation alliances and actors approach ownership of generated knowledge and technological products, as well as capacity development.

These questions offer a means of assessing and analysing the political economy of ongoing cooperative activities in the space of electromobility. I aim to present recommendations for a mutually beneficial cooperation between China and Germany and to comment on the technology cooperation framework of the UNFCCC as a tool for leveraging and accelerating increased technology cooperation in low-carbon sectors globally.

# 3 International technology cooperation: Sino-German bilateral initiatives in the electromobility sector

The above two sections have highlighted the relevance of the case of electromobility adoption, as well as the central role of international technology cooperation for the development and adoption of low-carbon technologies in less-developed economies. In order to assess the bilateral cooperation underway between China and Germany in electromobility, a brief assessment of the policy and technical aspects of the EV sectors in both countries is given. After that, the bilateral spheres of cooperation that have been announced and are currently being implemented are analysed and discussed, using our analytical framework that emphasises the basis of their priority setting, sources of financing, and eventual impact/gain.

## 3.1 Policy and technological contexts: space for cooperation?

**German EV competency and objectives:** The Federal Government of Germany is promoting electric mobility as a key area of innovation and action to help achieve its national emissions reduction targets, secure itself from petroleum dependence, enhance German competitiveness in mobility solutions, and transform Germany into a lead market and provider for electric cars (BMVI 2011). It aims to have one million electric vehicles operational in Germany by 2020 and to increase this number to six million by 2030. To support these ambitions and gear itself as a *lead market and provider for electric vehicles*, a National Platform for Electromobility (NPE) was set up in May 2010.[7] By the end of 2011, the platform had more than 140 members and was organised through seven working streams to address different aspects of electromobility development, ranging from *norms and standards*, *drive train and systems integration*, to *battery technology*.[8] A Ministerial *Joint Unit* was established as a basis for the NPE, under the auspices of the Federal Ministry for Economic Affairs and Energy (BMWi, formerly the Federal Ministry of Economics and Technology) and the Federal Ministry of Transport and Digital Infrastructure (BMVI, formerly the Federal Ministry of Transport, Building and Urban Development). This Joint Unit also included the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB, formerly the Federal Ministry of the Environment) and the Federal Ministry of Education and Research (BMBF) as the other two members, to coordinate the different issues and challenges of electromobility, and support the broad member-base so that a political capture of interests would be less likely. However, it is commonly accepted that most of the agenda of this platform is industry-led.

It is significant to take cognisance of two international developments that triggered Germany's interest in electromobility. Firstly, the European Union (EU) imposed emission norms on all European fleet manufacturers to lower the overall emissions of fleets, much to Germany's opposition as its automobile manufacturers are particularly well established in the premium car market; and, secondly, there was a dramatic rise in the global consensus towards electric

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7 This includes stakeholders from the government, civil society, industry and academia as members and is currently in its pre-market phase, set to run until 2014, where the emphasis is on research and development, and on setting up a few large-scale electric mobility showcases.

8 The seven work areas are: Drive technology; battery technology; charging infrastructure and network integration; standardization and certification; materials and recycling; qualification and training; framework conditions. For more information on the Platform, please refer to NPE 2011.

vehicles as a future mobility solution when China, as the largest single market for automobiles globally, joined the EV bandwagon with ambitious national targets alongside the United States, Japan, France, the United Kingdom, and other leading international car manufacturers. Thus, it was competitive (re)positioning as well as the mandate of emissions reductions that formed the basis for Germany's ambitions in electromobility (Altenburg / Bhasin / Fischer 2012).

Since Germany's dominant source of energy remains fossil fuels, the government's electromobility programme also established that the additional electricity needed for these vehicles should be sourced from renewable sources (NPE 2011). Germany is undertaking rapid development of renewable energy in its electricity mix which will supplement its EV ambitions. Moreover, integrating electric vehicles with smart applications and technologies that interact with the grid to tackle power supply fluctuations, energy storage from renewable sources, and net-metering have become strong focus areas for research in Germany – almost 25% of the NPE budget has been apportioned for information and communication technologies (ICT) and energy systems integrations, and recycling linkages (NPE 2011). A SWOT (strengths, weaknesses, opportunities, threats) analysis undertaken by the NPE to assess Germany's electromobility sector identified its leading position in industrial ICT; energy technologies; and established expertise in constructing complex system technologies as its biggest advantages. It also identified battery technology as the main area of weakness in its innovation system pertaining to electromobility (German Federal Government 2009).

**Chinese EV competency and objectives:** China has been attempting industrial *catch up* by developing its automobile sector and provisioning investments in manufacturing and technological innovation through concerted efforts over several decades. However, it has not yet been able to compete at par with conventional car incumbents globally. A few years ago, this led to a change in emphasis towards electromobility (Wang / Kimble 2011). Highlighting electromobility as a priority emerging industry in its 12th Five Year Plan, China's Ministry of Industry and Information Technology released a guiding document, "Draft development plan for the energy efficient and new energy car industry (2011–2020)", that aims for China's production capacity and sale of electric vehicles to reach 5 million by 2020.

In addition to wanting to gain industrial and market leadership in electric vehicles (and the entailed value chain) (Wu 2012; Altenburg / Bhasin / Fischer 2012), China is looking to electromobility as a solution to curbing its high oil imports and improving its increasing local air pollution levels.[9] Climate change mitigation, in contrast, is not the main motivation behind China's EV emissions as electricity is and will continue to be primarily sourced from coal-fired power plants.[10]

Supporting policies from the government are aimed at both the demand and supply sides, and include financial subsidies on purchase, tax breaks and reductions, demonstration projects, incentives for R&D, charging infrastructure, and a targeted experimentation in 25 cities in China. The overall financial support is expected to be approximately EUR 11 billion (Altenburg / Bhasin / Fischer 2012). The government in China has already provided

9 Interview with an implementing agency member (see Annex 2).

10 Coal will remain the dominant source of power generation in China, responsible for about 50% of power generation until 2050 (Zhou et al. 2011).

EUR 0.25 billion in R&D and demonstration support, and this is expected to increase tenfold within the coming decade (Watson et al. 2011; Lema / Lema 2012).

However, official reports suggest that the uptake of electric vehicles in China is far behind the targets set by the government. For instance, in the 25 cities that were selected to *"experiment with energy efficient and new energy vehicles",* the number of cars sold is only one-fifth of the anticipated target, and the majority have been purchased by the government itself (Green Book of Economic Information accessed in Xinhua 2012). The biggest reason cited for this slow-growth has been *'limits in technical maturity',* in addition to infrastructure, vehicle performance, and economic efficiencies.[11] Other reports from consultants also cite technical immaturity, and lack of infrastructure and standardisation as being the obstacles in EV-rollouts in China (China Daily 2013). In China, the production capacity set up in anticipation of the ambitious targets set by the government has outpaced the innovative acumen needed for EV rollout (Watson et al. 2011). In particular battery technology for EVs is considered to be one of the main bottlenecks for the Chinese development of this industry. This is interestingly the case despite initial speculation of China being able to lead on this particular technology front, given its experience and expertise in LED-based and other components of battery technology. Moreover, international counterparts have a much better handle on materials technologies and battery management systems required for EV batteries (Watson et al. 2011).

