European Climate Platform (ECP)

An Initiative by Mistra's Climate Policy
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for European Policy Studies (CEPS)

THE TECHNOLOGY AGENDA FOR INTERNATIONAL CLIMATE CHANGE POLICY:

A TAXONOMY FOR STRUCTURING ANALYSES AND NEGOTIATIONS

Background Paper for ECP Seminar

Strategic Aspects of Technology for the UNFCCC and Climate Change Debate:
The Post-Bali Technology Agenda

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BY

THOMAS L. BREWER, GEORGETOWN UNIVERSITY AND CEPS

A particular feature of ECP seminars is that each session introduces specially prepared short ECP Briefing Papers, typically consisting of between 3-6 pages. The papers are expected to complement each other and to be read together. The objective of these ECP Briefing Papers is to provide an authoritative overview on the issues, to discuss the principal ideas to address the problem and thereby help structuring the ECP seminar discussion. The ECP Briefing Paper should assist in fulfilling the objective of bringing substance to and stimulating a high-level dialogue, in order to move thinking on international climate change collaboration forward.

It is proposed to revise the Background Briefing after the meeting.

Contents

1. The nature and uses of a taxonomy

The taxonomy presented in this paper is focused on the needs of analysts and negotiators who are involved in negotiations concerning a post-2012 international climate regime.

In practical terms, a taxonomy can be used as a checklist of concepts and issues to be considered in particular negotiating circumstances. More generally, a taxonomy can also serve other related functions, such as structuring an analysis, identifying gaps in an analysis, and expanding the scope of an analysis. Furthermore, it can stimulate new ideas as well as codify existing knowledge. Ultimately, however, it can only facilitate analysis; by itself, it is neither a representation of reality nor a set of guidelines for negotiations. The inherent nature of a taxonomy is that much of it is already familiar, since it is developed partly inductively on the basis of previous work, and much of it is cryptic presentation of categories, since it condenses many ideas and much information into short lists and definitions.[1]

A key challenge in developing a taxonomy about any topic is to avoid lapsing into an analytically vacuous exercise that yields a list of ambiguous terms of undemonstrated significance. I have tried to avoid these pitfalls by drawing upon the previous work of the ECP, including the minutes of the May 2007 Steering Committee meeting in Bonn and Background Paper No. 1 for this seminar, so that the taxonomy is directly responsive to the stated needs of the ECP. I have also related the taxonomy to others' discussions of the post-2012 climate regime, so that it is grounded in a specific situation. Finally, I have used tangible examples, in order to clarify the meaning and relevance of the terms.

2. Elements of the taxonomy

The taxonomy is in four parts, each of which is focused on a particular element of a decision-making process. Together, they encompass a mixture of descriptive, explanatory, evaluative and prescriptive tasks. Although the elements are typically addressed in interactive and iterative decision-making processes in 'the real world', they can be separately identified as follows:

1. Describing technologies: What are their key features? How are they similar and different?
2. Identifying the context of technologies: How do economic and political factors affect the development and use of technologies?
3. Evaluating technologies: What goals and criteria are relevant for evaluating technologies?
4. Pursuing pathways into the future: How can the development and use of mitigating or adaptive technologies be facilitated? How can detrimental technologies be constrained?

These elements are discussed separately in this section of the paper and then expressed in the form of an analytic tree in the concluding section.

2.1 Describing technologies

A g*eneric definition of technology* is that it refers to know-how, whether explicit or tacit, concerning products, production processes, or managerial processes. The *form* of technology can be *explicit* or *tacit.* An example of an explicit form is a patent on a product or production process, while knowledge

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[1] Semantic issues about differences between a 'taxonomy' and an 'analytic framework', a 'conceptual model', an 'empirical model' and a 'paradigm' are generally ignored in the paper as being too academic. Briefly, a 'taxonomy' is a structured list of concepts; an 'analytic framework' or a 'conceptual model' links concepts verbally; an 'empirical model' links variables mathematically on the basis of systematic empirical data; a 'paradigm' is a widely accepted understanding (in verbal and/or mathematical form) of a particular phenomenon. For a discussion of paradigms of international climate change technology transfer, see Brewer (2007).

that is internalised in personnel and embedded in organisational processes, such as how to organize an international joint venture for R&D, is an example of a tacit form (Cantwell, 2001).

The *location* of technology can be *production processes* (e.g. how to set up a manufacturing process for a specific item such as a computer chip), or *managerial processes* (e.g. application of accounting rules to GHG emission credits), or *products* (e.g. thermostat). The products can be *goods* (e.g. computers) or *services* (e.g. software development).

There is also another distinction that is sometimes made: *Hard* technology refers to tangible things like machines or computers, while *soft technology* refers to knowledge.

