



E3G

Low Carbon Technology Cooperation

A Framework for EU-China
Dialogue

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E3G works closely with like-minded partners in government, politics, business, civil society, science, the media, public interest foundations and elsewhere.

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Acronyms and Abbreviations

BAU	Business-as-usual
CAS	China Academy of Sciences
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CECIC	China Energy Conservation Investment Corporation
CHP	Combined Heat and Power
CSP	Concentrating Solar Power
CWER	Danish Consortium for Wind Energy Research
DWIA	Danish Wind Industry Association
EC	European Commission
EERA	European Energy Research Alliance
EII	European Industrial Initiative
ELC	Enhanced Low Carbon
ERI	Energy Research Institute
ETI	Energy Technologies Institute
EU	European Union
EV	Electric Vehicle
FDI	Foreign Direct Investment
GHG	Greenhouse Gas
GW	Gigawatt
IGCC	Integrated Gasification Combined Cycle
IP	Intellectual Property
IPR	Intellectual Property Rights

JV	Joint Venture
LC	Low Carbon
LCTIDZ	Low Carbon Technology and Investment Demonstration Zone
LNG	Liquefied Natural Gas
MTCE	Metric Tonnes of Coal Equivalent
NDRC	National Development and Reform Commission
NGCC	Natural Gas Combined Cycle
PV	Solar Photovoltaic
R&D	Research & Development
RD&D	Research, Development and Demonstration
SET-Plan	Strategic Energy Technology Plan
SME	Small and Medium Enterprises
TNA	Technology Needs Assessment
TW·h	Terawatt hour
UNFCCC	United National Framework Convention on Climate Change
WOFE	Wholly-owned Foreign Enterprise

Executive Summary

International cooperation for developing and diffusing low carbon technologies is a core element of the global effort to mitigate climate change. As both a leading supplier and user of low carbon technologies, the EU has an important stake in this process. China equally has a crucial role to play as an important emitter of greenhouse gases (GHG) as well as being a manufacturing hub and an emerging technology provider and driver of cost reduction.

This paper focuses on the opportunities for technology cooperation between the EU and China, specifically in the area of low carbon technologies for mitigation. The frameworks and approach defined in this paper can also be applied to the development and diffusion of technologies for adaptation. Furthermore, while the discussion focuses on the EU-China relationship, the findings of this paper can inform the broader debate on technology cooperation in the international climate change negotiations.

The focus in the international negotiations is on technology transfer from developed to developing countries. Europe remains at the cutting edge of innovation and diffusion of many low carbon technologies and much of the analysis in this paper focuses on opportunities to share best practice with China.¹ However it must be recognised that China is ahead of Europe in some areas (e.g. local diffusion of solar water heaters) and catching up fast in others. The future will increasingly be about a two-way flow of ideas and investment and joint R&D of new technologies.

A final caveat: this paper focuses on the specific role of technology in driving the low carbon transition. However this transition also depends on broader lifestyle changes and other forms of “social innovation” such as better urban planning. EU-China exchanges of best practice across this broader agenda must also flow both ways.

Opportunities for ‘win-win’ cooperation

From the EU’s perspective, technology cooperation with China presents a number of opportunities:

¹ Lee et al. (2009)

- > Access to China's market, with associated benefits to the EU economy and job creation
- > Benefit to technology end-users and acceleration of low carbon transition in the EU due to China's influence on cost reduction through localisation of manufacturing and making the technology market more competitive
- > Acceleration of new technology development by pooling resources and capabilities, leveraging China's growing know-how and emerging role as a supplier of technology
- > Facilitating low carbon development in China provides global benefits in the effort to mitigate the impact of climate change

Similarly, from China's perspective cooperation with the EU offers important benefits:

- > Access to leading-edge technology to meet climate change mitigation and adaptation objectives
- > Socio-economic development through job creation driven by FDI, exports, and development of a domestic low carbon market
- > Technological development through spill-over effects of international science and technology cooperation

The challenge of intellectual property rights (IPR) in technology cooperation

The sharing and protection of IPR is an important issue in the context of technology cooperation and a sensitive topic in international negotiations. Solutions needed to be designed on a case-by-case basis depending on the technology in question and the importance of IP relative to other factors that encourage or discourage diffusion (e.g. manufacturing costs and tacit know-how). In all cases the challenge is to achieve the dual objective of ensuring that

- > innovation continues – hence the interests of current and future IP owners need to be properly addressed; and
- > diffusion is effective – available technology must reach those who need it at the speed and scale required to meet the challenge

China's technology needs

Recognising the importance of the low carbon and 'green' economy to its social, economic and energy security objectives, China has begun to establish a comprehensive set of policies and regulations to promote the development and uptake of low carbon technology. Progress will require concerted action across five key areas (Figure 0.1).

