RICHARD BRADLEY

Senior Manager for Climate Change and Energy Efficiency at the IEA

Climate change is an unprecedented challenge for governments and for the energy sector in particular. The intervovernmental Panel on Climate Change (IPCC) has advised that a goal in the région of 450 parts per million (PPM) would be appropriate, and all governments in the international Energy Agency (IEA) région and the world's major économies have endorsed this goal for the end of this century. 450ppm is associated with a 50-50 probability of having no more than a two-degree increase in global mean température. Every pathway to reach 450 requires that by the end of the century carbon émissions reach nearly net zéro.

Since the majority of the emissions originate in the energy sector, no resolution of this problem is imaginable without significant transformation in the ways in which we produce, transform, transport and consume energy.

The challenge presented by the transformation follows from four factors:

1. the declared emission reduction goals of the largest economies – consistent with an ultimate concentration of 450ppm;

2. the reality that greenhouse gases (GHGs) including carbon dioxide have very long atmospheric lifetimes – CO_2 lasts for a hundred years or longer;

3. the current rapid growth rate in fossil full consumption – the International Energy Agency's (IEA) World Energy Outlook (WEO) (IEA 2009) estimates that energy-related CO_2 will grow by 1.5% to 2030; and

4. the long lifetimes of the energy consuming and producing capital structure; e.g., electricity generating plants last for 50 years or more.

For political decision makers trying to develop and implement policies consistent with their emission reduction aspirations, the inertia of the energy system is particularly important consideration in developing policy. Time is not on the side of our political leadership. The WEO and the IPCC in their 4th Assessment Report both demonstrate that global emissions must peak within a decade if 450ppm is to remain an option. The problem for decision makers is therefore to transform our energy using and producing infrastructure into one that is virtually GHG emissions free over the course of this century and to change the current emission trend nearly immediately. This is the policy challenge in its most straight forward formulation. The near-term peaking of

emissions that is required mandates action now – at Copenhagen – if declared objectives are to be met.

What more specifically must happen at Copenhagen if the energy transformation is to occur? First, incentives for investment in both cleaner technologies for greenfield facilities and for refurbishment of the existing capital structure must be put in place. Refurbishment policy should be on the agenda because closing down all fossil fuel plants and energy consuming infrastructure is not practical or affordable. Over time capital will be replaced, but in the meantime, some must be refurbished to perform better. The relative percentage of new versus older capital is one of the distinguishing aspects of the differences among countries. As a general matter, IEA countries have relatively older capital structure – where both replacement and refurbishment policy will be essential – while emerging economies will have a newer capital structure. Policy focus for political leadership in different countries will therefore differ.

However, even beyond the modernisation of the existing capital structure, significant new construction will be required in response to the premature retirement of existing capital. The IEA estimates (IEA 2009) that the global closure of coal-fired generation up to the year 2030 will equal the existing generation capacity from coal of the US, the European Union and Japan. Incentives will be needed therefore which green new builds in addition to modernise continuing capital. The reality that so much of the existing coal-fired capacity requires closure in order to remain on the 450 track is not only an economic challenge but also a critical political challenge. With such dramatic energy sector changes there will be important corporate interests which will suffer by the transformation.

How can Copenhagen deliver on new incentives for clean technology investments? There are three categories of measures under discussions: (1) emissions markets involving trading and project/policy-based crediting approaches; (2) sectoral approaches – where policies or sector-based trading approaches are used; and (3) national policies which might be either internationalised by incorporating a country's commitment to implement the measure in the Copenhagen Framework or taken at the national level without a formal commitment. It seems likely, based on the negotiating positions of major groups of parties that a Copenhagen outcome will include all three categories.

The IEA (IEA 2008; IEA 2009b) has modelled such a structure providing the only quantitative analysis of a possible Copenhagen Framework. 450 ppm is still a possibility in this analysis if such a global framework which empoweres significant reductions emerges from Copenhagen. The cost of inaction is great. In fact, the WEO estimates that the cost could be $500 billion for every year of delay in providing the incentives required for 450ppm.

Sectoral approaches are a particularly intriguing and potentially critical component of a Copenhagen Framework. The IEA (IEA 2009a) has shown in a new book, *Sectoral Approaches in Electricity: Building Bridges to a Safe Climate,* that a sectoral approach to emissions reduction in this sector could extend participation in emissions trading to emerging economies. Alternatively, sectoral approaches may provide regulatory-based incentives where trading is politically more difficult to implement. Sectoral approaches offer the prospect of broadening participation in global mitigation by focusing on a key sector where emerging economies are likely to have better data

and regulatory control. This book also shows how sectoral approaches may unlock carbon financing for some of the more expensive reductions in non-capped countries.

Whatever the portfolio of policy measures governments' employed in response to Copenhagen, it will take time to transform the existing capital structure. Large capital projects generally take years to complete when considering not only construction but also the planning, permitting and public engagement requirements associated with such projects. Given the scale of the changes required if 450 is to remain an option, it is imperative that action be cost-effective and that timely. For this reason, energy efficiency policies will play a particularly crucial role in any effective response. Not only are energy efficiency measures generally the most inexpensive, many can also be employed more immediately. In the World Energy Outlook (IEA 2009b) energy efficiency accounts for two-thirds of the emission reductions by 2020 in a 450 scenario.

Energy efficiency is not only cost effective, but it buys us time to make the changes to our capital structure and to develop the technologies which will be necessary in a world of stabilised greenhouse gas concentrations. While much of the efficiency improvements need to occur with the long-lived capital, considerable savings are also possible with the shorter lifetime capital like appliances and consumer electronics (IEA 2003; IEA 2006; IEA 2009c). Energy consumption from these end uses where capital turns over more rapidly is larger than frequently recognized. For example, 17% of all electricity consumption globally goes to meeting lighting requirements. Switching from incandescent bulbs to compact florescence bulbs could return lighting energy consumption by 40% by 2030.

Finally, an effective framework will need to empower greater international cooperation. Certainly the critical role technology plays in providing the cleaner technologies of the future will require greater cooperation. No single government will have the capacity to produce the range of technologies which will be required to "green" the range of economic sectors that emit GHGs.

However, I would argue that enhanced international cooperation is important for a variety of other activities required to achieve low emissions as well. For example, emerging and developing countries will need assistance in the form of capacity building to develop and implement low-carbon strategies, technology assessments, reviewing action plans and providing access to best policy practice experiences. Such capacity will be important for facilitating a rapid global economic transformation. Additionally, monitoring, reviewing and verifying national compliance with commitments will be important to a framework.

It will not be efficient to develop all these capabilities in one secretariat like that of the Climate Convention. A Copenhagen agreement also needs to empower other international organisations. Other UN organisations like UNDP and UNEP in addition to non-UN organisations like the IEA, APEC, the Renewable Energy and Energy Efficiency Partnership, and OLADE all have capability in the relevant areas. A new framework could engage these organisations and perhaps provide more cohesion to what are now disparate intergovernmental organisation efforts.

In conclusion, Copenhagen will be a success to the extent that it broadens the economic and geographic reach of a price on carbon, empowers energy efficiency, fosters accelerated clean

technology development, and empowers a more cohesive international organisational support for the global economic and energy transformation to a low carbon future.

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