LONG-TERM ENERGY AND CLIMATE CHANGE STRATEGY

ADVICE ON SCOPING OF PHASE II RESEARCH

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AUGUST 4 2006

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EXECUTIVE SUMMARY

Phase I of the NRTEE's *Long-term Strategy on Energy and Climate Change* contained a scenario examining how existing and near-term technology could be used to reduce domestic energy-related greenhouse gas (GHG) emissions by 60 per cent by 2050 (hereafter referred to as the "wedges scenario"). [1] The NRTEE is now planning Phase II of this program, which will consider policies for the dissemination and adoption of these technologies at the levels suggested in the scenario analysis, and practical, realistic, feasible ways to provide long-term policy signals with respect to GHG reduction.

This report offers advice on the scoping of this Phase II research, considering:
i) Identification of related policies and policy research on the use and design of long-term signals (fiscal and regulatory) for deep emission reductions;
ii) Application of broad-based long term signals to reduce GHG emissions across the economy (charges and tradable emission permits); and
iii) Targeted measures for the three largest reduction wedges as identified in the scenario: carbon capture and sequestration, freight transportation and energy efficiency in commercial buildings.

A review of research on deep emission reductions suggests that the NRTEE will be in a select group in considering this issue from the perspective of **policy measures** for **deep emissions reductions**. The focus to date of most discussion on deep emission reductions has been from one of two perspectives: **emissions reduction goals** connected to keeping atmospheric GHG concentrations and associated global average temperature increases below levels that would induce "dangerous anthropogenic interference with the climate system", and **technology packages and pathways** for achieving deep emission reductions, akin to Phase I of the NRTEE's work. Organizations looking at policy approaches include the Tyndall Centre for Climate Change Research (UK), the Wuppertal Institute for Climate, Environment, and Energy (Germany), the World Business Council for Sustainable Development, and the 10-50 project of the Pew Center on Global Climate Change (U.S.). Within Canada, the David Suzuki Foundation and Simon Fraser's School of Resource and Environmental Management have put forward comprehensive policy proposals for deep emission reductions.

[1] National Round Table on the Environment and the Economy, *Advice on a Long-term Strategy on Energy and Climate Change*, Ottawa, 2006.

The United Kingdom is the only national government with an explicit long-term reduction goal,[2] backed by consistent, high level political focus on the issue, and matched with a comprehensive package of long-term signals, both broad-based and targeted to specific technologies. Other jurisdictions with stated long-term reduction goals are France and California, New Mexico, and the New England Governors/Eastern Canadian Premiers, but comprehensive policy frameworks are not in place to support these goals.

A review of general principles for evaluating and comparing fiscal signals for environmental protection identifies some fairly common criteria:

- **Effectiveness:** the extent to which the measure will deliver emission reductions. There are four dimensions to effectiveness: linkage and targeting, point of application, life cycle effectiveness, and policy coherence.
- **Efficiency**: the extent to which emission reductions will be reached with the lowest marginal economic costs, considered from the perspectives of the government administrator and the firms/households subject to the measure, and on both static and dynamic bases. There are five dimensions to efficiency: instrument choice efficiency, economic efficiency, administrative efficiency, adjustment efficiency, and dynamic efficiency.
- **Equity/Political acceptability*:*** the extent to which the effects between sectors, regions, individuals, and generations are equal. A balanced assessment of must also include the secondary impact of any compensation payments, tax reductions, and the induced employment effects, as well as the distributional effects of the environmental benefits resulting from the measure.
- **Impacts on competitiveness and trade:** the extent to which the international competitiveness of industries producing goods that are traded in the international marketplace is maintained. The competitiveness implications of the proposed measure should be considered in comparison to those of alternative policy instruments for achieving the same desired objective.

The lens on long term, deep emission reductions through the deployment of existing and near-term technologies highlights several essential characteristics that are needed from the policy framework, distinctive from what could be sufficient to drive smaller, near term reductions. These include:

- **breadth of coverage:** deployment of many different technologies and stimulation of behavioural change, across many sectors; addressing both the efficiency with which we use energy *and* the carbon intensity of energy production;
- **breadth of leverage:** the magnitude of the investment needed overwhelms government funding capacity. Measures to leverage the massive private investment

[2] Short-term targets for reducing carbon dioxide emissions by 20 per cent below 1990 levels by 2010, making real progress towards the 50 per cent goal by 2020, and putting the UK on a path to cutting carbon dioxide emissions by some 60 per cent from current levels by about 2050.

now directed at conventional development into low carbon technologies and development are also needed;

- **durability:** potential signals need to be durable—politically, fiscally, administratively—on a multi-decade timeframe, and hence whether they can be predictable and consistent signals to capital investment decisions;
- **reflect uncertainty:** by pursuing multiple technology options and avoiding an excessive focus on one or two, and by practicing adapting management in policy design.

The key rationale for applying broad-based fiscal instruments within the package of greenhouse gas policies is that these are the most effective in delivering on the *carbon reduction* policy objective, the most efficient in the allocation of abatement costs, create incentives for continuous improvement, and are neutral to technology choice. An overview of the general characteristics and experience to date with carbon charges and CO_2 emissions trading is provided, and an alternative emissions trading proposal designed to introduce emissions trading among energy end users, the Domestic Tradable Carbon Quota, is profiled. Carbon charges and emissions trading are compared from a theoretical and an applied perspective, and options and rationales for combining carbon charges and emissions trading are reviewed. Additional targeted approaches to engaging capital markets, to leverage ongoing private economy-wide investments towards low-carbon development, are reviewed.

Targeted measures are also needed to push and pull specific technologies that might not enter the market under a broad based signal. The appropriateness of various classes of measures to specific technologies is dependent on a number of factors, including the nature of the actors in the market, the market setting, and the development stage of the technology. The lessons from the NRTEE's previous program, *Economic Instruments for Long-term Reductions in Energy-based Carbon Emissions*, are summarized. These are then applied to the three largest reduction wedges identified in the wedges scenario-- carbon capture and sequestration, vehicle efficiency in freight transportation, and energy efficiency in commercial buildings—to identify priority classes of policy signals for further investigation.

1 BACKGROUND AND TERMS OF REFERENCE

In June 2006 the National Round Table on the Environment and the Economy (NRTEE) released *Advice on a Long-term Strategy on Energy and Climate Change,*[3] containing a scenario examining how existing and near-term technology could be used to reduce domestic energy-related greenhouse gas (GHG) emissions by 60 per cent by 2050 (hereafter referred to as the "wedges scenario"). One of the key findings was the urgent need for a long-term signal:

> The chief difficulty in significantly reducing GHG emissions is not the lack of relevant technologies—rather it is the lack of a long-term signal. Such a signal is needed to help the private sector make shorter-term investment decisions that take GHG reductions into consideration.

Among the next steps for the NRTEE is to go from the "what" to the "how", including policies to encourage the dissemination and adoption of these technologies at the levels suggested in the scenario analysis, and practical, realistic, feasible ways to provide long-term policy signals with respect to GHG reduction.

Wrangellia Consulting was retained to provide advice on the scoping of this Phase II research, considering both the application of broad-based long term signals to reduce GHG emissions across the economy (charges and tradable emission permits), and targeted measures for the three largest reduction wedges as identified in the scenario: carbon capture and sequestration, freight transportation and energy efficiency in commercial buildings.

This advice considers

a) related policy research (domestic and international) on the use and design of long-term signals to convey that deepening GHG emission reductions will increasingly be one context for capital investment decisions;
b) related policy research (domestic and international) on the use and design of ecological fiscal reform/economic instruments for environmental protection measures; and
c) the findings from previous NRTEE programs, in particular the *Economic Instruments for Long-Term Reductions in Energy-based Carbon Emissions* project of the former Ecological Fiscal Reform program.

[3] National Round Table on the Environment and the Economy, *Advice on a Long-term Strategy on Energy and Climate Change*, Ottawa, 2006

2 COMPARABLE RESEARCH AND EXPERIENCE ON LONG TERM SIGNALS FOR DEEP EMISSION REDUCTIONS

A review of research on deep emission reductions suggests that the NRTEE will be in a select group in considering this issue from the perspective of **long-term signals** for **deep emissions reductions**. The focus to date of most discussion on deep emission reductions has been from one of two perspectives:

i) **emissions reduction goals** connected to keeping atmospheric GHG concentrations and associated global average temperature increases below levels that would induce "dangerous anthropogenic interference with the climate system", as per the UNFCCC. (A summary of this discussion can be found in a previous NRTEE staff memo, *A Canadian Perspective On Dangerous Anthropogenic Interference With the Climate System*, August 2005*);* or

ii) **technology packages and pathways** for achieving deep emission reductions. Some of these are inspired by the Pacala and Socolow wedges scenario which assumes that deep reductions can be achieved using existing and near term technologies,[4] some of these assume the need for revolutionary new technologies following the thinking of Hoffert.[5] An overview of government and think tank work on low-carbon scenarios from eight countries, similar to the wedges analysis conducted by ICF Kaiser in Phase I of this NRTEE program, can be found in the record from a side event at the December 2005 COP 11 negotiations. [6]

However, only a small number of organizations are looking at the *policy* approaches to bring about long term, deep emission reductions – whether or how these would differ from approaches to more modest, short-term reductions, and what package of signals will be needed.

The following section identifies, where applicable:

- Jurisdictions with long term, deep emission reductions goals and what these goals are;
- Broad based price signals, in those jurisdictions with an explicit post Kyoto deep emission reductions goal; and
- Research focussing specifically on long-term signals for deep emissions reductions.

[4] Pacala and Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies* Science vol 305, p. 968 (2004).

[5] Hoffert et. al., *Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet* Science vol 298, p. 981-987 (2002).