Although the sales of EVs have not matched up with the targets set, China has still amongst the largest fleet of EVs sold globally[12] and has the largest market for e-bikes in the world. This market has been established mainly through indigenous technology, but there are several weaknesses in different parts of the innovation system. Moreover, while the domestic market size for EVs could be potentially the largest globally and remains the largest automobile market, the demand for EVs is yet unproven.

**Scope for cooperation:** It is clear that China has not yet been able to acquire the expertise required for a cohesive EV rollout in its own market, particularly for high-end consumers (Watson et al. 2011). As Huenteler and Schmidt (2012) explain, EVs consist of

> *thousands of customized components, automotive innovations require extensive simulation, testing, fine-tuning, and continuous improvements ... At the same time, manufacturers plan and run large production facilities and have to coordinate global supply chains to bring down manufacturing costs, making subsequent production engineering necessary for any modification of the product* (Huenteler / Schmidt 2012).

It is a very complex technological output, and while China has been able to upscale its production capacity, its quality of production and innovative capabilities is inadequate.

Given the above, the innovation system of China's EV sector is increasingly seeking to gain from foreign joint ventures: the recently launched China Programme on Electromobility Development mandates that all foreign manufacturers have to develop a new Chinese brand of cars, that are to be *New Energy Vehicles*, in cooperation with a Chinese company if they are interested in setting up manufacturing units there. It is a clear stipulation that aims to enable China's technological capabilities and innovation potential to grow. All major car

11 Reported by interviewees.

12 China ranked 5th globally in domestic EV sales in 2011 (Frost & Sullivan 2012).

producers are following in line because China presents a market that they cannot afford to ignore. Table 1 presents a synoptic capture of the proposed cooperation products and partners of German carmakers with counterparts in China, reflective of the Chinese mandate on foreign carmakers. The R&D outputs of these joint ventures are yet to reach commercialisation stages and have not been introduced to the market. Moreover, the lack of standards and regulations are delaying production and design outputs of EVs in China. Reportedly, there is also reluctance from firms to release their products onto the market for fear of imitation at this early stage of development (Watson et al. 2011).

**Table 1: Firm-level cooperation (German and Chinese) to develop electric vehicles**

| German company | Chinese counterpart | Anticipated product | Form of cooperation and technology-sharing mechanism | Current status |
|---|---|---|---|---|
| **BMW** | Brilliance | BMW 5 Series Sedan | Joint Venture, manufacturing plant owned by Brilliance Corporation | Shown at the Shanghai Auto Show 2012 (BMW Blog 2011) |
| | Tongji University | ECHO | Joint research project | Shown at the Beijing Motor Show 2010 (BMW Blog 2010) |
| | City of Shanghai | Mini E | City and product testing | Being tested in Shanghai, Beijing and Shandong as part of the BMW worldwide pilot test programme (China Economic Net 2012) |
| **Daimler/ Mercedes** | BYD | Denza, electric vehicle | Joint venture, 50:50 | Shown at the Beijing Auto Show in 2012. Both companies claim it is slated for release in 2013 (Daimler 2012) |
| **Audi** | FAW, Tongji University[13] | Plug-in hybrid sedan, A6 L e-tron | Joint venture | Shown at the China Auto Show Beijing 2012 (The GreenCar 2012) |
| **Volkswagen** | SAIC Motor Corporation (Bloomberg 2011) | A China-specific E car | Joint venture | Slated to be developed by 2018[14] |
| | FAW Corporation (Bloomberg 2011) | Kaili and Tantos and E Bora, all electric cars (AutoBlog Green, 2010; 2011) | Joint venture | Production said to begin in 2014 (China Car Times 2012) |

Source: Author's own compilation

13 Reported by interviewees.

14 Reported by interviewees.

The companies listed above in Table 1 are amongst the heavyweights of Germany's automobile sector. As mentioned earlier, this is the largest industrial sector in Germany, and also the most innovative (Bitonto / Kolbe / MacDougall 2012). Since over 75% percent of the cars manufactured in Germany are sold in other countries, it is a critical sector for Germany's international competitiveness and economic concerns (Bitonto / Kolbe / MacDougall 2012). Not surprisingly, it shares a close relationship with government agencies that undertake bilateral cooperation with strategic markets.

The details of firm-level technological cooperation being undertaken through these listed Sino-German joint ventures are not available and were not possible to attain, given their strategic value for companies. Details of patent protection and implementation, the system of knowledge production and sharing, as well as consequences on production processes and employment gains in both countries are undisclosed and their influence is yet to unfold in each nation's electric vehicle technology trajectory. Hence, we look to the publically funded bilateral technological cooperation in the next section to assess the prospective role of public policy in driving international technology cooperation, its anticipated benefit to the Chinese and German EV innovation systems, and to what degree these strategic partnerships accelerate the protection of the global climate good, and the local environment.

## 3.2 Assessing Sino-German national-level bilateral cooperation in electromobility

Germany and China initiated and signed a bilateral agreement on science and technology (S&T) in 1978. The S&T commission that got formed as a result meets every two years generally to coordinate cooperation between Germany and China. Within this framework, the first Intergovernmental Consultation between China and Germany took place in June 2011, where both governments signed a memorandum of understanding to create a strategic partnership in the field of electric mobility**.** The central objectives of this partnership were to intensify cooperation in standardisation and to strengthen collaboration between research centres, companies and local governments. The second Intergovernmental Consultation was held in August 2012, and its official declaration states:

> *The automotive industry, and particularly the innovative field of electric mobility, is very important to the economies of both countries. Both sides are committed to intensifying cooperation in the field of vehicle fuel efficiency, including as regards standards for $CO_2$ emissions from motor vehicles. Both sides will further intensify cooperation within the framework of the German-Chinese platform for electric mobility as well as cooperation on the German and Chinese demonstration projects in the field of electric mobility. The two sides will discuss collaborating on setting up demonstration projects in the field of charging infrastructure and the interaction between electric mobility and the electric vehicle smart grid* (Joint declaration on the second Sino-German Intergovernmental Consultations 2012).

Thus, there is a very clear high-level diplomatic positioning of cooperation between the two countries on various different aspects of electric vehicles. The *Joint Unit* of key German ministries responsible for electromobility established a large-scale cooperation initiative with Chinese counterparts in 2010. This initiative has the following components (see Table 2).

