



SIXTH FRAMEWORK  
PROGRAMME



# TOCSIN

## Technology-Oriented Cooperation and Strategies in India and China

Reinforcing the EU dialogue with Developing  
Countries on Climate Change Mitigation



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# Policy brief



### **Acknowledgment and disclaimer**

The results contained in this document were produced within the project TOCSIN "Technology-Oriented Cooperation and Strategies in India and China - TOCSIN" (Contract n. 044287), that has received funding from the European Community's Sixth Framework Programme.

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# This policy brief summarises the main policy-relevant results of the TOCSIN project.

The FP6 TOCSIN project has evaluated climate change mitigation options in China and India and the conditions for strategic cooperation on research, development and demonstration (RD&D) and technology transfer with the European Union. In particular, the project investigated the strategic dimensions of RD&D cooperation and the challenge of creating incentives to encourage the participation of developing countries in post-2012 GHG emissions reduction strategies and technological cooperation. This policy brief summarizes the main policy-relevant results of the project.

## It is necessary to act soon if one wants to stay close to 2 degrees warming.

We investigated the possibility and consequences of a 3.5 W/m<sup>2</sup> radiative forcing scenario. Under this scenario, the goal of limiting global temperature increase to 2 degrees compared to pre-industrial times may be reached, provided that the climate sensitivity is moderate (see figure 1). However, a 3.5 W/m<sup>2</sup> by no means guarantees that the 2 degree goal will be met if the climate sensitivity is found to be high. According to tolerable window simulations with the bottom-up integrated assessment model TIAM, the corresponding concentration of Long Lived GHGs is 535 ppm-CO<sub>2</sub>eq and 430 ppm for CO<sub>2</sub> only, at the end of the century.