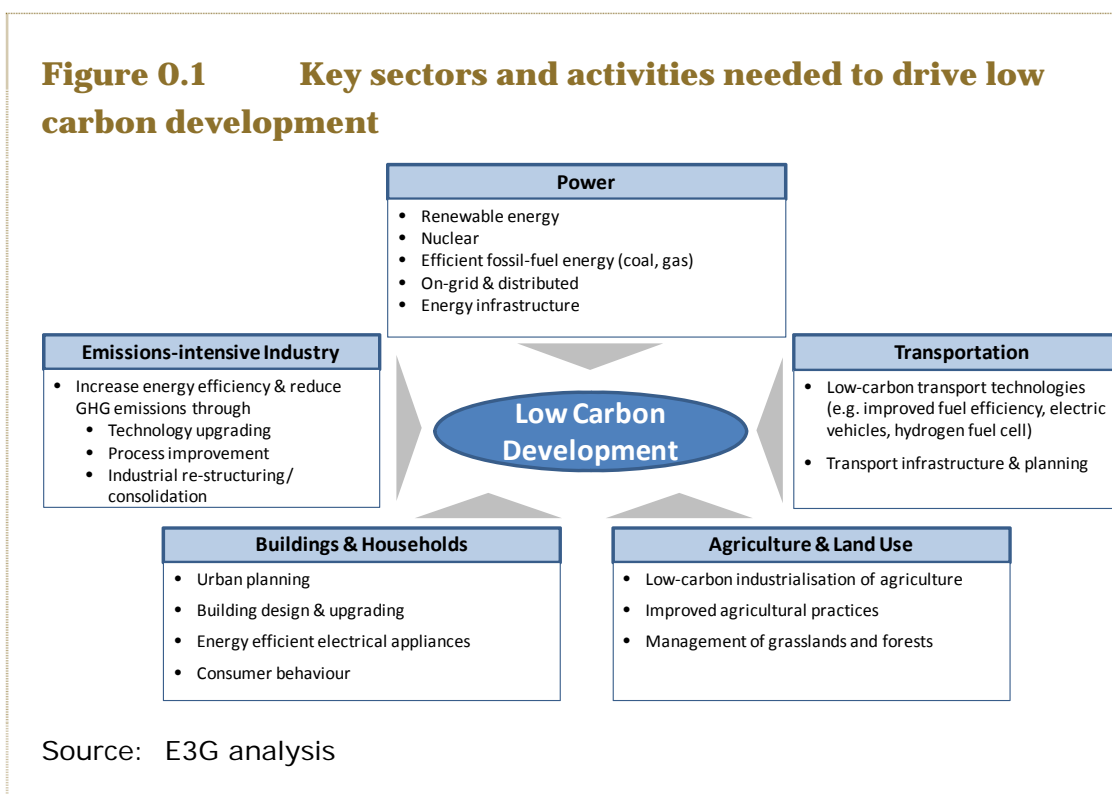


Figure 0.2 summarises the key technologies relevant to each of the above sectors, and the major 'levers' they act on to deliver low carbon development. In the short-term, accelerating the deployment of low carbon technologies in the power sector will play a critical role in achieving Chinese carbon intensity targets in 2020 and beyond. This will require changes to the electrical grid infrastructure as well as efforts to monitor and manage electricity demand.

Figure 0.2 Selected key technologies for low carbon development

Technology	Clean energy	Fuel-efficient energy	Energy efficiency (end-use)	GHG emissions reduction	Infrastructure/enabler	Technology	Clean energy	Fuel-efficient energy	Energy efficiency (end-use)	GHG emissions reduction	Infrastructure/enabler
Power Coal IGCC Coal Supercritical Coal Ultra-supercritical Natural Gas CCGT/NGCC Nuclear – 3rd & 4th generation Hydro-power Wind – onshore & offshore Solar PV Solar CSP Biomass IGCC & co-combustion CCS for power Power infrastructure - Smart grids						Transportation High fuel efficiency vehicles Advanced diesel vehicles LNG vehicles LNG vehicle infrastructure Hybrid vehicles Electric Vehicles (EV) EV infrastructure Hydrogen fuel cell vehicles Fuel cell vehicle infrastructure Biofuels – 1st, 2nd and 3rd generation					
Emissions-intensive Industry Industrial motor systems Technologies for improving industrial process efficiency: Iron & steel Non-ferrous metals Cement Chemicals Coal mining Waste management CCS for Industry						Buildings & Households Smart building systems Efficient building design Efficient boilers Energy efficient appliances High efficiency lighting Heat pumps Advanced heating & cooling tech Solar space & water heating					
						Agriculture & Land Use* Various technologies & land-use					

