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TRADE, INVESTMENT AND CLIMATE CHANGE SERIES

Greenhouse Gas Emission Impacts of Liberalizing Trade in Environmental Goods

Peter Wooders

October 2009

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IISD's Bali to Copenhagen project carries out research, analysis and networking on trade and climate change in six thematic areas: border carbon adjustment; liberalization of trade in low-carbon goods and services; investment; intellectual property rights and technology transfer; subsidies for greenhouse gas reductions; and fossil fuel subsidies. For more on IISD's work on trade and climate change see www.iisd.org/trade/crosscutting, or contact Aaron Cosbey at acosbey@iisd.ca.

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1 Introduction

1.1 Objectives

The environmental goods and services liberalization talks in the Doha Round of trade negotiations aim to lower or eliminate tariff and non-tariff barriers to trade in these goods and services. They have stumbled primarily on trying to define what an environmental good is. This seemingly intractable debate is likely to be eventually resolved on the basis of mostly political considerations.

Various proposals have been put forward in the negotiations to define a list of environmental goods. We do not yet have an understanding of the environmental implications of these proposals. This paper aims:

> *to define, with as much precision as possible, what the greenhouse gas (GHG) mitigation potential is for the Doha talks on environmental goods.*

It takes as a point of departure the proposed lists of goods put forward in the negotiations, determining the GHG mitigation potential that might reasonably be expected to result from the increased trade of the goods in question.

The analysis necessarily involves a number of assumptions about baseline and usage. The purpose of this exercise is to establish a "back-of-envelope" level of accuracy in estimating the potential gains from the EGS exercise: results are indicative, rather than definitive.

1.2 Context of this paper

IISD has a major Trade and Climate Change program running through 2008 and 2009. *From Bali to Copenhagen* is a two-year program of research and consensus-seeking on trade and climate change; one of the focus areas is "Trade Liberalization for Low Carbon Goods." The basic proposition is that if barriers (both tariff and non-tariff) to low-emission goods are lowered, there will be increased incentives to invest, and increased uptake, in those technologies and goods.

This paper is one of a series within the "Trade Liberalization for Low Carbon Goods" focus area. Others consider the lessons that can be learned from MEAs and from labelling, including on how lists of technologies and goods can be developed, maintained and updated.

2.0 Proposed Lists of Environmental Goods Put Forward to the WTO Negotiations

2.1 List of 153 environmental goods

A list of 153 environmental goods was submitted to the WTO's Committee on Trade and Environment Special Session (CTESS) as an informal document[1] in April 2007 by the Friends of the EGS Group[2] for discussion in the WTO. The Friends of the EGS Group comprises mainly developed countries. There has been strong opposition to the list, and indeed to the concept of using a list, by certain developing countries. This paper takes the view that the list as proposed is the most advanced one for analysis purposes but does not comment on whether such a list is economically or politically a good approach.

This list was derived from a larger list of more than 400 products that had been proposed over the previous two years.[3] The list was developed following a detailed review by the Friends of the EGS Group, which identified that a "Potential Convergence Set" of products was needed to permit greater focus and engagement from the CTESS. The list was developed using three principles—items that are considered by the Friends of the EGS Group to:

1. be particularly important—even critical—for environmental protection, and workable from a customs facilitation perspective;
2. have the potential for a high degree of convergence among members; and
3. serve as a basis for further work and negotiation under paragraph 31 (iii) of the Doha Declaration.[4]

The Friends of the EGS list of 153 products is sub-divided into 12 Product Specifications. Table 2.1 lists these and shows the number of products under each specification. An initial commentary on how important each specification would be as a potential source for GHG emission reductions, developed by IISD, is shown in the final column.

[1] Continued Work Under Paragraph 31 (iii) of the Doha Ministerial Declaration. (2007, April 27). Non-Paper by Canada, the European Communities, Japan, Korea, New Zealand, Norway, the Separate Customs Territory of Taiwan, Penghu, Kinmen and Matsu, Switzerland, and the United States of America. JOB(07)/54 Committee on Trade and Environment Special Session. 27 April 2007

[2] Ibid – see list of authors

[3] These items have all been compiled by the Secretariat in TN/TE/W/63.

[4] The Friends of the EGS Group notes that, "The WTO negotiations under paragraph 31 (iii) of the Doha Declaration have underlined the point that environmental goods are continually developing in new and often unexpected directions" and that "some form of review mechanism of any set of items agreed for liberalization would be useful."

Filtering the list shows that only Renewable Energy Plant (under Product Specification 4) has the potential to have a significant impact on GHG emissions. This is not wholly surprising—the list was developed to consider the wide range of possible environmental impacts, not only those concerned with climate change.

2.2 World Bank list of 43 environmental goods

Annex I contains the 43 items from within the full list of 153 goods that were identified as "climate friendly" by the World Bank, and formed the list submitted to the WTO by the EC and the U.S. on November 30, 2007.[5]

2.3 World Bank list of 12 environmental goods (not put forward to WTO)

The World Bank identified a shorter list of 12 goods for a study on trade and climate change published in 2008 (see Section 3.4 for full details; Annex II contains the list of 12 goods). The list was identified as being relevant to climate change but also had something of a "test" nature, being designed to examine the impacts on trade of removing tariff and non-tariff barriers on environmental goods in general. It includes goods related to wind power, solar power, energy efficient lighting and "clean" coal. Some of these items are covered in the list of 153; others are new. Section 3.4 discusses this list and its implications in more detail.

[5] See for example the EurActiv article of December 4, 2007, "EU, US eye WTO free trade pact for climate-friendly goods" (http://www.euractiv.com/en/climate-change/eu-us-eye-wto-free-trade-pact-climate-friendly-goods/article-168828).

Table 2.1: Friends of the EGS Group: Product specifications and their potential for GHG emission reductions

Product Specification	Number of Products	Potential for GHG Emission Reductions (IISD Analysis)
1. Air Pollution Control	13	**Negligible** – equipment would reduce other sources of pollution, possibly sometimes with a small energy penalty[6]
2. Management of Solid and Hazardous Waste and Recycling Systems	24	**Possibly some** – majority of equipment is concerned with waste storage, containment and recycling/disposal. Biomass boilers, waste heat recovery equipment and incinerators could all be used to generate energy and thus displace emissions from other sources. Improved landfill matting avoids methane emissions.
3. Clean Up or Remediation of Soil and Water	4	**Negligible** – equipment aims to remove oil or other compounds from soil and water and would consume some energy in its use
4. Renewable Energy Plant	28	**High** (depending on uptake) – equipment forms parts of wind, solar thermal, solar photovoltaic, CHP[7], hydroelectricity (small systems – only up to 1 MW capacity[8]), biogas, biomass and heat pump systems. Many items could be used for renewable energy plants or other energy plants, or other applications
5. Heat and Energy Management	6	**Possibly some** – four of the six items are meters (measurement programs can be used as a management tool for energy efficiency), the only two specific items are glass fibre (which can be used for building insulation) and heat exchangers (whose use is widespread throughout industry). This is a very small subset of the technologies which could improve energy efficiency
6. Waste Water Management and Potable Water Treatment	29	**Negligible** - includes some general purpose containers, which form part of many systems (including renewable energy plant such as waste to gas)
7. Environmentally Preferable Products, Based on End Use or Disposal Characteristics	7	**Negligible** – contains natural fibres, which could replace a small fraction of market for synthetic fibres
8. Cleaner or More Resource Efficient Technologies and Products	4	**Low** –includes only parts for solar stoves, batteries (which would be a part of some fuel cell systems) and devices with internal motors (primarily for waste processing)
9. Natural Risk Management	3	**Negligible** – contains surveying/measurement initiatives
10. Natural Resources Protection	3	**Negligible** – contains products to reduce turtle catch in fishing nets
11. Noise and Vibration Abatement	4	**Negligible** – no obvious link to GHG emissions
12. Environmental Monitoring, Analysis and Assessment Equipment	29	**Low** – contains a set of equipment that can be used to monitor and evaluate environmental emissions but has an indirect link to GHG emissions reductions at best
TOTAL	**153**	

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6 For example, flue gas desulphurisation (FGD) and electrostatic precipitators, used to remove oxides of sulphur and particulate matter respectively from coal and other fossil-fuel combustion exhausts.

7 Note that combined heat and power (CHP) can be fuelled by biomass but generally generates heat and electricity from fossil fuels at higher efficiency than if the heat and electricity were generated separately.

8 The European Commission's definition of the sizes of hydro schemes is "mini" (up to 1 MW capacity), "small" (up to 10 MW) and "large" (over 10 MW). These size categories are commonly used.