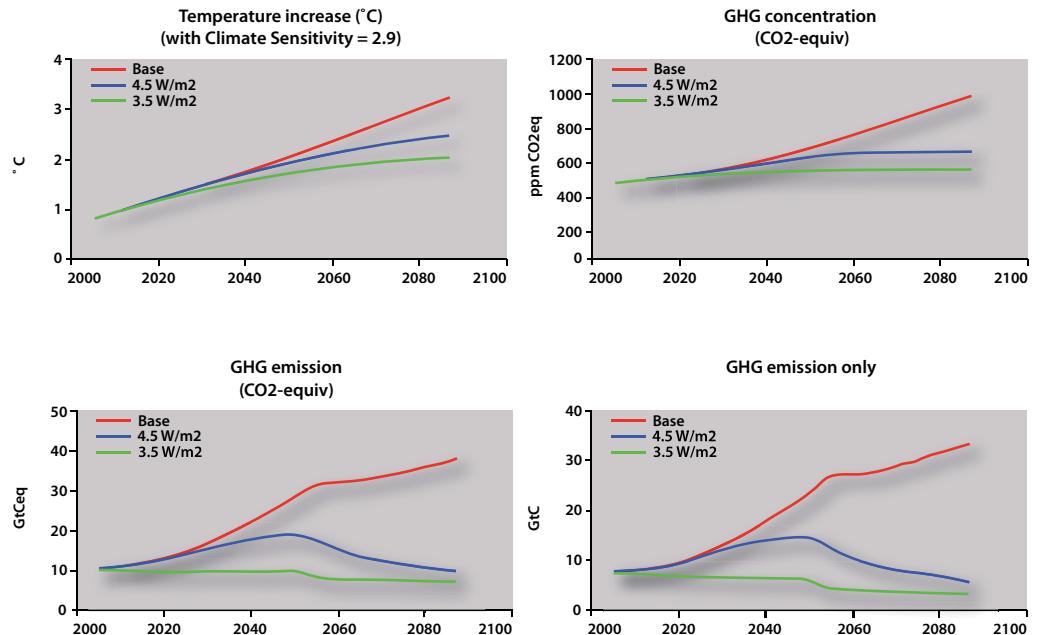


Figure 1: Greenhouse gases and global warming - Simulations with TIAM

As regards the CO<sub>2</sub> emissions, the 3.5 W/m<sup>2</sup> target requires a 65% reduction of global emissions by the end of the century compared to 2000 emissions. 2050 CO<sub>2</sub> emissions have to be reduced by 28% by 2050 according to TIAM, which is at the lower end of the range given by the IPCC (-30% to -60%). The cost, represented by the loss of surplus in TIAM, increases more than 4-5 fold with the 3.5 W/m<sup>2</sup> target compared to a 4.5 W/m<sup>2</sup> target. This illustrates the severity of the 3.5 W/m<sup>2</sup> goal. The corresponding net present value of the cost represents 1.3% of the net present value of GDP over the period 2005 to 2100. To put this cost into perspective: real GDP is assumed to increase by 415% over the same period. Let's remind that some countries - for example, the Alliance of Small Island States - and experts - for example, the NASA Chief Scientist James Hansen - are campaigning for a more ambitious target of 1.5-1.7°C.

As a 3.5 W/m<sup>2</sup> scenario will require very dramatic emission reductions, not just in future decades but almost immediately, TIAM simulations indicate that China and India will both need to begin to see large scale penetration of carbon capture and storage (CCS) by 2015-2020. Considering the lags associated between a decision to build a new power station and it coming online, the decisions needed for deployment by 2020 must be taken almost immediately in order to see any perceptible change in overall generation mix and to have an impact on near term emission trajectories.

Currently, there is a single CCS project underway in China, while there are no serious proposals to date in India. This single project places China as a global leader because of delays in the implementation elsewhere. However, since China has averaged over 50GW of new coal capacity per year, China will need dozens of similar projects to be announced and completed within the next five to ten years to have any discernible impact on Chinese electricity generation and carbon dioxide emissions. India has announced plans for numerous "ultra mega" supercritical pulverised coal units of 4GW in the next few years, with no immediate plans for even a CCS demonstration project.

In addition, 3.5 W/m<sup>2</sup> scenarios require major technology breakthroughs outside the electricity sector, which points to another major challenge. In simulations with the coupled GEMINI-TIAM bottom-up/top-down model, limiting the sector coverage in non-OECD countries to the electricity sector makes infeasible the limitation of the World radiative forcing to 3.5 W/m<sup>2</sup>. The smallest feasible radiative forcing would be 3.8 W/m<sup>2</sup>. GEMINI-TIAM bottom-up/top-down model, the limitation of the covered sectors of non-OECD countries to the electricity sector makes infeasible the limitation of the World radiative forcing to 3.5 W/m<sup>2</sup>. The smallest feasible radiative forcing would be 3.8 W/m<sup>2</sup>.

## Low carbon energy R&D and technology transfer are much talked about, very necessary, and to date completely insufficient.

Spending on energy R&D has significantly declined since the 1980s. What is more, to date only a small part of energy R&D is related to low carbon technologies. The CDM has had only a very limited effect on low carbon technology transfer, yet it is to date the most important mechanism designed for that purpose.

It has been widely recognised in the negotiations that significant change is needed in this field. The Bali Action Plan sets technology as one of the four negotiation tracks, next to mitigation, adaptation, and finance. There have been numerous recent proposals to dramatically expand technology transfer and R&D cooperation to address climate change. For example, G77 & China submitted a proposal in 2008 for a “Technology Mechanism under the UNFCCC”, focusing on enabling environments, intellectual property rights, capacity building, and meeting incremental cost. EU Environment Commissioner Stavros Dimas has suggested that the EU might contribute up to €15 billion to developing countries by 2020, with an additional €13 billion coming from the United States and €4.5 billion from Japan (Harrison, 2009). Several lines of research within TOCSIN also strengthen the case for addressing innovation and spillovers in climate policy (Verdolini and Galeotti, 2009; Bosetti et al., 2008).

The actual evolution of investment in recent years gives fewer grounds for optimism. In spite of strong continued growth in trade in goods and services, bilateral investment is actually going in the wrong direction. EU investment in China fell from €7.1 billion in 2007 to €4.5 billion in 2008. Chinese investment in Europe decreased even more dramatically, from 2.2 billion in 2006 to €616 million in 2007 and €71 million in 2008 (EC, 2009).

One of the main reasons for the slow transfer is the ongoing debate over intellectual property rights (IPR) of climate friendly technologies between developed countries and developing countries. One side of debate (largely developing countries) argues that IPR associated with low-carbon technologies should be bought up by an international fund and made freely available. The other side (led by developed countries) argues that the emerging economies should first tighten up their legal frameworks to better protect IPR before large scale transfers can be put in place. Such conflicts have almost resulted in the failure of previous international negotiations; for example the debate between China and other developing countries with the US nearly led to the failure of the Bali agenda. On the other hand, China’s position regarding IPR on low carbon technologies is starting to change, because China is becoming a technology leader in some sectors. For example, recent negotiations have revealed that China is no longer much in favour of a global license system for technologies.