[6] http://2050.nies.go.jp/2050sympo/cop11_side.htm

2.1. EU

2.1.1 Long term reductions policy:

The European Council has instead adopted a long-term objective of a maximum global temperature increase of 2°C over the pre- industrial level as the guide for its internal and external climate change policy.[7]

In March 2005 the Council of EU Environment Ministers proposed a goal of 15-30% reductions by 2020 and 60-80% reduction by 2050. The subsequent summit of EU leaders adopted a more equivocal statement saying that "reduction pathways for the group of developed countries in the order of 15-30% by 2020…should be considered", but only "in the light of future work on how the objective can be achieved, including the cost-benefit aspect". Precise targets for after 2020 were rejected. [8]

2.1.2 Broad based signals:[9]

The EU has established the EU Emissions Trading Scheme (EU ETS), which has become the largest emissions market in the world. In 2005, 362 million EU Allowances (EUAs) were traded, with a value of approximately €7.2 billion.[10] The EU ETS will operate in two phases – from 2005-07, and from 2008-12. In the first phase, the program covers CO_2 emissions only. Phase 1 covers direct emissions from the following sectors:

- energy sector: combustion (over 20 MW thermal, aggregated for all on-site activities), excluding waste combustion; oil refineries; coke ovens;
- metals sector: ores; pig iron and steel (over 2.5 tonnes (metric tons) per hour);
- minerals sector: cement (over 500 tonnes per day); lime (over 50 tonnes per day); glass (over 20 tonnes per day); ceramics (over 75 tonnes per day); and
- other sectors: pulp; paper (over 20 tonnes per day).

Over 12,000 installations, which are projected to account for an estimated 46% of EU CO_2 emissions in 2010, will be subject to the program's emission reduction requirements.

Phase 2 of the EU ETS (2008-12) could be expanded to regulate all six GHGs. It also may be expanded to cover the aviation, chemical and aluminium sectors. The EU

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[7] 1939th Council meeting, Luxembourg, 25 June 1996: "... the Council believes that global average temperatures should not exceed 2 degrees above pre-industrial level and that therefore concentration levels lower than 550 ppm CO2 should guide global limitation and reduction efforts...".

[8] www.euractiv.com/en/sustainability/eu-post-2012-climate-change-policy/article-137310#summary

[9] Extracted from National Round Table on the Environment and the Economy, *Consistency in Carbon Markets: Linking Canada's Domestic Market to International Markets*, prepared for the NRTEE by Doug Russell, GSCI-Natsource Consulting, Ottawa. April 2006.

[10] *Carbon Market Analyst*, February 14, 2006, via Point Carbon, http://www.pointcarbon.com.

"Linking Directive" allows for Certified Emission Reductions (CERs) to be used for EU ETS compliance starting in Phase 1, and Emission Reduction Units (ERUs) starting in Phase 2.

No announcements have been made about a post-2012 EU ETS policy.

2.2. UNITED KINGDOM:

2.2.1 Long term reductions goal:

The February 2003 Energy White Paper, Our energy future: creating a low carbon economy, adopted the Royal Commission on Environmental Pollution's recommendation that to put the UK on a path to cutting carbon dioxide emissions by some 60 per cent from current levels by about 2050. Subsequent policy statements on both climate change and energy policy have re-affirmed this long term goal, and added short-term targets for reducing carbon dioxide emissions by 20 per cent below 1990 levels by 2010, and making real progress towards the 50 per cent goal by 2020.[11]

The United Kingdom's clear policy on a long-term deep emissions reduction goal, a commitment that has been consistently reinforced at the highest political level and across ministerial mandates, has itself been an influential long-term signal to the private sector.

2.2.2 Broad based signals:

The United Kingdom has the most comprehensive package of broad based signals for emissions reduction. It includes a Climate Change Levy with companion Climate Change Agreements enabling discounts, and a domestic Emissions Trading Scheme.

2.2.2.1 Climate Change Levy

A "Climate Change Levy" (CCL) was announced in the 1999 Budget and introduced in 2001. The levy is a tax per unit of energy, imposed at the time of supply to industrial commercial, agricultural and public sector consumers. The rates are--gas and coal 0.15 p/kW ($45/tonne C for gas, $24/tonne C for coal), electricity 0.43 p/kWh ($46/tonne C), liquefied petroleum gas 0.07 p/kWh.

Households are exempt. There is a full exemption for fuel used for transport purposes;

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[11] Department of Trade and Industry (United Kingdom), *Our Energy Future: Creating a Low Carbon Economy*, The Stationary Office, London: February 2003; House of Commons, Science and Technology Committee, *Government Response to the Committee's Fourth Report: Towards a Non–Carbon Fuel Economy: Research Development and Demonstration* Sixth Special Report of Session 2002– 03. The House of Commons, London, 9 June 2003; and Her Majesty's Government, *The Energy Challenge: Energy Review Report 2006.* July 2006. At www.dtistats.net/ereview/energy_review_report.pdf Accessed July 17, 2006.

electricity from new renewables and 'good quality' combined heat and power plants; and for energy products that are used as chemical feed stocks and for electrolysis.

Energy intensive sectors who have signed negotiated “Climate Change Agreements” (CCA) to reduce energy use or carbon emissions receive an 80% discount; targets have been agreed between sectors and the Government for two year periods until 2010, and ongoing eligibility for the discount is contingent on meeting targets set under earlier agreements. These targets may be absolute (tonnes) or performance based (tonnes per unit output). Trading of emissions credits will be permitted between firms and sectors in order to meet targets.

The revenue raised from the CCL is recycled through three streams: a) £1 billion enabled offsetting cuts of 0.3% in employers' National Insurance Contributions; b) additional support for energy efficiency (technical support plus a 100% first year capital allowances for certain energy saving investments, which is expected to be worth up to £130m in 2002/03); and c) programs to stimulate the take-up of renewable sources of energy (£50 million per annum).

A new private, business-led, not for profit company, the Carbon Trust, has been established to lead energy efficiency research, development and integrated business support programmes. The intention is to leverage a new scale of private sector investment and engagement by working in a partnership business model. The Carbon Trust, for example, has a role in updating the list of energy saving technologies eligible for the enhanced capital cost allowances.

An evaluation of the UK’s CCL shows that there was an ‘announcement effect’ in the period after the announcement of the CCL in the Commerce and Public Sector which contributed a reduction in carbon emissions that was comparable to the pure price effect. Energy efficiency targets established under the CCAs were surpassed, as substantial cost effective efficiency opportunities in industry were taken up and perhaps because the targets were not so demanding due to an asymmetry of information.[12] Another study concluded that a given carbon reduction might have been cheaper to achieve with the CCL alone and without discounts, but that this ‘awareness effect’ means that CCL plus the CCAs may have outperformed a no-discount CCL both environmentally and (less certainly) economically.[13]

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[12] Agnolucci, Paolo, *Ex Post Evaluations of CO_2-based Taxes: A Survey*. Tyndall Centre for Climate Change Research, June 2004.

[13] Ekins, P., and Etheridge, B. *The Environmental and Economic Impacts of the UK Climate Change Agreements*, Energy Policy 2005. Quoted in Köhler, Jonathan, et.al. *New Lessons for Technology Policy and Climate Change, Investment for Innovation: a Briefing Document for Policymakers.* Tyndall Centre for Climate Change Research, Briefing Note 13. April 2005

2.2.2.2 UK Emissions Trading Scheme

The UK also has a domestic Emissions Trading Scheme, which was launched in 2002. It was the first cross-industry, national greenhouse gas emission trading scheme. Entry into the programme was voluntary, but mandatory penalties are imposed upon entrants once in the programme. The initial auction in March 2002 engaged 34 successful bidders for approx 4 million tonnes carbon. Companies subject to Climate Change Agreement targets under the Climate Change Levy (CCL) may trade in the ETS in order to meet their obligations.

2.3. FRANCE

2.3.1 Long term reductions goal:

France's Climate Plan presents the country's long term objective as being to reduce its greenhouse gas emissions by 75 to 80% by 2050. The plan sets out a strategy for technological research which will enable France to meet a target of reducing greenhouse gas emissions four- or fivefold by 2050.[14]

2.3.2 Broad based signals:

No domestic signals, but participant in EU Emissions Trading Scheme (see above).

2.3.3 Research:

France's Interministerial Task Force on Climate Change (MIES) is conducting research into factor 4 emission reductions by 2050. Nineteen scenarios for factor 4 emission reductions have been developed, exploring various degrees of energy efficiency improvements, demand side versus supply side emphasis, and breakdowns by energy type, and new integrated energy systems at a large-scale.[15] These scenarios have been analyzed to draw high-level conclusions about:

- **choices leading to a dead end**: trends that are incompatible with a factor 4 reduction in emissions,
- **imperative choices**: trends that must be followed,
- **difficult points**: uses where fossil fuels can be replaced the least and which will thus have priority when it comes to allocating the factor 4 emission potential,
- **areas of choice**: when different strategies lead to equivalent results, and
- **step changes:** grouping together major technological changes which could provide more room for manoeuvre.

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[14] Ministère de l'Écologie et du Développement Durable, Climate Plan 2004: Let's Act Together to the Challenge of Climate Change. Republique Française, At www.effet-de-serre.gouv.fr Accessed July 17 2006.

[15] Ministère de l'Écologie et du Développement Durable (France), *Reducing CO_2 Emissions Fourfold in France by 2050: Introduction to the Debate*. Republique Française, March 2004. At www.effet-de-serre.gouv.fr Accessed July 17 2006.

MIES' published work includes only considers public policies to guide these factor 4 reductions at a very preliminary level.[16]

2.4. U.S. STATES

2.4.1 Long term reductions goal:

Several U.S. States have adopted long term reduction goals:

- **California:** by 2010, reduce GHG emissions to 2000 levels; by 2020, reduce GHG emissions to 1990 levels; by 2050, reduce GHG emissions to 80 percent below 1990 levels.[17]
- **New Mexico:** Climate Change Advisory Group to develop "proposals to the (Climate Change Action) Council) to reduce Mexico's total greenhouse gas emissions to 2000 levels by the year 2012, 10% below 2000 levels by 2020 and 75% by 2050."[18]
- **New England Governors/Eastern Canadian Premiers**: "Long term goal: Reduce regional GHG emissions sufficiently to eliminate any dangerous threat to the climate; current science suggests this will require reductions of 75–85% below current levels."[19]

2.5. INDEPENDENT RESEARCH ON LONG-TERMS SIGNALS FOR DEEP EMISSION REDUCTIONS

2.5.1 Tyndall Centre for Climate Change Research

The UK's Tyndall Centre for Climate Change Research "undertakes integrated research into the long-term consequences of climate change for society and into the development of sustainable responses that governments, business-leaders and decision-makers can evaluate and implement." The research is a partnership between 10 U.K. universities, and a collaborative effort among climate scientists, social scientists, engineers and economists.