3.0 Potential GHG Reductions from Trade Liberalization of Environmental Goods on Proposed Lists

A method for establishing a "back-of-envelope" level of accuracy in estimating the potential gains is now described. It involves three stages, described in Sections 3.1 to 3.3:

1. potential uptake of technologies and impacts on GHG emissions;
2. drivers of uptake of technologies;
3. contribution of trade liberalization.

A more complex assessment method, based on the World Bank 2008 study, is described in Section 3.4.

3.1 Potential Uptake of Technologies and Impacts on GHG Emissions

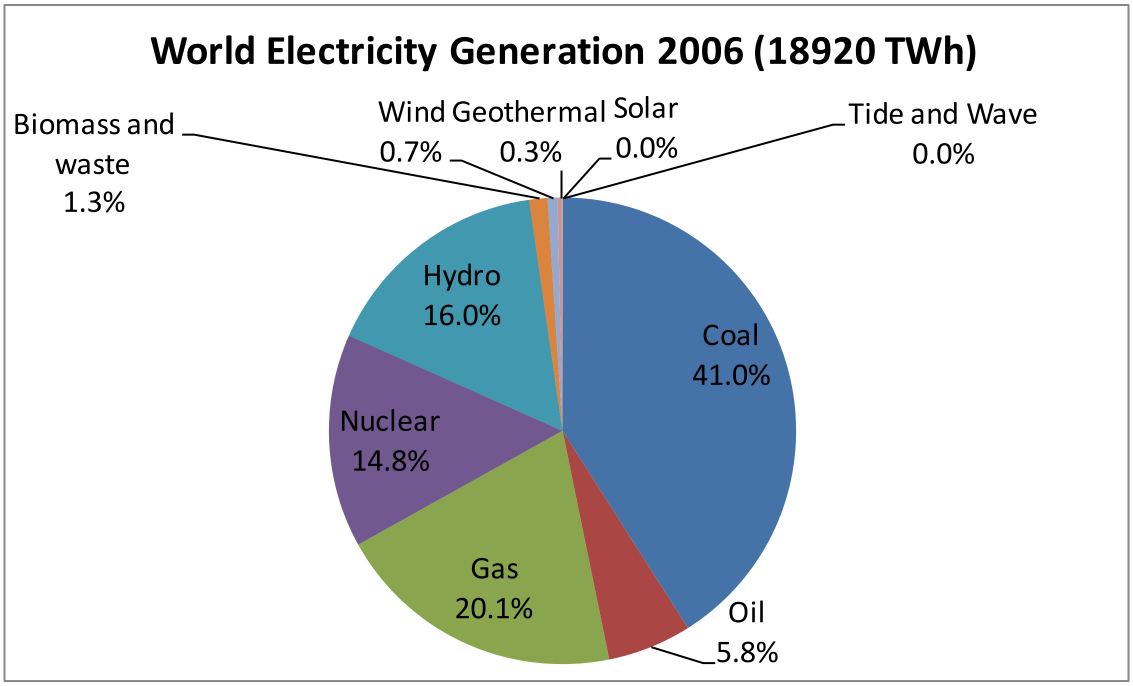
A wide range of studies estimate the potential for renewable electricity generation. Three of these are now described: the World Energy Outlook (WEO) and Energy Technology Perspective (ETP) studies of the International Energy Agency (IEA) and marginal abatement cost curves.

3.1.1 International Energy Agency, World Energy Outlook 2008[9]

Figure 3.1 shows world electricity generation in 2006. Renewables accounted for 18 per cent of electricity generation, nine-tenths of which was from hydroelectricity. Biomass and waste is the next biggest category (1.3 per cent of total world electricity), followed by wind (0.7 per cent) and geothermal (0.3 per cent). Generation from solar and tide and wave is currently negligible.

[9] IEA, 2008a.

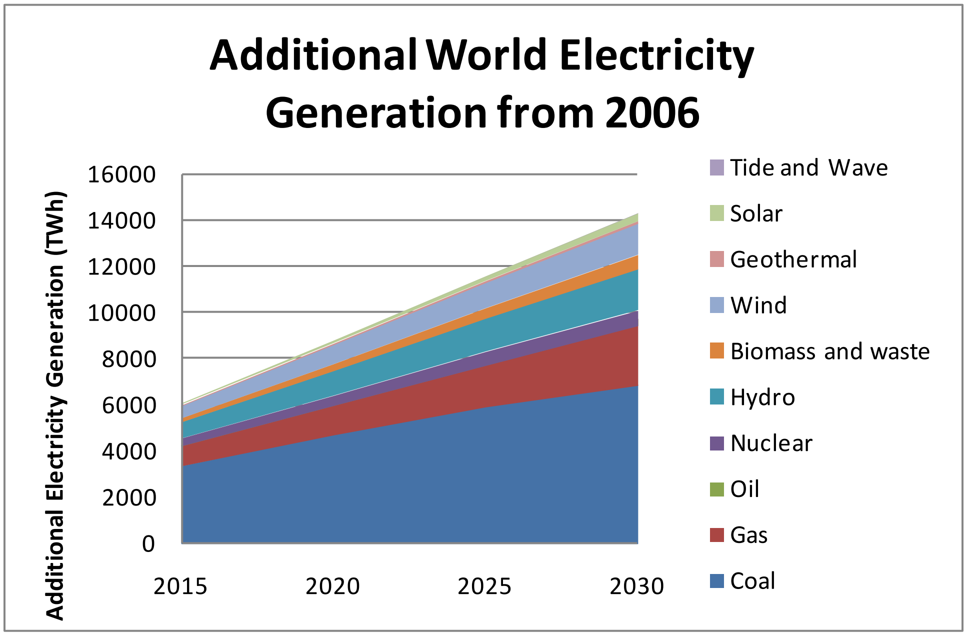
Figure 3.1: World electricity generation, 2006 (TWh)



The IEA WEO is one of many studies that project the future uptake of renewables. Its 2008 report contains three scenarios: a "reference" scenario—which enacts no new policies after 2008—and two others that aim to stabilize atmospheric GHG levels at 550 ppm and 450 ppm respectively. From the "reference" scenario, Figure 3.2 shows projections of increased electricity generation in the period 2006 to 2030, in TWh generated. Coal and gas are projected to account for two-thirds of the increase. Within renewables, hydro is projected to account for the largest growth in generation, followed by wind, then biomass and waste. Solar begins to have an impact towards the end of the period, but represents only 1 per cent of world electricity generation in 2030.

Renewable electricity generation is projected to more than double over the period, from approximately 3,500 TWh to approximately 7,700 TWh.

Figure 3.2: Additional world electricity generation from 2006 (TWh) – IEA WEO Reference Scenario



Renewables would play a much larger role in the scenarios that aim to stabilize GHG atmospheric concentration. Table 3.1 shows significantly higher growth in renewable generation under these scenarios, even though total electricity generation is 10 per cent and 20 per cent lower than in the "reference" scenario (the result of projected increases in efficiency). The scenarios project that a carbon price of \$90/tCO_2 (U.S. dollars, in nominal terms, are used throughout this paper unless otherwise stated) in "OECD+" countries by 2030, plus national policies and measures in the electricity sector in other countries would increase renewable generation by a further 1,500 TWh (an increase of 20 per cent of renewables from the "reference" case). A further 3,000 TWh (a further 40 per cent addition to the "reference" case) would result if the carbon price were raised to \$180/tCO_2 and other policies and measures were enacted to enable stabilization at a concentration of 450 ppm.

Table 3.1: Renewable electricity generation under three IEA WEO scenarios

Scenario	Scenario Assumptions	Electricity Generation, 2030 (TWh)	Renewables Generation, 2030 (TWh)	Renewables Generation, 2030 (per cent)
Reference	"Laissez-faire" – no new policies enacted after 2008	33,266	7,705	23 per cent
550	Cap and trade in OECD+[10], with carbon price at $90/tCO_2$ in 2030; national policies and measures in other countries	30,187	9,161	30 per cent
450	Cap and trade in OECD+, with carbon price at $180/tCO_2$ in 2030; national policies and measures in other countries	28,997	12,126	42 per cent

An estimate of the GHG emissions savings from renewables can be made by assuming that all additional renewables generation would have been met by fossil fuels.[11] The extreme ends of this range are that this would have all been met by coal or all been met by gas. Table 3.2 shows the estimates of GHG reductions due to increased renewable generation, using the average emissions factors for coal and gas in 2030. These show that, if there were no increase in renewable generation from 2006 figures, world GHG emissions would be 2.5–7.7 $GtCO_2$/year higher. This represents an increase of:

- 18–28 per cent in GHG emissions from electricity generation in 2030 under the "reference" scenario;
- 6–10 per cent in GHG emissions from all fossil fuel combustion in 2030 under the "reference" scenario.