* Also functions as a carbon sink

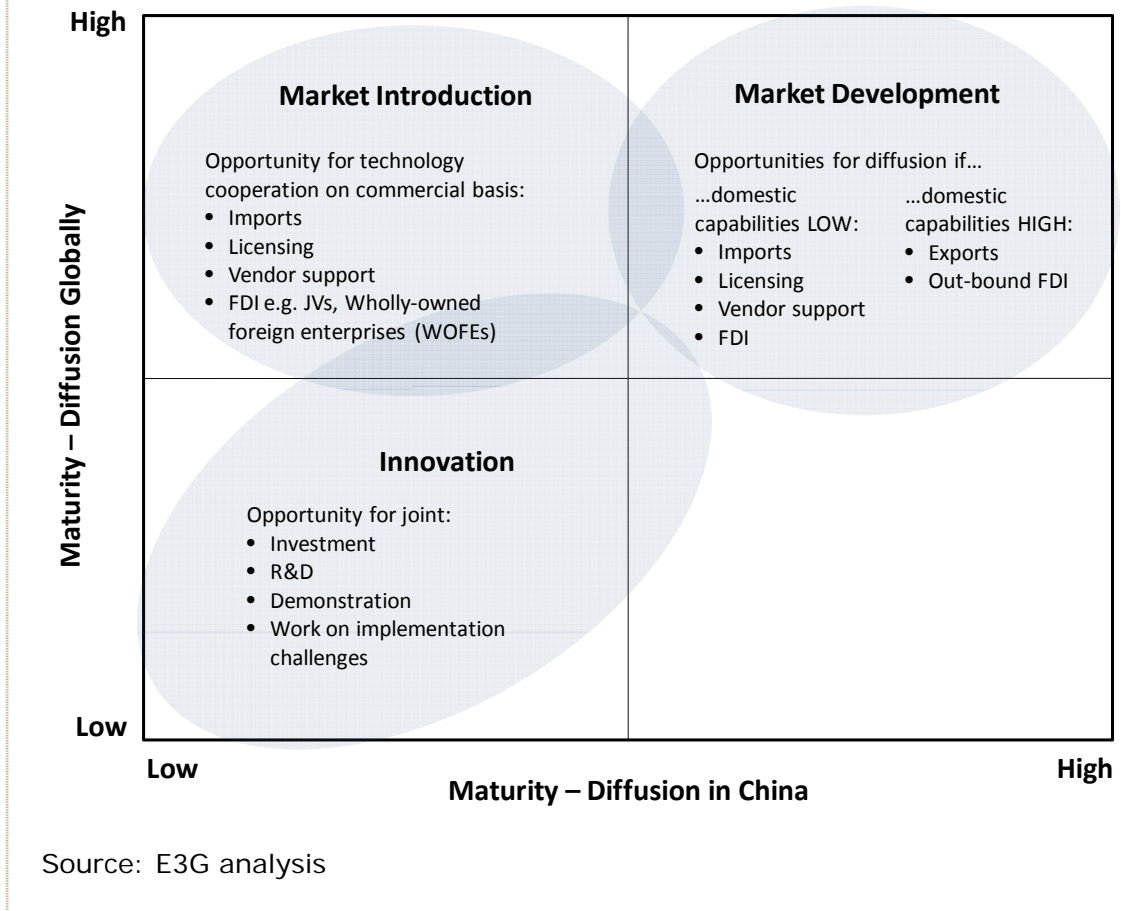
Source: E3G analysis

Framing the opportunities for cooperation

While the range of technologies that China needs to adopt and diffuse across its key sectors is vast, it is possible to group these into three areas for the purpose of discussing cooperation opportunities with the EU (Figure 0.3):

- > Innovation – Opportunity to jointly accelerate new and emerging technologies towards eventual commercialisation
- > Market introduction – Opportunity to facilitate China’s access to mature technologies
- > Market development – Opportunity to drive down costs of low carbon technologies, supporting their diffusion in China and globally

Figure 0.3 Potential areas of cooperation between China and global technology leaders²



By applying the above framework to key low carbon technologies in the energy and emissions-intensive industry sectors (Figure 0.4), the transport sector (Figures 0.5) and the buildings and households sector (Figures 0.6) a view emerges of potential areas of cooperation. This highlights a number of emerging technologies in which China is at a similar stage of development compared to the global level, or where the global maturity of technologies provides opportunities for co-investment and co-development with China.