One of the Tyndall Centre's four research themes is "Decarbonising Modern Societies"; its "Decarbonizing the UK: Energy for a Climate Conscious Future" explores 60% reduction scenarios using existing and emerging technologies. Of particular relevance to the NRTEE's future plan of work is the following observation:

> *…there are no simple answers for policy-makers and other stakeholders arising from Tyndall's Decarbonising the UK research theme. There is no "magic bullet" which will, by itself, provide sufficient incentives to provoke system innovation, whether it be in the form of a carbon or energy tax, an emissions trading scheme, a new set of regulations or a new technology. Indeed, it could be argued that part*

[16] Ibid, p. 33.

[17] Executive Order S-3-05 by the Governor of the State of California, June 1 2005.

[18] Executive Order 05-033, by the Governor of the State of New Mexico, June 9 2005

[19] New England Governors/Eastern Canadian Premiers, Climate Change Action Plan 2001. August 2001.

of the problem in past policy thinking towards decarbonization has been an over-reliance on a single or a few policy instruments, or the promotion of new innovative technologies without sufficient regard for the need for a receptive socio-technical regime.[20]

Among the several dozen working papers for this project are several which would be relevant to Phase II of the NRTEE's Wedges work.

2.5.2 Wuppertal Institute for Climate, Environment, and Energy

Germany's Wuppertal Institute for Climate, Environment, and Energy conducted a study on behalf of WWF Europe on policies and measures to reduce EU greenhouse gas emissions by 30% by 2020, relative to 1990. The study lays out a scenario for energy-related emissions reductions, similar to the NRTEE's Wedges report. It makes recommendations for a comprehensive policy package, including:

- Further develop and strengthen the European Emissions Trading Scheme (ETS). The ETS should form a central part of the overall strategy as it covers sectors responsible for 60% of the total emissions reductions expected by 2020. For the ETS to achieve its full potential, strict and reliable long-term emission reduction paths are crucial….
- Comprehensive sector- and technology-specific policies and measures for energy end-use and supply efficiency, combined heat and power production, and electricity generation from renewable energies;
- Targeted and intensive policies and measures for transport energy efficiency, support for thermal uses of renewable energies, and support for combined heat and power heating and renovation of households;
- Removal of direct and indirect subsidies for unsustainable energy generation and use patterns.[21]

2.5.3 World Business Council for Sustainable Development

The World Business Council for Sustainable Development (WBCSD) is a coalition of 180 international companies united by a shared commitment to sustainable development via the three pillars of economic growth, ecological balance and social progress. Members are drawn from more than 30 countries and 20 major industrial sectors, and the organization also benefits from a global network of 50+ national and regional business councils and partner organizations.

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[20] Tyndall Centre for Climate Change Research, *Decarbonising the UK: Energy for a Climate Conscious Future.* (no date) At www.tyndall.ac.uk/media/news/tyndall_decarbonising_the_uk.pdf

[21] Wuppertal Institute for Climate, Materials, and Energy. *Target 2020: Policies and Measures to Reduce Greenhouse Gas Emissions in the EU.* A report on behalf of the WWF European Policy Office. Wuppertal, September 2005.

In 2005 the WBCSD released "Pathways to 2050", an illustration of the extent of change needed in our energy infrastructure in order to reach an atmospheric stabilization level of 550 ppm of CO_2 in 2050. It considers current energy infrastructure and how it has to develop in the illustrated sectors and regions to stabilize in 2050 ; looks at the five main energy consuming and emission emitting sectors (power generation, indsutry and manufacturing, mobility, buildings, and consumer choices) which would have to achieve a « megatrend » shift by 2050 ; and breaks the analysis down for four different economic regions, including the USA and Canada. The USA and Canada regional scenario presents two extreme pathways to the same 2050 emissions level: an extreme focus on energy efficiency improvements (78% improvement in energy efficiency across the economy, or over 3% per year), with no decarbonization, or an extreme focus on decarbonization (energy decarbonization of 80%, meaning an almost total renewable / nuclear / carbon sequestration based economy), with no energy efficiency improvements. [22]

In considering the implications of this research, the WBCSD's interventions at the December 2005 COP 11 included a call for a longer term policy and framework to match the 20-50 year investment horizons of investment decisions in the global energy system. Market based mechanisms and instruments were seen as key to establishing a long-term value for carbon. They recommended that policy tools and fiscal incentives focus on providing the greatest flexibility to investors. One proposal was for policy reforms incorporating quantified objectives for low GHG emission technologies, in order to stimulate capital flows toward energy efficiency, renewable energy and low emission energy sources.[23]

The WBCSD also called for mechanisms and instruments to send economic signals strong enough to engage capital markets, and entice investors and financiers to allocate capital to low carbon infrastructure, products and services including support to adaptation strategies.

2.5.4 Pew Center on Global Climate Change

The U.S.-based Pew Center on Global Climate Change has a project entitled "The 10-50 Solution: Options for a Low Carbon Future." The project has many parallels to the NRTEE's Wedges program—the overall goal is to articulate a long-term vision of the technologies and industrial process changes that would have to be in place 50 years from now to address climate change effectively, as well as the policies that would have to be initiated in the short, medium, and long term to achieve this vision.

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[22] World Business Council on Sustainable Development, *Pathways to 2050: Energy and Climate Change*. November 2005.

[23] World Business Council on Sustainable Development, *COP 11: Sharpening The Focus For Action: A Business Perspective*. November 2005.

The Pew Center, along with the National Commission on Energy Policy hosted a workshop entitled "The 10-50 Solution: Technologies and Policies for a Low-Carbon Future" in March 2004. Among the workshops goals were to "identify policies and investments that could facilitate the development and deployment of these technologies." Many of the background workshop papers prepared for the workshop, as well as the themes and policy recommendations arising from the workshop, are relevant to the next phase of the NRTEE's wedges program.

2.5.5 Suzuki Foundation

The Vancouver-based Suzuki Foundation was the first, and possibly only other, organization to produce a 2050 low emission scenario. The Foundation relies on consultants to conduct its research work. The consultants for this project were Torrie, Smith and Associates, the same principal who prepared the ICF International wedges scenario.

2.5.6 Simon Fraser School of Resource and Environmental Management

Mark Jaccard at the Simon Fraser School of Resource and Environmental Management is the principal author of *The Morning After: Greenhouse Gas Policies for Canada's Kyoto Obligations and Beyond*, published by the C.D. Howe Institute in March 2004. This publication is particularly relevant to Phase II of the NRTEE's wedges work because of its emphasis on market-oriented regulations, both broad-based (cap and trade) and sector-based (for the adoption of specific technologies).

3 GENERAL PRINCIPLES FOR EVALUATING AND COMPARING ENVIRONMENTAL POLICY OPTIONS, INCLUDING PRICE SIGNALS

The criteria used to evaluate and compare environmental policy measures, including both broad-based and targeted price signals, contain some fairly common criteria: effectiveness, efficiency, political acceptability (akin to equity), and impacts on competitiveness and trade. The following section summarizes research conducted by the International Institute for Sustainable Development, the Organization for Economic Cooperation and Development, and the European Environment Agency. [24]

[24] More extensive discussion of these criteria can be found in Barg, Stephan, C. Guertin, E.S. Troutt, and L.K. Brown, *Ecological Fiscal Reform*. Context Paper. International Institute for Sustainable Development, National Round Table on the Environment and the Economy, Ottawa, December 2000; Organization for Economic Cooperation and Development, *Environmentally Related Taxes: Issues and Strategies*, Organization for Economic Cooperation and Development, Paris, 2001; European Environment Agency, *Environmental Taxes: Recent Developments in Tools for Integration, November 2000*. European Environment Agency, Copenhagen, 2000.

3.1.1 Effectiveness

Effectiveness refers to the extent to which the measure will deliver its ecological objective. There are four dimensions to effectiveness:

- **Linkage and targeting**: is the signal precisely targeted to the behaviour that needs to be modified in order to achieve emission reductions? Achieving this first requires a sound understanding of the cause-effect linkage between the emissions, and the environmental aspects of the activities, products, or processes that are causing the enissions and therefore need to be targeted. Targeting the choices leading to these emissions as directly as possible will enhance the effectiveness of the measure. Careful targeting will also reduce the unintended consequences of the measure, and prevent transfers from government or firms/individuals greater than those necessary for achieving the identified objective.

- **Point of application**: Measures can be applied at many points in the supply and demand chain. Targeting the actor(s) who has(have) the most ability to offer substitutes or alternatives, or to enable the change in behaviour desired, will increase the effectiveness of the measure. The choice of point of application will create incentives for different responses—for example, if the point of application is at the consumer stage (through a charge or incentive), the behavioural response may be to switch products if competitively-priced, lower emission substitutes are readily available, or to reduce consumption. If the point of application is at the production stage (through a charge, tax incentive, or tradable permit), a technology-based emissions abatement or pollution prevention response would be expected.

- **Life cycle effectiveness**: The measure should be designed to avoid leakage ---the shifting of emission burdens between parties or jurisdictions.

- **Policy Coherence:** The proposed measure needs to be implemented within a coherent policy framework. Any existing fiscal provisions that apply to the activities in question should be assessed to evaluate whether there are any existing provisions (e.g. tax incentives or subsidies) that have unintentionally introduced distortionary incentives contributing to the emssions. These so-called “perverse incentives” need to be restructured or removed in order to create an integrated set of incentives pointing towards emission reductions. This restructuring or removal should give due attention to the non-environmental objectives that the provisions were originally meant to serve.

3.1.2 Efficiency

Efficiency refers to the extent to which emission reductions will be reached with the lowest marginal economic costs, considered from the perspectives of the government

administrator and the firms/households subject to the measure. Efficiency should be considered on both a static and a dynamic basis.