There are numerous lists of *industries and products (both goods and services)* related to climate change. Among them are the following:

> In a European Commission (2003) ‘Environmental Technologies Action Plan’ document, there is a list developed by an advisory group. It includes 51 categories organised in a matrix based on two dimensions. One dimension is industry sector (e.g. energy supply); the other consists of energy efficiency/renewables/carbon sequestration/hydrogen&fuel cells. It appears as a table at the end of this paper.
>
> Pacala and Socolow (2005) identify 15 ‘wedges’ based on the potential contribution of 1 gtCO2e reduction per year by 2054, each one quantified according to the effort needed (e.g. introduce carbon capture and storage at baseload coal-fired power plants of 800 gigawatts).
>
> Stern (2007: 259) provides a list of nine types of technologies that could reduce carbon emissions in the energy sector: efficiency, carbon capture and storage, nuclear, biofuel, dCHP, solar, wind, and hydro.
>
> The U.S. Climate Change Technology Program (2006) itemizes hundreds of technologies, which are listed in “current portfolios” and “future research directions.” They are organized according to: end-use/infrastructure (e.g. transportation), energy supply (e.g. hydrogen), carbon capture-storage (e.g. geologic storage), non-CO2 GHGs (e.g. methane from landfills), measuring & monitoring capabilities (e.g. oceanic CO2 sequestration).
>
> A World Bank study (2007a) of trade issues related to climate change includes 43 climate-friendly *goods* identified by Harmonized System code numbers used in international trade.

Note that most of the items above rely at least in part on *industry sectors* as a basis for the classification of technologies. If the international negotiations on a post-2012 climate regime include a sectoral approach, among others, then the specific sectors used in the negotiations would be a natural basis for defining technologies.[2]

There are *related definitions.* For instance, ‘clean and efficient energy technology’ has been defined to include technologies that result in reduced emissions of GHGs.[3]

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[2] When identifying technologies in terms of standardized product or industry classification schemes, such as the Harmonized System (HS) of the World Customs Union, or the International Standard Industrial Classification system or the UN Product Code, there are a variety of technical issues, which can be important in negotiations. These and related issues have been raised recently, especially in regard to international technology transfer and thus trade issues (see Howse, 2006; OECD, 2006; Sugathan, 2006; World Bank, 2007). Furthermore, at the WTO, classification issues are different for goods and services because the agreement on goods (GATT) and the agreement on services (GATS) use different product classification schemes (Brewer, 2007).

[3] The complete definition in the proposed ‘International Climate Cooperation Re-engagement Act of 2007,’ which is part of a larger pending U.S. energy bill, is as follows [italics added]: ‘The term ‘‘clean and efficient energy technology’’ means an energy supply or end-use technology—(A) *such as*— (i) solar technology; (ii) wind technology; (iii) geothermal technology; (iv) hydroelectric technology; and (v) carbon capture technology;

2.2 Identifying the context of technologies

Differences among countries in their economic and political institutions, as well as their official status according to UNFCCC and Kyoto Protocol Annexes need to be taken into account. These differences include, in particular, countries' varying technological *needs* (UNFCCC, 2007) and *institutional capacities* for absorbing new technologies (Mytelka, 2007).

Key issues about the economic context of technologies concern *market failures*. There are two sets of problems. First, there needs to be a price on GHGs to internalise costs and create incentives for technological change. Second, other specific technology market problems need to be overcome to avoid underinvestment in climate technologies. These include (Fischer and Egenhofer, 2007: 1-2):

> *Knowledge spillovers*, i.e. innovating firms cannot capture all the benefits of their innovations because some of the new knowledge spills over to their competitors and other firms.
>
> *Adoption spillovers*, i.e. benefits accrue as a given technology becomes more widely adopted (sometimes called 'network externalities).
>
> *Incomplete information,* i.e. information about future government climate change policies and thus carbon prices, as well as information about the effectiveness of technologies.

As for the political context, the *level* of the institutional forum in which the issues are being considered and/or will be implemented needs to be taken into account. The levels are: multilateral (e.g. UNFCCC), plurilateral (e.g. WTO Government Procurement agreement), inter-regional (e.g. EU-Mercosur), regional (e.g. NAFTA), national, and subnational.

International technology transfer involves distinctive issues that arise from (a) differences in the economic, political-legal and cultural features of societies, and (b) barriers to transfers as a result of government international trade, investment and technology transfer policies (Brewer, 2007; IEA, 2001; UNFCCC, 2007).

Private technology transfers, including by multinational firms (Barton, 2007, Brewer, 2007, and Cantwell, 2003), are especially important in international technology transfers. Private sector modes of transfer include: trade, investment, licensing, and human mobility through employee international transfers and individual migration).