The flow of resources and technology from North to South has become a linchpin in determining the success of the current round of climate change negotiations although the ambitious goals will be difficult to realise. Licensing advanced technology is undeniably likely to facilitate significant transfers of resources and technology, but concerns over international competitiveness make such proposals politically fraught. Given the current economic downturn, the relatively stronger position of many emerging economies and lingering competitiveness concerns because of large trade deficits with emerging economies, developed economies may be inclined to limiting the resource flow to emerging economies such as China and India. Nevertheless, the importance of technology development and diffusion and of Chinese and Indian engagement in mitigation efforts makes a dramatic increase in technology and resource transfers inevitable if there is to be an effective international climate agreement.

## Who acts is not the same as who pays.

Leading emerging economies, including China and India, are mainly powered by coal<sup>1</sup>. China and India have been facing increasing pressure in climate change negotiations as they are among the main emitters of greenhouse gases, China being the largest emitter already today and India just having climbed to third place. India currently accounts for five percent of global emissions compared to 20 percent for the US and for China. In the future, China is very likely to dominate global emissions with a share of up to almost 50% in the reference case. The same percentage holds for future reductions under a 3.5 W/m<sup>2</sup> scenario. The contribution by India is far less high, with up to 11% of future global emissions and 16% of future global reductions under a 3.5 W/m<sup>2</sup> scenario.

Simulations with WITCH show that delaying participation of major developing countries in a meaningful climate agreement until 2030 might increase costs to an extent that ambitious targets become infeasible (Bosetti et al., 2009). Despite this, most developing countries, including India and China, argue against emission caps for their countries in the near future. Differences in ability to pay, historical responsibility and per capita emissions provide strong arguments for this. What is more, China argues that the emission intensive productions driven by developed countries' consumption have significantly contributed to China's recent years' emission surge.

Indeed, the high reductions of emissions in China do not necessarily mean that China will or should pay for these reductions. The Clean Development Mechanism of the Kyoto Protocol, or any other technology-oriented agreement between countries X and Y would be a way for country X to pay for the mitigation actions implemented in country Y. In the absence of such agreements, developing countries bear an important part of the worldwide cost of the climate policy, according to simulations with the coupled GEMINI-TIAM model.

<sup>1</sup> Emissions from power plants still account for more than half of the CO<sub>2</sub> emissions of these countries, although this share will be reduced by the rising importance of other emission sources, especially in China.

# Climate policy attitudes change, also in India and China, but Annex I support is needed.

India and China are two very different nations, both in terms of emissions and GDP per capita, hence it is beneficial for the discussion to think of their contribution and their commitment separately.

## India

India is the third largest emitter of greenhouse gases, but not a major emitter in per capita terms. India emits about 1.1 tonnes of CO<sub>2</sub> per capita while the corresponding figure for the US is more than 20 tonnes. India faces major development challenges - access to the basic amenities like drinking water, electricity, sanitation and clean cooking energy still remains a luxury for both urban and rural dwellers alike.

Although India has been building a reputation for intransigence on climate change, on the 17th of September 2009 the Indian Environment Minister said that India is ready to quantify the amount of planet-warming gas emissions it could cut with domestic actions to fight climate change, but will not accept internationally binding targets. The Integrated Energy Policy Roadmap 2006 (endorsed and accepted in 2009), links the energy sector to the goals of sustainable development by policies that promote efficiency and reflect externalities associated with energy consumption. Further in June 2008, the Prime Minister of India released India's first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programmes addressing climate mitigation and adaptation<sup>2</sup>. Emphasising the importance of high economic growth rates, the plan "identifies measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively." It says "these national measures would be more successful with assistance from developed countries", and pledges that India's per capita greenhouse gas emissions "will at no point exceed that of developed countries even as we pursue our development objectives."

