Removing Trade Barriers on Selected Renewable Energy Products in the Context of Energy Sector Reforms: Modelling the Environmental and Economic Impacts in a General Equilibrium Framework

Dr Veena Jha

ICTSD
International Centre for Trade and Sustainable Development

Global Green Growth Institute

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7 Chemin de Balexert, 1219 Geneva, Switzerland
Tel: +41 22 917 8492 Fax: +41 22 917 8093
E-mail: ictsd@ictsd.ch Internet: www.ictsd.org

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Senior Research Fellow:	Mahesh Sugathan

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The Global Green Growth Institute (GGGI) is a new kind of international organisation that has been established to accelerate "bottom up" (country- and business-led) progress on climate change and other environmental challenges within core economic policy and business strategies. The Institute provides an international platform for evidence based learning and policy innovation that helps to illuminate practical opportunities for progress on the twin imperatives of economic development and environmental sustainability, while deepening cooperation among developed and developing countries, the public and private sectors, and practitioners and scholars. Founded in June 2010 and established in Seoul, GGGI is committed to help developing and emerging countries pioneer a new "green growth" paradigm.

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Abbreviations and Acronyms

ADB	Asian Development Bank
APEC	Asian-Pacific Economic Cooperation
CCS	Carbon capture and storage
CDE	Constant difference elasticity
CES	Constant elasticity of substitution
CGE	Computable general equilibrium
CSP	Concentrated solar power
DANIDA	Danish International Development Agency
DFID	Department for International Development
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FITs	Feed-in tariffs
GDP	Gross domestic product
GGGI	Global Green Growth Institute
GHG	Greenhouse gas
GSI	Global Subsidies Initiative
GTAP	Global Trade Analysis Project
ICTSD	International Centre for Trade and Sustainable Development
IDRC	International Development Research Centre
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
ILO	International Labour Organization
IMF	International Monetary Fund
LCRs	Local-content requirements
LES	Linear expenditure system
OECD	Organisation for Economic Co-operation and Development
PIIE	Peterson Institute for International Economics

PV	Photovoltaic
RE	Renewable energy
SEGS	Sustainable Energy Goods and Services
SETA	Sustainable Energy Trade Agreement
SETIs	Sustainable Energy Trade Initiatives
TRIMS	Agreement on Trade Related Investment Measures
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
UK	United Kingdom
UN	United Nations
US	United States
WTO	World Trade Organization

Foreword

Climate change is an unprecedented challenge facing humanity today. As fossil fuel-based energy use is the biggest contributor to anthropogenic greenhouse gas (GHG) emissions, a rapid scale up and deployment of renewable or sustainable energy sources could significantly reduce the emissions responsible for climate change. From a development perspective, developing countries face the enormous challenge of reducing carbon intake while ensuring people's access to energy and powering rapid economic growth. Most countries are also seeking ways to enhance their energy security by reducing reliance on fossil-fuel imports. Developing sustainable energy through a transition to cleaner, low-carbon transport fuels and technologies along with greater energy-efficiency measures could make a positive contribution toward achieving these goals.

Efforts to scale up sustainable energy require generation costs to be as low as possible. Relatively high capital costs associated with renewable energy (RE) investments, the non-consideration of environmental and health externalities in fossil-fuel pricing, and the enormous levels of subsidies still granted to fossil fuels make this a challenging proposition. On the other hand, RE costs are enduring a rapid global decline that will likely continue for some time. In certain locations, RE generation has already attained 'grid parity,' equalling the cost of fossil fuel-based power generation.

Incentives, such as feed-in tariffs (FITs) and tax breaks, help reduce the cost of renewable power. At the same time, lowering the costs of equipment and services used to produce sustainable power can facilitate the scale-up process, enabling economies of scale and cost optimization for RE projects. Addressing barriers to trade in sustainable energy goods and services can also contribute to scale economies and cost-optimization, as trade in sustainable energy goods can be hampered by tariffs, subsidies, diverse or conflicting technical standards, and lack of harmonization or mutual recognition efforts. Even FITs could have adverse impacts on trade if designed in a protectionist manner so as favour local sourcing of equipment.

In striving to lower production costs, governments often seek to promote domestic manufacturing of RE equipment and the provision of services, with many policymakers viewing the sustainable energy sector as a potential engine for job creation. These factors could potentially induce sustainable energy policies designed with protectionist intent and trigger trade disputes in the sector. The recent Appellate Body ruling at the World Trade Organization's (WTO) first trade dispute (Canada vs. Japan and the EU) over RE FITs and local content led to a clear ruling against local content measures in the province of Ontario. Yet, these measures persist in a number of countries, and more such disputes may be expected. A number of other disputes also concern trade remedy measures centred on unfair incentives for manufacturers of clean energy products.

Moving forward, the urgency of addressing climate change will require, among other policy responses, a clear and coherent governance regime for sustainable energy and related goods and services supported by trade rules and robust markets. The current stalemate in the WTO's Doha negotiations, particularly in efforts to liberalize environmental goods and services, has prevented action to address barriers to trade in sustainable energy goods and services. Even a successful conclusion of the round would leave a number of trade-related rules pertaining to sustainable energy – including government procurement of Sustainable Energy Goods and Services (SEGS) – unclear, given the Doha mandate's lack of a holistic perspective on energy.

With such a scenario, sustainable energy trade initiatives (SETIs) may present worthwhile alternatives. These possibilities include a sustainable energy trade agreement (SETA), a stand-alone initiative designed to address barriers to trade and enable a trade policy-supported energy governance regime to advance climate-change mitigation efforts and increase sustainable energy supply.

This agreement might be pursued initially as a plurilateral option – either within or outside the WTO framework – and eventually be 'multilateralized.' It could serve to catalyse trade in sustainable energy goods and services and address the needs and concerns of participating developing countries, many of which may not be in a position immediately to undertake ambitious liberalization in SEGS. A SETA could also help clarify existing ambiguities in various trade rules and agreements as they pertain to sustainable energy and provide focalized governance through effective operational provisions.

It is important in this context to assess in a quantifiable manner how multilateral trade policies could contribute to the scale up of RE through its effect on output and trade in sustainable energy products in various domestic policy contexts that reflect global realities prevalent in the energy sphere. Such realities include the existence of subsidies and incentive measures for both fossil fuels and RE.

This paper examines in a quantifiable manner, based on a Global Trade Analysis Project (GTAP) modelling exercise, the combined impact of a reduction in import tariffs for selected groups of sustainable energy goods together with several scenarios, such as the removal of fossil-fuel subsidies, local-content requirements as well as FIT incentives for RE, on a number of economic and environmental variables. These variables include trade (exports and imports of these goods), energy and electricity prices, carbon emissions and employment generation, and income. The paper addresses the question of whether import tariff barriers and local-content requirements for RE equipment as well as FIT incentives to RE are required for sustained growth of selected products that can be clearly identified as being associated with the RE industry.

The paper concludes on the basis of analysis that local-content requirements (LCRs) and FITs may not be required for the sustained growth and trade of these selected products. However, trade reforms can contribute positively to an expansion of their trade, thereby helping to facilitate the eventual expansion of RE. Thus, the paper vindicates the importance of trade reform as a 'low-hanging fruit' that ought to be tapped early on by policymakers, given the challenges associated with other important but significantly more difficult measures, such as fossil-fuel subsidies.

This paper was conceived by the International Centre for Trade and Sustainable Development (ICTSD) and written by Veena Jha, Director of Maguru Consultants Limited, a consultancy company based in the United Kingdom (UK) that works with international institutions, such as the European Union (EU), the United Nations Conference on Trade and Development (UNCTAD), ICTSD, and International Development Research Centre (IDRC). Dr Jha has served as Visiting Professorial Fellow in the Institute of Advanced Studies at the University of Warwick, and Research Fellow at the IDRC in Canada, while consulting with the International Labour Organization (ILO), the Food and Agriculture Organization of the United Nations (FAO), the EU and the ICTSD in Geneva. Dr Jha has also served as Coordinator of the UNCTAD Office in India, and was responsible for a six-year programme on "Strategies and Preparedness for Trade and Globalisation in India," as well as coordinating projects on trade, investment, and environment issues with the United Nations Environment Programme (UNEP), the Asian Development Bank (ADB), the World Bank, and bilateral aid agencies, such as the Danish International Development Agency (Danida) and the UK Department for International Development (DFID). Dr Jha worked as an Economics Affairs Officer in the Trade and Environment Section of the International Trade Division, UNCTAD, and with the United Nations Conference on Environment and Development. Dr. Jha is a member of the Advisory Group at UNEP on Economic Instruments, and serves on numerous technical groups advising the EU, the United Nations (UN) and the Indian Government.

The paper is produced as part of a joint initiative of ICTSD's Global Platform on Climate Change, Trade and Sustainable Energy and the Global Green Growth Institute (GGGI). The concept of the research has been informed by ICTSD policy dialogues, in particular, a dialogue organized in Washington, DC in November 2011 by the Peterson Institute for International Economics (PIIE) with support of the GGGI and ICTSD; a high-level Roundtable in Geneva organized on 16 December

2011 on the occasion of the Eighth Ministerial Conference of the WTO that was attended by a number of high-level representatives from WTO missions and capitals, a session organized at the Global Green Growth Summit 2012 in Seoul, Korea on 11 May 2012 and ICTSD's Bridges China Dialogue in 2012. As a valuable piece of research, it has the potential of informing innovative policy responses on sustainable energy trade initiatives and will be a valuable reference tool for policymakers involved with procurement as well as trade negotiators. We hope that you will find the paper to be a thought-provoking, stimulating, and informative piece of reading material and that it proves useful for your work.

Ricardo Meléndez-Ortiz
Chief Executive, ICTSD

Executive Summary

The urgency of tackling climate change in order to prevent or at least minimize the adverse effects of a rise in average global temperatures beyond the 2 degree Celsius mark is well-recognized. A shift away from fossil-fuel energy sources towards low-carbon renewable energy (RE) sources is recognized as among the most important ways of reducing carbon emissions. While the sources of RE, such as sunlight and wind, are usually plentiful and free, the costs of harnessing them are expensive and require technologies to be deployed. This involves significant upfront investments. Generation costs of RE are also higher, owing to the intermittent nature of renewables and the lack of cost-effective storage options.

While costs are coming down, domestic policies may either encourage or tilt the playing field against renewables. First, explicit trade barriers and restrictions on RE equipment, such as import tariffs, can unnecessarily raise the costs to firms of procuring such equipment. Second, incentives for RE generation in one country can affect deployment and trade opportunities for other countries. Third, government support provided to fossil fuels and electricity can have dramatic impacts. Addressing barriers to trade in RE equipment created by these policies could help facilitate the scale up of RE and make it easier for governments to address not only climate change, but also provide access to sustainable energy for millions of people in the developing world who are presently not connected to the grid.

Addressing barriers to trade in RE equipment often requires governments to negotiate voluntary or binding agreements with each other. Such sustainable energy trade initiatives (SETIs) can take various forms, including a binding regional trade agreement that involves RE goods and/or services; a voluntary environmental goods liberalization initiative, such as APEC's September 2012 Vladivostok Agreement to liberalize tariffs on 54 product categories, including RE goods; or a possible binding agreement within the World Trade Organization (WTO) on RE goods. In the pursuit of these initiatives, it will be important for policymakers to gain a better understanding of greenhouse gas (GHG) as well as the economic welfare impacts of addressing tariff and non-tariff measures related to trade in sustainable energy equipment. A number of countries presently apply a range of import tariff barriers to such products. They also impose local-content requirements (LCRs), despite their being clearly prohibited under the WTO Agreement on Trade Related Investment Measures (TRIMS) as reaffirmed by a recent WTO dispute settlement panel (Canada-FITs) ruling against local-content measures for solar and wind energy introduced in Ontario, Canada.

A clearer understanding of the environmental and economic impacts of domestic energy and trade policies will contribute constructively to policy debates on such measures and in the crafting of realistic as well as sound sustainable energy trade initiatives (SETIs) and domestic policies to deploy RE and reduce GHGs, keeping in mind political as well as economic constraints and challenges. This paper will focus on a selection of domestic policy measures that could potentially affect trade in RE equipment. These include import tariffs, local-content requirements (LCRs) and RE incentives, like feed-in tariffs (FITs).

The objective of this paper is to highlight multilateral trade policies that could be used to stimulate the use of RE. The question that the paper addresses is whether import tariff barriers and LCRs for RE equipment as well as FIT incentives to RE are required for sustained growth of the single-use products associated with the RE industry. The paper concludes on the basis of the Global Trade Analysis Project (GTAP) analysis that LCRs and FITs may not be required for the sustained growth and trade of the products studied here. However, trade reforms can contribute positively to expansion of trade in single end-use products.

In order to better understand the contribution that trade reforms can make for RE, the paper also sets the context by exploring what would happen in another non-trade related sphere of domestic policy reform, namely removal of fossil-fuel subsidies. The model used in this paper is a GTAP-E model, which specifically incorporates both electricity and energy sources as inputs and outputs in a computable general equilibrium model. This model does not include energy services associated with RE or take account of dynamic technological changes, but is presaged on existing technology. It is also unable to take into account the dynamic effects of subsidies in fostering technological change. Rather, it provides a comparative static analysis of the differential impacts of energy and trade policy reform on some selected countries.