**Table 2: Initiatives established between German and Chinese government agencies for technology cooperation on electromobility**

| Federal Ministry of Transport and Digital Infrastructure (formerly the Federal Ministry of Transport, Building and Urban Development) (BMVI) ⇩ | Federal Ministry for Economic Affairs and Energy (formerly the Federal Ministry of Economics and Technology) (BMWi) ⇩ | Federal Ministry of Education and Research, Germany (BMBF) ⇩ | Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (formerly the Federal Ministry of the Environment) Germany (BMUB) ⇩ |
|---|---|---|---|
| **Sustainable Fuel Partnership**<br>Partner: Ministry of Science and Technology, China (MoST) | **Industrialisation**<br>Partner: Ministry of Industry and Information Technology, China (MIIT) | **"Electric Car Centre"**<br>Partner: Ministry of Science and Technology, China (MoST) | **Climate and the Environment**<br>Partner: Ministry of Science and Technology, China (MoST) |
| **Sustainable Fuel Partnership**<br>Partner: Ministry of Science and Technology, China (MoST) | **Certification**<br>Partner: General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) | | **Battery Recycling**<br>Partner: National Development and Reform Commission (NDRC) |
| **Cooperation on Model Regions**<br>Partner: Ministry of Science and Technology, China (MoST) | **Standardisation**<br>Partner: Standards Administration of China (SAC) | | **Fuel Economy**<br>Partner: Ministry of Industry and Information Technology, China (MIIT) |

Source: Author's own compilation

Although the above initiatives were announced between 2010 and 2012, information on their stages of implementation is sparse. On the basis of interviews with ministries and implementation agencies located in Germany and China[15], I found that the only real spheres of cooperation that are currently being implemented through these government-enabled mechanisms can be clubbed into basic joint-research efforts, and the cooperation on efforts mentioned below. The critical design elements of these aims are assessed, namely: Who finances the initiatives and, finally, who gains? That is: Does the initiative only benefit the competitive advantage of either of the two countries or does it benefit mitigation concerns from a global goods perspective. This discussion and the subsequent conclusions are presented in Section 3. Below is a description of these initiatives highlighting their financing, agenda, and impact characteristics.

Research on electromobility

i (a) The BMBF (Germany) and MoST (China) signed a Memorandum of Understanding (MoU) for scientific cooperation in the field of e-mobility in 2010 and several joint projects in the field of basic research for electromobility are to be operationalised through this partnership (EU 2012). The first of these was established between the

15 See Appendix 1 for the interview list.

Association of German Technical Universities (TU9), to be led by the Technical University Munich (TUM), and a group of Chinese universities (Tongji University is to be coordinating lead) in April 2012. It will receive funding of EUR 3.5 million from the BMBF (TU9 2012). At present, the universities are deliberating on the topics of research to be undertaken over the next years. The MoU had identified five projects relating to energy conversion and storage, drive concepts, communication and infrastructure as a priority. Interviewees from the government and implementation agencies stated that this cooperation on basic electromobility was initiated on Chinese insistence – Germany's BMBF was a *"reluctant*" partner to engage in scientific cooperation at a university level on electromobility, allegedly for fear of brain drain and a general sense of trust deficit with China. With regards to the outcome achieved, IPR and patent protection rules that universities in Germany have created and uphold for their research outcomes will most likely be applied.[16] These are based on the EU's "Commission Recommendation of 10 April 2008 on the management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research organisations". TUM, the German lead university in this initiative, has an IPR policy which stipulates that all knowledge produced must be utilised to provide maximum benefits to society through extensive dissemination, while simultaneously bringing economic benefits to the creators and to the university by supporting business entities to manage invented products that exploit university-generated knowledge.[17] The income derived is to be shared between the inventor(s) as provided by the Employee Inventions Act. However, it is not clear at this stage what sort of legal frameworks have been drawn up to address the knowledge generated through this bilateral initiative.[18] This initiative will involve research-capacity building and familiarity between the scientific communities involved of the two countries, since *"intensive exchange of students and scientists between the two countries is also planned"* (TU9 2012).

i (b) Given that electromobility ambitions were initiated in China for reasons other than climate change mitigation concerns, the BMUB suggested undertaking a *joint assessment of electric vehicles in Chin*a, to highlight the overall environmental impact of electromobility through a life-cycle assessment. Its aim is to analyse and recommend to policymakers the potential for decentralised urban grids and renewable energy production to improve the environmental sustainability impact of electromobility. At the time of finalising this paper, the life-cycle assessment of Chinese fleets was being concluded.[19] This study is being carried out by the School of Environment at Tsinghua University (Beijing) and the Öko-Institut e.V. in Germany. According to officials overseeing this cooperation, the presence of the Öko-Institut supplements policy and scientific advice based on their expertise on electromobility planning within Germany[20] and is to assure quality control of the research that experts at Tsinghua University are producing.[21] This cooperative

16 Interviews with the officials concerned at the universities were not granted/conducted.

17 For more information, see policy at http://www.forte.tum.de/fileadmin/w00bgt/www/_application_pdf-Objekt_engl.pdf.

18 Interviews with the officials concerned at the universities have not yet been granted/conducted.

19 October 2013

20 See, for example, http://www.oeko.de/research_consultancy/issues/sustainable_mobility/dok/1242.php.

21 Information based on interview responses.

initiative is entirely funded by the BMUB. The policy recommendations that will emerge from this seek to feed into China's climate change/emissions mitigation strategy; however, the buy-in from Chinese government officials towards this is seemingly minimal. Instead, it is the GIZ, the overarching implementation agency for the BMUB's cooperation initiatives on electromobility in China, which plans to communicate and make the recommendations known amongst the Chinese public.

i (c) The BMUB is also working with the Ministry of Transportation in China to analyse the inclusion of EVs in the public transportation systems. A report that underlines the guidelines for EV readiness in Chinese cities will be prepared by the Tongji University, under the aegis of BMUB funding. The incentives and infrastructure needs that it will highlighted are intended to be presented to the Chinese Academy of Mayors by the BMUB. This directly reflects the BMUB's motivations for facilitating EVs as a solution to climate change mitigation, as well as road congestion and air quality within Chinese cities.

*Norms, regulatory frameworks and standardisation*

As the electromobility sector emerges in differing trajectories across the globe, related certification standards and norms are emerging simultaneously and are yet to be standardised internationally. Having competing standards and norms creates different sets of rents and comes at additional prices to companies offering their products in foreign markets as they have to comply with these. China and Germany have bilateral committees working on norms and standardisation (detailed below), and this issue was an important clause of negotiation that was even brought into the high-level Second Intergovernmental Consultation between the two countries. Avoiding strategic negotiations and actions at this stage would only prove to be disadvantageous to German original equipment manufacturers (OEMs) who would otherwise have to switch to Chinese standards to operate in the Chinese market. Since the Chinese market is anticipated to be one of the largest for EVs, it is only natural that political and technical agencies are trying to negotiate and cooperate with the Chinese on homogenising norms and standards conducive to German technology and know-how.

ii (a) Within the *industrialisation* effort led by the BMWi in China, the only sphere of actual cooperation that is currently underway is the "Sino-German Standardisation Cooperation Commission" (Arnold 2011, and several interview responses). This working group was established by the BMWi and the Standards Administration of China (SAC). This is being routed through a sub-committee in the Standardization Commission of the German-Chinese Joint Committee of Industry and Trade (Arnold 2011). Thus far, it is preparing a study that reflects the differences between Chinese and international standards on electromobility and as a next step plans to create a joint *standardisation roadmap* with the Chinese Ministry of Industry and Information Technology (MIIT) to unroll the private EV market in China.[22] As per interviews with implementation agencies of the BMWi, a feasibility study that looks at prospective Sino-German cooperation on certification is also in the pipeline, to be released by the BMWi and the China Quality Certification Centre. Thus, we see that there is a great