- **Instrument choice efficiency** is the extent to which is the compliance/participation cost (technological plus administrative) for businesses and households is lower than it would be under an alternative policy instrument.

- **Economic efficiency** is the extent to which the measure tends to equalize compliance/participation costs across all targeted parties, thus reducing society's overall cost of meeting the ecological objective.

- **Administrative efficiency** is the burden of administration, reporting, monitoring and enforcement of the measure—in other words, the transaction costs of compliance/participation. This should be designed to minimize both government and firm/household costs.

  The administrative efficiency of a measure will strongly influence public acceptance of the measure, as well as public perceptions of fairness linked to the practical enforceability of the measure. Experience has shown that a fiscal initiative that is added to or a modification of existing fiscal instruments (taxes, charges, or subsidies), which already have an administrative infrastructure, improves administrative efficiency. Administrative efficiency decreases as the number of exemptions, rebates, or other special treatments rises.

- **Adjustment efficiency** is the degree to which the measure minimizes the unproductive costs incurred by firms/households during the transition stage when the measure is first introduced.

- **Dynamic efficiency:** refers to the type and cost of abatement before and after the measure is introduced. In other words, has the measure catalyzed new technologies and techniques, or lowered the cost of existing ones?

3.1.3 Equity/Political acceptability

The design of the measure should take into account the effects between sectors, regions, individuals, and generations. In the absence of mitigation or compensation measures, charges will be regressive—that is, they will constitute a larger portion of a low-income households' income than of a higher-income households'. In principle, no measure should be constructed in such as way that inequality is worsened for the disadvantaged.

A balanced assessment of distributional effects must also include the secondary impact of any compensation payments, tax reductions, and the induced employment effects, as

well as the distributional effects of the environmental benefits resulting from the measure.

3.1.4 Competitiveness

Maintaining the international competitiveness of industries producing goods that are traded in the international marketplace is a key consideration when designing a charge or emissions trading measure, which raise the marginal costs of production for polluting firms.

4 LONG TERM SIGNALS FOR DEEP EMISSION REDUCTIONS: DISTINCTIVE NEEDS

The lens on long term, deep emission reductions through the deployment of existing and near-term technologies highlights several essential characteristics that are needed from the policy framework, distinctive from what could be sufficient to drive smaller, near term reductions.

- **Breadth of coverage:** There is no one "magic" wedge—many or even all of the potential GHG reduction technologies need to be deployed at unprecedented rates. Furthermore, significant reductions can only be achieved by addressing both the efficiency with which we use energy *and* the carbon intensity of energy production. Policy packages therefore need to consider how to effectively deploy many different technologies, across many different sectors. This suggests that it will be necessary to use broad-based signals to reduce GHG emissions across the economy (charges and broad-based tradable emission permits among more technology or sectorally targeted measures). But such signals will not be sufficient: companion signals (fiscal and/or regulatory) tailored to the specific needs of priority technologies will also be required.

- **Breadth of leverage:** The magnitude of the investment needed overwhelms government funding capacity.[25] This suggests a shift from what might be categorized as governmental expenditures (be they direct program expenditures or forms of subsidies) to support emission reduction costs that are considered secondary to the main purpose of an investment, to an expanded consideration of measures to leverage the massive private investment now directed at conventional technologies and development into low carbon technologies and development, on both the demand and supply sides.

[25] Lambert, Gord, V.P. Sustainable Development, Suncor Energy Inc. "*Our Energy Dilemma: reconciling Societal Expectations for Energy and the Environment. An Energy Producer Perspective*". Presentation to NRTEE Plenary, For McMurray, November 8 2005.

- **Durability:** Potential signals need to be assessed as to whether they are durable—politically, fiscally, administratively—on a multi-decade timeframe, and hence whether they can be predictable and consistent signals to capital investment decisions. Investors in long-lived capital projects need this, particularly if they are to take on risk and higher capital expenditure by investing in low carbon infrastructure (new equipment, new processes, new power plants and new buildings). Most policy tools for reducing greenhouse gas emissions have been developed within the context of the Kyoto Protocol's 2012 timeframe and of modest reduction targets. In contrast, the life cycle of capital projects on which investment decisions are being made today may often be in the 25-50 year range, and it is generally expected that reduction target will tighten over the life span of that capital. The future return on low carbon capital projects, the future value of tradable emissions credits and the value of investment in low carbon infrastructure in emerging markets is very uncertain, representing a considerable disincentive to investment in long-lived, low carbon capital projects. Regulatory uncertainty and market risk cost money. For these reason, a roundtable convened by the World Economic Forum called for the establishment of a long term, market-based policy framework extending to 2030 that will give investors in climate change mitigation confidence in the long term value of their investments, and even for indicative signals extending to 2050.[26]

- **Reflect uncertainty:** Uncertainty is the only certain feature of the fifty-year time frame of this scenario. The policy framework thus needs to acknowledge and reflect uncertainty. Choices between technologies will depend upon many factors: technology costs, innovation and technical change, and social costs, values and perceptions, *inter alia*. Thus the importance of pursuing multiple technology options and avoiding an excessive focus on one or two.[27]

Some tension is inherent between the need for durability and the need to accommodate uncertainty in this multi-decade timeframe. One approach to acknowledging this is to maintain consistency on generally agreed objectives (the commitment to 60% reductions in CO_2 emissions by 2050) but practice adaptive management and learning by doing around the specifics of the policies and signals that will be used to achieve this objective.[28] The UK government has adopted this approach.

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[26] G8 Climate Change Roundtable, *Statement Of G8 Climate Change Roundtable Convened by the World Economic Forum in Collaboration With Her Majesty's Government*, United Kingdom 9 June 2005.

[27] Köhler, Jonathan, et.al. *New Lessons for Technology Policy and Climate Change, Investment for Innovation: a Briefing Document for Policymakers*. Tyndall Centre for Climate Change Research, Briefing Note 13. April 2005.

[28] For more discussion, see Tyndall Centre for Climate Change Research, *Decarbonising the UK: Energy for a Climate Conscious Future*, op.cit, p. 75.

5 BROAD-BASED INSTRUMENTS FOR ECONOMY-WIDE SIGNALS

5.1. GETTING THE CONTEXT RIGHT

Carbon charges and emissions trading are price signals designed with an explicit intention of abating CO_2 emissions.

However, the context within which these new instruments are introduced may be as influential in determining their success as the instruments themselves. One conclusion of the NRTEE's early work on Ecological Fiscal Reform (EFR) was that:

> *EFR includes not only the introduction of new fiscal measures, but also an examination of the influence of the present fiscal framework on sustainable development policy objectives. This requires a coherent, systemic approach to fiscal policy design, and the injection of sustainable development concerns into mainstream fiscal policy.*[29]

The identification and redirection or redesign of long term signals (fiscal and regulatory) which create incentives counter to long term deep emission reduction objective is essential to establishing coherent long-term signals to drive the ongoing renewal and expansion of the large infrastructure along a low-carbon pathway.

5.2. BROAD-BASED PRICE SIGNALS

5.2.1 Why Include A Broad-Based Price Signal?

The analysis of case studies conducted for the NRTEE's recent *Economic Instruments for Long-term Reductions in Energy-based Carbon Emissions* program concluded that a broad-based price signal (such as a charge or a permit market) is the most effective in delivering on the *carbon reduction* policy objective, and the most cost-efficient to society in that it allows for the greatest degree of flexibility in societal response. For this reason, the NRTEE's EFR and Energy Program recommended that the option of a broad-based price signal should be given serious consideration.

A key advantage of broad-based price signals, compared to policy instruments such as regulations or subsidies that might have equivalent environmental outcomes, is a greater efficiency in the allocation of abatement costs and the creation of incentives for continuous improvement.

One appeal of broad-based measures is that they are neutral to technology choice, leaving the choice of response to the subject parties. Because these instruments are

[29] National Round Table on the Environment and the Economy, *Towards a Canadian Agenda for Ecological Fiscal Reform: First Steps*, Ottawa, 2002.

performance-based, they avoid the risks associated with picking winners and, instead, enable winners to emerge through continuous improvement and innovation. Improvement and innovation occur because it is always in a party's interest to lower its marginal cost of abatement. For these reasons, the NRTEE's EFR and Energy Program participants considered that broad-based signals offer a better approach than the alternative array of complex and possibly arbitrary individual regulations, standards, and targeted fiscal measures.

These instruments increase the relative cost of emission-intensive technologies and products, creating a continuous incentive for innovation to improve emission efficiency or to shift to lower-emission substitutes. Broad-based measures will stimulate the most immediate response from mature, market-ready technologies; but applied in a predictable and durable fashion, they will also gradually stimulate the uptake of emerging technologies and investments in the development of new ones.

Another key feature of such instruments is that they are also effective in ensuring that some of a government's other objectives—notably in the area of innovation and technology development—are promoted.[30]

5.2.2 Carbon Charge: General Characteristics and Experience

5.2.2.1 General Characteristics

Carbon charges use a fixed, government-set price for carbon as their primary policy tool, and allow the market to determine the quantity of reductions. Governments may adjust the charge to achieve a desired level of emission reductions, and may also adjust the level of the charge for inflation and other changes. Because marginal abatement costs are unknown to policy makers and likely to vary between sectors and actors, setting the charge at the right level to achieve a desired level of abatement is a very challenging task.

Carbon charges are typically collected at the point of sale of fossil fuels and fossil fuel based electricity, based (albeit sometimes only loosely) on the carbon content of the fuel. Although much depends on the design of individual programs, this ready collection system generally makes carbon charges administratively simpler than emissions trading systems, making them better suited to broad application across the full economy (including for example small and medium sized enterprises, transportation sources, and households).

Revenue from a carbon charge accrues to government. This sum can be substantial—by illustration, a straightforward \$10/tonne CO_2e applied to Canada's current 740 million

[30] National Round Table on the Environment and the Economy, *Economic Instruments for Long-term Reductions in Energy-based Carbon Emissions*, Ottawa, 2005.

tonnes of emissions would raise $7.4 billion in revenue.[31] In existing carbon charges programs, revenue has been redistributed to address distributional effects, to provide transitional support for the adoption and development of new low carbon technologies, and to reduce distortionary taxes in other parts of the fiscal system, such as payroll taxes and income taxes.