It is clear from the IEA WEO study that increased renewable electricity generation is a significant factor in controlling world GHG emissions. It is not clear from the study what role trade liberalization would play in increasing the level of renewable electricity generation: the study does not include specific discussions of either trade liberalization or tariff reduction.

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[10] OECD plus EU countries not in OECD

[11] It would also be possible to increase the share of nuclear to compensate fully or partially for a declining share of renewables. In practice, nuclear and renewables do not tend to be direct competitors for new capacity. The "marginal" choice for new generating capacity in the majority of countries is fossil-fuel based, with the relative availabilities of coal and gas being a key driver in the choice. Nuclear new build requires a concerted government-led program. Even with such a program, the marginal technology for an increase in capacity still tends to be fossil-fuel based. Whilst somewhat of a simplification, we can reasonably conclude that new renewable capacity tends to displace new fossil-fuel based capacity.

Table 3.2: GHG Emissions reductions from additional electricity generation from renewables, 2006–2030

Scenario	Scenario Assumptions	GHG reductions if alternative was gas ($GtCO_2$ /year)	GHG reductions if alternative was coal ($GtCO_2$ /year)
Reference	"Laissez-faire" – no new policies enacted after 2008	2.5	3.9
550	Cap and trade in OECD+[12], with carbon price at $90/t$CO_2$ in 2030; National policies and measures in other countries	3.2	5.0
450	Cap and trade in OECD+, with carbon price at $180/t$CO_2$ in 2030; National policies and measures in other countries	4.8	7.7

3.1.2 *Energy Technology Perspectives (ETP) 2008*[13]

ETP 2008 is one of "a number of publications" produced in response to "the G8 and IEA Energy Ministers [having] asked the IEA to identify and advise on scenarios for a clean, clever and competitive energy future." It proposes two scenarios:

1. ACT Map scenario, which returns CO_2 emissions in 2050 to 2005 levels;
2. BLUE Map scenario, which reduces CO_2 emissions in 2050 to half of 2005 levels.

The baseline (business-as-usual) scenario projects that global CO_2 emissions will grow from 27 $GtCO_2$/year in 2005 to 62 $GtCO_2$/year in 2050. Reductions of 35 $GtCO_2$/year and 48 $GtCO_2$/year respectively are thus required under the ACT Map and BLUE Map scenarios.

The study assesses CO_2 abatement options across the economy and applies them in least-cost order, using partial equilibrium modelling. From the economy-wide Marginal Abatement Cost (MAC) curve, these options are characterized in least-cost order as:

1. end use efficiency;
2. power sector;
3. industry fuel switching and CCS;
4. transport alternative fuels.

[12] OECD, plus EU countries not in the OECD
[13] IEA, 2008b.

Marginal abatement costs are calculated as \$50–100/tCO_2 for ACT Map and \$200–500/tCO_2 for BLUE Map, with the range bounded by technology development perspectives (from optimistic to pessimistic).

ETP 2008 identifies the key technologies and sectors that would contribute reductions. Table 3.3 shows projected emissions reductions from renewable and from other options that have at least 1.0 $GtCO_2$/year emissions reduction potential under ACT Map in 2050. By 2050, it is expected that additional renewables would give 3.2 $GtCO_2$/year reductions under the ACT Map scenario, approximately 10 per cent of the reductions required. This increases to 7.1 $GtCO_2$/year, 15 per cent of the total required, under BLUE Map. Compared to the WEO study discussed above, there are differences in which technologies are expected to make the biggest contribution: wind is identified as the most important technology, followed by solar. The contribution of hydro is expected to be much lower, with biomass becoming significant only under BLUE Map.

Table 3.3: GHG emissions reductions from additional electricity generation from renewables, 2006–2030

	CO_2 Reductions ($GtCO_2$/year)	
Sector/Technology	**ACT Map**	**BLUE Map**
Power Generation		
CCS Power Generation	2.9	4.8
Nuclear	2.0	2.8
Fuel Switching Coal to Gas[14]	3.8	1.8
Renewable Electricity Generation:	3.2	7.1
Wind	*1.3*	*2.1*
Solar – Photovoltaics (PV)	*0.7*	*1.3*
Solar – Concentrated Solar Power (CSP)	*0.6*	*1.2*
Biomass IGCC[15] and Biomass co-combustion	*0.2*	*1.5*
Hydro	*0.3*	*0.4*
Geothermal	*0.1*	*0.6*
Buildings		
Fuel Savings	2.0	2.5
Electricity Efficiency	4.5	4.5
Transport		
Fuel Efficiency	6.0	6.6
2nd Generation Biofuels	1.8	2.2
Industry (incl. Blast Furnace + coke ovens)		
CCS Industry and Fuel Transformation	2.0	4.3
Electric Efficiency	1.0	1.4
Fuel Efficiency	1.9	2.3
OTHERS	**3.9**	**7.7**
TOTAL	**35**	**48**

[14] Via the early closure of coal-fired plants and the building of new gas-fired plants
[15] Integrated Gasification Combined Cycle

3.1.3 *Marginal Abatement Cost Curves*

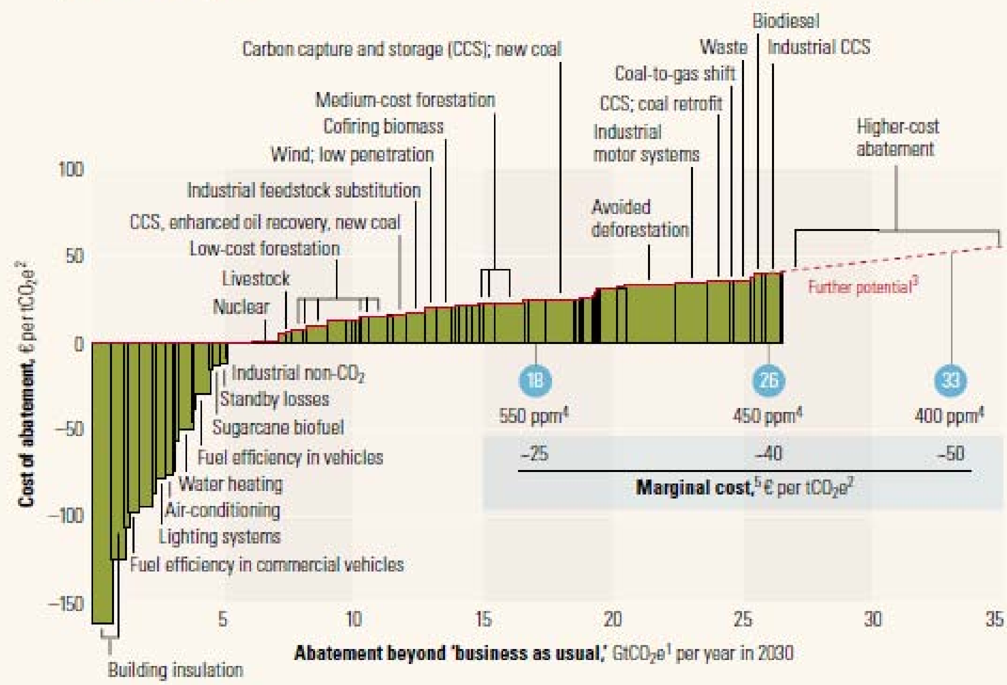
The marginal abatement cost (MAC) curve published by McKinsey in 2007 (Enkvist, *et al.,* 2007) is an example of a number of curves that have attempted to categorize the scale and cost of GHG reduction opportunities across the world. This widely-quoted study consolidates the work of many energy efficiency and carbon abatement studies into a single marginal abatement curve.

Figure 3.3 shows the world MAC curve up to 2030. No renewable technology is in the first 5 $GtCO_2$/year of reductions, a region referred to as the "negative cost" region because the study authors believe that implementing the options would both reduce emissions and reduce financial costs.[16] Within the positive cost options, which stretch the total to 27 $GtCO_2$/year of cumulative abatement and include options with a marginal abatement cost of up to \$40/tCO_2/year, only approximately 0.4 $GtCO_2$/year of wind and 0.6 $GtCO_2$/year of co-firing biomass is included from the renewables category.

The study shows that there is a range of divergent opinions on how much renewables could contribute and which technologies have the most potential. Future events are clearly subject to assumptions: for renewables, those relating to policy, site availability, costs and financial conditions are amongst the most important.