22 A workshop was recently held by the GIZ in Beijing, bringing relevant stakeholders together for an informed dialogue on standardisation as a means of easing market access. For more, see http://China.ahk.de/fileadmin/ahk_China/_temp_/Invitation_-_Sino-erman_Cooperation_and_Electro-Mobility_in_China.pdf.

deal of formal engagement being carried out by the BMWi with the aim of aligning German and Chinese standards and to ease German access to the Chinese market. Furthermore, this creates leverage for German OEMs to influence the EU's standards and certifiable norms *vis-à-vis* electromobility, particularly since France has established standards varying from those of German OEMs and are continuing to further develop these. As technology development makes progress, norms and standards relating to safety regulations, technology connectors, and the interfaces between the cars and infrastructure will become binding regulations in large markets. Thus, the race to establish norms and regulations in cooperation with those that will be implemented in China are critical for car-makers with aspirations towards the Chinese EV market, to save on conversion costs to the standards adopted in China in order to be viable products there. For example, plug interfaces for the charging infrastructure have all been developed with different current and charge types in Germany, the United States, France, Japan and other countries. All these nations are trying to influence the Chinese standard of charging infrastructure to avoid conversion costs. Since different standards have emerged in the component technologies within EVs globally, there is currently an open debate on whether the United States, France or Germany will succeed in their negotiations and cooperation with China on this front.

ii (b) Although still in the pipeline, the BMUB expects to work in close cooperation with the National Development and Reform Commission in China for the *recycling of strategic components*. At present, preparation of a feasibility study is under discussion between the two agencies to highlight the scope of such recycling, given the electromobility ambitions in China. To be finalised by the end of 2013, the BMUB then plans to create a large Sino-German working group in partnership with the BMWi and the National Development and Reform Commission (NDRC) that brings together car manufacturers, technology providers for recycling batteries, and waste management agencies from both countries as well as the province of Guangdong to undertake pilot testing of business models and recycling technologies. The financing for these strategic efforts towards recycling will be shared between the German BMUB and Chinese NDRC. Although the feasibility study is to be wholly funded by Germany, the working groups are hosted and financed by the respective countries twice a year. This strand of cooperation was developed out of an appraisal mission undertaken by the GIZ in China, and was put forth as an area of *improvement* in the EV value chain. Interviews with GIZ staff reported that the suggestion of this study and working group is based on the well-accepted need for German companies/OEMs to undertake sustainable recycling of their products' components. As societal norms and company image reflecting sustainability concerns are well established in Germany, the BMUB approached the NDRC in China in order to influence the Chinese regulatory frameworks to reflect these standards and help facilitate raising the bar of environmental protection (local and global). It subsequently signed an MoU on the issue of strategic recycling of components in 2012. Thus, this strand of cooperation represents a case of raising the environmental standards of the Chinese EV system. The working group also gives German and Chinese companies the advantage of getting to know the market players, developing new partnerships with technology providers (for recycling), as well as framing the business and regulatory environment around these technologies.[23]

23 Confirmed in interviews.

## 3.3 Discussion and conclusions

It must be noted that, despite the fact that a range of other cooperation initiatives have been announced in the past three years (presented in Table 2), only those highlighted above have been taken up and are operational. A synoptic view of these bilateral technological cooperation initiatives are presented in Table 3 below. Interview responses related to this mismatch between announced and operational cooperation initiatives suggest a lack of industrial backing and a deficit of trust in technology developers in China that government agencies do not feel equipped to deal with. Rather, they prefer to keep issues of actual knowledge development and IPR a prerogative of Germany companies.

All of the initiatives underway are oriented towards policy and regulatory frameworks, rather than actual technological development and market readiness. For instance, several announced initiatives which deal with city-level demonstrations, development and testing of the technologies, cooperation on core technological development, and others that would lead to an increase in the innovation capacity of China have not yet been operationalised. Thus, we see that Germany is undertaking diplomatic cooperation with China that reinforces its industrial strategies in electromobility. Its focus on norms and standardisation, as the dominant operational channel of cooperation, is reflective of these competitive concerns; the rest is left to individual private-sector initiatives that conduct their work in China through private joint-ventures. On assessing these real spaces of cooperative action on electromobility within the bilateral framework, it is evident that Germany and China have both taken systematic steps to frame *technology cooperation* such that it builds competitive advantages for each country in this sector within the Chinese market.

At the same time, the initiatives are also bringing emissions reduction and global goods protection through EVs into the Chinese policy-space as an important point of discussion. The early-stage cooperation that Germany is undertaking in China to bring out policy recommendations for the government in China draws attention to various environmental concerns relating to electromobility (see in Table 3: i. (b), i. (c), ii. (a), ii. (b)). These also reflect German ambitions and priorities, which stand for complying with a certain responsible environmentally-conscious image reflecting societal norms prevalent in Germany.

Despite the fact that these MoUs having been signed two years ago and specific partners identified to undertake this cooperation, these initiatives have not yet been operationalised, suggesting a dominance of German ambitions over those regarded as critical points by China which drew them into the Memorandum of Understanding between the two countries: interviewees reported that China negotiated hard-to-specify ICT (information and communication technologies) interfaces for electric vehicles as an important technological area of cooperation with Germany, as it was for university-level research and city-partnerships. However, IPR protection and trust deficit are a critical obstacle for cooperating with China and this was reported by all German stakeholders interviewed for this paper. Responding to these messages, interviewees from China invoked clauses of historical responsibility for the current state of climate change, and the need for less-developed countries to have financial and technical assistance from developed countries.

At the national level, trade-offs for Germany and China when cooperating in electric vehicle technological development are summarised broadly in the table below (Table 4).

**Table 3: Operational spheres of bilateral cooperation on electromobility in China**

| Initiative | Predominant actor in agenda-setting | Funding agency | IPR/knowledge ownership accrue to: | Benefits accrue to: |
|---|---|---|---|---|
| i (a) | Established on Chinese insistence from the Ministry of Science and Technology | Majority funding by the BMBF, Germany | University legal frameworks will apply | Chinese innovation system |
| i (b) | German BMUB | BMUB, Germany | Public domain | Environmental impacts of EVs in China |
| i (c) | German BMUB | BMUB, Germany | Public domain | Environmental impacts of EVs in China |
| ii (a) | German industry through the BMWi | BMWi | Public domain | Environmental impacts of EVs in China; and German OEM competitiveness |
| ii (b) | German industry through the GIZ and BMUB | 70:30 partnership between the BMUB and the NDRC, respectively | Public domain | Environmental impacts of EVs in China; and German OEM competitiveness |

Source: Author's own compilation

**Table 4: National-level imperatives for technology cooperation in electromobility**

| *China's and Germany's objectives* | *Scope of cooperation* |
|---|---|
| Reduce emissions globally | Positive |
| Reduce emissions from automobile sector nationally | Positive |
| Increase market access | Mixed, depending on 'rents' and entry barriers |
| Increase national industrial competitiveness, first-mover advantage in electromobility | Negative |

Source: Author's own compilation

The initiatives being implemented highlight how differing motivations can be brought together to advance emissions-mitigation aspirations. German companies are interested in being a part of the EV market and innovation system in China through the introduction of German technical standards, gaining familiarity with component recycling vendors and other local suppliers, while also wanting to keep environmental sustainability and minimal emissions output as a conscious aim of the image of their company. The BMUB and its main implementing agency in China, the GIZ, stand for promoting the global goods perspective of limiting emissions and improving the local environment through environmental life-cycle assessments and the recycling of components, amongst others. Chinese companies and agencies are looking to Germany for technological learning based on effectiveness and profit criteria, while also supporting China's ambition to become a market and a manufacturing hub for sustainable low-carbon technologies relating to EVs.