Using the same GTAP-E model the paper then analyses the macroeconomic effects of the removal of import tariffs, FITs, and LCRs, on selected countries whether the liberalization is by themselves or by their trading partners. Macroeconomic effects examined include gross domestic product (GDP), welfare, emissions, and electricity prices for the economy as a whole, while microeconomic effects are examined for the RE products that are listed in Annex III. These RE goods include those relevant to renewable electricity generation. Ethanol, which is relevant for sustainable transport systems, is also included as it is an important traded product, and transport accounts for a high proportion of GHG emissions. The goods included in this modelling exercise have been identified based on previous trade analyses conducted by ICTSD. They are listed in Annex III. They have been classified into three categories of goods. The first category, called RE equipment, consists of products used for generating or using solar energy, hydroelectricity equipment, and ethanol. (see Annex III) The second category of products consists of wind turbines. The third category of products consists mostly of parts of a wind energy generation system. The reason for choosing this small list is to ensure that the simulation exercises will be meaningful for negotiations at the WTO and elsewhere and the products have a direct correspondence with RE generation and usage. Essentially members of the WTO could be more favourably inclined towards tariff reduction for 'single use' goods that are easier to identify from an 'environmental end-use' perspective. Individual countries covered by this modelling exercise are listed in Annex II, comprising the top five GHG emitting economies and prominent exporters and importers of climate-friendly goods in 2010 (according to the 'ICTSD's single-end use goods list identified'). In addition, other large exporters, such as South Africa and Brazil, have also been included. With this inclusion, over 90 percent of global trade, GDP, employment and other macroeconomic indicators are covered by this modelling exercise. Thus, predictions and policy prescriptions resulting from the model could be extended to the global economy as a whole. One shortcoming is that the country coverage does not extend to oil-exporting countries, which account for the largest share of fossil-fuel subsidies.

Several arguments for removing subsidies on fossil fuels are presaged on levelling the playing field by increasing fossil-fuel energy prices and making RE more competitive. The analysis in this paper shows that this may not necessarily be the case. The most important reason for this is that 76 percent of the global total fossil-fuel subsidies go to oil and petroleum (generally not used for electricity generation); only 6 percent goes to coal (used for electricity generation); and a little less for natural gas (sometimes used for electricity generation). Hence, removing fossil-fuel subsidies alone may not level the playing field for RE.

The study shows that removing fossil-fuel subsidies does affect electricity and energy prices, but price rises are much higher in countries where coal is widely used for electricity generation, such as India, and South Africa. To the extent that renewables can be substituted for fossil fuels, the model shows a greater likelihood for the deployment for solar photovoltaic (PV) and hydro-equipment (represented by the renewable equipment category). The results make sense, as hydro represents one of the lowest-cost sources of RE, and solar-PV has reached close to grid parity in a number of locations. Solar PV can also be deployed in an off-grid, decentralized manner without necessarily investing in grid connections. According to a Navigant research report, distributed solar – the kind put up on rooftops and carports and other small-scale installations, and which Navigant defines as less than 1 megawatt in capacity – accounted for 69 percent of all solar PV installed in 2012.[1]

While the effects of removing fossil-fuel subsidies may be somewhat limited for the RE sector, emissions would be reduced significantly for most countries. Clearly, the largest emission reductions would be for countries that are intensive users of energy. Emission reductions do not include only those generated by lowered electricity usage, but also those achieved through lower usage of oil and petroleum, including for transportation. The countries that provided the largest subsidies, mostly developing countries, stand to see the largest declines in GDP and welfare. In most cases, welfare losses caused by liberalization cannot be compensated by welfare gains from emission losses, although current estimates of carbon prices may be low, owing to the global recession. Should carbon prices rise or reflect all externalities, the calculations of welfare gains and losses would be entirely different. However, carbon prices would have to rise more than fourfold to compensate for the welfare losses caused by decreased GDP in a number of developing countries. If externalities were to be completely internalized, this price rise is not outside the range of possibilities.

To generate a viable RE industry a number of domestic policies have been used globally, some of which may conflict with the existing body of WTO rules as shown by the recent spate of trade disputes in the RE sector. This paper examines with a GTAP model the impacts of removing some of these policies. These include the effects not only from a country removing its own barriers, but also the effect on the country from its trading partners removing barriers. The paper finds that the distributive effects of removing tariffs, subsidies, or LCRs would differ across the 12 countries studied. Nevertheless, on the whole, removing trade distortions would rebalance the RE industry and move it towards higher levels of deployment. However, it should be specified that the RE industry examined in this paper is based on a small group of single-use products that constitute a large volume of the total trade between the countries studied here. These products are also relevant to most of the issues that are currently covered by dispute settlement panels. Over the past few years, a number of domestic policies have targeted directly or indirectly production and trade in these few single-use products. While the discussion is not exhaustive, as comprehensive data does exist on trade in these single-use products, analysing them provides a bird's eye view of the RE sector as a whole.

Some limitations of this paper need to be emphasized. The data on subsidies are taken from the Organisation for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA) unless specified otherwise in the Annex Tables. It should also be understood that the GTAP model, like all general equilibrium models, provides a comparative static analysis and is indicative of the general trends. It is useful to analyse likely effects of changes of policies, particularly the distributive macroeconomic effects on factors, such as prices, employment, output, and trade. However, the model cannot take technology choices of electricity producers or changes in technology into consideration. It also does not include energy services, except for electricity, which enters as a good in the GTAP model. However, the model includes both production and consumption energy subsidies and is able to detect changes in prices.

This study provides three overall trade policy messages. First, there is no clear case to change WTO rules on LCRs and FITs. Second, most countries see a welfare gain with import tariff reform for RE products as well as an income gain. While the effects will not be uniformly spread across all RE sectors or all countries, there is little to suggest that any particular group of countries would be consistent losers from such reform. Hence, import tariff reform would be a first policy of choice for the limited group of products considered in Annex III. Third, countries could consider retaining FITs while phasing out LCRs, except as they apply for solar energy, where there is a good case for phasing out both FITs and LCRs. Such a phase-out of LCRs would also be in compliance with WTO rules that clearly prohibit LCRs. Finally, RE measures with potential trade impacts need to be implemented carefully, keeping long-term environmental, economic, and trade goals in mind. The industry is still evolving; the players are changing and the role of supportive policies in the global economy is far from clear.

Chapter 1

Introduction

In the near future, climate change will become increasingly perceptible all over the world. The impacts will vary substantially across countries and even across different regions within a country. In order to evaluate the costs and benefits of climate protection and prevention measures at a country level, it is necessary to use a specific general equilibrium model that corresponds to its economic structure and incorporates energy as an input and emissions as an output. This will help assess the impact of specific policy variables, such as trade or energy policy reform on future changes in socioeconomic variables at the national and global level. To foster global cooperation in the realm of SETIs, such analysis is imperative. Widespread deployment of RE is important for ensuring that all countries have access to RE sources and energy security as well as to help mitigate climate change.

Energy is an important input in several economic activities. Its usage affects the environment via carbon dioxide (CO2) emissions and the greenhouse effect. Modelling the energy-economy-environment-trade linkage is an important objective in applied economic policy analysis. Energy substitution from fossil to RE sources is a key factor in the chain of economic linkages that can help reduce GHGs, especially carbon emissions. While previous papers have explored the impact of removing fossil-fuel subsidies on the economy as a whole, there has been little economic analysis of whether such a policy will actually lead to the deployment of RE. This paper attempts to fill this gap. The model used in this paper is a GTAP-E model that specifically incorporates both electricity and energy sources as inputs and outputs in a computable general equilibrium model. This model does not include energy services associated with RE or take into account dynamic technological changes, but is presaged on existing technology. It is also unable to take account of the dynamic effects of subsidies in fostering technological change. Rather, it is a comparative static analysis of the differential impacts of energy and trade policy reform on some selected countries.

In addition to clean energy subsidies, trade policies, such as tariffs and local-content measures are often part of the overall mix of policies aimed at increased deployment of RE expansion. Trade policies have also been used to protect domestic RE industries, particularly the manufacturing sector. While some clean energy and trade policies may have a positive effect on the development of specific forms of RE in the country employing them, others may, depending on their design, have adverse effects on other countries, as is shown by the spate of dispute settlement panels related to RE in the WTO. The objective of this paper is to highlight multilateral trade policies that could be adopted to stimulate the use of RE in an efficient manner.

RE goods selected for the modelling exercise will include those relevant to renewable electricity generation. Ethanol, which is relevant for sustainable transport systems, is also included, as it is an important tradable product, and transport accounts for a high proportion of GHG emissions. These have been identified based on earlier trade analyses conducted by ICTSD. They are listed in Annex III. They have been classified into three categories of goods. The first category, called RE equipment, consists of products used for generating or using solar energy, hydroelectricity equipment, and ethanol. (see Annex III) The second category, or group of products, essentially consists of wind turbines. The third category of products consists mostly of a wind energy generation system. The reason for choosing this small list is to ensure that the simulation exercises will be meaningful for negotiations at the WTO and elsewhere. Essentially members of the WTO could be more favourably inclined towards tariff reduction for 'single-use' goods that are easier to identify from an 'environmental end-use' perspective. Individual countries covered by this modelling exercise are listed in Annex II and include the five economies with the highest GHG emissions and prominent exporters and importers of climate-friendly goods in 2010 (according to the ICTSD's single-end use goods list). In addition, other large exporters, such as Brazil and South Africa have also been included. Thus, more than 90 percent of global trade, GDP, employment and other macroeconomic indicators are covered by this modelling exercise. Predictions and policy prescriptions resulting from the model could be extended to the global economy as a whole. One shortcoming is that the country coverage does not extend to oil-exporting countries, which account for the largest share of fossil-fuel subsidies.

One of the key benefits of removing fossil-fuel subsidies would be the substitution of RE for fossil-fuel energy. Section I of this paper investigates whether eliminating fossil-fuel subsidies and reducing tariffs for selected RE products would lead to an increase in their output and trade. Presumably, the latter would lead to increased deployment of RE globally and hence contribute to growth and employment generation. For estimating these effects, this paper has used a GTAP-E model, which is explained in Annex I. Some of the limitations of this approach are also explained in this annex.

Experience suggests that eliminating fossil fuel is a long-term goal, and other low-hanging fruit could be harvested rather quickly to achieve a modest reduction in emissions. Trade reforms are one area where some discussion has already taken place. These include eliminating import tariffs on RE equipment and ethanol, removing LCRS or even FITs provided to RE. Emission reduction here is based on increased deployment of RE through the elimination of trade barriers. Recent dispute settlement panels on domestic RE measures also point to the need to examine the economic effects of these policies on trade, output, and employment in the RE equipment industry. Sections II, III and IV, use the GTAP-E model to analyse the macroeconomic effects on selected countries of removing import tariffs, FITs and, LCRs, respectively, either by the countries concerned or by their trading partners. While the macroeconomic effects examined include effects on GDP, welfare, emissions, and electricity prices for the economy as a whole, micro effects are examined for only products listed in Annex III. These include output, employment, and trade in the products listed in Annex III.

While section I of the paper is presaged on emissions arising from fossil-fuel energy generation, consumption, and trade, another important source of emissions is transport. Several countries have experimented with replacing fossil fuels with ethanol. Some countries provide subsidies for ethanol while others have asked for a reduction in import tariffs for it. Section V of the paper examines whether removing import tariffs and subsidies on ethanol would increase its production and bolster employment and trade and reduce emissions.

Finally, the paper concludes with a comprehensive assessment of the results of the GTAPE model for these selected products. It also recommends policies that could help reduce emissions with minimum economic and trade effects. These policies could be implemented at either the national level or at a multilateral level. Most policies suggested here relate to trade policy reforms. They could essentially form part of various SETIs.

Chapter 2

Removing Fossil Fuel Subsidies And Simultaneously Reducing Tariffs For RE Equipment

Because subsidies distort price signals and fail to reflect the true externality costs of energy use, they lead to inefficient levels of consumption of energy. As far as fossil-fuel subsidies are concerned, there are significant negative externalities in the form of environmental damage. For example, fossil-fuel combustion releases pollutants, such as sulphur dioxide, nitrogen oxides, and particulates into the atmosphere that can cause acute health problems as well as damage to structures and natural resources, including forests. Fossil-fuel combustion is also the major contributor to GHG emissions. In such cases, the removal of fossil-fuel subsidies can theoretically both increase economic efficiency and reduce environmental damage. The International Monetary Fund (IMF) estimates that eliminating fossil-fuel subsidies would reduce global carbon dioxide emissions by 4.5 billion tonnes, or 13 percent. The IMF also highlights the health benefits of reduced air pollution. (IMF, 2011)

Because of the importance of energy in the world economy, the removal of energy subsidies is also likely to have significant general equilibrium effects that make it difficult to predict the impacts of reform. Issues of importance in this context are the interaction between the markets for coal, gas, and oil products and other sectors of the economy. When energy prices rise following the removal of subsidies, for example, there will be impacts on the costs of production of other goods, especially energy intensive goods. As the production of most metals is energy intensive, the cost of production of most machines and equipment that use metals can also increase. For example, wind turbines are metal intensive, and an increase in the price of metals will definitely impact the production of wind turbines. This would apply equally to other RE equipment. Relative price changes will also affect the competitiveness of goods on world markets and may lead to changes in trade flows. Also of importance is the extent of support or protection in other parts of the economy that can hinder the efficient reallocation of resources following the removal of subsidies. All of these impacts can have important consequences for economic growth. On the other hand, fossil-fuel subsidies can have negative economic consequences. They can depress investment in the energy sector, crowd out spending on public goods, diminish competitiveness, provide incentives for smuggling, and make it harder to manage volatile international energy prices.