5.2.2.2 International Experience

Since 1991 eight countries (Denmark, Finland, Germany, Italy, the Netherlands, Sweden, and the United Kingdom) have introduced CO_2-based charges with the explicit intention of abating CO_2 emissions. For a summary of each of these taxes, the reader is referred to *Ex Post Evaluations of CO_2-based Taxes: A Survey,* by Paolo Agnolucci, published by Tyndall Centre for Climate Change Research (www.tyndall.ac.uk).

A 2004 ex-post evaluation of the eight systems of CO_2 based taxes reached the following conclusions:[32]

- They bear little relation to textbook examples of optimal environmental taxes, and differ substantially from each other, having been designed to take account of local conditions…
- CO_2 based taxes, either on their own or as part of a wider package, do reduce emissions. However, where the tax is part of a package of measures, the individual contribution of the component parts of the package is very uncertain.
- CO_2 based taxes seem to have been cost-efficient, in terms of the cost of collecting them, but because the packages have involved widely varying marginal costs being imposed on different emitters (due to agreements and subsidies). It is unlikely that they have been cost-effective in the sense of attaining their environmental benefit at the least possible cost.
- Revenues seem to have been broadly stable, and in no country did the taxes result in a precipitous decline in the use of carbon-based energy.
- Fears about competitiveness have resulted, in most countries, in the industrial sector and especially energy-intensive industries within it, being taxed less heavily than households. The exception is the UK's Climate Change Levy, from which households are exempt.

[31] This is mentioned for illustrative purposes only. A pure carbon tax of this form is politically extremely unlikely. The carbon charge systems that have been adopted internationally all contain important exemptions and discounts for certain sectors of the economy. One barrier to discussion of a carbon charge in the North American context has been the public's resistance to new taxes and suspicion of government competence in wisely managing public expenditures, a perspective which seems to be less prevalent in Europe.

[32] Agnolucci, Paolo, *Ex Post Evaluations of CO_2-based Taxes: A Survey*. Tyndall Centre for Climate Change Research, June 2004.

5.2.2.3 Canadian Experience

Discussion of this instrument in Canada has been stifled by regional and historical sensitivities connected to the 1980 National Energy Program, and there has been virtually no analysis of the potential role and niche for a carbon charge within Canada's national climate change plan. However, this last June the Quebec government announced plans to levy oil and gas companies for hydrocarbon products (heavy oil, gas, natural gas and propane) sold in bulk to retailers. The Quebec Energy Board has been asked to work out tax rates and other details. The estimated $1.2 billion revenue will be used to finance a "Green Fund" for projects such as improvements to public transportation, education about emission cuts and ways to make buildings more energy efficient.

5.2.3 Emissions Trading: General Characteristics and Experience

5.2.3.1 General Characteristics

Emissions trading sets a level of emissions as their primary policy tool, and allows the market to determine the price. An emission trading system requires emitters of GHGs to acquire emissions rights in the form of permits, and submit ("retire") permits equal to their emissions to an authority on a regular basis. Government issues these permits. They are tradeable certificates denominated in tonnes of CO2e. The limit on the total number of permits issued creates a cap on the total of emissions for the parts of the economy covered by the emissions trading system. The requirement to submit permits equal to GHG emissions creates a demand for permits.

An introduction to the issues in designing a greenhouse gas emissions trading program can be found in NRTEE, *Canada's Options for a Domestic Greenhouse Gas Emissions Trading Program*, 1999, andTradable Permits Working Group, *Using Tradable Emissions Permits to Help Achieve Domestic Greenhouse Gas Objectives, Options Report*, April 2000.

5.2.3.2 International Experience

Two mandatory emissions trading schemes are in operation: the European Union Emissions Trading Scheme (described above) is the world's largest emissions market; the New South Wales Greenhouse Gas Abatement Scheme operates in New Zealand. A voluntary international GHG trading program, the Chicago Climate Exchange, has been established among 129 companies that have committed to voluntary emission reductions. In July 2006 the Montreal Exchange and the Chicago Climate Exchange announced the establishment of the Montreal Climate Exchange.

Proposals exist for several other major emissions trading programs. Two competing national level proposals were considered the U.S. Senate in 2005 (one by Senators McCain and Lieberman, and one by Senator Bingaman) and are likely to be considered again in the future. A Memorandum of Understanding to adopt a Regional Greenhouse

Gas Initiative (RGGI) creating a cap and trade scheme was signed by seven north eastern US States in December 2005. A state-based trading system is being designed in Australia, with the aim of coming online by 2010.

For a summary of each of these taxes, the reader is referred to *Consistency in Carbon Markets: Linking Canada's Domestic Market to International Markets*, prepared for the NRTEE by Doug Russell, GSCI-Natsource Consulting, Ottawa. April 2006.

5.2.3.3 Canadian Experience

Emissions trading is the price signal which has received the most discussion in the Canadian context. Extensive consultations over more than 5 years led to a draft for a Large Final Emitters' emissions trading system in late 2005. The implementation of the system was suspended by the election of the new government in January 2006, and the future status of the program and any changes that may be made are not known at the time of this writing.

The LFE system, as elaborated to date, is intended to achieve 45 Mt (million tonnes) of CO_2e (carbon dioxide equivalent) emission reductions annually in 2008-12. Its key design elements include:

- coverage of direct GHG emissions from large industrial emitters, which are forecast to account for approximately 50% of Canada's 2010 GHG emissions;
- emissions intensity targets (rather than absolute emissions targets) based on a 12-15% reduction in 2010 Business As Usual (BAU) emissions intensity;
- a baseline-and-credit allocation approach in which LFEs do not receive allocations, and receive LFE credits only after demonstrating that they have over-complied with their targets;
- a price cap of C$15 per tonne CO_2e, which was a prior commitment of the previous two Prime Ministers; and
- a set of instruments that could be used to comply with LFE targets, including LFE credits, contributions to the Technology Investment Fund (TIF) at the rate of one compliance unit per C$15 contribution[33], offsets created under the domestic offset system, "green" Assigned Amount Units (AAUs), Certified Emission Reductions (CERs) created from Clean Development Mechanism (CDM) projects in developing countries, and Emission Reduction Units (ERUs) created from Joint Implementation (JI) projects in countries with economies in transition. CERs and ERUs created from land use, land use change and forestry (LULUCF) activities, and from large hydro power projects, which are not eligible under the EU Emissions Trading Scheme (EU ETS), would be usable for LFE compliance.[34]

[33] Total contribution for the TIF was capped at 9 Mt to be shared among all LFEs.

[34] Extracted from National Round Table on the Environment and the Economy, *Consistency in Carbon Markets: Linking Canada's Domestic Market to International Markets*, prepared for the NRTEE by Doug Russell, GSCI-Natsource Consulting, Ottawa. April 2006.

5.2.4 An Alternative Emission Trading Model—Domestic Tradable Quotas

Because of administrative efficiency and the high transaction costs associated with administering tradable emissions markets, proposals for trading in carbon emissions have focussed on large emitters rather than individuals or end users.

The Domestic Tradable Carbon Quota (DTQ) is a proposed policy instrument designed to introduce emissions trading among energy end users. Because the NRTEE's Wedges scenario allocated emissions associated with the production of electricity and the production of oil and gas to the domestic end-user, this proposal may merit the NRTEE's consideration as an alternative to a carbon charge.

Under this policy proposal, individuals would receive annual allocations of carbon units on a free and equal per capita basis; organizations would purchase carbon units from a national carbon market, also open to individuals wishing to buy additional carbon units. Fuels and electricity would be assigned a carbon unit rating and when individuals or organizations purchased fuel or electricity, they would surrender the number of carbon units corresponding to their purchase. These units would be passed up the supply chain and on reaching the primary energy producer or importer would be surrendered back to the government.

The relationship between a DTQ system and a Large Final Emitters trading system would be similar to those between the DTQ and the EU Emissions Trading Scheme. Some initial thinking is available on the integration of those two schemes.

More information on DTQs can be found at www.dtqs.org and in Dr. David Fleming's *Tradable Quotas: Using Information Technology To Cap National Carbon Emissions,* European Environment, 7 (5): 139-148 (1997).

5.2.5 Comparing Carbon Charges And Emissions Trading:

While carbon charges and emissions trading both set a price on carbon emissions, their approach to doing so is fundamentally different: carbon charges fix the price, and emissions trading fixes the quantity.

The theoretical properties of tradable permits and charges are to a large extent similar. The optimal choice between the two theoretically depends on the degree of uncertainty and the correlation between the marginal damage and the marginal abatement costs.

- **Charges** are preferable if the environmental damage is flat relative to the marginal abatement cost curve. The lack of a clear, short-term threshold for severe climate changes favours the use of taxes.

- **Emissions trading**, with its fixed quantity limit, is preferable if there is a steep marginal damage curve, since this implies a threshold that should be avoided.[35]

From a national perspective, the marginal benefit curve for carbon emission reductions is relatively flat, therefore favouring the use of taxes. From a global perspective there are, however, thresholds that should not be exceeded and the possibility of a catastrophic development. This speaks clearly in favour of using a quantity-based instrument as in a cap and trade system.[36] An international emissions trading system also allows for the most cost effective emissions reductions; however, experience to date with a mechanism such as the Clean Development Mechanism demonstrates that the transaction costs of these systems can be significant.