[16] Whether or not such "negative cost" options exist is not universally accepted, with a common criticism being that the curves include only technical costs and thus ignore the wider costs of policy switching. There is much more widespread agreement that the options in the region are those that would have the lowest financial costs, whatever these costs turn out to be in practice.

Figure 3.3: Marginal abatement cost curve for 2030 (Enkvist, *et al.*, 2007)



[1] $GtCO_2e$ – gigaton of carbon dioxide equivalent; "business as usual" based on emissions growth driven mainly by increasing demand for energy and transport around the world and by tropical deforestation.
[2] tCO_2e – ton of carbon dioxide equivalent.
[3] Measures costing more than €40 a ton were not the focus of this study.
[4] Atmospheric concentration of all greenhouse gases recalculated into CO_2 equivalents; ppm – parts per million.
[5] Marginal cost of avoiding emissions of 1 ton of CO_2 equivalents in each abatement demand scenario.

3.2 Drivers of uptake of technologies

The barriers to the uptake of increased levels of renewables are well understood: according to the *World Energy Outlook 2008* (IEA, 2008a), they include:

- the relatively high costs of some technologies in the absence of subsidies;
- relatively limited research and development until recently;
- growing concerns about the impact on food availability of the use of crops for energy;[17]
- a lack of skilled labour;[18]
- a lack of policymaking capacity;
- regulations that discourage variable and distributed power-generating systems;
- inadequate investment in electricity networks; and
- scepticism on the part of major incumbent players in the energy sector on the economic viability of renewables.

Similar lists can be found in many other studies. Of note is that trade liberalization, or tariff reduction more specifically, is generally not mentioned.

The lists do not indicate the most important barriers, but this can be implied from the policies that have been put in place to support renewables to date. Large hydroelectric plants are generally built by countries when their electricity systems are in a relatively early stage and are under state control. Landfill gas and sewage sludge systems are generally competitive with fossil fuel-fired generation, but the majority of other renewables require financial support or, in its place, some sort of guaranteed purchase scheme (e.g. a quota or feed-in tariffs). IEA (2008) gives estimated "levelized"[19] generating costs for hydro, onshore wind and biomass in 2006 as between $40 and $100/MWh (i.e. UScent 4 to 10/kWh),[20] with a bias towards the upper end of this range. Both concentrating solar power (CSP) and photovoltaic (PV) solar generating costs are considerably higher.

[17] This concern does not apply to lingo-cellulosic biomass (e.g. bio-waste and forestry residues).

[18] Note that remediation may be possible by sourcing expertise and equipment from abroad.

[19] "Levelized" generating costs attribute part of the initial investment cost to each unit of electricity generated, by assuming that capital will be repaid at a certain interest rate over a certain period of time. Assumptions must be made as to the appropriate interest rate ("discount rate"), period of capital payment and annual quantity of electricity that the technology would generate. Proponents of technologies can sometimes suggest lower discount rates and higher capital repayment periods should be used than those unconvinced of the merits of the technology: The "correct" rates to use are often contentious.

[20] The basis used for the capital cost estimates in studies such as the IEA's vary: some are based on recorded costs from actual installations whereas others are more theoretical; the treatment of tariffs and taxes varies between the studies. It is generally difficult to say whether estimates explicitly include or exclude tariffs.

Prices from fossil fuel generation are clearly highly dependent on fuel prices and also tend to alter under a number of other criteria (for example, the level of scarcity of generation capacity). Giving precise figures is not a straightforward task, but a range of $30–70 MWh can be considered indicative.[21]

Countries that have seen renewables increase significantly in the past decade have either had:

- feed-in tariffs (FIT), a guaranteed payment to each unit of electricity generated by qualifying schemes and technologies; or
- portfolio standards, whereby a minimum share of electricity generated must be from qualifying schemes and technologies.

Both schemes tend to lead to renewables being paid significantly in excess of wholesale electricity prices. Feed-in tariffs in Denmark and Spain currently give a minimum premium of approximately $50/MWh (UScents 5/kWh); FIT for wind in Germany and South Africa ($122/MWh and $138/MWh respectively) imply a slightly higher premium.[22] FITs increase for smaller schemes and for those where technologies are further from commercialization (e.g. solar).[23] The U.K.'s Renewable Obligation imposes a portfolio standard that increases annually. In its first five years, payments to qualifying schemes were around £50/MWh ($75/MWh) per unit of electricity generated.[24]

The major increases in renewable electricity generation shown in the two IEA studies discussed in Sections 3.1.1 and 3.1.2 require carbon costs of $50–200/t$CO_2$. At these prices, renewables would benefit by $50–200/MWh when compared to coal;[25] if renewables were employed instead of natural gas-fired CCGT, the cost saving would be $20–80/MWh. These figures are of a similar order of magnitude as those from feed-in tariffs and portfolio standards.

It should be noted that such carbon prices may well be a good policy response to the climate change issue; and that feed-in tariffs may also be a good alternative option to internalize the GHG emissions reductions due to renewables into their costs. This section discussed the range of support renewables require to be competitive with fossil fuels, not whether such support is justified or not.

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[21] See, for example, average wholesale prices for the U.S. in the period 2001–07 of $36–57/MWh (see figures from the North American Electric Reliability Corporation [NERC] on the US Energy Information Administration Web site at http://www.eia.doe.gov/cneaf/electricity/wholesale/wholesale.html)

[22] Wind-works.org summarizes feed-in tariffs from around 30 countries at http://www.wind-works.org/articles/feed_laws.html#Renewable Energy Tariffs by Country.

[23] Ibid.

[24] See the UK's Office of the Gas and Electricity Markets (ofgem), the regulator responsible for the RO scheme. http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx

[25] Emissions from coal-fired electricity generation are typically 1.0 tCO_2/MWh; those from natural gas CCGT are around 0.4 tCO_2/MWh.

Many studies[26] project that renewables generation costs will decrease with time, as markets become larger and technology improves. It is possible that renewables will be competitive with fossil fuels without any form of support in the future, but it is generally accepted that this is not the case as yet.[27]

This section has showed that the barriers to trade are well understood and that tariff removal does not tend to feature strongly among them. Wholesale prices tend to be significantly below the cost of renewable electricity generation, which typically requires feed-in tariffs with premia of the order of UScent 5/kWh higher for its development. Whether such premia are justified depends on factors, notably including the carbon price required to meet targets and how much an investment in renewables now will lead to a decrease in their costs in the future.

3.3 Contribution of trade liberalization

3.3.1 Estimating the impact of tariff removal on renewables generating costs

Levelized generation costs for hydro, onshore wind and biomass were noted above to be in the $40–100/MWh range. The majority of these costs result from capital payments: renewables are capital intensive, with operating and maintenance costs relatively low. A study by the Royal Academy of Engineering (2004) indicates capital's share of costs from biomass and wind (onshore and offshore) as 55–75 per cent.[28] IEA ETP (2008) indicates that for wind, around 80 per cent of costs are capital.[29]

The impact of trade liberalization only applies to that share of the costs that is tradable. For wind, the majority of capital costs relate to tradable equipment. Conversely, for large hydroelectricity schemes, civil works to construct the dam and reservoir dominate capital costs; these activities are generally not tradable.[30] These two examples set the extremes of the range. It is important to also take into account the share of goods used in renewable energy projects that are general components useable for many purposes. Thus, there are markets for general components such as motors as well as for specialized components such as wind turbine blades. In general, component markets are larger than specialized equipment markets.

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[26] For example, the two IEA studies in Section 3.1.1 and 3.1.2 both refer to technology learning curves and project lower renewables prices going forward.

[27] Note that some regions with high average wind speeds may be commercially competitive with fossil fuels without any support as may certain niche applications, for example small-scale solar in regions off the electricity grid.

[28] Excluding provisions for standby generation; the study adds extra costs to allow integration into the electricity grid.

[29] It estimates that 74–82 per cent of wind generating costs relate to capital.

[30] Only "mini" hydro schemes are included in the List of 153. Such schemes require different sets of technologies and skills, with capital costs of mini schemes having a relatively higher share of equipment compared to civil works.

The final part of the calculation is the tariff level. Amongst the top 25 countries for renewables trade in 2007, only India (with a most favoured nation tariff of 25 per cent), had a tariff of more than 12 per cent (Jha, 2009). The majority of countries had tariffs of under 5 per cent. Specifically for wind, a World Bank study published in 2008 indicates tariffs of 0–15 per cent for 18 high-GHG emitting developing countries.

The maximum financial impact of trade liberalization is when:

1. the renewables cost is at the top of the range;
2. the share of capital within these costs is highest;
3. this capital equipment is all tradable; and
4. the tariff applied is highest.