Fossil-fuel subsidies also create an uneven playing field for competing technologies like RE. The Earth Policy Institute found that global fossil-fuel subsidies were more than seven times higher than RE subsidies. (Earth Policy, 2013) In addition, fossil-fuel infrastructure has benefited from government investment and support over decades, putting RE at a distinct disadvantage.

Measuring energy subsidies is difficult, because of the variety of policy instruments that governments use to reduce the costs as well as the poor quality of available data. In these circumstances, the most common method used is to adopt the ‘price gap’ approach. (World Bank 1997, International Energy Agency 1999) The basic idea underlying the price gap method is that subsidies to consumers lower domestic prices and result in higher consumption levels. Domestic prices are compared with a reference price to measure the price gap. The reference price represents the efficient price that would prevail in a market undistorted by subsidies and corresponds to the marginal cost per unit of energy. The price gap can be presented as a dollar value of subsidy per unit or as a percentage of the reference price.

A number of issues and assumptions are important when using the price gap approach as a measure of subsidies. For example, the estimation of the reference price plays a key role. Different reference prices can produce very different subsidy estimates. The choice of exchange rate used to compare domestic and international price is also important. The use of official exchange rates will give very different results than the use of purchasing power parities in some economies. For the purposes of this paper, official exchange rates have been used despite the shortcomings of this approach. Problems of tiered markets for energy also complicate calculations of subsidy. For example, in India as in several other countries, energy prices for firms and households differ. For the data on subsidies and the sources, see Annex V.

In 2011, global pre-tax fossil-fuel subsidies reached USD480 billion (0.7 percent of global GDP or 2 percent of total government revenues). Petroleum and electricity subsidies accounted for about 44 percent and 31 percent of the total, respectively, with most of the remainder coming from natural gas. Coal subsidies are relatively small at USD 6.5 billion. (IMF, 2013)

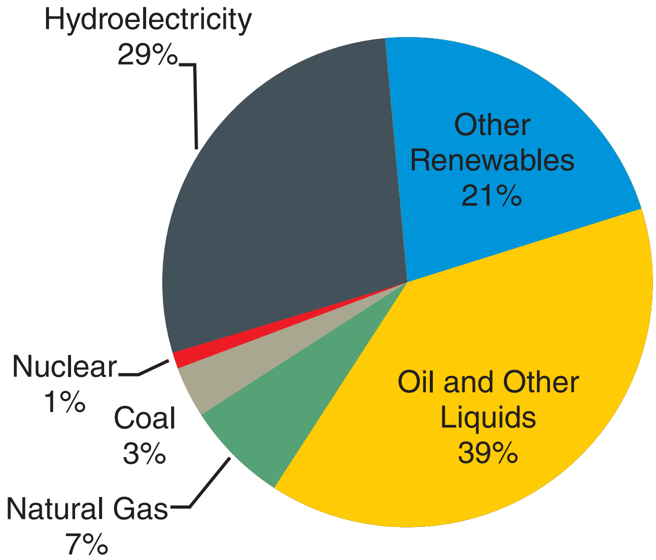
2.1 CGE Results of Eliminating Fossil-Fuel Subsidies and Tariffs Simultaneously

The objective in this scenario is to examine the implications of removing fossil-fuel subsidies for growth, trade, employment, emissions, and energy prices for the countries listed in Annex II in this paper. These are the macroeconomic effects. However, the primary purpose of this paper is to examine the effects on the RE industry when trade reforms take place. Hence, along with the elimination of fossil-fuel subsidies, import tariffs on RE products are reduced to 0 to examine whether levelling the playing field between fossil fuels and RE would stimulate the deployment of RE.

First, we need to clarify at the outset that the GTAPE model considers subsidies net of taxes. Hence, when fossil-fuel and electricity subsidies are eliminated a number of developed countries see an increase in prices, because the tax effect kicks in. All countries experience a loss in economic welfare, although the losses are largest for countries where fossil-fuel subsidies are the highest. In the words of Marshall, "man earns money to get material welfare." (Marshall, 1890)These countries include France, India, the United States (US), China, Italy, and the Republic of Korea. No country, except Brazil, sees an improvement in welfare. This is because its energy base is less reliant on fossil fuels.

Moreover, Brazil has no fossil-fuel subsidies according to data reported by the IEA. (see Annex IV) Brazil began its energy price reforms as early as the 1980s, and Petrobas, Brazil's partly state-owned company, actually distributes dividends. (Reuters, 2013) Also, Brazil has been helped by rising prices of oil in international markets. Hence, welfare increases with the removal of fossil-fuel subsidies, because international oil prices would rise, benefiting Brazilian exports of oil, while domestic prices may remain constant because of substitution between different types of energy. Ethanol exports are also likely to increase from Brazil as fossil fuel becomes more expensive.

Figure 1. Total Primary Energy Consumption in Brazil by Type (2010)



Source: EIA, International Energy Statistics

While a reduction in import tariffs on Annex III products increases welfare marginally for all countries, removal of fossil-fuel subsidies reduces welfare substantially for all candidate countries, except Brazil. Welfare refers to the material well-being of a country and includes three measures: the effect of policy change on national income, prices and hence real income, and how the economic benefits are evaluated by citizens. For example, in this case, the removal of fossil- fuel subsidies would probably lead to a fall in economic welfare, because of negative GDP and price of electricity effects. However, the welfare benefits arising from reduced emissions would be positive. The important issue is whether the negative welfare losses can be compensated by the positive welfare benefits.

As electricity enters as an input in several sectors of the economy as well as households, a rise in electricity prices consequent to the removal of fossil-fuel and energy subsidies is likely to reduce the GDP of a nation. The interaction of removal of fossil-fuels and electricity subsidies with the rest of the economy is captured through GDP effects. (see Table 1)

The welfare losses in most countries are explained both by a rise in electricity prices, which would affect output, employment, exports, and imports of a number of products, and fuel prices in general, which would affect transportation. The largest reductions in welfare and GDP are for larger countries. The two exceptions are Japan and Germany, which have already moved to high levels of energy efficiency and substitution with renewables as well as other energy regulatory regimes that compensate for the loss of fossil-fuel subsidies.

Table 1: Welfare and GDP Losses (in US$ Mn)

Country	GDP changes	Tariffs	Subsidies
China	-14141.25	270.79	-14412.04
Japan	-3635.50	192.19	-3827.69
Germany	-6073.75	-39.62	-6034.13
France	-62079.50	10.29	-62089.79
Italy	-20633.13	14.39	-20647.52
USA	-34567.00	33.75	-34600.75
Canada	-2833.75	0.71	-2834.46
Taiwan	-968.16	64.81	-1032.97
Korea	-18089.13	103.03	-18192.16
India	-53937.38	40.07	-53977.44
Brazil	254.25	34.56	219.69
South Africa	-4295.63	7.33	-4302.95
Rest of World	-63924.00	278.86	-64202.86
Country	**Welfare**	**Tariffs**	**Subsidies**
China	-14667.15	268.31	-14935.46
Japan	-4365.51	256.88	-4622.39
Germany	-6964.62	-51.07	-6913.55
France	-63067.71	9.34	-63077.05
Italy	-20797.16	17.63	-20814.79
USA	-35792.91	12.86	-35805.77
Canada	-711.55	-1.50	-710.05
Taiwan	-1584.55	89.22	-1673.77
Korea	-17376.60	121.19	-17497.79
India	-52955.75	6.18	-52961.94
Brazil	191.11	36.21	154.90
South Africa	-4609.51	8.53	-4618.04
Rest of World	-62167.12	237.45	-62404.57

While energy prices in South Africa increased by large amounts, (see Table 2 below) its welfare losses were smaller than those of other countries that have seen lower increases in energy prices. In the case of South Africa, electricity consumption (see Annex IV) is roughly one-third that of India and only one-fifth that of China. Also, only two-thirds of the households in South Africa have access to electricity grids, and the industrial base is small. Thus, welfare losses in US dollar terms are smaller than in comparable countries with a lower increase in energy prices.

Table 2: Increase in Energy Prices (in percent)

1 China	3.35
2 Japan	1.37
3 Germany	1.49
4 France	0.55
5 Italy	2.80
6 USA	1.51
7 Canada	0.98
8 Taiwan	1.41
9 Korea	2.47
10 India	10.49
11 Brazil	0.93
12 South Africa	40.56
13 Rest of World	1.86

Emission reductions were significant for countries whose subsidies were the highest. (see Table 3 below) For example, South Africa, which has the highest dependence on coal, shows the largest decrease in emissions. Brazil, which has the lowest subsidies for fossil fuels, has minor reductions in emissions, as do Japan and Chinese Taipei. Moreover, allocative efficiency will generate welfare gains as will the correction of market failures associated with environmental externalities generated by fossil fuels. The improvement in health generated from emission reduction is generally not included in calculations of carbon cost. Implicitly it may be included in the trading price of carbon, but it is difficult to say whether it captures the entire externality cost of impaired health. In this paper, welfare gains have been estimated by looking at the volume of emissions reduction and using a price of USD 25 per metric tonne of carbon. This price of carbon is based on an IMF study. (IMF, 2013) However, there are varying estimates of carbon prices and these may rise over time. (IMF, 2013) The price range varies from USD 20 to USD 75. Higher prices of carbon would by definition generate higher welfare gains, but they are unlikely to compensate for the economic losses in the entire economy, which arise from an increase in energy prices owing to the removal of fossil-fuel and energy subsidies. Hence, any subsidy reform that countries put in place will need to be well-thought out and implemented in a manner that will minimize the negative economic impacts. As the earlier observation on the modelling results shows, the losses are lesser in Germany and Japan and this could be attributed to their move towards greater efficiency and the scale up of renewables within their economies as well as other regulatory regimes that would compensate for the removal of energy subsidies.

Table 3: Emission Reductions and Welfare Gains

Emission reduction (per cent)		Initial Emissions in million metric tonnes	Reduction in million metric tonnes of Co2	Welfare gains from reduction in emissions in millions of dollars
1 China	3.43	5268.80	**180.65**	4516.13
2 Japan	1.25	1067.78	**13.35**	333.84
3 Germany	4.20	747.77	**31.40**	784.98
4 France	6.48	393.03	**25.47**	636.80
5 Italy	6.49	439.87	**28.55**	713.78
6 USA	1.46	5583.40	**81.60**	2040.01
7 Canada	1.60	557.43	**8.94**	223.59
8 Chinese Taipei	0.59	258.33	**1.52**	38.06
9 Korea	3.99	424.13	**16.93**	423.28
10 India	0.71	1303.67	**9.23**	230.83
11 Brazil	0.46	316.38	**1.47**	36.78
12 South Africa	-0.04	342.23	**-0.12**	-3.06
13 Rest of World	2.03	9821.48	**199.16**	4979.01

With the reduction in subsidies on fossil fuels and rise in prices of electricity as well as liberalization of tariffs on the products listed in Annex III, it is to be expected that output and trade in the renewable products covered by this exercise would increase. However, in fact, this is not uniformly the case, as can be seen from Table 4 below.

Table 4. Changes in Output, Employment and Trade When Fossil-Fuel Subsides and Import Tariffs on Annex III Products Are Reduced to 0%

Output	China	Jap	Ger	Fran	Italy	USA	Can
R.E equipt	1.57	0.0	0.64	-0.10	-0.04	0.12	-0.09
Wind turbine	-0.20	0.0	0.01	0.01	0.00	0.01	0.01
Other Equipts	-0.20	0.0	-0.03	-0.03	-0.01	0.00	-0.03
Empt							
R.E equipt	1.47	0.0	0.61	-0.10	-0.04	0.11	-0.09
Wind turbine	-0.12	0.0	0.00	0.01	0.00	0.01	0.02
Other Equipts	-0.30		-0.04	-0.03	-0.01	0.00	-0.03
Exports							
R.E equipt	7.86	-3.6	1.69	-1.14	-2.61	-1.44	-0.94
Wind turbine	-0.18	0.0	0.08	0.02	0.01	0.03	0.04
Other Equipts	0.29	0.0	-0.02	-0.06	-0.05	-0.01	-0.04
Imports							
RE equipt	-3.07	1.3	-0.62	0.55	0.20	-0.04	0.63
Wind turbine	0.11	0.0	-0.06	0.02	0.00	-0.01	0.01
Other Equipts	0.13	0.1	-0.03	0.06	0.09	0.09	0.05

Output	Tai	Kore	India	Brazil	S. Africa	R.O.W
R.E equipt	-0.03	-0.01	8.29	-0.02	33.73	-0.15
Wind turbine	0.10	0.04	-0.83	0.01	-1.07	0.00
Other Equipts	0.21	0.05	-1.40	-0.21	-0.60	-0.05
Empt						
R.E equipt	-0.03	-0.02	7.92	-0.03	32.61	-0.16
Wind turbine	0.10	0.05	-0.03	0.01	-0.65	0.01
Other Equipts	0.21	0.06	-1.03	-0.20	-0.50	-0.04
Exports						
R.E equipt	-3.75	-3.44	38.2	-2.35	84.43	-3.30
Wind turbine	0.15	0.15	-1.01	0.02	2.09	0.04
Other Equipts	0.32	0.29	-0.02	-0.12	5.17	-0.01
Imports						
RE equipt	0.97	2.24	-14	0.35	-68.13	0.82
Wind turbine	0.09	0.01	0.00	0.23	-2.26	0.04
Other Equipts	0.16	0.30	-0.46	0.63	-5.37	0.11

The output and trade of RE equipment for most countries increases with a decrease in tariffs and the removal of fossil-fuel subsidies. However, the increase is relatively minor for most countries, except India and South Africa. Even for these countries, the increase will not be high in value terms, as their initial production base of these products is very small. These countries experience a strong substitution effect, even though the absolute increase will not be major. The products included in this category are solar energy devices, including PVs, solar heaters, hydroelectricity equipment and bio fuels. Obviously, these countries also have a comparative advantage in the production of some of these products, and the removal of fossil-fuel subsidies would tilt the balance in favour of solar and hydroelectric equipment. Exports and employment also follow trends in output, and imports reduce as expected. Brazil is projected to experience a small drop in output for these categories of equipment, because electricity prices in Brazil would not change enough for it to invest in solar or hydroelectricity. However, changes in Brazil's output, employment, exports, and imports for RE products listed in Annex III in terms of percentages are low.