2.3 Evaluating technologies

There are at least six *evaluative criteria* for assessing technologies and proposals concerning them:

1. *Environmental impact*. What are the potential reductions of GHG concentrations and emissions? Which technologies have the potential for the largest reductions of GHGs?

2. *Technical feasibility and efficiency.* Which technologies are the most feasible and/or efficient in engineering terms?

3. *Economic cost-benefit relationships.* What are the relative monetized cost-benefit relationships among technologies?

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and (B) that, over its life cycle and compared to a similar technology already in commercial use — (i) is reliable, affordable, economically viable, socially acceptable, and compatible with the needs and norms of the country involved; (ii) results in — (I) *reduced emissions of greenhouse gases; or* (II) *increased geological sequestration; and* (iii) may — (I) substantially lower emissions of air pollutants; *or* (II) generate substantially smaller or less hazardous quantities of solid or liquid waste.'

4. *Political effects.* What will be the distribution of costs and benefits of adopting the technology?
Who pays, who benefits from a technology? Who supports it/opposes it?

5. *Social effects.* What are the beneficial and detrimental non-economic impacts of adopting the technology? Which communities or other groups experience renewal and which experience decline or dislocation?

6. *Ethical issues.* How do the political and economic and social impacts of the adoption of a technology vary across groups in terms of their responsibility for creating the problem? Do relatively wealthy or poor groups pay or gain?

This paper emphasises *mitigation* technologies, but of course there are also numerous technologies for a*daptation.*

Climate-friendly technology is a relative concept. Further, technologies can become more or less climate-friendly over time, as technologies change. 'Energy efficiency,' for instance, is a 'relative and evolving concept' (Sugathan, 2006: 8). For instance, as progress is made in home appliances to make them more energy efficient, earlier models become less energy efficient in relative terms.

The specific goals of a technology can be described in terms of its:

Scope - Are the goals global, regional, national, or sub-national?

Time frame - Are the goals short-term (within a year), medium-term (1-10 years), long-term (more than a decade)?

Relationship to other goals - Are particular technologies also relevant to energy security and/or sustainable economic development? Are specific technologies mutually reinforcing, compatible, or conflicting?

Specific technologies can constitute *threat wedges* (Wellington, et al., 2007: 6) - that is, technologies that are adopted for objectives other than climate change mitigation and that would increase carbon emissions. Three such technologies have received much attention in the context of energy security concerns, namely the production of synthetic fuels from coal, the extraction of oil from tar sands, and the production of oil from crushed rocks (oil shale).

2.4 Pursuing pathways into the future

There are numerous *stages in the technology innovation process* - including Basic R&D, Applied R&D, Demonstration, Commercialisation, and Diffusion (Stern, 2007: 395-399). Government policies often focus on the first three stages (sometimes with business partnerships), but there are also numerous ways for governments to facilitate commercialisation and diffusion - including subsidies for production, investments or purchases, market share mandates, performance standards, liability limitations, government procurement requirements, consumer information regulations, infrastructure development, and international technology transfer support (Newell, 2007: 3).

Portfolios of technologies are useful as a way to address the problem of *a priori* uncertainties about the cost-effectiveness of individual technologies (Stern, 2007: 273, 407-9, 418-19).

Programs for climate change mitigation or adaptation can *interact* with other climate change programs. The proceeds from cap-and-trade allowance auctions or revenues from climate taxes can be used to support technological research and/or other stages of the innovation process. Issues that may arise from such uses of funds include: How much money is available? What are the technological objectives? What are the constraints on the use of the funds?

Estimating and supporting the *scale of the technological effort* needed to address climate change issues is problematic (Wellington, et al., 2007). Stern (2007: 394) estimates that a doubling of present annual world-wide government expenditures on *energy R&D* to US$ 20 billion is needed (also see UNFCCC, 2007, and World Bank, 2007b). An example of large-scale *diffusion of many technologies at the project level* is the development on an island near Shaghai, China, of an entirely new ‘eco-city’ that is being built in a previously rural area (Stern, 2007: 437).

3. Analytic tree

The analytic tree depicted below highlights key nodes and choices when applying the taxonomy. This is only a partial synopsis; the entire analytic process in reality is of course highly iterative and interactive. In reality, the elements depicted here are typically addressed repeatedly and in a variety of sequences, when applied to a particular situation.