The maximum impact will occur when each of these factors is at its maximum level: this is estimated as being when the renewables cost is at $100/MWh, the share of capital within these costs is 80 per cent, 100 per cent of the capital equipment is tradable and the tariff applied is 25 per cent. Multiplying these factors gives $20/MWh (i.e. not applying a tariff) would reduce the costs of generation by $20/MWh (UScent 2.0/kWh). This is below the typical, current feed-in tariff and is equivalent to a $50/tCO$_2$ carbon price if renewables replace natural gas-fired CCGT plant. It is at the bottom end of the carbon price range estimated by the IEA as necessary to meet their ACT Map scenario (as described above).

A more realistic assessment of the impact of tariff removal is to assume a renewable cost of $80/MWh, a 60 per cent share of capital, 75 per cent of equipment being tradable and a 5 per cent tariff. Again multiplying these factors, the impact of removing the tariff in this case would be just $1.8/MWh, less than 5 per cent of the wholesale electricity price and less than 5 per cent of the typical current premium from feed-in tariffs.

3.3.2 Estimating the impact of tariff removal on GHG emissions

On average, the current incentive required to make renewables cost-effective is in considerable excess of what could be achieved by tariff removal alone. From this simple analysis, it can be concluded that tariff removal alone would not result in a significant increase in renewable uptake and thus would not result in a significant reduction in GHG emissions.

This conclusion does not take into account the distribution of generation costs for technologies: both fossil fuel and renewable technologies will be distributed around a mean value. Figures 3.4 and 3.5 show costs for gas and renewables normally distributed around mean generation costs of UScent 5/kWh and UScent 8/kWh respectively, plus a shift (to the dotted line) of the renewables curve by

$1.8/MWh (UScent 0.18/kWh), in line with the average impact of tariff removal discussed in the preceding section.

The estimates made in Figures 3.4 and 3.5 are for indicative purposes only. Key assumptions made include the standard deviation of the distributions (which is arbitrary) and that "renewables" are a single category rather than a series of different technologies with different means and distributions of costs. Nevertheless the analysis does provide some insight: for the "narrow" range, the proportion of "renewable," which is at or below the cost of gas is 6.7 per cent without a tariff reduction of $1.8/MWh and 7.9 per cent with the tariff reduction. For the "wide" distribution of renewables costs, the figures become 21.5 per cent and 23.6 per cent respectively.

In both cases, tariff removal, at the rate of average current tariffs, appears to bring another 2 per cent of renewables below the cost of gas. This supports the contention that tariff removal alone, at the rate of average current tariffs, would have a relatively low impact on increasing renewables penetration.

Figure 3.4: Generation costs for gas and for narrowly-distributed renewables with and without tariff removal

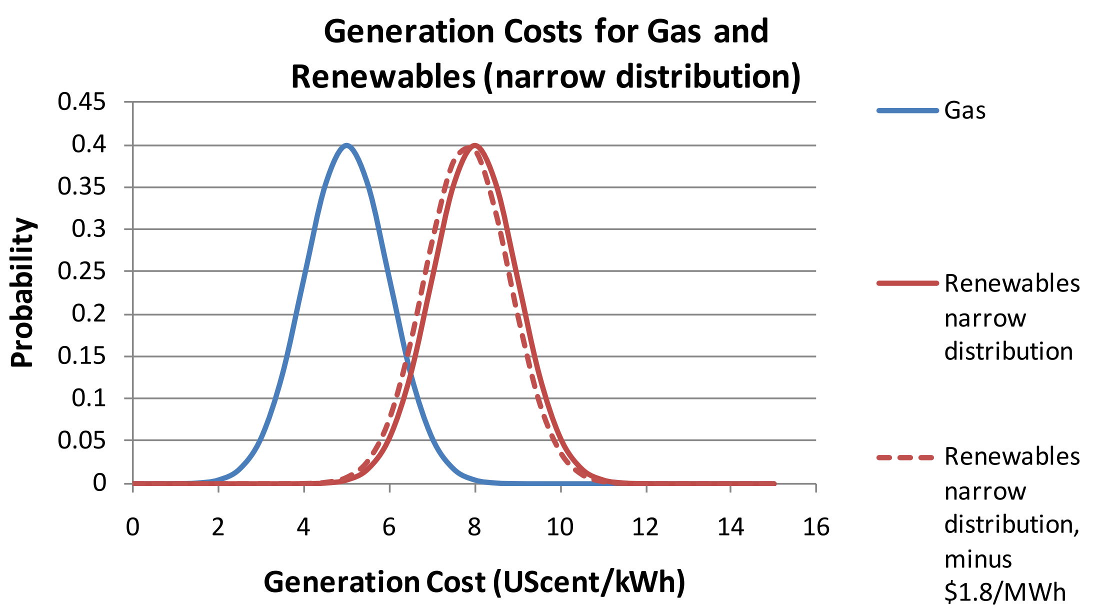
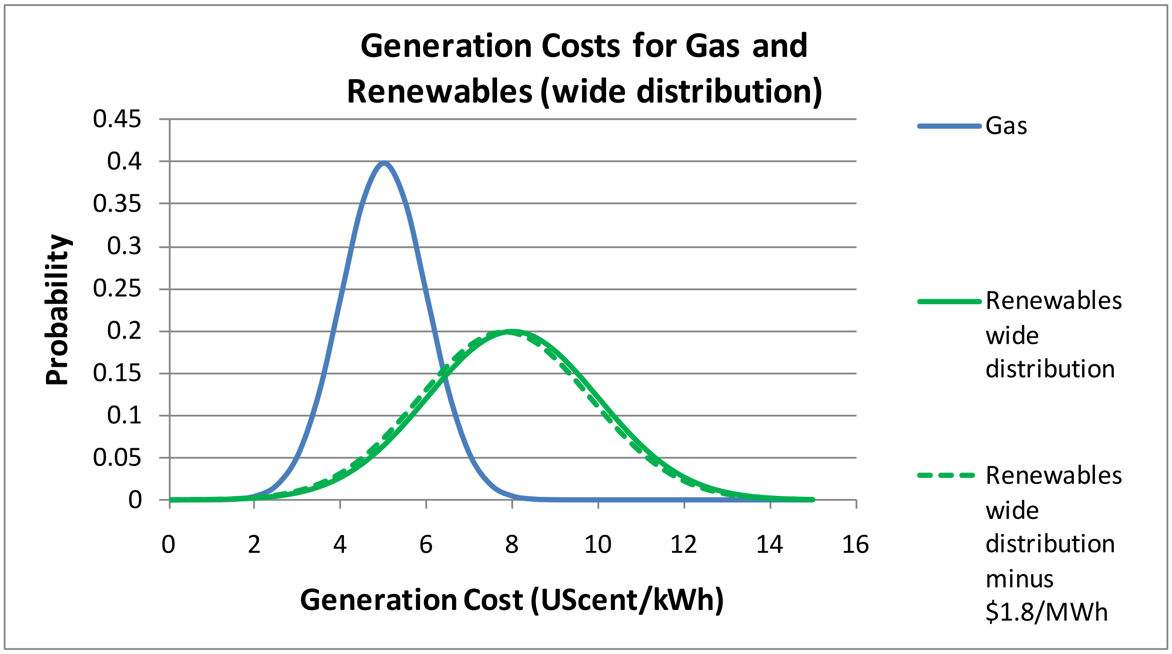


Figure 3.5: Generation costs for gas and for widely-distributed renewables with and without tariff removal



Tariff removal could still make a difference to emissions in two cases:

1. if it were part of a package of measures, for instance it is combined with a feed-in tariff
2. if the cost of renewable electricity declines relative to the cost of fossil-fuel generation.

In either case, the impact due to tariff removal alone would be a relatively low share of the total impact. Calculating the exact impact would require a power system planning model and a range of assumptions covering both the short- and long-term, but a very rough calculation is useful as a heuristic.

The analysis in Section 3.3.1 showed that tariff removal was less than 5 per cent of the typical feed-in tariff premium (i.e. the cost reduction required to make renewables financially competitive with fossil fuel-fired generation). A first order estimate[31] is that tariff removal would be responsible for a similar share of potential GHG emission reductions from renewables. Section 3.1 estimated that renewables could reduce GHG emissions by between 1.0 and 7.7 $GtCO_2$/year by 2030. Figure 3.2, taken from the IEA's *World Energy Outlook 2008,* showed that hydro was a major part of these projected reductions (accounting for 13 per cent of renewables in world primary energy demand in 2030 under the 550 scenario, and 16 per cent under the 450 scenario).[32] Hydro-electricity schemes larger than "mini" in size (those greater than 1 MW) are not included in the Friends of the EGS list

[31] Likely to be a generous estimate – see analysis in the remainder of Section 3.