The remaining technologies fall within the Market Introduction and Market Development areas, in which the role of government in technology development is relatively low, and transactions will mainly occur among private companies. Opportunities in this case will mainly be driven by

² As noted at the start of the paper, Market Introduction could also happen in Europe for technologies that are more mature in China, e.g. solar water heaters or electric bicycles.

commercial channels for technology acquisition and transfer described above, while governments should provide an enabling environment to facilitate this.

Figure 0.4 Example of opportunities within the energy and industry sectors

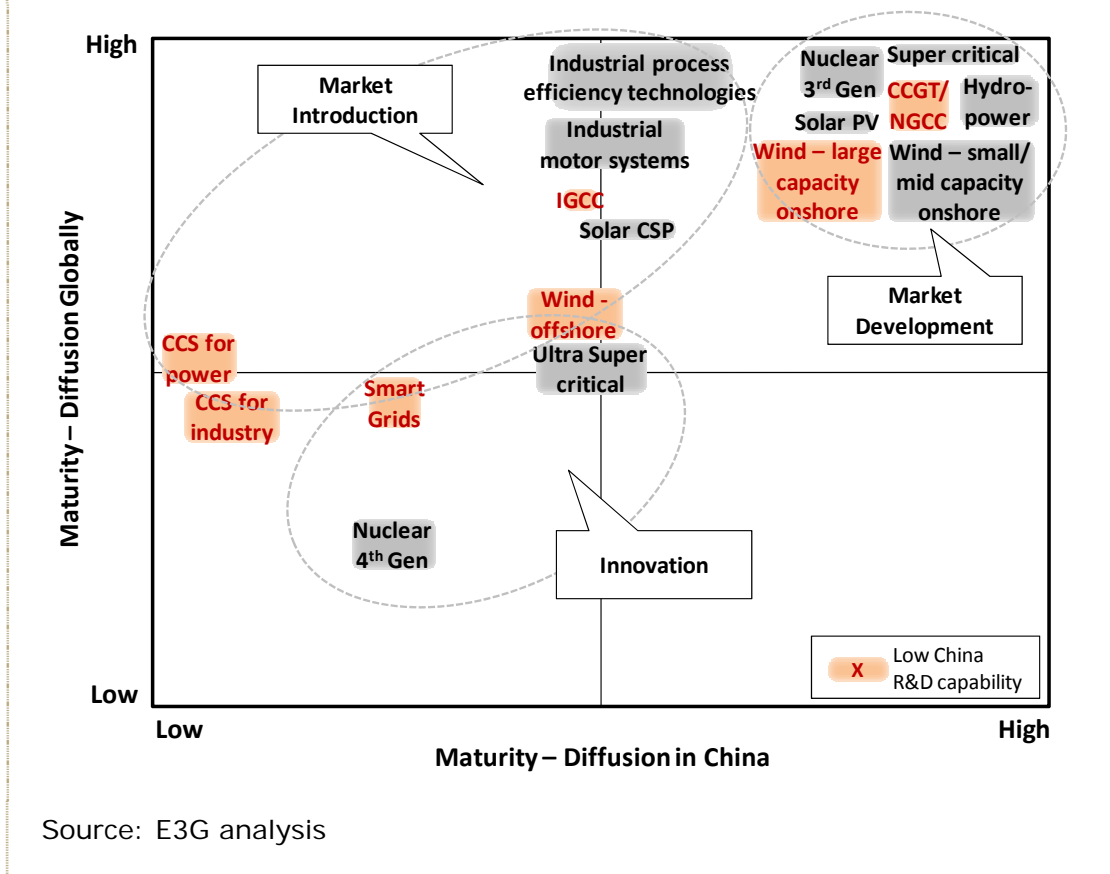
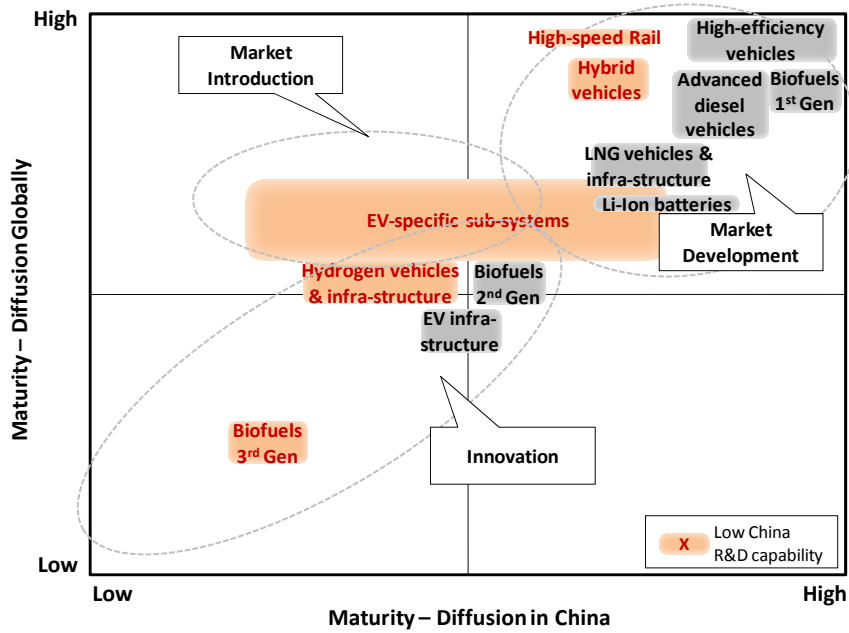
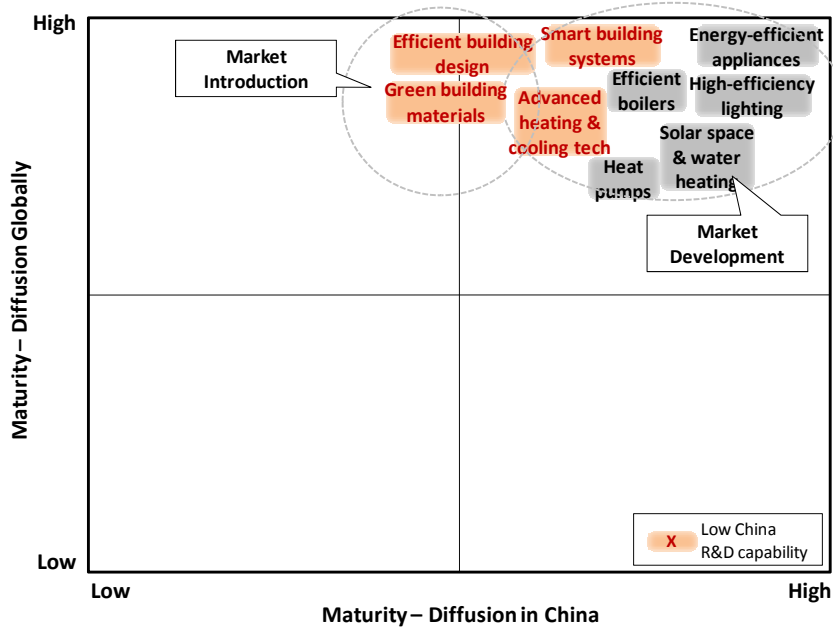


Figure 0.5 Opportunities within the transport sector



Source: E3G analysis

Figure 0.6 Opportunities within the buildings and households sector



Source: E3G analysis

Lessons from EU Experience

By examining EU capabilities as well as case studies and examples of how low carbon technologies have been developed, introduced into the market and broadly diffused, we draw ten key insights and lessons that are relevant to the three areas of cooperation defined above.

Innovation-focused opportunities

1. The EU and China have very similar technology development agendas, providing opportunities for joint initiatives based on existing R&D platforms

The EU and China have common interests in developing and commercialising new and emerging technologies, ranging from specific projects and initiatives (e.g. at university level) to large-scale programmes.

Mechanisms for cooperation in large-scale programmes have not yet been developed, however these can leverage existing platforms for public-private cooperation such as the SET-Plan's European Industrial Initiatives. Smaller-scale cooperation models such as Innovation China-UK (ICUK) provide practical lessons on how to develop effective win-win opportunities between EU and Chinese research institutions.