But from the applied perspective of the real world, the differences between tradable permits and charges can be striking. Although much depends on the specific design of each policy (factors such as coverage [breadth, emission thresholds], point of imposition, initial allocation models for permits, recycling of revenue), a number of generalities can be made about the differences between carbon charges and emissions trading in practice. These are summarized below:

	Carbon Charge	Emissions Trading
Scope of application	Can apply to diffuse and point source emissions.	Best suited to large emissions sources because of transaction costs for trading, monitoring and reporting. Difficult to apply in SMEs, transportation, service, and household sectors
Environmental effectiveness	Directional signal: actual reductions dependent on market response	Reduction target is assured
Price/tonne CO_2e reduced	Price is known	Price responds to market demand and supply
Cost-Efficiency of abatement		Most economically efficient in theory, although in practice transaction costs may make lowest abatement options less attractive
Dynamic efficiency	Greater dynamic efficiency: permanent incentive to reduce emissions	Dynamic efficiency depends on removal of permits from the system
Emissions fungibility (among 6 GHGs)	Each GHG needs its own tax; administratively more complex to apply to non-CO_2 gases.	Best suited to addressing all six GHGs in integrated strategy

[35] Vattenfall, *Curbing Climate Change: An Outline for a Framework Leading to a Low-Carbon Society.* January 2006. At: www.vattenfall.com/www/vf_com/vf_com/Gemeinsame_Inhalte/DOCUMENT/360168vatt/386246envi/Curbing_climate_report.pdf. Accessed July 17 2006.
[36] Ibid.

Administrative complexity/ transaction costs	Familiar instrument to policy-makers and all consumers. Monitoring and enforcement mechanisms can build on existing tax infrastructure. Low transaction cost.	Administrative infrastructure complex, many technical issues and transaction costs related to trading, monitoring, enforcement.
Revenue	To government; often recycled into companion GHG reduction initiatives or reductions in other taxes	May initially go to government if allocation is by auction; Retained by permit seller once permits allocated; creates a private market for reductions.
Distributional equity	Revenue recycling may address distributional impacts	Equity can be addressed in initial allocation.
Political acceptability	Strong political resistance in North America	Preferred price instrument in North America

5.3. ADDRESSING CONCERNS ABOUT BROAD BASED SIGNALS

The broad-based application of emissions charges and emissions trading imposes a high standard for "getting it right". Many of the concerns raised about their application can be addressed with careful design. Key among these concerns are impacts on competitiveness, equity, and the overall tax burden.

5.3.1 Competitiveness

Maintaining the international competitiveness of industries producing goods that are traded in the international marketplace is a key consideration when designing charge or emissions trading measures, since these raise the marginal costs of production for emitting firms. This concern is particularly strong where the climate change policies of trading nations diverge, and where substitution options are limited. Concern about reduced international competitiveness is highest among those industries that are the most emissions intensive. The OECD has identified a number of design options to reduce negative impacts on competitiveness of EFR measures, without erosion of the environmental effectiveness of the EFR measure. These include: [37]

- **Integration of environmental reforms within broader fiscal reform.** Sectoral and nation-wide competitiveness will be determined by the combined effects of the fiscal regime within which firms operate, not by the environmentally-motivated incentives alone. This form of broad based revenue recycling may enable revenue neutrality for industry as a whole, but not necessarily for individual businesses. German experience has shown that the introduction of environmental taxes works best when

[37] OECD, *Environmentally Related Taxes: Issues and Strategies*, Policy Brief. OECD, Paris, November 2001.

they are part of a policy package that includes tax reductions elsewhere in the economy.[38]

- **Two tier rate structures**: The use of lower charges for more internationally exposed sectors can maintain the incentive effect of the charge and the integrity of the polluter pays principle, while reducing competitiveness impacts.

- **Conditional exemptions or lower charges:** Exemptions from charges or lower charges can be provided to firms adopting equivalent mitigation measures on a voluntary agreement basis. If the firm does not honour the agreement, the full charge is reinstated. Where appropriate monitoring, verification, and sanction systems accompany these voluntary agreements, this approach can address international competitiveness concerns while limiting the negative environmental effects of blanket exemptions or rate reductions.

- **Rebates:** the charge can be accompanied by measures to channel some or all of the revenue back to the sector or individual firms in such a way that the marginal abatement incentives are not reduced—for example under the Swedish NOx charge, plants are charged per kg NOx emitted, and reimboursed based on total energy output. However, the earmarking of revenue to specific programs may be a barrier to the future re-evaluation and modification of the programs, since the spending program becomes dependent on the revenue from the charge, and bureaucratic inertia may prevail. To avoid this, the environmental and economic rationale of the measures should be regularly evaluated.[39]

- **Charge-ceilings:** A maximum payment can be set.

- **Border charge adjustments:** Border charge adjustments can be used to impose equivalent charges on imported goods and redeem the charge for exported goods. This is one method of avoiding 'leakage'—that is, the unintended transfer of environmental damage to jurisdictions that do not have equivalently rigorous greenhouse gas emission reduction policies in place. An example is the US border tax adjustment on ozone depleting substances. Border charge adjustments must be designed to be consistent with international trade agreements, and consideration must also be given to preventing smuggling.

[38] Kai Schlegelmilch, German Ministry of the Environment, at the Supporting a Sustainable Future: Making Dollars and Sense International Conference on the Use of Economic Incentives and Instruments in Environmental Policy. December 2000.
[39] Flip de Kam, *Discussion Paper for the Conference on Environmental Fiscal Reform*, OECD, Berlin June 27 2002.

The competitiveness implications of the proposed measure should be considered in comparison to those of alternative policy instruments for achieving the same emissions reduction objective. Alternative policy instruments (command and control or voluntary agreements) would also impose costs, but may do so with less equity or economic efficiency.

5.3.2 Equity/Distributional Impacts

In the absence of mitigation or compensation measures, charges will be regressive—that is, they will constitute a larger portion of a low-income households' income than of a higher-income households'. In principle, no charge should be constructed in such as way that inequality is worsened for the disadvantaged.

This principle can also be considered from a regional perspective (a key political consideration in Canada) and a sectoral perspective.

Distributional concerns may be addressed either through mitigation or through compensation:

- **Mitigation** alleviates the distributional impacts of the program itself through strategies such as charge-free floors or reduced rates or exemptions for certain populations/sectors. However, mitigation approaches dilute or cancel the price signal of the measure, and hence its effectiveness.

- **Compensation** offsets the distributional impact by providing aid through a separate program—for example, reductions in other taxes (tax shifting) or transfer payments targeted to the disadvantaged population/sector. For example, EFR measures in northern Europe have been accompanied by a revision of fiscal brackets. Compensation approaches maintain the price signal of the core EFR measure, while leaving the individual party no worse off. Danish experience has been that the information required to administer measures to address distributional effects generally resides with income tax and welfare authorities, and therefore a compensation approach through the income tax and social benefit system has a lower administrative burden.[40]

5.3.3 Impact On Overall Tax Burden

Key to public and political support for emission reduction measures will be acceptance of how the revenue and expenditure aspects of the measure will be handled. This aspect is particularly key in North America, where a distrust of governments' abilities to

[40] Hans Larsen, *Comments on Discussion Paper, OECD Conference on Environmental Fiscal Reform, Berlin, 27 June 2002.* Ministry of Taxation, Denmark, 2002.

responsibly manage public funds has presented a distinctive challenge to discussions about emission charges and other cost-internalization tax measures.

Some jurisdictions, such as the U.K., have adopted a revenue-neutral tax reform model for their climate change policy packages, along the principle has been that there should be no increase to the overall tax burden. However, in the NRTEE's former Ecological Fiscal Reform Expert Advisory Group, the general feeling was that this would be too rigid because the Canadian approach to EFR is broader than tax reform—it includes restructuring, removal, or introduction of subsidy and expenditure-based programs.

The following approaches can be considered:

- **Revenue-recycling for revenue-generating programs**: If the measure creates new revenue, this should be recycled such that the implementation of the measure does not result in an increase in overall government revenues.

  There are many options for the use of carbon emission-derived revenues. A broad-based approach recycles the revenue back into reductions in other taxes. A sector-based approach recycles the revenue back into the sector of origin, through the use of credits, tax reductions, direct rebates, or program expenditures. Under the sector-based approach, revenue-neutrality for the sector as a whole does not necessarily mean revenue-neutrality for the individual firm. An entity-level approach recycles revenues back to the individual firm/household such that the individual party, having taken the desired environmental action, is no worse off than before.

  Revenue-recycling constitutes a form of revenue earmarking. From a fiscal policy perspective, earmarking is discouraged because it is seen to introduce rigidities into the fiscal system. Earmarked expenditure programs are no longer evaluated on the basis of their merits, and the result may be inefficient government spending.

  Revenue-recycling can be used to alleviate concerns about the competitiveness and equity/distributional impacts (see above two sections).

- **Expenditure-neutrality for subsidy and expenditure programs:** Subsidy and expenditure programs can be designed so as not to increase the general revenue requirements of the government. This can be done by:
  - *Reforming subsidies***:** so that existing subsidy envelopes are redirected to emission reduction initiatives;
  - *Expenditure reforms***:** where new expenditures in emission reductions lead to a reduced need for expenditures in another; or

- *Cross-funding from revenue-raising emission reduction measures:* where a new expenditure or subsidy program is funded from the revenue raised by a revenue-raising program that is part of the same policy package.

- **Transparency**: Whatever the final funding and revenue features of the final EFR measure or package, transparency is essential for ongoing public and political support. Any taxes or charges should be visible. Revenues raised and expenditures made through the EFR measure should be publicly reported on a regular basis.

5.4. ENGAGING CAPITAL MARKETS

Broad based price signals such as carbon charges and emissions trading alone are not likely to be sufficient to drive the adoption of low carbon options in the ongoing renewal and expansion of the large infrastructure assets found in the energy and transport systems. Broad-based price signals give only indirect incentives to innovation, by indicating that low carbon technologies are likely to have higher value in the future if and as emission targets are strengthened through successive negotiating rounds; but this is unlikely to be sufficient to finance the degree of risky technology and innovation investments required. Therefore more active policies to stimulate innovation directly, across the full innovation chain from R&D to large-scale commercialisation, will continue to be needed as a complement to carbon taxes or tradable permits.

Some of this can be achieved through measures targeted directly to priority technologies, as discussed in section 6, below.

Some, however, will need to come from initiatives outside of government, through the engagement of the capital markets that will be financing this ongoing renewal and expansion of the large infrastructure assets in becoming promoters of low carbon technologies and performance expectations, themselves.