[32] See IEA, 2008a, tables 18.2 and 18.3.

of 153 environmental goods. Furthermore, the majority of capital costs of large hydro plants are from civil works and are thus not traded. If we deduct all hydro from the total GHG emissions from renewables covered under the list of 153, we arrive at between 0.9 and 6.5 $GtCO_2$/year.

If tariff removal were responsible for up to 5 per cent of GHG savings of 0.9–6.5 $GtCO_2$, savings could be in the range 45–325 $MtCO_2$/year. This is 0.1–0.9 per cent of projected "reference" case GHG emissions from fossil fuel combustion worldwide in 2030.

Are these results representative?

The range of estimates is not overly significant as it is, but it is almost certainly overstated:

- the calculations assume that tariffs will be eliminated on *all* the goods necessary for uptake in the covered renewables technologies (solar, wind, etc,). That is, we have assumed that liberalization will impact uptake of solar technologies *as a whole*. To use the example of solar, though, only eight categories of goods are specified in the list of 153 to cover: concentrated solar, solar PV and solar hot water. Analysis by Izaak Wind (2009) for ICTSD indicates that there are over 20 categories of goods used in these technologies. Future lists are unlikely to cover the full set of goods contained within renewable technologies. Besides political and economic considerations, there is also the problem of "dual use" of goods (see Section 3.3.3 below);
- uptake will depend on other policies and measures being in place. Jha (2009) calculates that a number of factors influence trade in environmental goods (for example per capita GDP, and FDI flows), but that tariff levels are relatively minor among them. Non-tariff barriers are also likely to be important. In other words, tariff liberalization may need to be accompanied by flanking measures that address the other obstacles to dissemination if it is to have a significant impact. Assuming that a price effect equivalent to 5 per cent of typical feed-in tariffs would have the effect of fostering 5 per cent of the increase in renewables foreseen under the 450 and 550 scenarios is almost certainly generous.

A number of sensitivities could be applied to the result obtained. Key amongst these are: the distribution of wind and renewable costs; mean renewable generation costs; mean gas generation costs; and the distribution of tariff reduction (as a fraction of the cost difference between average gas and renewable generating costs). The analysis above indicated that the distribution of costs was unlikely to have a major influence on the impact of tariff reduction. The most important factors are thus the mean costs of gas and renewable generation. A simple analysis shows:

- a 10 per cent increase in gas generation cost would increase the impact of tariff reductions by 10 per cent, with a 10 per cent decrease in gas generation cost making tariff reduction 10 per cent less effective;
- a 10 per cent increase in renewable generation cost would reduce the impact of tariff reduction by 20 per cent, with a decrease in renewable cost having the opposite effect.

It seems reasonable to conclude that tariff reduction alone can only be responsible for a small reduction in the potential reductions from implementing the Friends of the EGS list of 153 environmental goods. This conclusion may need to be revisited if average gas and renewable generation were much closer in their generation cost than they are at present.

3.3.3 The importance of product coding systems

The starting point of analysis from the trade sector is to use the Harmonized Commodity Description and Coding System (HS). This includes product codes at the six-figure level that have been harmonized (i.e. are applicable) by Customs Unions around the world. Thus a consistent set of statistics in the trade of these products exists. An example of such a product code is shown in Table 3.4. It illustrates two challenges when using the HS:

1. several products may be included under a single code
2. some or all of these products may be fully or partially parts of renewable energy systems and/or conventional energy systems and/or a range of other systems

Table 3.4: Example good under a six-figure HS Code

HS Code 761100	Aluminum reservoirs, tanks, vats and similar containers, for any material (other than compressed or liquefied gas), of a capacity exceeding 300 l, whether or not lined or heat-insulated, but not fitted with mechanical or thermal equipment: tanks etc, over 300 litres capacity, aluminum.

Many countries go beyond the 6-figure level, adding sub-divisions. In some cases, these are consistent among a number of countries; in others, they can vary widely. How to create a more environment-focused sub-divided system is now being considered.[33] The potential to create new HS codes appears difficult, as it would require decisions to be made by the World Customs Organization (WCO). Their review process occurs only every 5 years and it is not evident that the desire to enable better targeted tariff reduction for the purposes of dealing with environmental issues would be deemed sufficiently important to introduce sub-divisions.

[33] For example by the International Centre for Trade and Sustainable Development (ICTSD)

A proposed solution, as employed in the Friends of the EGS Group's list of 153 products, is to specify an "Ex-Out/Additional Product Specification." The table below continues the example for HS Code 761100, suggesting ex-outs to cover biogas, water purification and solar systems. Again, there are serious concerns over whether such ex-outs could be negotiated and how long the process may take.

Table 3.5: Example good under a six-figure HS Code – with optional ex-outs

HS Code 761100	Aluminum reservoirs, tanks, vats and similar containers, for any material (other than compressed or liquefied gas), of a capacity exceeding 300 l, whether or not lined or heat-insulated, but not fitted with mechanical or thermal equipment: tanks etc, over 300 litres capacity, aluminum.	*Optional ex-outs may include: Tanks or vats for anaerobic digesters for biomass gasification; cisterns, vats and reservoirs for waste and potable water; and solar pre-heating storage tank.*

3.4 More complex assessments

A number of models aim to assess how trade would change if tariffs and/or non-tariff barriers were removed. If these results were then fed into a comparative assessment of "before" and "after" portfolios of electricity generation technologies, GHG emission reductions could be calculated.

World Bank (2008) includes a partial equilibrium model,[34] which applies a database of import elasticities of demand to price changes caused by the removal of tariff and non-tariff barriers. The study selected four technologies covering 12 specific environmental goods[35] that are used in the production of the following equipment/plants:

1. Clean coal plant (defined in the study as IGCC – Integrated Gasification Combined Cycle)
2. Wind power
3. Solar PV (Photovoltaics)
4. Energy-efficient lighting

The list approximates to an extract from the wider list of 153 products submitted by the Friends of the EGS Group but was designed primarily to test the methodology and scale of impacts. Thus energy efficient lighting has been added to the list of 153 and clean coal plant has been given more prominence than the wider list gives it. The report then simulates how the take-up of these environmental goods would change if tariff regimes were altered by considering two cases:

[34] In partial equilibrium analysis, the determination of the price of a good is simplified by just looking at the price of one good, and assuming that the prices of all other goods remain constant. The Marshallian theory of supply and demand is an example of partial equilibrium analysis. Partial equilibrium analysis is adequate when the first-order effects of a shift in, say, the demand curve do not shift the supply curve. (http://en.wikipedia.org/wiki/General_equilibrium)

[35] See Annex II for this list.

1. Removal of tariffs
2. Subsequent removal of non-tariff barriers (NTBs)

Within the context of the current global trade regime, results from the study are that trade volumes of wind power equipment in the 18 highest GHG-emitting developing countries[36] would increase by 12.6 per cent if tariffs were eliminated and by 22.6 per cent if tariffs and non-tariff barriers were eliminated. For the four technologies considered, trade volume increases are 7.2 per cent and 13.5 per cent respectively.

World Bank (2008) concluded that there was "considerable increase in the volume of clean energy technologies traded" and that "the impact of trade liberalisation could be reasonably substantial." The study does not attempt to calculate the impact on GHG emissions from these trade volume increases. The following should be considered when making the calculation:

- The majority of trade in environmental goods such as wind power takes place among developed countries;[37]
- The use of import elasticities of demand assumes that past response to price differences will continue into the future. This is dependent on the set of policies and incentives being maintained without alteration. The analysis presented in Section 3.3 established that a feed-in tariff with a significant premium, or an equivalent measure, was required for significant increase in renewable generation. In most developing countries, this would be a step change and it is questionable whether elasticities derived before the implementation of the policy would still apply after it; the study categorizes goods using HS codes at the six-figure level. There are significant challenges to using these as a basis for liberalization, as summariszed in Section 3.3.3.

[36] The study concentrated only on these 18 countries for the purposes of its trade modelling. No global estimates were produced.
[37] Jha (2009) shows 28 per cent of both imports and exports were associated with developing countries in 2007 (financial value, using the WITS database and considering the top 20 importers and exporters only).