## China

China is willing to collaborate on projects to enhance energy efficiency and green energy technology developments. A clear message can be discerned, besides 'no binding commitments in post 2012', that their attitudes can be changed step-wise according to the amount of financial supports and transfer of core technology elements (e.g. design, production of key elements and maintenance) they could potentially receive from Annex I countries. China's Vice Premier Li Keqiang said that we should be aware of the severity and urgency of coping with climate change and that the U.S. and China were well positioned to work together on climate change, despite different national situations and development stages. Recent domestic policies also indicate that a change in attitudes is already underway: China has announced in the 11th Five-Year Plan in 2006 that the country's energy intensity should be reduced by 20% from 2005 to 2010. More recently, China has been raising exports taxes for three times in about 13 months since the end of 2006 on certain carbon intensive products.

<sup>2</sup> The plan identifies eight core "national missions" running through 2017 and directed respective ministries to submit detailed implementation plans to the Prime Minister's Council on Climate Change. Among other things, it mandates the retirement of old inefficient coal-fired power plants and supports R&D in Integrated Gasification Combined Cycle (IGCC) and super-critical technologies. It also envisages initiatives like renewable portfolio standards for all states and mandatory energy audits for energy intensive industries. A new Climate Science Research Fund is envisaged that supports activities like climate modeling, increased international collaboration, and private sector initiatives to develop adaptation and mitigation technologies.

## Technology-oriented agreements can help to advance and diffuse low carbon technologies and address competitiveness concerns.

Elements of technology-oriented agreements (TOAs) can be knowledge sharing, joint research programs, collaborative programs for large-scale demonstration, arrangements on intellectual property rights, technology transfer, capacity building, technology standards, and incentive mechanisms for technology development and diffusion.

The usual idea behind any kind of sectoral technology policy is to correct specific market failures and overcome barriers that prevent the large scale development and diffusion of promising low carbon technologies. Barriers are especially high in developing countries, where lack of credit, information gaps, lack of absorptive capacity, energy subsidies, and public inefficiency constitute severe obstacles to technology diffusion. If technology-oriented agreements are tailored to overcome the specific barriers that a given low carbon technology faces, they are likely to contribute to effective mitigation.

On the other hand, technology policy is criticised, because it requires government intervention in the choice of technologies. While wrong private choices are corrected under market competition, wrong choices by governments can become very costly for society. For international technology-oriented agreements, there is the additional risk that the more powerful countries exercise their power to push forward the technologies which they have a competitive advantage in. Obviously, these technologies do not need to be the best or most cost-effective.

For these reasons, TOAs are unlikely to be a good replacement for a global cap and trade system, because the latter is more consistent in setting global targets and incentives. However, a global cap and trade system is far from being implemented. In this situation, TOAs offer opportunities for engaging major developing countries in mitigation efforts or even – in more general terms – for engaging big emitters in emission reduction agreements (de Coninck, 2009). When these big emitters are industrialized countries, TOAs can offer them opportunities for exploiting first mover advantages in the commercialisation of low carbon technologies. When the big emitters are developing countries, they can profit from favourable conditions for adopting advanced low carbon technologies. In general, TOAs can offer benefits to big emitters which pure emission reduction commitments cannot. This is an important advantage, considering that the environmental effectiveness of the Kyoto Protocol has suffered from lacking or insufficient involvement of big emitters, notably of the USA and China.

Currently, negotiations about technology benefit from an important psychological advantage over negotiations on emission reductions: Technology is associated with innovation, export opportunities, development and growth, while emission reductions are associated with costs. These attributes may change as TOAs that achieve significant

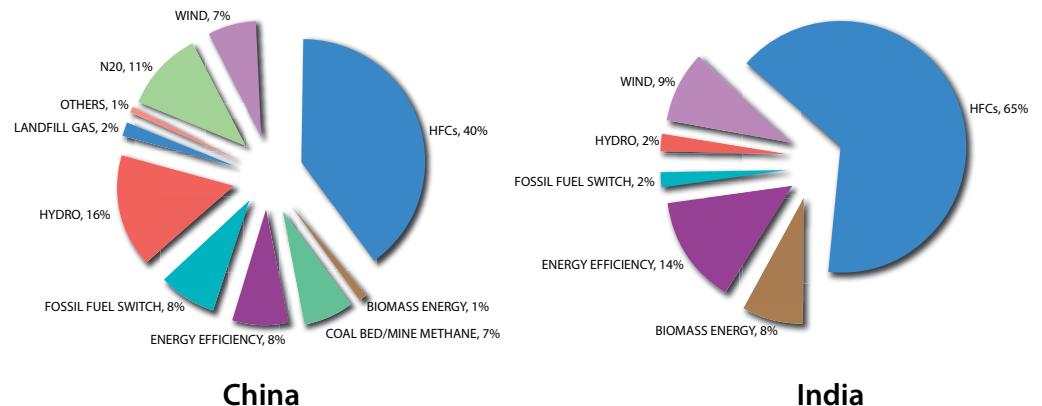
emission reductions come at a cost as well. Developed and emerging nations are more equal in technology than in most other fields, with countries like China and Brazil pioneering in the commercialisation of important low carbon technologies. This could be an advantage when negotiating TOAs.