Photovoltaics do use energy in their production. According to a study on the Netherlands and the US, under typical UK conditions, it would take 2.5 years to payback the energy costs of a 1 square metre of PV panel. (Fthenakis, Kim and Alsema, 2008) As PV panels have an expected life of at least 25-30 years, it is expected that during its lifespan a solar-PV panel would produce many times more energy than required for its manufacture. Moreover, the carbon emissions of PV are 10 times lower than fossil fuels. Obviously in countries that use more fossil fuels and have a lot of sunlight the payback time would be shorter and the energy production would be higher. In these cases, the carbon footprint of PV will be even lower.

The surprising results are for wind energy turbines and other equipment that serve as components for wind towers. Most of the countries expected to experience a fall in output, employment, and trade of these products are precisely the ones that have a comparative advantage in producing them. This counterintuitive result is explained by the high increase in electricity prices. Wind turbines and wind towers use a lot of metals (95 percent steel in a wind tower), concrete, and other energy-intensive products. The cost of energy represents approximately 20 percent of the total cost of making steel. Steel Mills use coal and coke, a derivative of coal, in furnaces, and much of the electricity used in steel manufacturing is produced at coal-based power plants. Currently, roughly 50 percent of the energy used in steel is derived from coal. Worldwide, approximately 13 percent (about 717 million tonnes) of total hard coal production is currently used by the steel industry, and almost 70 percent of total global steel production is dependent on coal. Hence, the removal of coal subsidies would impact the steel industry, and the increase in energy prices would result in a decrease in output and employment in this product. (Congressional submission by the Steel Federation, 2012) Manufacturing windmills accounts for 80 percent of the total energy consumed by a wind turbine during its life cycle. According to one source, energy costs account for roughly 13 percent to 20 percent of the cost of running a windmill (EWEA LCA, 2013) By extension, removing fossil-fuel subsidies and increasing energy costs, would raise the cost of production and the cost of running wind energy farms, leading to a reduction in output, employment, and trade in the products listed in Annex III. However, it is to be noted that while there is a reduction, the percentage reduction is rather low. This applies to all countries except Brazil for the reasons cited above. While solar PV is also energy-intensive during its manufacture, the ease with which it can be deployed particularly in terms of off-grid and rooftop energy could give it an advantage compared to when energy and electricity prices rise in general.

When import tariffs are reduced to zero for the products listed in Annex III there are insignificant changes in total emissions and electricity prices, except for Taiwan and Korea, which had higher tariffs of more than 20 percent before the reduction. (see Table 6) This is because these variables are affected by changes in fossil-fuel subsidies to a much larger extent than by the import tariffs on the products in Annex III.

The effects of removing fossil-fuel subsidies overwhelm the effects of reduction in import tariffs, thus there is little change in emissions and electricity prices by tariff reduction alone. (see Table 6)

However, there are minor changes in welfare. Eliminating import tariffs for the products in Annex III increases welfare, thus reducing net welfare loss. (see Table1) This holds for all countries, except Germany, where there are net welfare losses, owing to a decrease in import tariffs to zero. These changes are very small. As far as GDP changes are concerned subsidy removal overwhelms the import tariff effects as is to be expected. Only Brazil experiences a small increase in GDP, which follows the trends in welfare changes or vice versa. The ranking of countries in terms of GDP and welfare losses remains the same when import tariffs were reduced to zero.

These surprising results for the RE sector are explained by the fact that the demand for RE equipment is a derived demand. It increases when the demand for RE increases, which in turn is a policy and target-driven demand that is heavily reliant on FITs and other such subsidies. In the absence of such incentives, merely removing fossil-fuel and non-RE subsidies would not by itself generate a RE industry. As over 76 percent of the fossil-fuel subsidies are provided to oil and petroleum, which is not a direct competitor to RE, it is hardly likely that more even competition will arise from renewables to coal and gas (used for power generation) through the removal of these subsidies.

Expansion of RE will, therefore, require targeted support and policy initiatives until meaningful 'grid parity' is achieved. This section also shows that internalizing externalities and pricing carbon offsets is a major challenge, and in the short run, the output and employment effects may overwhelm the environmental externalities. In the EU, the recent fall in carbon prices from EUR 30 to less than EUR 3 per metric ton (Financial Times, 16 April, 2013) reflect the relevance of the economic recession to environmental targets. Concerns about the loss of competitiveness for some sectors led to free allocations of carbon permits. In the absence of these concerns the supply of permits would have been tighter and the prices higher. Developing countries face similar trade-offs, and the global economic climate explains to a large extent the sluggish progress on subsidy elimination in G-20 developing countries. Moreover, while general equilibrium effects, such as GDP, welfare, energy prices, and overall emissions on the economy as a whole may be large, as shown in Tables 1 and 4, the effects on the selected products in Annex III are not large. Targeted instruments such as tariffs, FITs, and LCRs would affect these products more directly. Hence, in terms of policy targets, these trade reforms may be easier and better targeted to the deployment of RE.

As stated above, eliminating fossil-fuel subsidies is a long-term goal, and trade reforms may be more easily achievable. With constant existing energy prices (keeping fossil-fuel subsidies and energy subsidies), eliminating tariffs on the select single-use products in Annex III could have positive effects on the environment. This issue is examined in the next section.

Chapter 3

Liberalising Trade In RE Products Listed In Annex III

Given that fossil-fuel subsidies may be difficult to remove, it may be useful to start trade reforms that are more in the realm of possibility. This paper examines reducing import tariffs to 5 percent, because member of Asian-Pacific Economic Cooperation (APEC) have agreed to reduce tariffs on a more extended list of about 54 items to 5 percent. Hence, reducing import tariffs to 5 percent for a much smaller list (Annex III) may be possibly at the WTO. However, as the mandate in the WTO was to eliminate tariffs altogether for environmental goods and services, this paper also examines the macroeconomic effects of reducing tariffs of Annex III products to 0. To understand theoretically the overall economic effects of these shocks it is necessary to understand why countries impose tariffs on these products in the first place. A close examination of the renewables industry shows that there may be a number of reasons, but three main categories can be identified. For the RE sector, governments may impose tariffs for the following reasons:

- To protect fledgling domestic industries from foreign competition, in this case RE goods.
- To encourage tariff jumping investments and technology flows in renewable industries. This would, however, be better targeted through incentive measures, such as subsidies.
- To protect domestic producers from dumping by foreign companies or governments. In this case, countervailing duties could be imposed, though some countries may take pre-emptive action by raising tariffs. Dumping occurs when a foreign company charges a price that is "too low." In most instances "too low" is generally understood to be a price that is lower in a foreign market than in the domestic market. In other instances "too low" means a price that is below cost, so the producer is losing money.
- To generate government revenue

The cost of tariffs to the economy is not trivial. Two kinds of effects can be disassociated:

- The impact on the country that is exporting the product
- The impact on the country that is importing the product

It is easy to see why a foreign import tariff hurts the economy of the country exporting renewables. A foreign tariff raises the costs for domestic producers, which causes them to sell less in the foreign market. Producers cut production, owing to this reduction in demand, which causes job losses. These job losses impact other industries, as the demand for consumer products decreases because of the reduced employment. Foreign import tariffs, along with other forms of market restrictions, cause a decline in the economic health of a nation. All these interactive effects have been captured by GTAPE simulations below.

The effects on the country imposing the import tariff are more complicated. Import tariffs are a boon to domestic producers, which face reduced competition in their home market. The reduced competition causes prices to rise. The sales of domestic producers should also rise, all else being equal. The increased production and price causes domestic producers to hire more workers, which causes consumer spending to rise. Import tariffs also increase government revenues, which can be used to the benefit of the economy.

However, the price of RE products with the import tariff will increase, thus the consumer is forced to either buy less of this good or less of some other good. The price increase can be thought of as a reduction in consumer income. Since consumers are purchasing less, domestic producers in other industries are selling less, causing a decline in the economy.

Generally, the benefit caused by the increased domestic production for the protected industry plus the increased government revenues does not offset the losses. The costs of imposing such tariffs would also include the cost of collecting the tariff, which in some cases can be high. If we consider the possibility that other countries might put tariffs on these goods in retaliation, the costs would be even higher. Such a situation of retaliatory tariffs between the US and China are already being observed in the case of solar energy products. These interlinked reactions are captured by the GTAP-E model used in this analysis.

3.1 Results of Reducing Import Tariffs to 5 Percent

The results of the simulation where import tariffs on products listed in Annex III are reduced to 5 percent are summarized in Table 5 below. This level of reduction may become the starting point of the negotiations, and hence, is used here. Output and employment increase for most countries, except Brazil and India. Minor decreases were also observed for Canada and Germany. The decrease in output and employment would occur, because some domestic output and employment would be replaced by more competitive imports probably from China. The dramatic changes in Brazil and India are attributable to the prevailing high import tariffs. In India, applied tariffs were in excess of 7 percent, and they were in excess of 14 percent in Brazil. Surprisingly, Germany's average tariff for some of these products was also 8 percent. (see Annex V for selected tariff rates) This explains why these countries see a decline in output and employment. Germany's output and employment in this sector would be reduced by about 1 percent, while the reduction in Brazil and India would be about 3-4 percent. As can be observed from section 1, import tariff reduction effects are different when fossil-fuel subsidies are removed.

Emissions decrease marginally for all countries, but there is a minor increase in South Africa. All changes are very small, with the highest decline for Korea at about 0.3 percent.

Electricity prices do not change by much. Small increases or decreases much lower than 1 percent have been observed.

As expected, imports of wind energy products for most developing countries increase at much higher rates than those of developed countries. The only exception is South Africa, where imports increase marginally, probably because, for most import tariff lines, the applied import tariff in South Africa is already low, and deployment of RE in the absence of incentives, such as FITs, is unlikely to be high. The expected increase in imports for Brazil, China, and India is about 10 to 26 percent.

Exports for most countries also increase, except for Canada and the European countries where there are minor decreases. However, these decreases are very small. As expected, China, India, Korea, and South Africa show the highest increases in exports, owing to their current competitiveness. India's exports increase by 15 percent, as could be expected given that it is competitive in this sector. Moreover, the increase in imports of parts may make India more competitive in exports of wind turbines.

Table 5: Effects of Reducing Import Tariffs on Products in Annex III to 5 Percent

Output	China	Japan	Ger	France	Italy	USA	Can
Renewable Electricity Products	0.1	0.02	-0.002	-0.0002	0.002	-0.0002	0.001
Wind Energy Equipments	0.9	1.09	0.00E+00	0.03	0.2	0.012	-0.03
Other Equipments	-0.6	0.7	0.4	0.2	0.4	-0.01	0.04
Employment							
Renewable Electricity Products	0.17	0.006	-0.001	0	0	-0.001	0
Wind Energy Equipments	1	1.1	-0.06	0.03	0.24	0.02	-0.03
Other Equipments	-0.54	0.7	0.45	0.23	0.37	-0.01	0.035
Exports							
Renewable Electricity Products	1	-0.3	-0.02	-0.006	-0.03	-0.003	-0.004
Wind Energy Equipments	7.8	7.6	-1.2	-0.85	-1.2	0.6	-0.12
Other Equipments	1.8	1.2	0.73	0.55	0.85	0.04	0.08
Imports							
Renewable Electricity Products	-0.36	0.17	0.01	0.01	0.02	-0.01	0
Wind Energy Equipments	10.6	1.6	0.7	0.2	0.9	-0.9	0
Other Equipments	3.8	0.6	0.2	0.09	0.2	-0.02	-0.01

Output	Taiwan	Korea	India	Brazil	S.Africa	R.O.W.
Renewable Electricity Products	0.3	0.12	-0.08	-0.01	-0.08	-0.0002
Wind Energy Equipments	3.2	1.5	-4.3	-3	1	-0.5
Other Equipments	4.7	0.4	-7.7	-5.5	0.08	0.1
Employment						
Renewable Electricity Products	0.3	0.26	-0.08	0.01	-0.06	0
Wind Energy Equipments	3.5	1.8	-4.47	-2.85	1	-0.47
Other Equipments	4.83	0.49	-7.79	-5.4	0.09	0.12
Exports						
Renewable Electricity Products	-0.93	-2	2.2	-0.06	-0.3	0.01
Wind Energy Equipments	0.7	8.1	15.2	1.5	9.3	-0.7
Other Equipments	6.3	2.05	5.1	2.4	0.4	0.25
Imports						
Renewable Electricity Products	0.6	1.6	-1	0.04	0.08	-0.015
Wind Energy Equipments	10	4.2	214	26.1	3.5	1
Other Equipments	14	1.7	199	14.3	0.03	0.01

Table 5: Effects of Reducing Import Tariffs on Products in Annex III to 5 Percent

Emission reduction from renewables (positive means reduction)		Electricity Prices	
China	0.1	China	-0.2
Japan	0.05	Japan	0.05
Germany	0	Germany	0
France	0.01	France	0
Italy	0.01	Italy	0
USA	0	USA	-0.01
Canada	0	Canada	-0.01
Taiwan	0.3	Taiwan	0.15
Korea	0.3	Korea	0.3
India	0.07	India	-0.4
Brazil	0.02	Brazil	0.01
South Africa	-0.01	South Africa	-0.05
Rest of World	0	Rest of World	0

3.2 Results of Reducing Import Tariffs To Zero

When import tariffs are reduced to zero, China, Japan, the Republic of Korea, and Taiwan show the highest increases in output, trade, and employment. This is because these countries are most competitive in the production of industrial products. Hence, when import tariffs are reduced to zero, it is expected that they would expand their production in response to market signals. These countries also see more significant declines in emissions, with a 2.4 percent decline in Korea. Because of its superior capacity to produce renewables, Korea may be able to able to substitute fossil fuels with renewables more rapidly.