2. Well-designed IPR management regimes can create the right conditions for collaborative R&D in the EU and China

Despite the fact that IPR is a contentious issue in global climate change negotiations, EU and Chinese organisations are successfully using models to share and protect IP, enabling joint development and commercialisation of technologies.

Effective cooperation requires an IPR framework that is clear, but flexible enough to accommodate the rights and interests of the various parties involved. To be effective, a process of technology cooperation needs to be based on

- > Clear rules that lay out the responsibilities and rights of different participants
- > A governance process for agreeing the terms of cooperation and handling issues as they arise

3. Corporate R&D can be a mechanism for joint innovation between European and Chinese institutions when interests are aligned

Localisation of corporate R&D can provide commercial as well as knowledge spill-over benefits to foreign and local partners. Attracting the localisation of foreign corporate R&D requires investment in local capabilities and expertise, support for the domestic low carbon technology market, and implementation of policies and regulations that encourage companies to locate IP development activities in China.

4. Implementation of joint R&D initiatives requires ‘hands-on’ facilitation as well as incentives for joint commitment to ensure success

While identifying common areas of interest is relatively easy, making joint R&D collaboration work is very difficult. Specific challenges include:

- > Cultural and language barriers
- > Different systems of governance and funding in the research sector
- > Lack of knowledge on where relevant expertise lies across a vast range of organisations
- > Different expectations on the roles, responsibilities and benefits of cooperation

In order to overcome these challenges, a mechanism needs to be established to proactively facilitate communication and address issues as they arise through all stages of the process. This requires strong institutional and governance arrangements, as well as a strong team that is able to bridge the inevitable cultural, knowledge and process gaps.

Market introduction-focused opportunities

5. Technology access through commercial channels needs to be supported through market incentives

Mature low carbon technologies are accessible by Chinese companies through a number of commercial channels.

For manufacturers of low carbon technologies, this includes purchasing and/or licensing of core components and sub-systems when local technology isn't available (e.g. several domestic wind turbine manufacturers).

For users of low carbon technology such as companies in emissions-intensive industries, importing key plant and equipment is an option for upgrading and modernising their production processes. This can however represent a substantial expense to local firms that do not have the financial resources for this type of investment -- a particular challenge for small and medium-sized enterprises in China given their limited access to capital. Technology adoption is therefore often driven as a parallel effect of industry restructuring, modernisation, and FDI.

Broad adoption of technologies by Chinese end-users will require a mixture of regulatory and financial incentives and support, which can be a focus of EU-China collaboration.

6. Acquiring technology through outbound FDI is an option for Chinese companies

In a similar way to companies in developed countries, Chinese enterprises are increasingly looking to invest abroad in order to acquire technology and enter new markets. This is both an opportunity for introducing technology into China, as well as a means to make the low carbon market more competitive.

At the government level, EU-China cooperation in this area should ensure market openness and transaction efficiency for mergers and acquisitions (in both directions).

7. Commercialisation of new technologies can be achieved through effective public-private cooperation and management of IPR issues

Public-private partnerships can provide effective structures for overcoming barriers to technology implementation and pushing broad diffusion beyond early adopters. Enabling several organisations to pool complementary expertise and capabilities can help to address cost-drivers and technical issues. IPR issues will also need to be managed to ensure effective collaboration, as discussed in Point 2 above.

Market development-focused opportunities

8. Investment in local capabilities and development of the local value chain is needed to promote diffusion in China and globally

EU experience has shown that development of a low carbon industry requires a mixture of private sector entrepreneurialism as well as public sector support in R&D and other areas to enable industry to grow and develop.

Chinese industry is now approaching the point in several areas of low carbon technology where further development requires deepening links between industry players in the supply chain as well as with the domestic research community. Growing local capabilities in R&D (both basic and applied) and engineering and management talent is crucial, and will have positive impacts on innovation and market development opportunities. This can, for example, take the form of local centres of technology excellence, coupled with mechanisms to diffuse know-how and IP developed within them.

EU-China cooperation can help develop local capabilities, as well as build links between industry in Europe and China. This will create opportunities for technology buyers and suppliers and help drive innovation and diffusion of low carbon technology in both regions.

9. FDI and open markets play important roles in continued diffusion of mature technologies

For China to continue developing its low carbon technology market, it needs to remain an attractive place for EU and other foreign companies to invest and do business. This provides domestic buyers with the choice they need, as well as spurring the improvement of local product quality and industry capabilities. Attracting high value-added FDI (i.e. beyond assembly) is particularly important for China given the eventual spill-over effects for its own industry as talent grows and flows between foreign-owned companies or JVs and local companies.