The designs of the cooperation initiatives also show that there are no strict *German* and *Chinese* positions. There are stakeholders on both sides that are interested in global good gains, as well as competitive advantages. The conflict between these two perspectives thus exists in both countries and not necessarily between the two nations; however, this makes international technology cooperation between the two countries quite complex. For example, the BMUB is engaged with a view to leveraging emissions reduction through EVs in China. The BMBF too is looking to engage with EVs in China using renewable energy for charging. Our results find that the space for international cooperation between Germany and China in electromobility has been *designed* to include most aspects of the innovation cycle of electric vehicles as a prioritised sector of low-carbon development, ranging from basic research to testing and demonstration, as well as energy charging systems. However, until now, initiatives being implemented remain limited to firm-level ventures and mostly policy-informing activities. While this reflects the strategic nature of electromobility in particular, and international technology cooperation in general, climate change concerns require technologies to be developed assiduously, rather than delayed as is currently the case. This delay in implementing and executing the larger technological cooperation initiatives that would benefit EV as a technology lies particularly at odds with Germany's and China's positions within the international climate regime: Germany's projects itself as being a climate change mitigation leader globally, and China had claimed to be serious about tackling its already large emissions base through low-carbon technologies, without which its emissions are likely to grow manifold in the coming decades.

Given these limitations in bilateral cooperation, attention will now turn to multilateral initiatives (Section 4) before policy conclusions are drawn in Section 5 in connection with the leveraging of innovation systems and deployment strategies of electric vehicles through both channels: bi- and multilateral.

## 4 International technology cooperation: multilateral electromobility initiatives

Given the strategic value accorded to EVs and the limited scope of bilateral cooperation – even between two countries that are both strong protagonists in the climate regime – what are the prospects of multilateral initiatives?

The EU in its high-level meeting with China on energy announced enhanced cooperation in the automotive sector, *"aiming at the promotion of the common objectives of reduction of energy consumption and emissions, notably via development of electromobility"* (EU 2012, 2). At the same meeting, it was agreed to strengthen science and technology cooperation between the two regions, in particular to promote the effective development and deployment of innovative solutions to major societal challenges of common interest. Such language is well suited to the case of electric vehicles and the ongoing private-sector cooperation in the electromobility sector between Europe and China. Although the European Commission has established several MoUs and working committees with China, particularly garnered towards low-carbon sustainable development[24], there has been no tangible cooperation or progress on technological cooperation between China and the EU on EVs so far. It is not

24 See Annex 1.

surprising that a concerted push for electric vehicles as such is still missing at the level of the European Union in its external engagement with other countries since the EU has steered clear of taking a unified stand on electromobility standards and norms so far even within its member-base, stemming from the fact that several member states are still trying to create a niche and break into this nascent sector, and are competitors amongst themselves.

However, for the global goods perspective to gain traction through technological cooperation, a norm within the climate regime and outside of it must support it. In this section, multilateral cooperation relevant to EV technology development will be described. The focus is on the UNFCCC as a pillar for facilitating climate mitigation action; as well as the International Energy Agency's Electric Vehicle Initiative (IEA EVi). The intention is to take stock of the actors and impacts that these international channels of cooperation are having, and can have, on EVs technology development.

## 4.1 The International Energy Agency's Electric Vehicle Initiative (IEA EVi)

This is the only initiative dedicated to the electromobility sector at a multilateral level. It seeks to bring data on electromobility into the public domain, and create a facilitating environment for bilateral partnerships to be set up. Established in 2011, it has a membership base of fifteen countries across the globe and is open to participation from the International Energy Agency (IEA). It also has participation from automakers, think-tanks, as well as city-level government agencies. Primarily a knowledge-sharing network, it published an "EV Cities Case Book" in 2012 that profiles case-studies of the electromobility initiatives of 16 cities. Through this publication and its online portal, the EVi seeks to showcase best-practice examples for urban electromobility (IEA 2012), relevant R&D designs for public deployment programmes, as well as to bring the public and private sector to engage in designing respective roles to create and invest in a holistic EV ecosystem, as has been confirmed by interview correspondence of IEA representatives.[25] It does not fund actual research or city partnerships; rather brings together practitioners who are all focussed on building EVs as a mobility solution and product; and is particularly geared to highlighting the relevance of policy frameworks required for successful development and deployment of this technology. This initiative includes both China and Germany as participants, and through the network linkages the EVi provides, Volkswagen has announced that it would be undertaking demonstration activities in a special "China Demonstration Zone" to be set up by the government there. Studying these private-sector initiatives facilitated through the network that the EVi provides, however, is beyond the scope of this paper.

## 4.2 The United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC lies at the heart of the global climate change regime. It *"remains the one platform where global ambition and equity can be discussed and potentially agreed upon"* (Moncel / Levin 2012). Over the past years, the UNFCCC has not been able to negotiate sufficient emission-mitigation commitments from countries. However, it has made remarkable strides in creating funding mechanisms. More than USD 35 billion has been pledged by different countries as climate change adaptation and mitigation funds (Heinrich

25 For more information, please see http://www.worldevcities.org/.

Boll Stiftung / ODI 2013). In the space of technology cooperation, the progress has been slower, owing in no small degree to the trade-offs discussed earlier. Technology cooperation, facilitated by the UNFCCC between member countries, is negligible in the case of electromobility. Although transportation is a sector that is clearly mentioned as being an integral recipient of such technological and financial transfers, there is little or no mention of UNFCCC-facilitated cooperation on electromobility. Surprisingly, there is also no information available on electric vehicles or electromobility under the UNFCCC technology database (UNFCCC 2012a). The following are the most relevant corridors, institutions and mechanisms through which cooperation and negotiation on technology takes place within the UNFCCC.

**Articles in the UNFCCC:** The Convention stipulates that all Parties are to promote and cooperate in developing, applying and diffusing – including transferring – technologies, practices and processes that reduce or prevent GHG emissions (Article 4.1 (c)). According to Article 4.3, Annex I countries are to provide financial resources for the transfer of technology. Article 4.5 urges Annex I Parties and Annex II parties to take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other parties, particularly to developing countries, to enable them to implement the provisions of the convention. The extent to which developing country parties will effectively implement their commitments under the convention will depend on the effective implementation by Annex I country Parties with regards to financial resources and transfer of technology (Article 4.7).