Table 6: Effects of Reducing Import Tariffs for Products in Annex III to Zero

Output	China	Japan	Ger	France	Italy	USA	Can
Renewable Electricity Products	0.8	0.1	0.01	0.02	0.01	0.01	0.03
Wind Energy Equipments	4.2	3.1	-1.4	0.3	0.7	0	-1.15
Other Equipments	0	4.3	-1.05	0.08	0.5	0.1	-0.7
Employment							
Renewable Electricity Products	1.2	0.03	0	0.04	0.01	0.01	0.05
Wind Energy Equipments	5	3.4	-1.5	0.4	0.8	0.02	-1.13
Other Equipments	0.2	4.4	-1.1	0.1	0.5	0.1	-0.7
Exports							
Renewable Electricity Products	0.2	-1.7	0.04	0.03	-0.05	-0.03	0.02
Wind Energy Equipments	22.2	14.2	-1	4	1.8	6.2	-1.4
Other Equipments	16.7	7.9	-0.9	1.3	2	3.9	-0.2
Imports							
Renewable Electricity Products	0.7	0.9	-0.01	0.03	0.03	0.02	0.03
Wind Energy Equipments	26.8	9.2	-0.5	1.4	3.1	3.7	1.8
Other Equipments	18.2	3.8	0.7	1.05	1.7	2.4	0.4

Output	Taiwan	Korea	India	Brazil	S.Africa	R.O.W.
Renewable Electricity Products	1	0.87	-0.0	-0.02	-0.03	0.02
Wind Energy Equipments	11	3	-5.6	-4.5	1.8	-2.4
Other Equipments	12.5	3.4	-11.5	-9.7	0.5	-1.5
Employment						
Renewable Electricity Products	1	2.2	-0.1	0.02	0.7	0.07
Wind Energy Equipments	12.1	4.8	-5.9	-4.2	2	-2.1
Other Equipments	12.8	3.9	-11.5	-9.6	0.6	-1.5
Exports						
Renewable Electricity Products	-2.9	-15.3	3.1	-0.05	-6.5	0.01
Wind Energy Equipments	8.5	13.5	32.6	15.1	24.3	3.5
Other Equipments	19.2	17.7	15.3	4.8	9.7	2
Imports						
Renewable Electricity Products	1.9	9.8	-1.4	0.05	3.6	0.04
Wind Energy Equipments	35.8	24.4	31.9	37.8	18.7	7.5
Other Equipments	0.4	15.6	31.5	25	4.8	3.2

Table 6: Effects of Reducing Import Tariffs for Products in Annex III To Zero

Emission reduction from renewables (positive means reduction)		Electricity Prices	
China	0.8	China	-0.3
Japan	0.3	Japan	0.2
Germany	0	Germany	-0.02
France	0	France	-0.08
Italy	0	Italy	-0.02
USA	0.01	USA	-0.05
Canada	0.01	Canada	-0.12
Taiwan	1	Taiwan	0.4
Korea	2.4	Korea	2.1
India	0.1	India	-0.7
Brazil	0.03	Brazil	-0.03
South Africa	0.65	South Africa	-0.5
Rest of World	0.03	Rest of World	-0.07

Export increases are the highest for wind turbines for India at 32 percent, which is consistent with its competitiveness in this sector. However, paradoxically both output and employment decline for all three developing countries, i.e. Brazil, India, and South Africa. This is because, with the reduction in import tariffs, cheaper imports may replace domestic production of some components in which they do not have a natural competitive advantage. The higher levels of both imports and exports also indicate that the imported content of exports is likely to increase and be high. As far as developed countries are concerned, the changes, as expected, are relatively minor, indicating that tariffs were already low, and they would not be able to take advantage of lowered tariffs in other countries as they are not competitive in the production of most of these products. The slight decline in Germany's figures for output, employment, and trade may be indicative of the fact that in traded products, such as wind turbines, Germany maintained an import tariff of 8 percent. (see Annex V)

Minor decreases in electricity prices result for all countries, except for Korea, Japan, and Taiwan. This would appear to be counterintuitive for these three countries, as energy generated by renewables is more expensive per unit than that generated by conventional sources, such as fossil fuels. However, if we take account of the fact that renewables in almost all countries get much higher subsidies per unit than conventional sources (to a scale of 1:5), this result can be explained. The fact that China and India see the highest declines in prices may be attributable in part to substitution by renewables for which higher subsidies are available. In part, the strategy of both these countries has been to export RE products and projects while using cheaper conventional energy sources at home.

Looking at emissions, we observe minor reductions in all countries, except Korea and Taiwan, where they are more significant. This is in keeping with their increase in production, employment, and trade in RE products, probably signalling increased deployment of

RE. These countries may find it easier to switch to renewables, because the cost of production of RE equipment may be competitive, and the cost of fossil fuels may already be very high as they import most of what they consume.

However the reduction in emissions in South Africa and China are higher than in Japan. A simple explanation for this would be that tariff reduction induces an increase in China's output and domestic deployment of RE as does its investment in South Africa. There are already indications that one of the largest solar photovoltaic investors in South Africa is China. As Japan already is less reliant on fossil fuels and deploys clean energy for domestic purposes, its output increase may be focused on increasing trade.

Chapter 4

Removing FITs And Reducing Import Tariffs For Annex III Products To Zero

Subsidies whether they are for fossil fuels or renewables have the same kind of economic effects. They also tend to be more or less trade distorting, depending on what they are and how they are applied. The most commonly applied subsidy for renewables is FITs. In fact, FITs are applied in several developing and developed countries and have led to an increase in the deployment of RE.

Governments justify public support to RE on some of the following grounds:

- Externality: level the playing field with polluting incumbents;
- Support nascent industry to reduce costs (learning effect)
- Job creation
- Removal of non-market barriers to investments
- Overcoming entrenched behaviour
- Energy security, mitigating fuel price volatility
- Equity and affordability

Applying these reasons to FITs, recent empirical evidence shows that FITs may minimize revenue risk, and help leverage investments, and would equally be accessible to small players, owing to low transaction costs. They may also be administratively easier to implement and be more technology and trade neutral than specific RE component subsidies or RE subsidies contingent on certification. However, the use of FITs exposes investors to political and fiscal risks as in the case of Spain. Governments may also find that the supply of RE is inadequate, or when prices fall, governments may unnecessarily lose revenue. Administrative costs will go up when adjustments have to be made to FITs consequent to changes in technology. Finally, the FIT-setting process may be vulnerable to lobbying and rent seeking, as is the case with other procurement subsidies.

It is often argued that reducing fossil-fuel subsidies would improve the scope for providing RE subsidies. This is especially important in view of the fact that fossil-fuel subsidies are so much higher than RE subsidies. While several sources have provided absolute amounts of subsidies provided to different kinds of energy, the Global Subsidy Initiative divided the total subsidy estimate by the quantity of energy produced. According to these figures, the average subsidy per unit of produced RE was over six times higher than support for a unit of fossil fuels-based energy and three times more generous than subsidies for nuclear power. (GSI, 2010) (see Table 7 below)

However, these figures do not include negative externalities associated with fossil-fuel and nuclear energy. Back of the envelope calculations suggest that, taking a carbon price of EUR20/tCO2e would reduce the gap by 30-40 percent (at 750kg CO2/MWh for the weighted average fossil-fuel plant and an exchange rate USD 1.35 to the euro. (GSI, 2010) Adding subsidies to large hydro plants could change the gap either way. On the one hand, large hydro has economies of scale; on the other, they are heavily subsidized. A high level of aggregation masks possibly large differences within each category. Traditionally, natural gas has been far less heavily subsidized than coal or oil. The same is true for RE sources – PV and concentrated solar power (CSP) tend to be much more heavily subsidized than wind or small hydro. Subsidies to waste-to-energy plants and landfill gas recovery projects are common in the many countries, and often flagged as support for RE.

Table 7: Estimates of Subsidies by Type of Energy

	Subsidy estimate (US$ billion/year)	Energy produced (2007)	Subsidies per energy unit (US cents/kWh)
Nuclear energy	45	2,719 TWh el.	1.7
Renewable energy (excluding hydroelectricity)	27	534 TWh el.	5.0
Biofuels	20	34 Mtoe	5.1
Fossil fuels (non-OECD consumers)	400	4,172 Mtoe	0.8

Source: The Global Subsidies Initiative, Relative Subsidies to Energy Sources: GSI Estimates, April 2010

Notwithstanding these shortcomings, a Global Subsidies Initiative (GSI) comparison of subsidies shows that RE is on average already heavily subsidized. Massive scaling up of renewable power in national energy portfolios may not be possible without rapid reduction in costs of generation. These heavy subsidies have been justified on the grounds that, in this age of economic crisis, RE creates jobs. However, job creation in this sector through these sources has to be pitted against the possible losses in other sectors that result from a rise in electricity prices.

The "25 percent by 2025" and "30 percent by 2030" goals of the EU might indeed create hundreds of thousands of new jobs in the renewables industry, but higher-cost electricity would necessarily reduce available income for other goods and services and for investment, and reduce overall economic growth. Indeed, in Spain, it has been calculated that for every job created in the RE sector, 2.2 jobs have been lost elsewhere. (Navigant Report, 2012) Ironically, the Navigant Report noted that nearer-term renewable standards are required to "mitigate a flattening or decline in industry supported jobs that will otherwise occur across industries with the expiration of tax incentives and stimulus-related policies." In other words, without continued subsidies and renewable portfolio mandates, the RE industry would contract.

Accurately predicting how specific policies would change output and employment in every industry is probably impossible. Therefore, most economic impact studies rely on so-called static models that are based on a 'snapshot' of the economy at a given time. When the models are used to estimate the economic effect of renewable generation construction, they allocate the expenditures for that construction in different sectors of the economy (e.g., cement, turbine manufacturing, wire, wages, etc.) and determine how those expenditures would ripple through the economy. For example, increased demand for wind turbines would mean more purchases of cement for foundations and increases in demand for sand and gravel. Similarly, wages paid to construction workers would be spent on goods and services; this would increase the demand for those goods and services and cause further increases in employment. Renewable resource advocacy studies generally ignore the economic effects caused by higher electricity prices. Households where electric bills increase because of RE mandates have less money to spend on everything else. At the same time, goods and services that require electricity for production will face increased cost. So, consumers have less money to spend on goods and services that cost more to produce. That is no different than imposing a tax on consumers and producers. Higher taxes reduce economic growth. A study performed to examine the economic effects of a proposed renewables requirement in Pennsylvania, US, for example, found that for each $100 million increase in electricity costs from renewables, 640 jobs would be lost. (Lesser, J., 2010) To capture some of the CGE results from removing FITs a GTAP-E model was used.