UK research identifies this as a key area neglected by most policy research. Their research suggests that asset managers can be stimulated to consider climate change by measures such as the following:[41]

- Regulatory guidance that climate change is a material issue to corporate reporting;
- Defining the duties of investment professionals and trustees as including consideration of long-term issues such as climate change.

The UK climate change plan has sought to leverage and engage capital markets by giving a major role to the Carbon Trust, a business-led, Government backed

[41] Dlugolecki, Andrew, and Mansley, Mark. *Asset Management and Climate Change*, Report on a Workshop Sponsored by the Tyndall Centre. Technical Report no. 20 (London: Tyndall Centre for Climate Change Research, 2004).

independent not-for-profit company funded in part through the Climate Change Levy. The rationale for the Carbon Trust has been to find a new business model for broadening leadership on climate change beyond government to business, NGOs, the research community, and trade unions. The trust deploys a range of financial and non-financial support both to develop new technologies and to deploy existing ones—for example, an energy efficiency best practices program, managing the list of technologies eligible for 100% first year capital cost allowances, an interest free loan scheme for SMEs to invest in energy efficient equipment, and support for innovation through a Low Carbon Innovation Fund.[42]

5.5. ADVICE ON SCOPE AND FOCUS FOR RESEARCH INTO LONG TERM SIGNALS IN PHASE II OF THE NRTEE'S "WEDGES" WORK

This advice assumes that Canada's Large Final Emitters program will be proceeding, perhaps with some modifications, and therefore its design up to 2012 should not be the focus for the NRTEE's work on long term signals for carbon emission reductions.

Three foci for research on long-term signals are proposed, listed by order of priority:

- Broad-based price signals for those emissions *not* covered by the draft LFE program. This would examine the application of a broad-based price signal to sectors such as the household, transportation, manufacturing, and commercial sectors.
  A carbon charge would be the key instrument investigated. For the purpose of comparison, domestic tradable quotas should also be researched although they are less likely to prove attractive.
  The application of a price signal beyond the large final emitters' group is vital to the approach taken in the Wedge scenario, which emphasizes end use efficiency.
  Because of the public/political resistance to carbon charges, it is recommended that the research have a particular focus on the design choices that can be available to respond to public concerns. This would be similar to the NRTEE's early work on emissions trading, summarized in *Canada's Options for a Domestic Greenhouse Gas Emissions Trading Program* (NRTEE, 1999).

- Engaging capital markets in long term deep emission reductions. This would include ground-truthing the measures mentioned directly above in a Canadian setting, following up on some of the ideas put forth by Gord Lambert in his presentation to the NRTEE plenary in Fort McMurray (particularly his recommendation to "follow the money" and explore why capital is and isn't flowing to desired activities),[43] and

[42] *Canada and Kyoto—a European Perspective*. Presentation by Grubb, Michael, Associate Director of Policy, The Carbon Trust. Hosted by IISD, Ottawa, October 2002.

[43] Lambert, Gord, "Our Energy Dilemma: Reconciling Societal Expectations for Energy and the Environment. An Energy Producer Perspective", Presentation to NRTEE Plenary, Fort McMurray, November 8 2005.

exploring the idea of different business models for engaging capital markets in taking leadership on deep emission reduction pathways.

- As mentioned above, it is assumed that Canada's Large Final Emitters program will proceed in a relatively similar format. The focus for any NRTEE research on the LFE program should therefore focus on the post-2012 period. Possible emphasis includes:
  - Lifting the price cap;
  - Broadening coverage as an alternative to a carbon charge;
  - Linking with other existing and emerging emission trading schemes.

  The latter point is raised because of the high priority this is expected to have as the LFE program rolls out. The key issues have already been identified in recent work by the NRTEE (Doug Russell, GSCI-Natsource Consulting *Consistency in Carbon Markets: Linking Canada's Domestic Market to International Markets*. Ottawa. April 2006.) However it should be noted that the wedges scenario assumed entirely domestic emission reductions, so fungibility with other trading schemes is not essential to its implementation.

6 TARGETED MEASURES FOR THE THREE LARGEST WEDGES

6.1. INTRODUCTION: TARGETED MEASURES

The UK experience with broad-based instruments (the Climate Levy and Emissions Trading) is that these are a key driver, but are in themselves too blunt to stand alone. Effectiveness and efficiency are improved by combining these with targeted measures to support innovation and take up of new technologies.[44]

The challenge is to design policy packages that combine measures neutral enough to promote the development and deployment of a suite of low carbon technologies, yet also tailored enough to push and pull some specific technologies that might not enter the market under a broad policy mechanism. New technologies come to the market through an innovation chain that may require policy intervention at different points to overcome institutional and market barriers. This policy intervention must be appropriate to the phase of innovation and adequate to see the new technology through to commercial competitiveness.[45]

[44] *Canada and Kyoto*, op.cit.

[45] Alic, J, Mowery, D, and Rubin, E. *U.S. Technology and Innovation Policies: Lessons for Climate Change*. (Arlington: Pew Centre on Global Climate Change, November 2003.)

The targeted measures described below illustrate the types of measures that are needed to support the adoption of new technologies, in complement to broad-based price signals such as carbon charges and/or emissions trading.

6.2. RELEVANT LESSONS FROM THE NRTEE'S ECOLOGICAL FISCAL REFORM PROGRAM

In addition to the criteria outlined in Section 3, previous research in the NRTEE's Ecological Fiscal Reform program has identified some other factors that would be helpful in screening whether generic classes of fiscal instruments will be appropriate to specific wedges. These include:

- **Nature of emission sources***:* are the emissions from large point sources or from diffuse sources?
- **Nature of actors—capacity***:* Do the actors have the capacity to engage in policy instruments that are administratively complex and are they able to shoulder transaction costs?
- **Nature of actors—corporate***:* Does the corporate model of the actors make them eligible/subject to the measure? Some actors, for example crown corporations and municipalities, are not subject to the same tax regime as private corporations. This influences the choice of fiscal instrument.
- **Market setting***:* The size and structure of the Canadian market needs to be considered in evaluating long-term signals.
  - Is the Canadian market a technology taker? The comparatively modest size of the Canadian market may make it difficult for Canada to adopt, on an autonomous basis, technology forcing measures for technologies with no readily available substitutes or alternatives—threshold levels of demand, higher than Canada can create, may determine the market's ability/willingness to supply these technologies.[46]
  - Is the price that firms can charge for their product or service set in the global market (price taker), or can costs of abatement be passed on to consumers? Is there an ability to differentiate the product or service on the basis of emissions performance, and to charge a "green premium"?
  - How many actors are there, and how many sources of emissions? Instruments such as emissions trading, and associated components such as banking and averaging, require a critical mass of actors and emission sources to create a competitive and dynamic market. Small numbers of actors in the Canadian market and/or few sources of emissions can undermine the economic efficiency that is a core rational for these instruments.
- **Development stage of technology***:* How mature is the technology?

[46] This was found to be a key issue in the NRTEE's EFR Cleaner Transportation case study, which considered fiscal instruments to facilitate the adoption of ultra-low sulphur diesel fuel and diesel freight and mass transit engines. Dewees Consulting Limited, *Fiscal Instruments for Diesel Emission Reduction: A Preliminary Analysis"*, Report to the Cleaner Transportation Working Group, NRTEE, October 1 2001.

- Mature technologies are at a market-ready or market-entry stage of development; there is no appreciable cost difference between these technologies and incumbent technologies. The focus should be on demand-pull instruments that facilitate and promote the uptake of existing technologies.
- Emerging technologies span demonstration to early market-entry stages, and successfully addressed performance issues; there is a moderate price differential versus incumbent technology. The focus on instruments that help bridge the price gap between mature technologies and the emerging ones. The operating assumption is that the price gap will close with increasing market penetration and progressively favourable economies of scale.
- Longer-term new technologies are still in fundamental research to demonstration stages. They are characterized by large cost differential between the new technology and incumbent technologies, and still have to resolve performance issues. The focus for these should be on promoting R&D through R&D subsidies and investment incentives.[47]

6.3. NOTE RE: MEASURES PROPOSED FOR FURTHER RESEARCH

The measures listed under the "Advice to the NRTEE" section for each of the three following wedges are proposed with the following caveats:

- It is assumed that a broad-based price signal (charge or tradable permit) is also in place;
- The measures represent of **menu of options** to be considered based on a review of relevant literature. They have not been screened for effectiveness, efficiency, equity, or competitiveness concerns, however there has been some consideration of development stage of the technology(ies) and nature of actors.
- Subsequent analysis and screening should include the criteria outlined in sections 3 and 6.2, with a particularly a firm eye to the emissions reduction objective.

It is recommended that the analysis for each wedge include a preliminary assessment of the extent to which any **existing** fiscal signals may be incenting carbon emissions.

6.4. FREIGHT TRANSPORTATION

6.4.1 Wedge 2050 Scenario Summary

- **Vehicle Efficiency** (158 Mt CO_2e reduction): triple Light and medium truck vehicle efficiencies, and double Heavy truck efficiency. Fifty percent reductions in rail energy intensity and 25 percent reductions in marine energy intensity.

[47] National Round Table on the Environment and the Economy, *Economic Instruments for Long-term Reductions in Energy-based Carbon Emissions*, Ottawa, 2005.

6.4.2 Analysis

For Small and Medium trucks, existing, demonstrated and cost-effective technologies to increase energy efficiency by 50 percent exist today, through reduced vehicle weights, increasing engine efficiency and aerodynamics, use of hybrid motors to allow recovery of braking energy, and more appropriate engine sizing.[48] The development stage of the technology can therefore be classified in the range from emerging technologies to mature technologies.

This wedge is characterized by diffuse emissions from millions of sources. Actors range from individual owners and small companies, to large private and public organizations with corporate fleets. Certain portions of the market (e.g., long haul heavy trucks) operate in highly competitive, bi-national markets with very small profit margins. Other portions of the market (e.g., truck fleets for commercial operators) are less constrained.

Political resistance to fuel price increases, particularly in the highly-competitive and low-profit long haul trucking sectors, needs to be considered in assessing politically realistic options for influencing freight vehicle efficiency.