**Clean Development Mechanism:** A flexibility mechanism of the Kyoto Protocol[26], the Clean Development Mechanism (CDM), allows an Annex I country to implement an emission-reduction project in developing countries with the aim of earning saleable carbon-reduction credits to meet their own emission reduction targets set under the Kyoto Protocol. In 2011, the methodology and criteria for using electromobility as a technology to reduce emissions and gain carbon credits was presented for small-scale projects under the CDM (CDM 2011). Currently, China is not a part of any such CDM programme; it does have the largest number of running CDM projects in the world though.[27]

**Poznan Strategic Programme on Technology Transfer:** The GEF (Global Environment Facility) Council and the Least Developed Country Fund (LDCF) / Special Climate Change Fund (SCCF) Council approved the Strategic Program on Technology Transfer in November 2008, to scale up investments for transfer of environmentally-safe technologies. This entails three funding opportunities for developing countries: one, technology needs assessment; two, conducting pilot projects on priorities identified through the Technical Needs Assessment; and three, disseminating experiences and successfully demonstrated environmentally-safe technologies (UNFCCC 2011). China is partaking of the UN Poznan Strategic fund for technology in the following two ways: firstly, a Technical Needs Assessment is being undertaken for China which would entail a detailed analysis of its low-carbon technology requirements; and secondly, having been accepted as a pilot project, a *green transport project* began in November 2011 in China's Guangdong province.

26 Article 12 of the Protocol

27 However, four projects were registered in India (with Switzerland as a partner) for avoiding emissions through sale and use of 2-wheeler ebikes towards late 2012. (For more information, see http://cdm.unfccc.int/Projects/projsearch.html.)

However, this project makes no mention of electric vehicles, rather green *energy efficient technologies* for trucks[28] (UNFCCC 2011).

**Technology Mechanism:** Established through the Cancun Agreements as an outcome of the Conference of Parties held there in 2010, the Technology Mechanism is expected to facilitate cooperation on technology development and transfer in order to support mitigation and adaptation activities through (a) a Technology Executive Committee (TEC), and (b) a Climate Technology Centre and Network (CTCN) (UNFCCC 2010). The TEC met for the first time in 2011, and a UNEP (United Nations Environment Programme)-led consortium was made host of the Climate Technology Centre in late 2012. The functions of the Technology Mechanism can be summarised as follows:[29] (a) Providing an overview of technological needs along with an analysis of technical issues relevant for the development and transfer of technology in climate change mitigation and adaptation; (b) Assisting in the creation of international, regional and national technology action plans to promote cooperation in technology, and (c) Promoting the collaboration on the development and transfer of technology related to mitigation and adaptation between governments, private-sector actors, non-profit organisations and research and academic communities.

The functions of the CTCN are complementary to those of the TEC, listed above. The core functions include: (a) Identifying technology needs for the implementation of environmentally sound technologies, practices and processes in developing countries and facilitating the prompt deployment of existing technologies; (b) Promoting their ability to maintain, operate and adapt technology; (c) Promoting R&D cooperation including through South-South and trilateral channels; (d) Facilitating international partnerships among public and private stakeholders to accelerate the innovation and diffusion of environmentally sound technologies to developing country parties.

In essence, the Technology Mechanism comprises the Technology Executive Committee which is intended to function as the policy arm, and the Climate Technology Centre and Network (CTCN), which is meant to promote and create partnerships that foster technology development and deployment. However, both these new institutions are still facing several open questions, ranging from financing to defining the roles and priorities that would enhance technology development and cooperation.

In the UNFCCC negotiations, developed Annex I countries, including Germany, have voiced the need for appropriate *enabling environments* in less-developed countries, conducive for foreign investments. Emerging and less-developed economies have been negotiating for *push factors* from developed countries such as increasing financial and technical support to enhance indigenous technical capacities, increasing private-sector participation and government-level transfers to create further leverage. By bringing together a concerted representative group of Annex I and non-Annex I countries, the balanced governance structure of the TEC holds promise of a true partnership in agenda-setting and capacity-building, rather than looking at developing countries as being just *recipients* of technology transfers. However, for this to materialise, it is important that the Technology Mechanism takes up certain concrete measures that lie at the core of technology cooperation. This is addressed in more detail in the next section with the aim of highlighting

28 For more information, see http://cleanairinitiative.org/portal/sites/default/files/Project_Summary_38_-_Guangdong_GF_Project.pdf.

29 For details, see UNFCCC 2010, paragraph 121 of Decision 1/CP 16.

current gaps and of offering recommendations that may help accelerate international technology cooperation.

The UNFCCC financing mechanisms also include Joint Initiatives, the Green Climate Fund as well as the Adaptation Fund.[30] While the UNFCCC and other financing mechanisms that lie outside its ambit (such as the GEF[31]) are undertaking a great deal of cooperative work with China, electromobility and electric vehicles find no mention in any of these undertakings or planned proposals.

The above indicates that there is little real cooperation taking place between China and international partners on EVs through multilateral frameworks. The global goods argument is challenged by national competitive concerns. It is important to note here that trade-offs between the two are multiplied at the multilateral level as it brings to the fore the competitive concerns amongst and between early industrialisers as well as developed countries (as the European Union case shows). The attempt is made to address this in the next section by outlining some key policy suggestions that may be adopted to benefit deployment and development of electromobility in particular, and other low-carbon technologies in general.

## 5 Conclusions and policy recommendations

The above discussions have outlined the scope of technology cooperation as extending much beyond simple *transfers* of products and associated maintenance knowledge. Innovation in emerging low-carbon technologies such as electromobility requires simultaneous and consistent endeavours, from market demonstration, to end-user approaches, as well as research and product development. While the multilateral and bilateral cooperation initiatives that have been highlighted above acknowledge this larger approach towards innovation, the reality on the ground does not reflect this as much. The previous sections have described the low level of technology cooperation that is underway in the electromobility sector in China at a bilateral level with Germany along with multilateral efforts in general. While this can point to the strategic and as-yet unfolding nature of electromobility, given the relevance of electromobility for curbing GHG emissions, this section offers recommendations that may be applied in order to aide the development of innovation systems for electric vehicles and other nascent low-carbon technologies in the future as well. These are presented in two subsections, dealing with the *bilateral* and the *multilateral* levels of international technology cooperation, respectively.