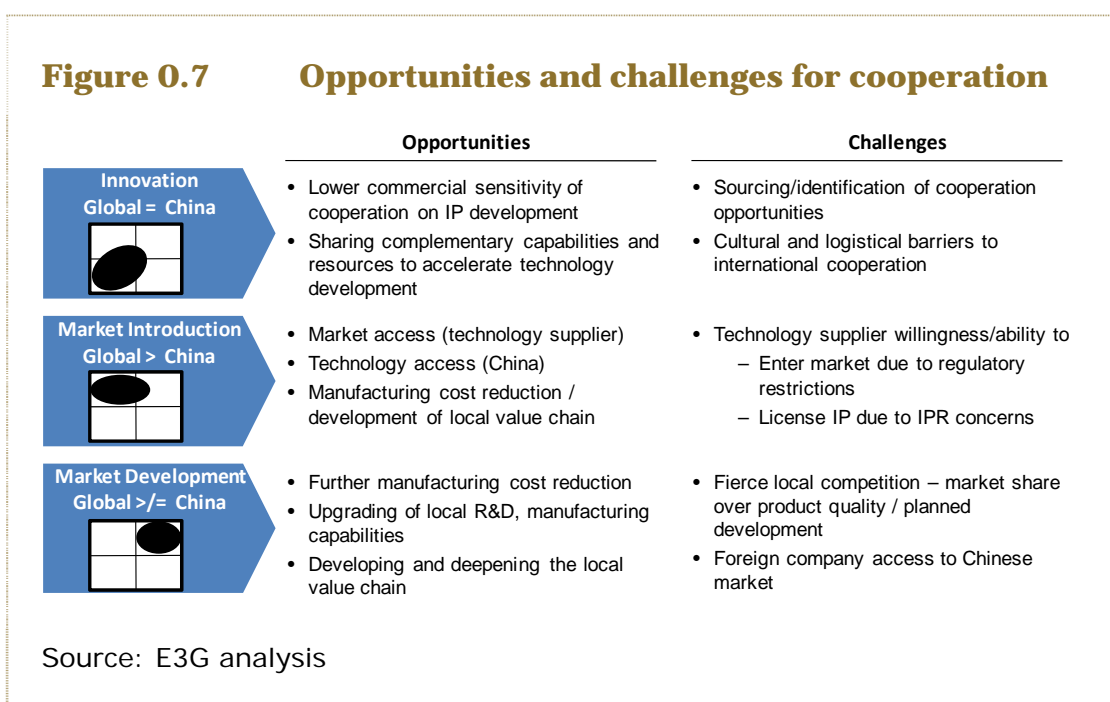
10. Establishing comprehensive performance standards for low carbon technology enables effective implementation and drives diffusion

The harmonisation and implementation of low carbon standards within the EU has established a strong market incentive for industry that will drive technology development and diffusion.

Similarly, cooperation between the EU and China on performance standards relevant to energy efficiency and GHG emissions is mutually beneficial for the long-term development of the low carbon economy in both regions. The EU and China should continue to grow their engagement in this area, and position themselves as global leaders.

Models of cooperation

EU-China cooperation on low carbon technology can yield a number of win-win opportunities. Defining opportunities into three areas (innovation, market introduction, and market development) distinguishes the different requirements of each area and enables a more focused discussion of the key challenges.



Depending on the area of cooperation, requirements can be defined around five key issues: technology and IP; financing; local capabilities; infrastructure; and regulations and policy.

Table 0.1 Key requirements for innovation-focused cooperation

Area	Requirements
Technology / IP	<ul style="list-style-type: none"> > Effective IPR management regime needed to address <ul style="list-style-type: none"> > Sharing/exchange of complementary IP > Joint creation of new IP and subsequent licensing/commercialisation > Cooperation with private sector to commercialise technology
Financing	<ul style="list-style-type: none"> > Funding required for speculative activities of high technology risk > Mechanism required for identifying promising RD&D and allocating funds based on priorities
Local capabilities	<ul style="list-style-type: none"> > Qualified scientists and engineers > Standardisation and certification processes > IPR management for innovation and commercialisation
Infrastructure	<ul style="list-style-type: none"> > R&D infrastructure and facilities > Testing facilities > Proximity to centres of technology excellence
Regulations & policy	<ul style="list-style-type: none"> > Incentives for localisation of R&D (e.g. tax breaks) > Effective IP protection laws and enforcement > Strategic policies and integrated programmes for planning and coordinating R&D