6.4.3 Advice on Measures to Investigate in Phase II of the NRTEE's "Wedges" Work

- Extent to which existing fiscal signals may be incenting purchase and retention of less efficient trucks.
- Carbon charge on diesel fuel (with advance notice of implementation and gradual increase over time)
- Extend LFE system to include tailpipe emissions from freight transport, indirectly through diesel fuel suppliers. [49]
- Freight vehicle acquisition and ownership charges based on fuel efficiency:
    - Sliding annual licensing fees based on fuel efficiency;
    - Fee/rebate taking into account weight class and/or purpose of the truck to encourage truck purchasers to buy the most efficient vehicles within their desired market segment;
    - Preferential capital cost allowance for most efficient/lowest emission trucks per unit size or weight, for low rolling resistance tires, etc

[48] Torrie Smith Associates Inc., *Greening the Canadian Courier Fleet—Strategies for Improved Fleet Efficiency*, prepared for Sierra Legal Defence Fund and Greenpeace, 2001. Quoted in ICF International, *Energy-Related Greenhouse Gas Emissions in Canada in 2050 – A Low-Emission Scenario*, prepared for NRTEE, May 2006.

[49] For a description of how this might work within the EU ETS, see Grayling, Tony, Gibbs, Tim, and Castle, Ben. *Tailpipe Trading: How to include road transport in the EU Emissions Trading Scheme*. London: Institute for Public Policy Research, June 2006. (www.ippr.org)

    - Tax credits or subsidies to make most efficient vehicles price competitive with incumbents.
- Low emission freight vehicle portfolio standards:
    - Vehicle emission portfolio standards for truck manufacturers: low emission trucks.
    - Corporate fleet emission portfolio standards for fleets above a certain threshold.

The lessons learned through two previous NRTEE projects, the Cleaner Transportation Working group (2001) and the vehicle fee/rebate study (2005) should be considered.

6.5. CARBON CAPTURE AND GEOLOGICAL STORAGE

6.5.1 Wedge 2050 Scenario Summary

Combined reductions of 191 Mt CO_2e, from:

- **Electrical Generation**: All fossil-fired electrical generation in Alberta, Saskatchewan and Manitoba uses CO_2 capture and storage by 2050 (90 per cent emissions reduction);
- **Oil and Gas industry:** Emissions reduction of 30 percent by 2030, and 60 percent by 2050.

6.5.2 Analysis

The development stage of the technologies for carbon capture and sequestration vary:[50]

- Carbon capture in natural gas production is a mature technology;
- Post-combustion carbon capture in power generation is a well developed technology, but expensive and energy-intensive;
- Pre-combustion carbon capture systems are at or near commerciall demonstration stages for coal feed and petroleum coke;
- Oxygen-combustion carbon capture in power generation is still in development stages.

[50] Benson, Sally. *Carbon Dioxide Capture and Storage in Underground Geologic Formations*, from workshop proceedings, "The 10-50 Solution: Technologies and Policies for a Low-Carbon Future." The Pew Center on Global Climate Change and the National Commission on Energy Policy; and Griffiths, Mary; Cobb, Paul; and Marr-Laing, Thomas. *Carbon Capture and Storage: An Arrow in the Quiver or a Silver Bullet to Combat Climate Change?* Pembina Institute, November 2005; Intergovernmental Panel on Climate Change, *Special Report on Carbon Dioxide Capture and Storage; Summary for Policy-Makers*. Sept 25, 2005; keman, Brent; Gunter, Bill; and Mitchell, Bob. "A Technical Overview of CO_2 Capture and Geological Storage". Paper commissioned for the NRTEE, Alberta Research Council, May 2005.

- Compression and transport of CO2 are well established technologies that are used routinely today for enhanced oil recovery, beverage carbonation, and fire suppression
- The technology to inject CO2 underground is mature and practiced routinely in CO2 enhanced oil recovery projects. Little to no new injection technology will be required to enable CCS.

In sum, conventional technologies and industry practices are presently available for each step in the production chain: the manufacture of hydrogen; the separation of pure CO2; the pipeline transport and geological sequestration of CO, and the pipeline transport of hydrogen. New technologies are under development to broaden the application of CCS as a net emission reduction strategy. However, the integrated system remains untested, particularly on the scale being considered, and key elements of the transport infrastructure are not yet in place.

The development stage of the technology suggests a "technology pull" approach, with modest targets commensurate at the initial stage with the potential of the mature and well developed technologies, and growing in rigour over time as new technologies emerge.

The ecological, human health and safety aspects of this technology are still under debate, posing a distinctive dilemma to an aggressive policy push for CCS adoption. The legal, regulatory, and liability framework for widespread CCS have not yet been developed.

This wedge consists of large point source emissions. All actors are large firms, but with substantially different corporate models—private corporations in the oil and gas sector and some Alberta electricity generators, and crown corporations for much of the electricity generating actors. This wide variation among the actors suggests that a tax-based measure would not be practical. Furthermore, new mines and major expansions in the oil sands already receive high rates of capital cost allowance (eligible capital expenditure for new mines or major expansions as well as capital costs exceeding 5% of gross project revenue may be deducted to the extent of income from a particular mine), effectively saturating tax-based incentive options even among the actors who could be influenced by a tax measure.

Opportunities to derive income from CO_2 in enhanced oil recovery will provide favourable economics in the early phase of take-up of this technology.

6.5.3 Advice on Measures to Investigate in Phase II of the NRTEE's "Wedges" Work

There are two different approaches that could be adopted to encourage the deployment of CCS.

The first targets CCS directly, through technology-based measures. As described above, tax incentives are not likely suitable to this technology.

- Technology-focussed quantity-based instrument: CCS standard, requiring a minimum level of CCS across the oil and gas and electricity generation sectors. This would be a tradable obligation, akin to the renewable portfolio standards.[51]

The second targets CCS as part of a system of production, and would focus on tightening emissions performance targets for the oil and gas and electricity generation sectors. This latter approach is not technology prescriptive (ie other approaches such as energy efficiency, renewables could also be used to meet the performance target), but the target would be set knowing that it would most likely be met through CCS.

- Post 2012 LFE targets for the oil and gas and electricity generation sectors, set at a level that assumes certain levels of CCS.

As for the previous measure, analysis should begin with a consideration of the extent to which any existing fiscal signals may be impeding the uptake of CCS.

In addition to resolving legal, regulatory, ecological and health and safety issues such as that lie in the public policy domain, progress on CCS may be impeded without resolution of the liability issues which lie in the private domain of the insurance industry. The NRTEE may wish to examine the role of the insurance industry in creating a coherent enabling framework for deployment of this technology.

6.6. COMMERCIAL BUILDINGS -- ENERGY EFFICIENCY

6.6.1 Wedge 2050 Scenario Summary

- **Existing Buildings Retrofits** (28 Mt CO_2e reduction): As of 2010, all retrofits of commercial buildings would be designed to Leadership in Energy and Environmental Design (LEED) Platinum standard;
- **New Buildings—Integrated Building Systems** (26 Mt CO_2e reduction): As of 2010, all new commercial buildings are built to LEED Platinum standard.
- **New Buildings—Lighting and Equipment – Electrical efficiency** (20 Mt CO_2e reduction): reduce lighting energy use by 50 percent by 2050; improve auxiliary equipment efficiency by 25 percent; reduce water heating energy by 35 percent; reduce energy use by auxiliary motors by 20 percent; reduce cooling requirements by 30 percent.

[51] These are proposed in more detail in Jaccard, op.cit., p.18-20.

6.6.2 Analysis

Technologies to achieve the wedges scenario are mature or emerging to mature technologies. Some of these technologies already receive accelerated capital cost allowance under Class 43.1.

This sector is characterized by thousands of small, medium and large sized actors. This makes the use of market-based performance standards challenging, due to their administrative burden.

Among the barriers that must be considered in implementing this measure is the culture of the sector. The construction and commercial buildings management sectors are conservative with low inherent innovation---the same basic set of technologies has been in use for at least a half century. Lower-carbon technologies do not offer the marketing incentive of product differentiation (insulation, or new generation technology, does not change the product that final consumers see).[52]

6.6.3 Advice on Measures to Investigate in Phase II of the NRTEE's "Wedges" Work

The research conducted for this advisory note leads to the conclusion that command and control regulations, via building codes and requirements for LEED performance standards, should remain the major long term signal for improving energy efficiency in commercial buildings.

Expansion of the grants already available under NRCan's Energy Retrofit Assistance Program and Commercial Buildings Incentive Program should also be investigated. This may focus on the design of the program (participation rates) as much as on the amount and eligibility of the incentive itself.

As with the previous wedges, the research should begin with a consideration of the extent to which existing fiscal signals may be incenting the renovation and building of commercial buildings to efficiency standards below best available technologies.

7 THE (EVEN) LONGER TERM PERSPECTIVE

While the wedges scenario (and the discussion of long term signals, below) is limited to consideration of deployment of existing and near-term technologies, this is not to imply that policies to support the research and development of new technologies can be shelved.

[52] Carbon Trust, Carbon Trust Submission to Consultation on Review of the UK Climate Change Programme, March 2005.

Over the course of the half-century considered in the wedge scenario, new and as yet unproven technologies may emerge to provide more cost-effective and innovative solutions to greenhouse gas emission reductions than the technologies available today.

The original wedge analysis at the international scale, conducted by Pacala and Socolow, [53] pointed out that even if the carbon and climate problem of the first half of the century can be managed simply by scaling up existing and near term technologies, many of the wedge strategies saturate by mid-century (land for biofuels, formations for CO2 storage, space for windfarms, etc). To maintain a less-than doubling trajectory (stabilization at 450 ppmv or below) in the **second** half of the century, we will need to go beyond emissions stabilization and to do this, revolutionary technologies will be required. Therefore the need for an expanded R&D program for so-called revolutionary technologies (such as space-based solar power satellites, deep-sea CO2 sequestration, nuclear fusion and climate engineering) arguably remains.[54]

[53] Pacala and Socolow, Science vol 305, p. 968 (2004).

[54] Hoffert et. al., Science vol 298, p. 981-987 (2002).

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