### 5.1 Bilateral cooperation

As noted in Section 3, although high-level announcements of bilateral cooperation between Germany and China on electromobility have been made with a view to strengthening the innovation systems of EVs in both countries, practical cooperation is fairly limited. It relates mostly to regulatory frameworks and policy-informing research

30 For more information, see: http://unfccc.int/focus/finance/items/7001.php.

31 For example, GEF is also funding a China Renewable Energy Scale Up Programme, and Green Energy schemes for low carbon Shanghai, outside the funding scope of the Poznan Strategy.

initiatives, which – although important – are only one aspect influencing the technology cycle. Thus, a major recommendation would be to actually implement the bilateral programmes that have been announced as these have correctly identified several areas of cooperation that would constitute a *win-win* for both countries. These include product testing, market behaviour studies, basic technical research, and capacity-building, amongst others. One of the factors stalling implementation of these initiatives is the lack of an *enabling environment* in China. Chinese national policies do not encourage foreign collaboration in this sector, in particular owing to the rather coercive policies of forming joint ventures and mandatory technology transfer. This has undermined trust in Germany regarding respect for intellectual property rights, although German participation has been lively in public-alliances where direct benefit can be accrued to their strategic goals, such as in standardisation committees.

Given the large emissions reduction and sustainable development potential of low-carbon technologies, China must – as a first – address this trust deficit and attempt to create an enabling environment for cooperation through bilateral and multilateral platforms. Instruments for China to do so lie beyond the scope of this paper; however, we do suggest the following to increase cooperation in the field of low-carbon technologies:

1. **Develop innovation plans[32] for the technology bilaterally, aligning these with areas of strong capabilities in each country.** As noted in Section 2, both countries have strengths and weaknesses in different parts of the innovation system for electric vehicles. Undertaking a systematic review of these in comparison for both the countries would benefit industrial development of low-carbon technologies by highlighting space for *win-win* industrial and technical cooperation efforts across national borders. This would allow the identification of technology areas in pre-commercial stages that could be jointly built up and help create linkages with local supplier groups across countries. The long-term development potential of less-developed countries could also be enhanced with such an effort as it would pinpoint areas for building innovation capabilities for these technologies. Capacity-building could then be taken up as an area of added concern and impetus by various different bilateral partners.

2. **Develop technological innovation systems relative to an emissions baseline** in China.[33] Electromobility could play a critical role in avoiding emissions from China's transportation sector. Linking China's policy goals for the rollout of EVs more explicitly to emissions reduction targets could enable greater international support from bilateral partners as well as through multilateral frameworks. A next step for bilateral Sino-German cooperation could be to set up a joint working group that develops a technological roadmap for China driven by an environmental logic and emissions outcome.

3. Link ongoing city-level pilot and showcase projects of both countries through the **creation of a research programme with ownership by both governments**. This would undertake a comparative study of the impacts of these projects in each country, and extract lessons from consumer behaviour and market development. This would be similar to the

32 This is one of the recommendations submitted by De Coninck and Byrne 2013 for national-level policy interventions for low-carbon technologies.

33 This is one of the recommendations submitted by De Coninck and Byrne 2013 for national-level policy interventions for low-carbon technologies.

German concept of *Begleitforschung* (accompanying research), which is conducted in close collaboration with implementing agencies to monitor different impacts and the uptake behaviour of technologies and to assess policy effectiveness, and which puts results into the public access. This exercise is being undertaken in Germany, to compare the different *Schaufenster* (or showcase) programmes of electromobility that are being conducted in various different cities.[34] Since there are similar city-level programmes being conducted in China, having a scientific, centrally-funded research programme compare the two countries' city-level programmes would be helpful in progressing business interests and government incentive/infrastructure systems, based on neutral scientific evidence. This could also be used to gain traction within the IEA EV Initiative.

4. **Continue negotiating for emissions standards and establish voluntary environmental benchmarks** for the recycling of component materials and renewable energy use for charging electric vehicles. It was voluntary emission standards that were adopted in the EU, Japan and then Korea in different sectors that led to these becoming mandatory in the EU. The German mandate of using only renewable energy to power electric cars presents a unique emissions-free mobility option. Negotiating for this to be streamlined into Chinese EV ambitions through its technological sub-systems (the grid-interface, for instance), Germany can push for environmental benefits to accrue through this technology, in order to avoid a race to the bottom.

## 5.2 Multilateral cooperation

Given the lack of international technological cooperation underway at a multilateral level, we focus our attention particularly on UNFCCC. As the central institution regulating the global regime on climate change, its relevance as a facilitator and global norm-setter could be critical. A summary of the available cooperation mechanisms that seek to encourage technological cooperation which can be applied to the case of electromobility were presented in Section 4. These are the specific clauses enshrined in UNFCCC that encourage developed or Annex I countries to undertake and financially facilitate technology transfer and development in developing countries so that the latter may adopt and adapt to low-carbon technologies in all possible sectors. However, there is no norm or mandate that facilitates a definite technological cooperation between nations as discussed earlier in this study, that is, one which encourages *technological cooperation* as a means of building up of innovation systems for low-carbon technologies. As the emerging technology mechanism unfolds, certain opportunities and suggestions that may do so in a more concerted manner could be proposed:

**1. Engage with the business community.** As noted in the bilateral initiative established between Germany and China, the lack of private-sector support is impeding its successful development and deployment. The cases where there has been progress within the bilateral initiatives have all been backed by support from industry, or have enjoyed direct participation from private-sector firms as broader alliances. Moreover, globally over two-thirds of low-carbon investments and technology stem from the private sector of

34 For more information, see http://www.bine.info/en/topics/energy-systems/electric-mobility/news/elektromobiles-siegertreppchen/.

developed Annex I countries.[35] Thus, if the Technology Mechanism is to succeed in bringing technology cooperation to the fore in the development and climate change agenda globally, the private-sector needs to be made a part of the Technology Mechanism from the onset. So far, however, it has negligible buy-in from the private sector. While the advisory board of the CTCN has one business NGO (non-governmental organisation) as a non-voting member and several business NGO observers and contributors, their role needs to be defined. Interviewees from these business NGOs and industrial associations stated that there was no clarity on how they could move forward in helping to operationalise the Technology Mechanism. We suggest the Technology Mechanism could engage with the private sector in the following ways:

- Create public-private alliances for the development of specific technologies across the developed and developing country divide geared towards testing and R&D. In addition, to support dissemination and enable technology adaptation to the local environment, the Technology Mechanism should seek to foster linkages with local supplier networks. The private sector has shown interest in such an alliance approach as it lowers technological uncertainties in developing countries and assures international property rights protection due to the presence of multilateral and government agencies in such cooperation initiatives. Moreover, it helps generate market familiarity in new technological sectors in less-developed economies.

- Create space for individual companies/Chief Executive Officers (CEOs) to come on board the CTCN. The Technology Mechanism would benefit from the private sector more directly by bringing on board certain firms who already have extensive experience in undertaking technology development in non-Annex I countries, as members to the CTC network for example. This could be a platform to share best practices and suggest innovative ways of creating enabling environments for technology development in non-Annex I nations, as well as to prominently publicise the socially-responsible work that these companies have led. The CTCN, in its mandate, is open to private-sector organisations as members. However, no systematic steps to inform or include firms have been taken so far.