4.0 Proposing Alternative Lists

4.1 Introduction

It was concluded in Section 2.1 that implementing the Friends of the EGS list of 153 would have a material impact on GHG emissions only due to its inclusion of most renewable electricity generation technologies. Alternative lists, focusing primarily on GHG emissions reductions from a wide range of technologies across all sectors of the economy, are thus indicated, and a number of possibilities exist. They could lead to significantly higher emission reductions than the list of 153. The list of 12 developed by the World Bank (see Section 3.4) is a first attempt at such a list.

Any list proposed would have to deal with the problems caused by the product coding system (see Section 3.3.3). Additionally, there are issues defining what constitutes "clean energy" technologies. One useful definition, which would include clean versions of conventional technologies such as coal-fired generation, is "those that emit substantially fewer GHGs than their conventional counterparts" (UNFCCC, 2006).

4.2 Potential for using UNFCCC technology needs assessments (TNAs)

The UNFCCC (2006) synthesis document, "presents information on technology needs for mitigation and adaptation to climate change contained in 23 technology needs assessments (TNAs) and 25 initial national communications submitted by parties not included in the Annex I to the Convention (non-Annex I Parties)."

The list of technologies in the Synthesis document is very wide in scope and simply counts numbers of submissions of technologies. This leads to issues around the taxonomy (e.g. there are almost 90 instances of renewable and nine of coal, which could be explained by there being 10 renewables types). It also does not weight in any way how important the technologies could be (e.g. useful to weight this by size of country/sector in GHG or economic terms, should be roughly same order of magnitude). Finally it also includes both "hard" and "soft" measures, although whether countries have used the same scope is very much open to interpretation. It is concluded that the TNAs are of little practical use.

4.3 A list based primarily on GHG emissions

Table 3.3 summarized the key technologies identified within the IEA's ETP 2008 as having a significant potential role in reducing world GHG emissions in the period to 2030. Table 4.1 takes this as a starting point and adds more detail to the technologies required. Seven key options are included, which together account for 20 $GtCO_2$/year of the 35 $GtCO_2$/year savings required for the ACT Map scenario (stabilizing 2050 emissions at 2005 levels). Of this total, and under this scenario, the only renewables technology with a potential saving of more than 1 $GtCO_2$/year is wind power.

The seven key options can all be considered almost entirely mass market in their nature, which is to say they require the large scale implementation of technology that is not "high tech." Options whose large-scale implementation is considered to be far into the future (carbon capture and storage and second generation biofuels) have been excluded. Nuclear power has also been excluded since it is considered controversial by many commentators.

Mapping these technologies to goods would encounter the same problems around dual-use coding of goods described for renewables technologies in Section 3.3.3. Indeed, the problems are likely to be greater as the possibility for using components for non-green technologies or other uses entirely is even higher than for renewables.

Table 4.1: Key technologies for reducing GHG emissions, 2006–2030

Sector/Technology	CO_2 Reductions ($GtCO_2$/year) - ACT Map	Technology Requirements
Power Generation		
Wind	1.3	• Wind turbine components • Gas turbine components (for peaking plant needed to support wind implementation)
Fuel Switching Coal to Gas	3.8	• Gas turbine components
Buildings		
Fuel Savings[38]	2.0	• Building shell efficiency (during refurbishment) – insulation, etc. • Gas condensing boilers • District heating/small-scale CHP • Double/triple glazing (for refurbishment) • Solar hot water (initially in developing countries) • Hot water system insulation • Heat pump systems
Electricity Efficiency	4.5	• Higher efficiency lights (CFL, etc.) • Higher efficiency appliances (refrigerators, freezers, washing machines, etc.) • Air conditioning & HVAC systems • CHP
Transport		
Fuel Efficiency[39]	6.0	• Material substitution (25 per cent lower weight) • Improved engine (variable valve timing, higher compression ratio, etc.) • Wide range of marginal benefits from improvements to lights, tyres, etc.
Industry (incl. blast furnace and coke ovens)		
Electric Efficiency	1.0	• Improved motors and drives
Fuel Efficiency	1.9	• Industry and process dependent. Due to the size of its emissions, of note are iron and steel sector options: residual heat recovery, hot stoves, etc.[40]
OTHERS	**14.5**	
TOTAL	**35**	

Beyond the specific options considered is the vision of an electricity system that is largely decarbonized. The wide-scale use of renewable generating technologies and moves towards

[38] List taken from IEA, 2008b, p. 103.
[39] Note that a major move to either hybrid, electric or fuel cell powered vehicles is not envisaged.
[40] See IEA, 2008b, p. 108 for details.

decentralized grids both require major investments in grid equipment (cables and controls). Key technologies include:

- DC (direct current) transmission;
- new conductors;
- high-efficiency transformers;
- information systems; and
- power system stabilization.

5.0 Conclusions

5.1 The Friends of the EGS list of 153 environmental goods

This paper concludes that the Friends of the EGS list of 153 goods would have an impact on GHG emissions almost exclusively due to its inclusion of renewable electricity generation technologies. No other parts of the list would have a comparable material impact on GHG emissions.

Worldwide, studies estimate that increased renewable electricity generation from the technologies whose goods are included within the list of 153 could result in reductions of 0.9–6.5 $GtCO_2$ annually by 2030. A rough upper boundary approach to ascribing what share of these savings could result from tariff removal concludes that less than 5 per cent of savings, or 45–325 $MtCO_2$/year, could be ascribed. This borders on a significant contribution to efforts to address climate change, but, on its own, is clearly far from being enough to reduce GHG emissions to proposed "safe" levels. Whilst relatively small, the analysis does confirm the view that trade liberalization would be beneficial as it would result in higher trade (and thus production) of climate-friendly technologies.

In practice, savings are likely to be much lower for a number of reasons. Two key conditions that must be met to maximize the potential are:

1. *A broader coverage* needs to be achieved for the goods that are necessary in each relevant technology;
2. *Accompanying measures* would be necessary to ensure that the potential for uptake offered by tariff liberalization is actually exploited. These would include attention to non-tariff barriers, and attention to the capacity of host states to absorb new technologies (strong energy policy that gives long-term price signals to investors; adequate regulatory and enforcement regimes with incentives for new technology dissemination; functioning and informed domestic institutions of financing; adequate domestic innovative capacity, etc.).

5.2 An expanded list of goods to increase greenhouse gas reductions

It can be concluded that tariff liberalization could contribute to a reduction of GHG emissions to some degree. If an expanded list of greenhouse gas-reducing technologies were developed, the same two conditions—a broader coverage of goods and accompanying measures—would need to be met.

A broader coverage of goods

On the first condition, Aguilar, *et al.* (2009) argue the need for an environmental basis for the creation of the list of goods to be liberalized in the WTO, arguing that the current focus on commercial gain prevents the drafting of a list that will have any significant impact. This paper supports this view, at least in the context of climate change concerns. It is not unreasonable for WTO members to seek to tilt the list toward the goods that they currently export, and to prevent liberalization in technologies where they would like to establish infant industries. This is, in fact, the bread and butter of trade negotiations. But it is, at the same time, inimical to environmental effectiveness. If the effort does not expand to a more solid environmental basis, it may not be worth the time spent on it. The list would probably have to be developed based on an objective source of information on the potential and need for climate-relevant technologies, such as the IEA's ETP, rather than on the basis of commercial negotiations. If lists could be stripped down to include only goods that had single uses, this may make negotiations simpler.[41] An alternative, raised by India and supported by many developing countries, is a project-based approach where tariffs of goods in approved products would be reduced. Gaining an agreement on this approach may be more difficult than a list-based approach and the resources required to implement the agreement would be significantly higher.

For importers of environmental goods (and it is noted above that importers and exporters do not break down easily into developing and developed countries), the question is whether it is better to import such goods more cheaply, thereby fostering greater environmental improvement, or to erect infant industry protection to foster domestic industries. This latter course may have short term environmental and economic costs, but if successful may pay off in the longer run. Such strategies are not always successful, however. Point Carbon (2008) note that the effort by the Ukraine to develop a domestic wind energy sector saddled it with installation costs of two to three times the world averages, and a near complete lack of foreign or domestic private investment in the sector despite otherwise favourable conditions. Supporting the opposite strategy, a study conducted for the WTO in 2004 adds that "most countries that are open to trade adopt cleaner technologies more quickly, and increased real income is often associated with greater demand for environmental quality."

The other issue here, surveyed briefly above in section 3.3.3, is the issue of dual use of goods. Again, there is a tension between environmental effectiveness and commercial objectives. A more widely specified list that included all the necessary goods for renewable technologies would also include a large number of dual-use goods, which is unpalatable to those that import such goods or that wish to develop or protect domestic industries that produce them.