Table 8: Output, Employment and Trade in Annex Iii Products from Removing FITs and Reducing Import Tariffs To Zero

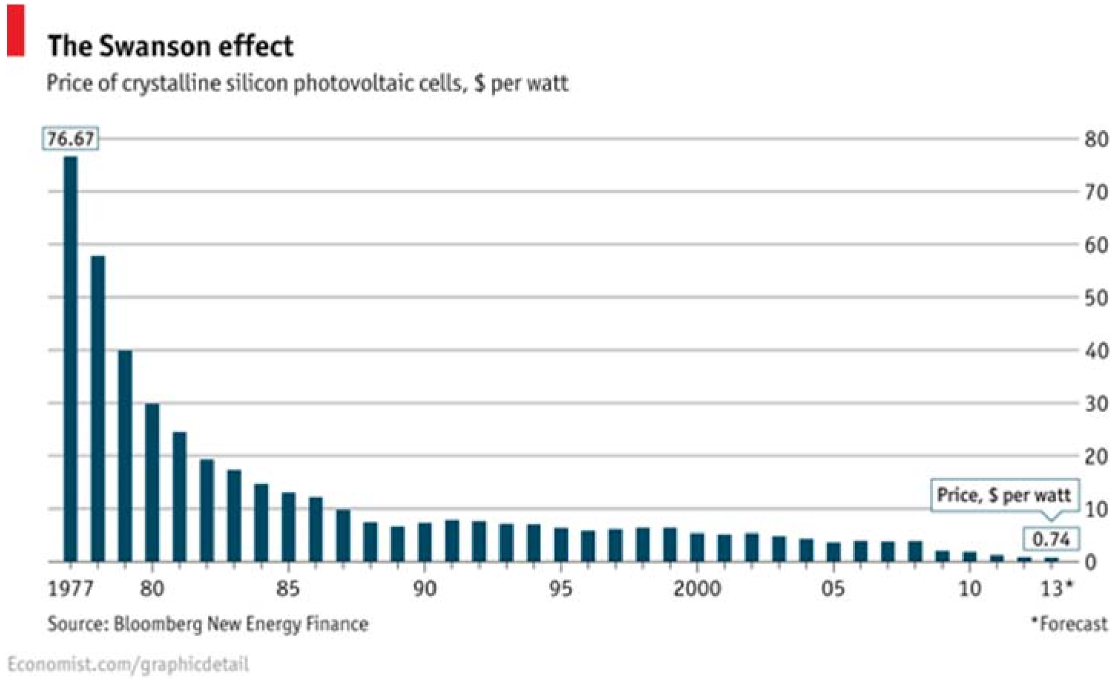
Output	China	Japan	Ger	France	Italy	USA	Can
Renewable Electricity	1.97	0.22	7.57	3.15	5.46	0.03	4.71
Wind Energy Equipments	-0.27	-0.01	-0.16	-0.09	-0.19	-0.01	0.00
Other Equipments	-0.27	-0.05	-0.06	-0.05	-0.24	-0.04	0.22
Employment							
Renewable Electricity	1.84	0.21	7.25	2.97	5.26	0.01	4.86
Wind Energy Equipments	-0.18	0.00	-0.26	-0.13	-0.26	-0.01	-0.17
Other Equipments	-0.40	-0.04	-0.20	-0.10	-0.21	-0.03	0.04
Exports							
Renewable Electricity	6.14	-6.99	26.18	6.52	21.18	-8.99	13.08
Wind Energy Equipments	-0.33	-0.15	0.35	0.13	0.35	-0.25	0.46
Other Equipments	0.20	-0.20	0.38	0.08	0.23	-0.32	0.52
Imports							
Renewable Electricity	-2.87	2.63	-7.44	-0.92	-6.88	9.68	-7.12
Wind Energy Equipments	0.12	0.08	-0.56	-0.16	-0.51	0.10	-0.38
Other Equipments	0.10	0.24	-0.80	-0.17	-0.62	0.26	-0.44

Output	Taiwan	Korea	India	Brazil	S.Africa	R.O.W.
Renewable Electricity	-0.05	-0.03	9.95	-0.06	33.98	-0.46
Wind Energy Equipments	0.09	0.03	-1.00	0.03	-1.09	-0.05
Other Equipments	0.18	0.03	-1.64	-0.24	-0.65	-0.14
Employment						
Renewable Electricity	-0.05	-0.04	9.49	-0.11	32.84	-0.48
Wind Energy Equipments	0.09	0.04	-0.02	0.05	-0.64	-0.04
Other Equipments	0.18	0.04	-1.18	-0.23	-0.54	-0.13
Exports						
Renewable Electricity	-9.58	-8.47	41.09	-8.88	84.15	-8.89
Wind Energy Equipments	0.12	0.10	-1.40	-0.30	1.93	-0.14
Other Equipments	0.25	0.20	-0.27	-0.47	4.96	-0.19
Imports						
Renewable Electricity	4.58	3.60	-16.28	1.45	-67.85	4.16
Wind Energy Equipments	0.04	0.00	0.05	0.41	-2.20	0.08
Other Equipments	0.19	0.33	-0.58	0.90	-5.27	0.18

Given current cost profiles and technologies, removing FITs will would slow or stop growth in certain forms of RE. The results for wind turbines and other wind energy components show a small decline in most countries when FITs are removed. This shows that wind energy is more dependent on FITs. However, the small decrease shows that in the short run the installation costs of wind turbines are so high they would need to recover their capital costs. They would only scrap the mills once the capital losses have been recovered.

The surprising result is the increase in production of RE equipment. That includes hydroelectricity equipment, solar, and ethanol. With the removal of FITs there is likely to be a substitution of hydro for solar in countries where it is possible. This would happen perhaps in Canada. In other countries, such as China, France, Germany, India, and Italy, there is likely to be an increase in output, employment, and trade of RE solar PV modules and hydro-electric turbines. The increase is likely to be predominantly solar in places where further expansion of hydro may be difficult or in places where off-grid solar is dominant or rooftop solar is close to grid parity. This is vindicated by a recent Deutsche Bank report, which concludes that the global solar market will become sustainable on its own terms by the end of 2014, no longer needing subsidies to continue performing. (Deutsche Bank Report, 2013) "Grid parity has been reached in India even despite the high cost of capital of around 10-12 percent," the Deutsche Bank notes. This is despite a slight rise in module prices (of 3 to 5 cents per kilowatt) in recent months, which would of course increase supply and hence output of PV in India. Deutsche Bank says that for small commercial enterprises that can achieve 50 percent or more self-consumption, solar is competitive with grid electricity in most parts of Italy, and commercial businesses in Germany that have the load profile to achieve up to 90 percent self-consumption are also finding solar an attractive source of power generation. UBS also concluded an "unsubsidized solar revolution" was in the works, "Thanks to significant cost reductions and rising retail tariffs, households and commercial users are set to install solar systems to reduce electricity bills – without any subsidies."(UBS, 2013) According to the Macquarie Group, costs for rooftop solar in Germany have fallen so far that even with subsidy cuts "solar installations could continue at a torrid pace." The cost of manufacturing solar panels in China fell to an all-new low of 42 cents per watt in 2015, and power generated from solar is expected to undercut that produced by both coal and most forms of natural gas within a decade. Investments from China in South Africa in the solar-energy sector have increased. With a reduction in FITs in China and a glut in the PV industry, investments from China to other economies are likely to increase. (CAI report, 2012) Figure 2 below shows the sharp decline in prices of crystalline silicon PV cells between 1977 and 2013.

Figure 2: The Swanson Effect: Dramatic Fall in Prices of Crystalline Silicon Photovoltaic Cells (1977-2013)[2]



Source: www.economist.com from Bloomberg New Energy Finance

Table 9: Percentage Change in Emissions and Welfare Gains

Country	% reduction in emissions (positive means reduction)	Welfare gains from emission reduction (positive means improvement)
1 China	0.85	1120.10
2 Japan	0.03	9.30
3 Germany	2.64	493.15
4 France	0.12	11.74
5 Italy	1.19	130.36
6 USA	-0.02	-23.38
7 Canada	0.60	84.03
8 Taiwan	-0.05	-3.31
9 Korea	-0.03	-2.79
10 India	3.84	1250.73
11 Brazil	-0.05	-3.79
12 South Africa	19.47	1666.09
13 Rest of World	-0.19	-456.94

There is a small reduction in emissions for some countries. The reduction in emissions was the highest for countries and locations where grid parity has been achieved through distributed solar power, and removal of FITs would not reduce the deployment but may even increase it. These countries include China, Germany, India, and Italy as shown above. South Africa could substitute its fossil-fuel use in part through an increase in investment in solar energy. However, Brazil, Korea, the US, and Taiwan see a slight increase in emissions, perhaps because they do not report FITs and hence removal of FITs has only minor effects on their emissions.

There is a uniform increase in RE prices in most countries. This is the direct effect of removal of FITs. The rise in prices will be the highest where the cost of reaching grid parity is lowest and where the deployment of RE is the highest. Thus, in Brazil, Japan, Korea, the US, and Taiwan where both RE deployment or FITs are low, the rise in RE prices was minimal.

Table 10: Percentage Change In RE Prices

Country	
1 China	2.47
2 Japan	0.38
3 Germany	6.73
4 France	3.04
5 Italy	5.98
6 USA	0.26
7 Canada	4.57
8 Taiwan	0.08
9 Korea	0.09
10 India	11.70
11 Brazil	0.17
12 South Africa	40.44
13 Rest of World	0.09

Removing FITs reduces GDP and welfare for most countries, except those that do not provide FITs, while tariff reduction improves welfare and GDP for most countries. But, the more dominant effect of FITs can be observed by both the GDP and welfare change decomposition.

Table 11: Decomposition of Changes in GDP and Welfare When FITs and Import Tariffs are Reduced To Zero (millions of US dollars)

Country	GDP changes because of removal of FITs and reducing import tariffs to 0	GDP changes from removal of import tariffs	GDP changes from removal of FITs	Welfare changes from removing FITs and removing import tariffs to 0	Welfare changes because of import tariff reduction	Welfare reductions because of removal of FITs
China	-5413.25	270.78	-5684.03	-5661.32	269.35	-5930.67
Japan	258.00	192.73	65.27	567.76	257.91	309.85
Germany	-11520.50	-39.62	-11480.88	-11500.72	-50.68	-11450.04
France	-3374.00	10.03	-3384.03	-3417.57	9.14	-3426.71
Italy	-6696.25	14.60	-6710.85	-7060.72	17.85	-7078.56
USA	1881.00	36.55	1844.45	2574.29	15.21	2559.09
Canada	-3234.38	0.85	-3235.37	-3258.47	-1.26	-3257.21
Taiwan	-26.97	64.92	-91.93	-61.61	89.50	-151.12
Korea	73.88	102.84	-28.96	53.82	120.54	-66.72
India	-5627.13	38.34	-5665.59	-6276.09	1.63	-6277.72
Brazil	300.25	34.97	265.28	370.20	37.08	333.12
South Africa	-3513.00	7.39	-3520.39	-3838.74	8.61	-3847.35
Rest of World	300.00	279.87	22.15	920.09	237.71	682.38

Chapter 5

Effects Of Removing Only Local Content Requirements (LCRs) And Reducing Import Tariffs For Annex III Products To Zero

Local content requirements (LCRs) mandate foreign or domestic investors to source a certain percentage of intermediate goods that are being used in their production processes from local manufacturers or producers. Often, legislation requiring LCRs calls for a gradual increase of the percentage of inputs or intermediate products that need to be sourced locally. The overall objective of LCRs may be either developing locally competitive industries or increasing employment. (Tomsik and Kubicek, 2006) However, this may not always be the case, as is shown in the modelling results below.

Table 12: LCRs in Renewable Energy in Selected Countries

Country	Technology	LCR % (start year)	LCR % (2012)	Notes and Remarks
Brazil	Wind	60% (2002)	60% (2012)	
China	Wind	20% (1997)	70% (2009)	The LCR requirement was formally abolished in 2009
France	Solar	(2012)	60% (2012)	10% bonus on EDF repurchasing price
India	Solar	30% (2011)	30% (2011)	Feed-in tariff conditionality
Italy	Solar	Variable (2011)		5 to 10% bonus if local content used
Ontario (Canada)	Wind	25% (2009)	50% (2012)	Feed-in tariff conditionality
Ontario (Canada)	Solar	50% (2009)	60% (2012)	Feed-in tariff conditionality
Québec (Canada)	Wind	40% (2003)	60% (2012)1	
South Africa	Wind	35% (2011)	>35% (2012)	
Spain	Wind	70% (2012)2		
Turkey	Wind	Variable (2011)		Additional feed-in tariff if local content used
Turkey	Solar	Variable (2011)		Additional feed-in tariff if local content used

Source: Rivers, Nicholas and Wigle, Randy, Domestic Content Requirements and Renewable Energy Legislation (June 11, 2011). Available at SSRN: http://ssrn.com/abstract=2129808

Turkey's Renewable Energy Sector from a Global Perspective, PWC. (April 11, 2012). Available at PWC: http://www.pwc.com/tr_TR/tr/publications/industrial/energy/assets/Renewable-report-11-April-2012.pdf

"Sourcing row in Jawaharlal Nehru Solar Mission" (Mar 21, 2012). Available at Economic Times: http://articles.economictimes.indiatimes.com/2012-03-31/news/31266631_1_trade-related-investment-measures-local-content-requirement-wto

Solar Energy Protectionism – Italy joins India, Canada in formulating Domestic Content Requirements. (May 10, 2011) Available at Green World Investor: http://www.greenworldinvestor.com/2011/05/10/solar-energy-protectionism-italy-joins-indiacanada-in-formulating-domestic-content-requirements/

"South African PV market in position to promote local manufacturing growth" June 1, 2012. Available at RenewableEnergyWorld.com: http://www.renewableenergyworld.com/rea/partner/first-conferences/news/article/2012/06/south-african-pv-market-in-position-to-promote-local-manufacturing-growth

"France offers domestic-content bonus". Feb 3, 2012. Available at Renewable International - The Magazine: http://www.renewablesinternational.net/france-offers-domestic-content-bonus/150/452/33245/

As shown above, LCRs are often linked to other policy measures, such as government procurement or the provision of specific subsidies. In the case of RE development, often eligibility to receive government support is conditioned on an LCR. (Rivers and Wigle, 2011) Some countries use LCRs as a precondition in their government procurement tenders in RE projects. In other cases, a content requirement has been used as a condition to receive a tariff rebate on other inputs (Beghin and Sumner 1992) or to receive FITs or preferential tax treatment. LCR are often used to complement such incentive schemes to benefit the local economy. Incentive schemes alone are difficult for policymakers to sell, especially in times of fiscal restraint, without at least some arguments that the environmental benefits will also be accompanied by economic benefits.