- Play an integrating role with regard to standards and norms, establishing the environmental benefits of these technologies as a benchmark. Standardisation is a key area of concern for the private sector in upcoming low-carbon technologies. As discussed in Section 3, this is particularly due to uncertainty related to these technologies and competing global manufacturing and distribution networks. In the absence of undefined standards, having a voluntary benchmark would enable an open market approach to trade and commerce, as different countries may adopt these into laws and regulations. Although the Technology Mechanism would not take on the role of a standardisation and certification authority, it could transparently highlight the best environmental norm or standard from an emissions-mitigation perspective.

- Encourage enabling environments in developing countries to attract foreign technical and financial engagement. The most common hurdle cited by Annex I firms and countries against engaging in technology cooperation is the lack of an enabling environment in developing countries. This includes the regulatory framework that

35 Policy guidance for investment in clean energy infrastructure, OECD 2013

encourages foreign investments and collaborations, as well as the local capacities to adapt and adopt new technologies. It is well accepted that policy coordination amongst different agencies and authorities within a country can positively impact the enabling environment for new technologies. Thus, the Technology Mechanism should help build capacity within developing countries to bridge between various ministries within a non-Annex I country looking to build a particular low-carbon industry. By doing so, a balance can be struck between the *performance requirements* imposed on international firms (for example, local content, local ownership, etc.) and policies that attract business investments (such as feed-in-tariffs, tax breaks, etc.). This would lower the bureaucratic hurdles that international firms face in developing countries; as well as help guide domestic agencies to identify gaps in the domestic capacities required to successfully adopt and adapt to these new technologies.

**2. Harmonise international property rights regimes and low-carbon technology development.** Interviews for the case study drew out concerns from both China and Germany with regard to IPR. As discussed earlier, German interviewees remarked on trust deficit with regards to knowledge/property rights not being respected; Chinese interviewees claimed complexity and inaccessibility of IPR as hampering technology cooperation. Although not included in the mandate of the Technology Mechanism, the issue of international property rights has been raised by non-Annex I parties consistently within and outside the UNFCCC framework as a hurdle to low-carbon development. Some options for the Technology Mechanism to address these concerns, and encourage technology development, diffusion and cooperation are:

- The Technology Mechanism could help promote and utilise a number of patented technologies that are officially made available through *patent pools*, open access, patent information databases, etc. The Technology Mechanism could bridge the gap between developing countries and these licensing mechanisms by building capacity within national agencies. Such efforts should be geared towards understanding the legal nuances of using these pools, negotiating for access to patented technologies, technology management and familiarising scientists and lawyers in developing countries with patent drafting; in addition they should identify projects that can utilise these open-access technologies.

- The Technology Mechanism could attempt to apportion funds towards IPR sales and usage rights from the global pool of 100 billion dollars per year, agreed to be pledged towards climate mitigation by Annex I countries after 2020. The CTCN could create larger technology projects using these technology patent sales to help develop the technological sector, and associated capacity and employment in non-Annex I parties.

- Using its CTCN, the Technology Mechanism could facilitate the setting up of a multilateral research network, akin to CGIAR Research Programmes and Funds (established as the Consultative Group on International Agricultural Research). These would work towards strategic outcomes that are accessible and available for public use, and involve R&D of low-carbon technologies cutting across national borders based on global public goods concerns relating to climate change. This would also enable a shift away from the dominant research institutes of Annex I countries by globally encouraging scientific innovations and boosting the innovation capacities of developing countries.[36]

Based on the above recommendations and our findings, this paper concludes with the understanding that, while examining the commercial viability of new low-carbon technologies is critical for it to develop within a particular country, it is also important to understand and standardise its environmental benefits globally. Thus, in order to stimulate international technology cooperation to accelerate the pace of low-carbon transitions globally, further research should focus on the various different technological scenarios and their environmental benefits for countries adopting these technologies. This would garner support from a different set of lobbyists, namely various environmental and civil society groups at the domestic and international level. Combined with the push from companies seeking to profit through these technologies, this would benefit a quicker and more holistic transition to these technologies.

36 For more information, see http://www.cgiar.org.

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# Annexes

**Annex 1: EU-level cooperation**

The most relevant channels for cooperating on electromobility with China:

**European Investment Bank (EIB):** The EU Green Cars Initiative[37] provides loans through the European Investment Bank. A total of EUR 1 billion has been earmarked for R&D through the joint funding programmes of the European Commission, the industry and the member states. It includes an industrial advisory group and has 50 projects in its ambit. No cooperation with non-EU nations seems to be planned. However, outside the ambit of the Green Cars Initiative, the EIB granted China EUR 500 million in loan under the Climate Change Framework Loan II (CCFL II; a similar framework loan was granted to China in 2007 as well) to help achieve targets set by the Chinese government in its 11th and 12th Five Year Plans, through different climate mitigation projects (maximum 15) in different parts of the country that promote renewable energy and energy efficiency.

**FP7:** The EU's 7th Framework Programme (FP7) ran from 2007 until the end of 2013. It bundled all research-related EU initiatives together under a common roof, playing a crucial role in reaching the goals for growth, competitiveness and employment. It has a budget of EUR 32.413 billion, and China is the third largest partner behind the United States and Russia with approximately 220 Chinese research institutions and businesses being involved as of the 7th FP. Amongst the ten thematic areas that come under the *Cooperation Objective* of the FP7 are energy, transport and the environment.

In particular, electromobility development and deployment is being garnered through the following high-level **bilateral cooperation channels** established between EU and China: the EU-China Summit 2012 saw the launch of a **China-EU Partnership on Sustainable Urban Development**, and reinforced the **EU-China High-Level Energy Meetings** to enhance cooperation in the automotive sector, *aiming at the promotion of the common objectives of reduction of energy consumption and emissions, notably via development of electromobility*. At the same summit, it was agreed that cooperation should be strengthened in the **Science and Technology Cooperation Agreement** between the two regions, in particular to promote the effective development and deployment of technology innovative solutions to major societal challenges of common interest. Such language is well suited to the case of electric vehicles and the ongoing private-sector cooperation in the electromobility sector between Europe and China.

The EU and China also have a flagship initiative called the **Europe China Clean Energy Centre (EC2)** in Beijing, and an **International Institute for Clean and Renewable Energy** in Wuhan. These are the main channels, as per the EU factsheet on cooperation with China, for cooperation towards energy and sustainable development. Besides the above, the EU has several cooperative arrangements with China at a diplomatic level. These include the **EU-China Climate Change Partnership**, the **High-Level Economic and Trade Dialogue**, and the **Strategic Dialogue**, amongst others.

37 Supported by CAPIRE (Coordination Action within the framework of the European Green Cars Initiative) and ICT4FEV initiates, also no developing country partnerships through these; more information available at http://www.green-cars-initiative.eu/.

| **Annex 2: Interview list** | |
|---|---|
| **Organisational position of interviewee** | **Number of persons interviewed** |
| **Multilateral level** | |
| UNFCCC and Technology Mechanism representatives | 19 |
| Development banks | 3 |
| International development agencies | 11 |
| **National level** | |
| Federal ministries | 5 |
| Implementing agencies | 9 |
| Think-tanks | 10 |
| Industry association | 5 |
| **Other** | |
| University professors/researchers | 18 |

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