The onus for this first condition seems to be squarely with the WTO members. If real effective action on climate change is desired, alternative lists could be proposed. Section 4 makes an initial

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[41] Noting that lists must be maintained over time, as technologies and their costs change, new applications of existing products are developed and certain products currently at an R&D stage are commercialized. If lists are not maintained, they will lose their effectiveness. Changes in technology availability and costs may act to increase or decrease the potential GHG emission reductions identified within this paper.

proposal, based on mass-market technologies, that cover significantly higher potential GHG emissions savings than the list of 153. At present, however, no alternative lists are being discussed within the WTO negotiations.

World Bank (2008) proposes two alternatives, taking into account the political economy:

1. WTO members representing a minimum share of trade in climate-friendly goods could make an agreement that is a sub-category to a larger negotiated package or independent of it. Members could sign up to it as their circumstances permitted.
2. Regional Trade Agreements (RTAs) may offer a vehicle for increasing markets in EGS, noting the constraints that their limited membership can entail.

Accompanying measures

On the second condition, Cosbey, *et al.* (2008) argue strongly that a number of pre-conditions limit investment in clean energy technologies, particularly in developing countries where most of the growth in energy supply will occur between now and 2030. Barriers include general investment climate conditions such as macroeconomic stability, lack of energy, transport and communications infrastructure, and weak bureaucracy related to investment. Specific barriers include lack of price signals given by a strong energy policy, lack of regulatory structures to encourage clean energy investment, legal uncertainties, subsidies to conventional energy fuels and technologies, and lack of knowledge or capacity in financial institutions.

These sorts of barriers might be cast as non-tariff barriers, for which there is a mandate for the WTO under the Doha Declaration's paragraph 31 (iii), but they are probably best left to other agencies to address. The WTO does not have a long and successful track record of addressing non-tariff barriers, and what seems indicated in this context is not a rules-based deregulatory approach, but rather a capacity-building approach. Here, there is some hope in the current UNFCCC negotiations where there seems to be growing agreement that developing country commitments post-2012 may take the form of nationally appropriate mitigation actions (NAMAs) that receive financial and technical support from developed countries.

5.3 Final Recommendation

A final recommendation is for further work to improve our understanding of the potential of tariff and non-tariff approaches to the dissemination of environmental goods and services. For one thing there needs to be much more work on services, an area that this paper has more or less excluded from analysis. For another, there needs to be a more rigorous approach to defining potential benefits in terms of GHG emission reductions. This paper has taken a very rough upper boundary approach to that estimate, but further work should be undertaken to improve confidence in the estimates. Such further work would need to take account of the effects of other policies and measures and would ideally take account of power-system planning in the short- and long-terms.

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Annex I: "Friends of the EGS" List of 153 Environmental Goods

This table lists the 43 goods described by the World Bank (2008) as being "climate friendly." For the full list, see pages 5–25 of: http://www.mfat.govt.nz/downloads/NZ-WTO/wto-doha-ministerialdeclaration27apr07.pdf.

HS Code	Product Description	Low- and Middle-Income WTO Members: Maximum Average Bound Tariffs	Low- and Middle-Income WTO Members: Average Applied Tariff Rates	High-Income WTO Members: Maximum Average Bound Tariffs	High-Income WTO Members: Average Applied Tariff Rates
392010	PVC or polyethylene plastic membrane systems to provide an impermeable base for landfill sites and protect soil under gas stations, oil refineries, etc. from infiltration by pollutants and for reinforcement of soil	30	13	15	5
560314	Nonwovens, whether or not impregnated, coated, covered or laminated: of manmade filaments; weighing more than 150 g/m^2 for filtering wastewater	33	14	16	4
701931	Thin sheets (voiles), webs, mats, mattresses, boards, and similar nonwoven products	34	13	17	4
730820	Towers and lattice masts for wind turbine	28	10	16	3
730900	Containers of any material, of any form, for liquid or solid waste, including for municipal or dangerous waste	32	12	17	4
732111	Solar driven stoves, ranges, grates, cookers (including those with subsidiary boilers for central heating), barbecues, braziers, gas-rings, plate warmers and similar non-electric domestic appliances, and parts thereof, of iron or steel	36	18	15	5
732190	Stoves, ranges, grates, cookers (including those with subsidiary boilers for central heating), barbecues, braziers, gas-rings, plate warmers and similar non-electric domestic appliances, and parts thereof, of iron or steel—Parts	36	14	15	4
732490	Water saving shower	28	19	17	4
761100	Aluminum reservoirs, tanks, vats and similar containers for any material (specifically tanks or vats for anaerobic digesters for biomass gasification)	31	11	16	4
761290	Containers of any material, of any form, for liquid or solid waste, including for municipal or dangerous waste	31	13	14	4
840219	Vapor generating boilers, not elsewhere specified or included hybrid	24	5	15	4
840290	Super-heated water boilers and parts of steam generating boilers	21	5	15	4

HS Code	Product Description	Low- and Middle-Income WTO Members		High-Income WTO Members	
		Maximum Average Bound Tariffs	Average Applied Tariff Rates	Maximum Average Bound Tariffs	Average Applied Tariff Rates
840410	Auxiliary plant for steam, water, and central boiler	25	5	15	3
840490	Parts for auxiliary plant for boilers, condensers for steam, vapor power unit	25	4	16	3
840510	Producer gas or water gas generators, with or without purifiers	24	5	13	2
840681	Turbines, steam and other vapor, over 40 MW, not elsewhere specified or included	28	5	13	3
841011	Hydraulic turbines and water wheels of a power not exceeding 1,000 kW	24	4	15	3
841090	Hydraulic turbines and water wheels; parts, including regulators	24	4	15	3
841181	Gas turbines of a power not exceeding 5,000 kW	20	5	13	2
841182	Gas turbines of a power exceeding 5,000 kW	20	5	13	2
841581	Compression type refrigerating, freezing equipment incorporating a valve for reversal of cooling/heating cycles (reverse heat pumps)	29	13	16	4
841861	Compression type refrigerating, freezing equipment incorporating a valve for reversal of cooling/heating cycles (reverse heat pumps)	21	7	17	4
841869	Compression type refrigerating, freezing equipment incorporating a valve for reversal of cooling/heating cycles (reverse heat pumps)	21	7	16	4
841919	Solar boiler (water heater)	27	10	17	4
841940	Distilling or rectifying plant	23	4	15	3
841950	Solar collector and solar system controller, heat exchanger	24	5	15	3
841989	Machinery, plant or laboratory equipment whether or not electrically heated (excluding furnaces, ovens etc.) for treatment of materials by a process involving a change of temperature such a heating, cooking, roasting, distilling, rectifying, sterilizing, steaming, drying, evaporating, vaporizing, condensing or cooling.	25	6	12	3
841990	Medical, surgical or laboratory stabilizers	24	6	12	2
848340	Gears and gearing and other speed changers (specifically for wind turbines)	22	8	16	3
848360	Clutches and universal joints (specifically for wind turbines)	23	9	15	3

HS Code	Product Description	Low- and Middle-Income WTO Members		High-Income WTO Members	
		Maximum Average Bound Tariffs	Average Applied Tariff Rates	Maximum Average Bound Tariffs	Average Applied Tariff Rates
850161	AC generators not exceeding 75 kVA (specifically for all electricity generating renewable energy plants)	27	7	15	3
850162	AC generators exceeding 75 kVA but not 375 kVA (specifically for all electricity generating renewable energy plants)	26	7	16	3
850163	AC generators not exceeding 375 kVA but not 750 kVA (specifically for all electricity generating renewable energy plants)	26	5	16	3
850164	AC generators exceeding 750 kVA (specifically for all electricity generating renewable energy plants)	28	5	16	3
850231	Electric generating sets and rotary converters; wind-powered	26	5	16	3
850680	Fuel cells use hydrogen or hydrogen-containing fuels such as methane to produce an electric current, through an electrochemical process rather than combustion	25	18	16	3
850720	Other lead acid accumulators	24	16	16	5
853710	Photovoltaic system controller	26	10	17	3
854140	Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes	21	4	9	1
900190	Mirrors of other than glass (specifically for solar concentrator systems)	30	7	16	3
900290	Mirrors of glass (specifically for solar concentrator systems)	29	12	18	3
903210	Thermostats	33	7	14	3
903220	Manostats	33	6	13	2

Annex II: World Bank 2008 List of 12 Environmental Goods

1. Clean coal technologies (HS codes 840510, 840619, 841181, 841182, 841199)
2. Wind energy (HS codes 848340, 848360, 850230)
3. Solar photovoltaic systems (HS codes 850720, 853710, 854140)
4. Energy-efficient lighting (HS code 853931)