With a view on COP15 at Copenhagen, developing countries demand to first negotiate on support, then on action. Elements of support to be negotiated are financing and technology. Negotiations on financing can be expected to be extremely difficult, while the field of technology lends itself for trade-offs.

## A “programmatic CDM” offers opportunities for enhanced technology spillovers.

There are three flaws in current CDM implementation. Firstly, many CDM projects are not “additional”, which means that many projects registered under the CDM would have been built anyway, but allow industrialised countries to emit more. It is estimated that 75% of all approved CDM projects were already up and running at the time they were approved (Friends of Earth, 2009).

Secondly, many CDM projects do not entail technology diffusion. It has been estimated that on a global scale, only about half of the current CDM projects comprise some kind of technology transfer. This is also true for China and India. For example, 16% of the CDM reductions in China originate from about 700 hydropower projects. Half of all new hydropower capacity being built in China is in the CDM pipeline. Although hydropower is a low carbon technology, the fact is China is far more advanced than many developed countries in building and running hydropower plants. Furthermore, HFC-23 emission abatement accounts for a large share of the CDM reductions (65% in India and 40% in China, see Figure 2). While the first projects of this kind typically claim some kind of technology transfer, the dominance of this project type indicates a lack of diversification also in terms of technology.



**Figure 2:** Percentage of CDM emission reductions by project type in China and India

Thirdly, the scale of the current CDM is small, and its effective scope is limited to a few sectors. Many CDM projects in China have been developed in the power industry. Still, they account for less than 1% of total installed capacity in this industry. China as well as India expect much more financial and technological support from developed countries to tackle the emissions from their coal-dominated power industries. Furthermore, the CDM has proven to be ineffective in reducing emissions from end use sectors such as transportation and households.

If a new post-2012 CDM is to be effective on a much larger scale, it needs to address end use sectors and to consider continuity and sustainability of low carbon technologies development and spillovers. For example, developed countries could provide the initial funding and technology to start a low-carbon project, while China or India implement domestic policies to develop the project to larger scale. Furthermore, BRIC countries, like China or India, can play a valuable role not only in absorbing advanced technologies from the West, but also in creating further spillovers by technology diffusion to other developing countries, including LDCs and LLDCs (Guan and Reiner, forthcoming), with the necessary financial and technological support.

## **Emissions trading could alleviate the macroeconomic cost for India and China.**

It is well known that an international ETS is an efficient instrument for reducing the costs of mitigation. Simulations with GEMINI-TIAM show that also developing countries that have the capacity to implement such a scheme can profit from an international ETS, at least if they receive a sufficiently large allocation of emission rights. Despite this, it would be more than difficult to make China or India accept a binding commitment on climate change mitigation in the near term. Neither China nor India have expressed any official interest in cap and trade and both countries remain opposed to putting binding commitments for developing countries on the agenda, which would be a necessary step for engaging in cap and trade. In China, which has substantial government involvement in technology development, government officials consider large scale market orientated mechanisms risky, which includes a cap and trade system.

However, it might be possible for China or India to implement interregional ETS within the country. India and China are very large countries with great regional disparities. Many regions like Beijing, Shanghai, Delhi or Mumbai are well developed. Implementing a domestic ETS could help China and India to accelerate technology adoption and to stimulate the diffusion of green technologies in relatively less developed regions. Through domestic emissions trading, China and India could test whether they should fully engage in an international cap and trade system at a later date. During the phase of domestic trading they would build up confidence and regulatory capacity.