Table 0.2 Key requirements for market introduction-focused cooperation

Area	Requirements
Technology / IP	<ul style="list-style-type: none"> > Mechanism to effectively and efficiently identify sources of technology, assessing suitability and negotiating agreements with IP providers > Effective and cost-efficient channels for accessing technology: imports, licensing > Effective IP protection regime providing guarantees to technology suppliers
Financing	<ul style="list-style-type: none"> > Financing market introduction activities for new technology > Funding of market uptake to address cost barriers for technology users (e.g. zero/low interest loans) > Provision of project finance for large infrastructure projects (e.g. power plants)
Local capabilities	<ul style="list-style-type: none"> > Engineering/technical skills to absorb and implement new technologies > IPR management for licensing and protecting IP
Infrastructure	<ul style="list-style-type: none"> > Electrical grid and transport/logistics infrastructure needed to implement large energy projects (e.g. wind farms, power plants) > Development of industry zones for new/emerging technology (facilitates future development and ‘seeds’ the creation of industry clusters)
Regulations & policy	<ul style="list-style-type: none"> > Policy targets and regulations (e.g. pollution regulations, renewable energy targets) > Effective IP protection laws and enforcement > Market incentives to drive uptake

Table 0.3 Key requirements for market development-focused cooperation

Area	Requirements
Technology / IP	> Effective IP protection regime providing guarantees to technology suppliers (domestic and foreign)
Financing	> Funding of local capacity-building > Funding market uptake (e.g. preferential loans, subsidies, feed-in tariffs)
Local capabilities	> Applied R&D for technology improvement > Manufacturing and systems integration > Marketing/sales and channel development > Management (planning, control, financial)
Infrastructure	> Development of industry networks and clusters to support localisation of supply chain (e.g. high-tech zones for low-carbon industries) > Electrical grid infrastructure needed to implement new energy technologies
Regulations & policy	> Product performance standards (e.g. energy efficiency standards) > Policy targets and regulations (e.g. pollution regulations, renewable energy targets) > Effective IP protection laws and enforcement > Market incentives to drive uptake > Policies encouraging FDI and localisation of value chain

Potential models for EU-China cooperation

EU-China technology cooperation can take a number of forms depending on the area of focus, and the scope of requirements it seeks to address. It can also concentrate on a single technology field, or a portfolio of technologies. Nevertheless, some broad models can be considered based on the different objectives.

The key objective of innovation-focused opportunities is to **accelerate the development and commercialisation of new technologies**. This could be achieved through:

- > Joint RD&D programmes and initiatives
- > EU funding and support of Chinese innovation

The objective of market introduction-focused opportunities is to **enable relevant technologies to be identified and adopted in China**. This can be achieved by:

- > Facilitating the licensing of technologies to Chinese companies
- > Facilitating the entry of EU companies with innovative technologies into China

The objective of market development-focused opportunities is to **deepen capabilities and localisation of value chains in China in order to drive down technology costs and promote diffusion – globally and in China**. Potential models include:

- > Development and harmonisation of policies, regulations and standards
- > Attracting high value-added FDI and developing linkages with Chinese industry

Making it work – key success factors

Whatever the model employed, experience has highlighted three factors that are important to the success of any initiative:

Frameworks for managing and protecting IPR must be fit-for-purpose

The management and protection of IPR is a contentious issue within the international negotiations. It is clear that tackling climate change will require the protection of incentives for future innovation while accelerating the diffusion of low carbon technologies. At a practical level, companies and institutions have already developed models that enable them to successfully work together. The key is to ensure that responsibilities and relevant processes are clear and agreed upfront.

Incentives for joint collaboration need to be built into relationships

While collaborative agreements set the framework for a relationship, creating the right incentives is the key to success. A common means of doing this is through joint and equal investment by the partners involved, so that they have the same stake in the risks and benefits of the venture, and are encouraged to work towards the same outcomes. Joint ownership can however also create challenges in a relationship that need to be addressed through clear and agreed governance and decision-making processes.

The right level of institutional and organisational support needs to be provided

When the structure for cooperation is complex or the scope for problems arising due to communication, cultural issues or knowledge-gaps is large, an adequate support structure is essential. At the core of this structure should be a strong team that has the experience, knowledge and resources needed to address issues as they arise.