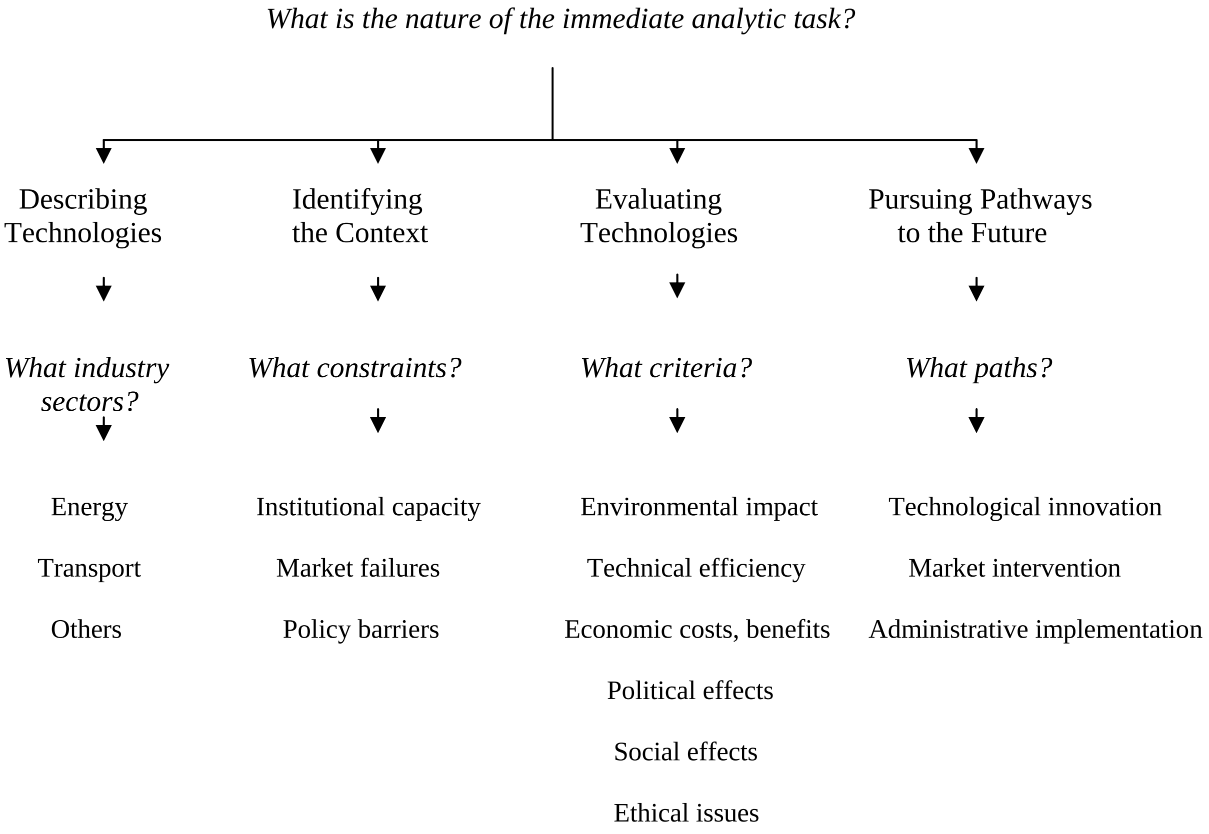

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Table: Identification of key technologies for the reduction of greenhouse gases (Source: European Commission, 2003: 12-13)

	Energy Supply	**Energy demand-households + services**	**Energy demand industry**	**Transport**	**Agriculture**	**Waste**
Energy efficiency	-Advanced macro CHP -Micro CHP -Coal bed methane -Ultra high efficiency combined cycle gas turbines -High efficient clean coal technology	-Building fabric -Integrated building design -Controls & building energy management systems -Heating & cooling & ventilation equipment - Energy efficiency equipment-office and domestic equipment -Lighting	-Alternative equipment -Combustion technologies -Low temperature processing materials -Process control -Separation technologies -Waste heat recovery	-Improvement internal combustion engine (diesel & gasoline) -Hybrid vehicles -Aeronautic technology -Traffic management systems	-Diet composition for reduced enteric fermentation	-Waste treatment technologies -Recycling/recovery (including eco-design)
Low carbon-technologies **Renewables**	Including -Direct solar (Photovoltaic, Solar thermal power stations) -Wind onshore/offshore -Biomass-electricity generation -Geothermal -Tidal wave -Small hydro	-Biomass-local heat generation -Passive solar systems	-Biomass-process heat	-Bio-fuels-transport	-Production of biomass	-Capture of bio-gas
Low carbon technologies- CO2 sequestration	-CO2 capture and storage (various options)				-Biological carbon sequestration	
Hydrogen & fuel cells	-Production of hydrogen from renewable energy sources (including options such as photo electrolysis), fossil fuels with CO2 sequestration	-Fuel cells-domestic CHP	-Fuel cells- industrial	-Hydrogen internal combustion engine -Fuel cells-transport -Hydrogen storage - Hydrogen infrastructure	-Production of biomass for hydrogen productions	