## Finding the right mix of instruments and targets for a successful climate agreement is largely a matter of addressing manifold national interests and concerns, while making the climate deal effective.

Simulations with the WITCH hybrid bottom-up/top-down model show that increased energy R&D spending alone is not sufficient to solve the problem of climate change. It provides no direct incentives for the adoption of new technologies and it focuses on the longer term, missing near-term opportunities for cost-effective emission reductions.

A global carbon price signal could provide the type of incentives needed. Game theoretic simulations in TOCSIN explore allocations of emission rights between developing countries (including India), newly industrialised countries (including China) and two groups of industrialised countries under a tradable permits scheme (Drouet et al., forthcoming).

Developing countries as well as newly industrialised countries are very sensitive to the allocation rules. The group of newly industrialised countries tends to be a loser of mitigation policies, mainly because of deteriorating terms of trade due to the decrease of worldwide fossil fuel energy consumption. Indeed, Russia and the Middle East countries are part of this group. This is why in the negotiations, these countries ask for financial transfers to compensate welfare losses. Among the industrialised countries, the group with the USA, Canada and Australia generally suffers more important welfare losses than the group that mainly includes the EU and Japan. These results are coherent with the observed positions of countries in the climate negotiation.

Despite this, we show that allocations can be found which lead to a self-enforcing (i.e. signatory Parties comply out of self-interest), meaningful climate agreement. The corresponding allocation is fairly close to Contraction and Convergence by 2050<sup>3</sup>. Nevertheless it gives more to the group of newly industrialised countries at the expense of the group which includes the EU and Japan in order to equalise surplus variations across regions. This result shows that even if standard allocations proposed by literature fail to find an acceptable agreement, we can find an allocation which could conduce to a stable and acceptable agreement. According to our game theoretic simulation, this agreement has the following characteristics:

- The split of tradable emission rights until 2050 is 17% for the group which includes USA, Australia and Canada, 9% for the group which includes the EU and other high-income industrialised countries, 44% for newly industrialised countries including China, and 30% for developing countries including India.
- It gives an overcompensation to the group of newly industrialised countries, compensating especially the loss of income of fossil fuel exporters.
- It is rather generous to the USA, Canada and Australia to compensate their dependence on oil consumption.

<sup>3</sup> Contraction and Convergence [C&C] is the name of the global GHG emissions-management-model introduced by GCI to the UNFCCC negotiation in 1996. Some current information about the origins, meaning and application of C&C is available here: <http://www.tangentfilms.com/GCIEAC10nov09.pdf> and <http://www.gci.org.uk/briefings/ICE.pdf>.

- In contrary, the allocation to the EU and Japan is slightly restrictive, taking into account their present energy efficiency.
- Finally, the allocation of allowances to low-income developing countries is below the one suggested by an equal per capita emissions rule.

Considering TOCSIN results that are based on 149 stakeholder interviews (Gainza et al., 2009), it is unlikely that such a global agreement until 2050 is going to be reached in Copenhagen. Stakeholders share a very limited consensus about what will be the shape of the future international climate policy. This will imply, according to them, that the next period and nature of commitments will not be significantly different from the current one - i.e. a Kyoto Protocol "redux" scenario. Furthermore, they recognise that a post-2012 regime will depend largely on the type of commitment assumed by the U.S. Despite this, our game theoretic analysis shows that balancing the interests of different groups of countries is possible and that this is the key to making signatories of a climate agreement stick to their mitigation targets.

## Technology-oriented agreements can help to strike a meaningful climate deal.

Technology-oriented agreements (TOAs) could be an important element in finding and strengthening a self-enforcing climate deal. TOAs could address concerns of the biggest emitters and ideally make their pay-offs from a climate deal positive. However, a significant contribution of TOAs to solving the climate change problem can only be expected if they are meant to be more than good will statements, i.e. if they actually lead to significant emission reductions. For this, they have to include ambitious technology standards or mandates as well as strong incentives and considerable financing, e.g. through an international fund (de Coninck, 2009).

Another key factor are arrangements on intellectual property rights that allow for widespread diffusion, yet leave sufficient incentives for research and development where needed. Smart decisions on these arrangements depend, among other things, on the maturity of the technology addressed. Many foreign companies are not motivated to transfer their patents and it is unfair and impractical to ask firms to share their patents without an appropriate compensating mechanism. Therefore, we suggest that an international R&D funding scheme be developed in order to design, research and share new technology. The challenge is that such cooperation has been a mainstay of discussions among policy elites for at least three decades. Changing attitudes towards climate policy could make the difference today.