The use of LCRs in most countries studied here has to be understood against the background of a global recession. Global recovery is expected to slow, halt, or even reverse in some parts of the world, mainly because of the European sovereign debt crisis. (IMF, 2012) Financial uncertainty was also felt in job markets around the world, with an increase of 27 million unemployed since 2009 to a total of 200 million. Labour markets showed little improvement, with insufficient corporate investments being an important cause. (ILO, 2012) At the same time, climate change poses a great threat to sustainability in both developing and developed countries.

Most countries base their policy choices on political motivations, rather than on economic and empirical analyses, especially in the case of LCRs. However, studies show that under certain conditions LCRs may facilitate the development of a global innovator capable of competing in international markets and thus pushing down technology costs. (Kuntze and Moerenhout, 2012) These conditions are many, country- and technology-specific, and complex. The study also shows that while LCRs will incur short-term costs and may inflate retail power prices, a medium-term benefit of increasing competition and innovation on the international market may offset those costs. It is important to note that this is a theoretical possibility. To date, these potential positive spillover effects have not been demonstrated conclusively.

A theoretical analysis by Rivers and Wigle (2011) concludes that the overall potential of LCRs to create jobs is ambiguous. In addition, the 'infant industry' concerned may never 'grow up.' If LCR proportions are too high or successively increased, this may increase the costs of production and hence electricity prices. This may produce less RE than would be the case without LCRs. This reduced output will be translated into reduced employment (the output effect), which will not be compensated by an increase in employment due to a relative increase in domestic manufacturing (the substitution effect). Thus, in a general equilibrium sense, LCRs could reduce, instead of increase, the amount of green jobs created. However, there may be learning-by-doing potential and related medium-term spillover effects, which also include job creation and which is one of the most frequently cited rationales for industrial policy in the first place.

This study simulated the effects of removing LCRs in a GTAP model. Two scenarios were used: one where only LCRs were removed, while keeping FITs in place, and another where LCRs were removed along with FITs. It should be noted that the effects shown for each country are those arising from the domestic removal of import tariffs and LCRs (in case a country does apply LCRs) as well as the removal of import tariffs and LCRs by selected trading partners (i.e. the countries listed in Annex II). In case a country does not apply LCRs, such as for instance, Germany, the effects shown are those stemming from its own removal of import tariffs only plus the removal of LCRs and import tariffs by their trade partners.

Table 13: Effects of Removing LCRs and Reducing Import Tariffs To Zero

Output	China	Japan	Ger	France	Italy	USA	Can
R.E equipt	-0.08	0.0	-0.0	-0.6	0.0	-0.0	-0.2
Wind Turbines	6.0	0.0	-0.8	3.0	0.0	-0.6	0.8
Other equipt	1.0	0.4	-0.3	1.3	-0.1	-0.2	0.3
Employment							
R.E equipt	0.1	-0.0	-0.0	-0.3	0.0	-0.0	-0.0
Wind Turbines	4.0	0.0	-0.6	3.4	0.0	-0.6	1.6
Other equipt	1.2	0.4	-0.2	1.5	-0.1	-0.2	0.5
Exports							
R.E equipt	-1.2	-11.6	-0.5	-3.1	-1.5	-4.3	-0.9
Wind Turbines	18.8	2.6	-0.6	8.8	1.2	-0.8	0.0
Other equipt	3.6	1.1	-0.2	1.9	0.0	0.1	0.2
Imports							
R.E equipt	-80.1	-0.1	-0.7	-13	-0.5	-0.4	-2.7
Wind Turbines	12.4	2.4	0.4	20.4	1.4	2.8	1.0
Other equipt	3.2	-0.1	-0.1	1.9	-0.1	0.1	0.4

Output	Taiwan	Korea	India	Brazil	S.Africa	R.O.W
R.E equipt	0.0	0.0	-0.1	-0.4	-0.0	-0.0
Wind Turbines	-1.6	-0.8	6.6	10.6	-1.0	-1.4
Other equipt	0.5	0.1	1.3	4.7	-0.2	-0.5
Employment						
R.E equipt	-0.0	-0.0	0.1	-0.8	-0.0	-0.0
Wind Turbines	-1.2	-0.6	1.0	15.0	-1.0	-1.2
Other equipt	0.5	0.2	0.4	5.3	-0.2	-0.5
Exports						
R.E equipt	-6.3	-12.1	-2.0	-4.1	-0.5	-1.3
Wind Turbines	-3.4	-2.2	34.2	18.0	-0.8	-2.4
Other equipt	0.8	0.5	8.5	5.6	-0.1	-0.7
Imports						
R.E equipt	-0.2	-0.2	-23.6	-2.4	-0.1	-0.2
Wind Turbines	4.6	5.4	-8.4	2.0	2.2	1.2
Other equipt	0.4	0.5	2	2.6	0.1	0.1

The simulations show very interesting results. The effects of removing LCRs are at best ambiguous. While many countries see a fall in output and employment, some also see a rise in output, employment, and trade. This scenario does not neutralize FITs, but only examines the effect of removing LCRs. LCRs are not trade neutral. In fact, the trade effects are far more important than output effects. Developing countries, such as Brazil, China, and India actually see an increase in their output, employment, and trade as LCRs are removed in all these countries. This is especially true for wind turbines and components, suggesting that LCRs in these industries are particularly trade distorting. Removal of LCRs in other countries would naturally stimulate increases in exports from competitive countries.

These results are supported by theoretical analysis too. A theoretical analysis by Rivers and Wigle (2011) concludes that the overall potential of LCRs to create jobs and affect output is ambiguous. If local content proportions are too high or successively increased, the output effect is likely to dominate the substitution effect. This simply means that, because of an increase in costs of production, less RE will be produced than would be the case without LCRs. This reduced output will be translated into reduced employment (the output effect), which will not be compensated by an increase in employment due to a relative increase in domestic manufacturing (the substitution effect). In their numerical simulations, LCRs would then reduce, rather than increase, the amount of green jobs created. Thus, removing LCRs would lead to an increase in output, employment, and trade as shown in Table 13.

For Brazil, China, and India output and trade of wind turbines and other equipment increases when LCRs and import tariffs are reduced. Removing LCRs in other countries improves exports from competitive countries especially for wind turbines and parts. The results for France are explained by the fact that it does not provide LCRs for wind turbines. Hence, the trade incentive introduced by the removal of LCRs in other countries, especially Germany, may stimulate its industrial capacity for wind turbines and their parts.

Chapter 6

Effects Of Removing Both Local Content Requirements (LCRs) And Feed-In-Tariffs (FITs) And Reducing Import Tariffs For Annex III Products To Zero

In this scenario, the effects shown for each country are those arising from their own removal of import tariffs, FITs, and LCRs (in case a country does apply LCRs) plus the removal of import tariffs, FITs, and LCRs by their selected trading partners (i.e. the countries listed in Annex II). In case a country does not apply LCRs, such as for instance Germany, the effects shown are those stemming from its own removal of import tariffs and FITs only plus the removal of LCRs, import tariffs, and FITs by their trade partners.

The effects of removing FITs and LCRs while maintaining import tariffs at zero are indeed different from either removing only FITs or only removing LCRs. There is a reduction in output, employment, and trade of almost all countries, except as related to solar-PV equipment in the case of Canada, Germany, and Italy. Only minor changes occur for other countries, except India, where output falls. In the case of Germany and Italy, as previously noted, grid parity for solar PV has been reached in certain cases. In addition, Germany had no LCRs and the LCR related to solar energy in Italy it was not high. Hence, removing them has little effect, as was the case for the removal of FITs. India sees a reduction in output of solar from the removal of FITs and LCRs. While removing LCRs depressed output slightly, removing FITs actually increased output. However, removing the two together reduces both output and employment

Most countries experience negative production and employment effects from removing FITs and LCRs in wind turbines and component parts. There is a slight increase in France, India, and South Africa's exports of wind turbines and components of wind turbines.

Table 14: Effects of Removing LCRs, FITs, and Import Tariffs

Output	China	Japan	Ger	France	Italy	USA	Can
Re equipt	0.53	0.56	6.41	0.06	6.77	0.13	4.27
Wind Energy Equipments	-0.60	-0.41	-0.45	-1.20	-0.92	-0.35	-0.82
Other Equipments	-0.58	-0.94	-0.43	0.20	-1.03	-0.38	-1.05
Employment							
Re equipt	-0.86	-0.47	5.63	0.19	3.53	-0.97	4.36
Wind Energy Equipments	-0.77	-0.40	-0.62	-2.41	-1.59	-0.39	-1.06
Other Equipments	-0.92	-0.97	-0.63	-1.08	-1.44	-0.48	-1.32
Exports							
Re equipt	-3.43	-16.39	19.78	-1.14	27.54	-12.74	-11.95
Wind Energy Equipments	-1.03	-1.92	-0.43	3.06	0.35	-1.25	-1.17
Other Equipments	-1.02	-2.09	-0.43	3.17	-0.03	-1.48	-1.27
Imports							
Re equipt	-79.36	1.98	-5.94	-13.59	-10.61	9.12	-9.84
Wind Energy Equipments	-0.23	0.56	-0.43	-3.27	-1.60	0.11	-0.25
Other Equipments	-0.11	0.86	-0.39	-3.49	-1.81	0.44	-0.31

Output	Taiwan	Korea	India	Brazil	S.Africa	R.O.W.
Re equipt	0.34	0.67	-3.30	-0.70	-0.69	-0.15
Wind Energy Equipments	-0.50	-1.45	-3.23	0.21	-0.45	-0.30
Other Equipments	-0.59	-0.25	-2.74	-0.27	-0.78	-0.18
Employment						
Re equipt	-0.90	-1.88	-4.63	-0.63	-0.55	-2.18
Wind Energy Equipments	-0.57	-2.79	-5.68	0.20	-0.64	-0.55
Other Equipments	-0.71	-1.99	-6.37	-0.27	-1.05	-0.51
Exports						
Re equipt	-13.17	-11.50	-0.72	-15.23	-1.29	-5.58
Wind Energy Equipments	-0.65	-0.93	4.19	-2.57	-1.57	-0.46
Other Equipments	-0.80	1.37	6.74	-3.04	-2.15	-0.18
Imports						
Re equipt	4.30	-0.53	-33.12	0.05	2.71	2.50
Wind Energy Equipments	-0.41	-1.30	-6.36	1.46	0.37	-0.23
Other Equipments	0.04	-2.22	-7.33	2.23	0.63	-0.30

This shows a capacity to import and re-export, assemble, and advance in technology development in these products in these countries. These results are vindicated by other studies. (Farrell, 2011) This study evaluates Ontario's "Buy Local" policy and how it maximizes jobs from clean energy. The study concludes that the domestic content requirement is successful in creating green jobs. It emphasizes the promise of 43,000 new jobs and dozens of new manufacturing plants. However, the study fails to distinguish between the job creation effect of the Ontarian FIT and the job creation effect of the LCR attached to it. Therefore, it cannot be concluded that it is the LCR that is creating jobs. No study has tried to decompose the effects of different policies on either overall welfare or GDP growth. The GTAP model allows us to decompose the effects of import tariffs, FITs, and LCRs on welfare and output.

Table 15: Decomposition of Welfare Effects of Removal of Import Tariffs, FITs, and LCRs and Reduction of Emissions (millions of US dollars)

Country	Import tariffs	FITs	LCR	Welfare gains from emission reduction
1 China	268.271	-16346.380	37.528	4516.13
2 Japan	256.835	-4609.018	-44.720	333.84
3 Germany	-50.826	-17549.172	27.456	784.98
4 France	9.473	-67394.266	192.120	636.80
5 Italy	17.807	-28221.172	13.186	713.78
6 USA	12.534	-33364.090	33.976	2040.01
7 Canada	-1.454	-4067.833	23.022	223.59
8 Taiwan	89.210	-1743.869	17.641	38.06
9 Korea	121.185	-17518.355	28.170	423.28
10 India	6.309	-54133.480	-0.519	230.83
11 Brazil	36.024	377.014	185.540	36.78
12 South Africa	8.528	-4636.427	2.228	-3.06
13 Rest of World	237.392	-62763.961	441.890	4979.01

The negative welfare effects of removing FITs are much more important than the positive effects of import tariff reduction or the generally positive effects of LCR removal. Obviously, emission reduction (see Table 16 below) has a positive effect on welfare, but all effects are swamped by the negative welfare effects of removing FITs. Thus, while the overall effects of FIT removal are significant, the localized effects of import tariffs and LCRs on output, employment, and trade on Annex III products are more significant.

Table 16: Emission Reduction from Renewables (positive means reduction, in percentage terms)

1 China	3.43
2 Japan	1.25
3 Germany	4.20
4 France	6.48
5 Italy	6.49
6 USA	1.46
7 Canada	1.60
8 Taiwan	0.59
9 Korea	3.99
10 India	0.71
11 Brazil	0.46
12 South Africa	-0.04
13 Rest of World	2.03

There is a lot of speculation about the overall GDP effects of LCRs, FITs, and import tariffs. The effect of removing FITs is the strongest on overall GDP. The effects of removing import tariffs and LCRs have only marginal effects on overall GDP. The same does not apply to FITs, perhaps because of their effect on RE prices and their depressive effect on GDP.