It is commonly recognized that the post-2012 climate policy needs to address technology issues much more than the Kyoto Protocol. TOAs are especially needed for key technologies that are known to be crucial for achieving mitigation goals, but are unlikely to be widely applied at a large scale under other instruments of the climate deal. Given the dependence

of China and India on coal as well as the reluctance of both countries to accept binding economy-wide emission targets, carbon capture and storage (CCS) is the most prominent example. Furthermore, technologies that are associated with considerable risks and/or international negative externalities are candidates for TOAs. Examples are biofuels, because of their influence on food markets, and geoengineering.

The main risk of the TOA approach is the emergence of a fragmented patchwork of agreements with reduced transparency and accountability (Benvenisti and Downs, 2007). TOAs cannot fully replace agreements on emission reductions. Rather they complement these other agreements. If designed properly, they can increase the effectiveness of the climate deal by fostering development and diffusion of important low carbon technologies, especially in countries that are not (yet) ready to accept binding emission targets. To prevent fragmentation, it is desirable to create an institutional link between the TOAs and the climate regime under the UNFCCC. One possible way of linking that is being discussed concerns the integration of TOAs into Nationally Appropriate Mitigation Actions (NAMA) of developing countries.

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## Partners

### Ecole Polytechnique Fédérale de Lausanne

#### REME Laboratory

Switzerland

Coordinator



ÉCOLE POLYTECHNIQUE  
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REME (Research Lab on the Economics & Management of the Environment) is part of the Faculty of the Natural and Built Environment of the Ecole Polytechnique Fédérale de Lausanne (Swiss Federal Institute of Technology). It is responsible for the Faculty's teaching and research on the economics and management of the natural and the built environment. REME strongly developed its research in environmental economics and policy since joining the National Centre of Competence in Research on Climate Change. REME counts on average 10 persons: 1 professor, 2 senior researchers, 5 PhD students, 2 secretaries. Their academic disciplines are economics, mathematics, political sciences, engineering sciences, and architecture.

### Fondazione Eni Enrico Mattei

Italy



The Fondazione Eni Enrico Mattei (FEEM) is a no-profit, no-partisan research institution established to carry out research in the field of sustainable development. Recognised by the President of the Italian Republic in July 1989, it has since become a leading international research centre. One of its principal aims is to promote interaction between academic, industrial and public policy spheres in order to comprehensively address concerns about economic development and environmental degradation. The Fondazione's activities are guided by four fundamental criteria: to analyse relevant and innovative research areas; to focus on "real" world issues; to integrate multi-disciplinary approaches; to create and foster international research networks.

### Hong Kong Baptist University

#### Center of Game Theory

China



The Center of Game Theory at Hong Kong Baptist University (HKBU-CGT) was established in 1999 and was the first of its kind in Hong Kong. The Center aims to promote research in game theory in all disciplines. The Center aims to assist and equip decision-makers to meet the challenges of the new millennium, by engaging in the following activities: To foster and support study, research, and intellectual exchange in game theory; to encourage the applications of game theory to real world problems; to disseminate and popularize game theoretic reasoning to the public; to promote the application of game theory to public policy; to publish a Working Papers series; to host and co-host public lectures and seminars on game theoretic applications in finance.

### Indian Institute of Management Ahmedabad (IIMVA)

India



The Public Systems Group (PSG) at the Indian Institute of Management Ahmedabad promotes research which will generate new concepts and theory for effective management of public systems, and provides opportunities to managers and administrators for developing managerial skills and attitudes for effective management of public systems. Energy and Environment policy research is carried out in close interaction with various ministries of the Government of India, industry associations, and international organizations. Some prominent areas of research include long term energy and emissions scenarios and modeling, global environmental negotiations, technology strategy, environmental risk assessment, implications of economic reforms on environment. International funding agencies that support PSG activities include UNEP, Asia Pacific Network, and UNDP.

**KANLO Consultant**  
France



KANLO is a research corporation based in France, and created by researchers with more than 25 years each of expertise in mathematical and economic modeling of energy and environment systems, directed at the analysis of local, national, regional, and global policies in the domain of energy and the environment, with special emphasis on global issues such as climate change. KANLO's strength derives from a unique blend of a strong theoretical and algorithmic expertise, an extensive experience with the construction and use of large models, and the ability to build advanced software tools to facilitate and enhance the construction, handling, and maintenance of large scale models. KANLO, with its two sister organizations HALOA Inc and KanORS Inc, operates in policy analysis and methodological developments and software design.

**ORDECSYS/C-ORDEE**  
Switzerland



ORDECSYS is a company created in 2002 to bridge academic research on decision-making and control theory with the needs of firms and organizations in a global competitive environment. The founders of the company were professors at University of Geneva and an international consultant in decision support systems. The company benefits from a considerable accumulated experience in the design and implementation of decision support systems based on the paradigms of optimization, activity analysis for resource planning, stochastic and dynamic programming. ORDECSYS offers services in the following domains: industrial economics, Logistics, Decision support systems, Environmental management, Risk management, Technology based training.

**Tsinghua University**  
**3E Institute**  
China



Energy, Environment and Economy Institute (3E) is one of the institutes in Tsinghua University. 3E and its former ITEESA (Institute of Techno-Economics and Energy System Analysis, Tsinghua University) have long been on the international and domestic fronts of addressing energy, environment and economic challenges ever since the 1980s, and have come to be recognized, with its distinguished academic achievements, as an important policy decision supporting and advising think-tank for government agencies, and a leading research institution in the field of energy system analysis, resource management and sustainable development as well as global climate change mitigation. Over the global climate change issues, 3E has been involved in the national key science and technology programs during the 8th, 9th and 10th Fiveyear Plan periods, and international cooperation projects, especially focusing on the energy system modelling, global strategy on GHG emission mitigation, GHG emission reduction technology options and corresponding social-economic impact assessment.

**University of Cambridge**  
**Electricity Policy Research**  
**Group**  
United Kingdom



The Electricity Policy Research Group ( EPRG ) is based at the Faculty of Economics and at the Judge Business School, University of Cambridge. The core research discipline is economics, within a framework that encourages collaboration between experts from different academic traditions, drawing on insights from engineering, political science and law. Through publications and via the Energy Policy Forum ( EPF ), the group offers rigorous independent research output that informs public and private sector decision making in the electricity and energy industry.

# The Project TOCSIN

Project website:  
<http://tocsin.ordecsys.com>

The project TOCSIN (2007-2009) was funded within the framework of the specific research and technological development programme “Integrating and strengthening the European Research Area”, under the European Community’s Sixth Framework Programme.

It aimed at evaluating **climate change mitigation options in China and India** and the conditions for a **strategic cooperation on R&D and technology transfer with the EU**. The project identified and assessed technology options that might significantly reduce greenhouse gases (GHG) emissions in China and India in key sectors (i.e. power generation, transport, agriculture, and heavy industry). It also defined the necessary institutional and organisational architecture that stimulate technological cooperation. The research emphasised the strategic dimension of RD&D cooperation, and the key role of creating incentives for the participation of developing countries (DCs) in post-2012 GHG emissions reduction strategies and technological cooperation. Finally, it evaluated how the Clean Development Mechanism (CDM) and international emission trading (IET) might improve the attractiveness of new energy technology options for DCs, and thus contribute to stimulate RD&D cooperation and technology transfers toward China and India. The research was structured around the use of an ensemble of models that was coupled together via advanced large scale mathematical programming techniques:

- (i) World and regional (i.e. China and India) MARKAL/TIMES bottom-up techno-economic models permitting a global assessment of technology options in different regions of the world;
- (ii) a CGE multi-country and multi-region model of the world economy (GEMINI-E3) that includes a representation of developing countries’ economies (i.e. China and India) permitting an assessment of welfare, terms of trade and emissions trading effects;
- (iii) a multiregional integrated model (WITCH) representing the effect on economic growth of technology competition in a global climate change mitigation context;
- (iv) a game theoretic framework analysing self-enforcing agreements (i.e. agreements that the signatories stick to even in the absence of a higher authority able to deter non-compliance) regarding abatement commitment and technological cooperation.

Project website: <http://tocsin.ordecys.com>

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Layout by Renato Dalla Venezia, Venice (Italy)

Printed at EPFL, Lausanne (Switzerland)