Table 17: Decomposition of GDP Effects of Removal of Import Tariffs, FITs, and LCRs on Annex III Products (percentage)

Country	% change	Import tariffs	FITs	LCR removal
1 China	-0.438	0.008	-0.450	0.004
2 Japan	-0.087	0.004	-0.091	-0.001
3 Germany	-0.501	-0.001	-0.500	0.000
4 France	-2.502	0.000	-2.513	0.010
5 Italy	-1.304	0.001	-1.305	0.000
6 USA	-0.232	0.000	-0.232	0.000
7 Canada	-0.428	0.000	-0.431	0.003
8 Taiwan	-0.254	0.016	-0.273	0.003
9 Korea	-1.723	0.010	-1.735	0.002
10 India	-4.459	0.003	-4.466	0.004
11 Brazil	0.047	0.003	0.029	0.016
12 South Africa	-1.510	0.003	-1.513	0.001
13 Rest of World	-0.320	0.001	-0.323	0.001

If we aggregate the effects of FITs, import tariffs, and LCRs, the impact on RE prices is very significant.

Table 18: Overall Increase In Renewable Energy Prices (in percentage terms)

1 China	1.83
2 Japan	1.63
3 Germany	7.00
4 France	2.86
5 Italy	8.84
6 USA	1.39
7 Canada	5.32
8 Taiwan	1.43
9 Korea	2.48
10 India	2.86
11 Brazil	0.46
12 South Africa	1.56
13 Rest of World	1.87

Chapter 7

Results And Analysis Of Removing Ethanol Import Tariffs And Subsidies

With rising petroleum costs and a plethora of other influences, notably RE targets and blending mandates for gasoline used in vehicles, international ethanol demand continued to grow at an unprecedented rate during the last decade. In this context, discussions on trade liberalization have become an important point of debate for the ethanol production industry. Although there have been many studies on the results of the removal of trade barriers, there has been little emphasis on the potential impact it would have on domestic industrial organization. This paper analyses the possible effects of ethanol trade barrier removal between the countries listed in Annex II on their output and employment. Obviously, the reasons for such changes lie in the industrial organization of the respective countries. The policy changes considered here, i.e. tariffs and subsidies would influence incentives for consolidation in both farm and non-farm sectors of the ethanol production industry in Annex II countries. Both the existing deadweight loss due to the accumulation of trade-barrier costs and the potential for costs associated with increased market concentration underlie the evaluation process. The evaluation and incorporation of theory on trade flows and market structure resulting from trade tariff removal also form the basis of the overall results from the simulation analysis.

The economic factors affecting the demand for ethanol imports determine the long-run price and income elasticities of import demand. These elasticities could be used to analyse the impact of government policies, such as mandatory gasoline/ethanol blends and import tariffs.

A study by Farinelli et al has estimated the import demand with ordinary least squares (OLS), using quarterly time series data for the period 1997-2007. (Farinelli, et.al) The results suggest that the factors influencing the import demand for ethanol vary across countries. Markets adopting mandatory blends of renewable fuels tend to have less price elastic import demand schedules. Ethanol imports were found to be price elastic and statistically significant in the Caribbean region (-1.66), Japan (-1.44), Mexico (-2.08), and Nigeria (-1.38), while import demand was price inelastic and not statistically different from zero in Europe (-0.21) and the US (-0.76). The regression results could not determine the impacts of import tariffs for Mexico, Nigeria, and the United States on the quantity of imports, because import tariffs did not vary during the period studied. Results show that mandatory gasoline/ethanol blends have been an important determinant of ethanol imports.

On import tariff reduction, two scenarios have been considered. The first is the reduction of import tariffs to 5 percent and the second is reduction to zero percent.

Table 19: Percentage Change in Output, Trade of Ethanol

Output	China	Japan	Ger	France	Italy	USA	Can
Ethyl Alcohol	0.3	-0.05	-0.4	-0.3	-0.1	0.4	0.2
Employment							
Ethyl Alcohol	0.3	-0.04	-0.4	-0.3	-0.2	0.4	0.2
Exports							
Ethyl Alcohol	29.4	5.4	-2.6	-1	-0.8	8.4	2.7
Imports							
Ethyl Alcohol	8.5	3.4	0.1	0.08	0.1	0.2	0.4

Output	Taiwan	Korea	India	Brazil	S.Africa	R.O.W.
Ethyl Alcohol	-0.1	-0.8	-0.6	3.2	2.4	-0.1
Employment						
Ethyl Alcohol	-0.08	-0.6	-0.6	3.2	2.5	-0.7
Exports						
Ethyl Alcohol	26.8	32.8	61.3	41.7	20.2	4
Imports						
Ethyl Alcohol	5.6	26.1	58.3	5.1	3.9	6

Emission reduction from renewables (positive means reduction)	
China	0
Japan	0
Germany	0
France	-0.01
Italy	-0.01
USA	0
Canada	0
Taiwan	0.02
Korea	0.06
India	0.02
Brazil	0.02
South Africa	-0.05
Rest World	0.02

7.1 Simulation Results When Import Tariffs on Ethanol Are Reduced To 5 Percent

Output of almost all countries declined, except for those countries where import tariffs on ethanol are well below 5 percent, such as Brazil, Canada, South Africa and the US. Employment followed the same trend as that of output. However, the decline in output was very low at less than 1 percent. There was a rise in output for Brazil, China, South Africa, and the US. The increase in Brazil is to be expected because of its competitiveness in this sector. The increase in output in South Africa can be explained by the possible increase in investment as in the case of PVs.

Trade, however, followed a different trend. Imports increased for all countries, with the highest increase for India of about 58 percent. However, these large percentages may not be significant in the case of India because of low initial volumes. The increase in both exports and imports shows some capacity for refining or processing in India.

Exports increased for all countries. However, they decreased marginally for European countries, showing lower competitiveness as evidenced by the high volume of subsidies provided by these countries. Moreover, import tariffs are well above 5 percent in the EU, showing that the EU protects its ethanol industry with both import tariffs and subsidies.

The highest increases in exports were for Brazil and India in the range of 40 - -60 percent. As shown above, these are import tariff effects and the volume of exports from India would be very small and insignificant.

7.2 Simulation Results When Import Tariffs for Ethanol Are Reduced To Zero

When import tariffs are reduced to zero, both imports and exports of all countries increase. The largest increases are for developing countries, between 40 percent and 60 percent, rather than for developed countries. Output and employment decline for some countries, but increase for Brazil, China, South Africa, the US, and European countries. Brazil sees an increase in output and employment of more than 3 percent, while South Africa sees a 3 percent increase in output and employment.

Table 20: Output, Employment, and Trade in Ethanol When Import Tariffs Are Reduced To Zero

Output	China	Japan	Ger	France	Italy	USA	Can
Ethyl Alcohol	0.3	-0.1	0.07	0.6	0.3	0.4	-0.3
Employment							
Ethyl Alcohol	0.3	-0.1	0.1	0.6	0.3	0.4	-0.2
Exports							
Ethyl Alcohol	33.5	9.8	0.8	2.5	2.4	12.2	3
Imports							
Ethyl Alcohol	13.7	7.02	1	0.9	0.5	1.4	5

Output	Taiwan	Korea	India	Brazil	S.Africa	R.O.W.
Ethyl Alcohol	-0.6	-0.8	-0.7	3.2	2.9	-0.1
Employment						
Ethyl Alcohol	-0.5	-0.7	-0.65	3.2	2.9	-0.02
Exports						
Ethyl Alcohol	3.2	37.5	64.2	44.03	25.1	7.3
Imports						
Ethyl Alcohol	10	30.1	61.3	10.2	9.2	10.7

Emission reduction from ethanol (positive means reduction)	
China	0
Japan	0
Germany	0
France	0
Italy	0
USA	0
Canada	0.02
Taiwan	0.03
Korea	0.06
India	0.02
Brazil	0.02
South Africa	-0.051
Rest World	0.03

The effects on emissions are negligible, owing to an import tariff reduction in the specified products. A small reduction of much less than 1 percent or so are observed for Brazil, Canada, India, Korea, Taiwan and the rest of the world. South Africa has a statistically insignificant increase. As ethanol is used mostly for transport purposes it does not affect electricity prices.

7.3 Removal of Subsidies on Ethanol Over and Above Import Tariff Reduction

Government subsidies for the ethanol industry have been in place for a long time, often combined with a government mandate, requiring refiners to blend ethanol with gasoline. These subsidies were meant to strengthen the industry and encourage production of alternative fuels to reduce carbon emissions. Today, the US is the world's leading producer and consumer of ethanol. In fact, the US now produces enough ethanol to export it to other countries, including other ethanol-producing countries, such as Brazil.

The debate surrounding ethanol and other biofuels has long centred around three issues:

1. Food vs. fuel (Does the use of crops for fuel raise food prices?)

2. Trade distortion (Do subsidies and tariffs constitute unfair trade-distorting practices?)

3. Environmental effects (As more crops are needed to meet demand for both food and fuel, will this lead to more deforestation and higher emissions worldwide?)

How will the end of subsidies affect these issues? More specifically, what impact will the end of government subsidies have on the ethanol industry? While the examination of the effects of the removal of ethanol subsidies on the food industry is beyond the scope of this paper, the CGE analysis does focus on its impact on production, trade, and emissions.

Studies by the International Food Policy Research Institute (IFPRI) have shown that:

1. The ethanol mandate is not the sole driver of the high level of ethanol consumption in some countries. With high oil prices, ethanol will remain attractive to consumers and thus profitable for producers. Therefore, ending subsidies should have no substantial effect on the ethanol industry.

This result has been contradicted by other studies, particularly state-level studies in the US, although the overall impact of the elimination of subsidies especially in the US was seen to be small.

2. Research has shown the overall impact of ethanol production on US food prices to be very weak, meaning that the end of subsidized production will not act to reduce food prices.

3. Other ethanol-producing countries will benefit from the removal of the trade-distorting subsidies and import tariffs.

4. While subsidies may end, the ethanol mandate will continue and could pose a bigger threat to food prices and food security.

In this context it is to be noted that it is difficult to model the impact of the ethanol mandate on production of ethanol, but it is easier to model subsidies. Ethanol subsidies in the US were removed by 2012, but there is a government mandate called the Renewable Fuel Standard. This programme generates government guaranteed demand for ethanol and corn. It states that at least 37 percent of the 2011-2012 (most likely the same in following years) crop will be used for ethanol production. In reality, this programme is a subsidy, but it is called by another name. It still generates the same result, as the price of corn for the farmers is supported by this programme.

Table 21: National Estimates for Ethanol Subsidies

Country	Year	Subsidies (in billion USD)
Brazil	2009	2.6
Canada	2008	0.4
China	2009	0.4
France	2009	0.5
Germany	2009	0.3
Italy	2009	…
United States	2009	7.7

Source: GSI and IISD Report, 2011. For France and Germany the figures have been calculated on the basis of their share of EU subsidies.

While the earlier subsidies were low, Brazil's government announced an aggressive plan in February 2012 to raise flagging ethanol output over the next four years by showering the sector with BRL 65 billion (USD 38 billion) in subsidized credit. (Reuters, 2012) The government will allocate funds via banks to mills and independent growers for the expansion and replanting of older cane where yields have fallen. Credit will also be available to build up ethanol stockpiles. However, there is scepticism that subsidies alone would correct more fundamental problems that have limited investment in production in previous years. High prices for ethanol turned many drivers away from ethanol back to gasoline. Private sector investments in the production of ethanol have largely dried up over the past few years, owing to uncertainty in local market conditions. The government's policy of keeping gasoline prices cheap compared with rising international oil prices has made the production of hydrous ethanol unprofitable. Hence, while Brazil is generally efficient in the production of ethanol, it is currently unprofitable, necessitating a high level of subsidies. Removing these subsidies would have a serious negative effect on the production, employment, and trade of ethanol as is shown below.

In Canada, subsidies accounted for 20- 70 percent of the retail market prices for biofuels. While transfer payments are levelling off, ethanol from corn (maize), the most common product in Canada, requires subsidies of between USD 0.50 and USD 0.70 a litre to replace an equivalent litre of fossil energy—enough to purchase the displaced fuels with the subsidy alone. To remove one ton of GHGs from the atmosphere via corn- or wheat-based ethanol costs between CAD 200 and CAD 400. By comparison, one tonne of CO2 reductions costs CAD 4.25 on the Chicago Climate Exchange or CAD 33.85 on the European Climate Exchange. (GSI-IISD report, 2011)

Even under the most optimistic scenarios for Chinese biofuel production, domestic production of biofuels would have a negligible effect in reducing China's oil consumption or increasing energy security. The net benefits for pollution reduction also appear to be limited, and the potential for negative unintended consequences is high, including for vulnerable rural communities. Hence, the utility of ethanol subsidies for both the environment and production is questionable. (GSI- IISD, 2011)

In the EU, government support is provided through a multitude of policies at the local, regional, national, and community levels. These policies include exemptions from or reductions in fuel-excise taxes; direct payments to producers in some member states; capital grants or cheap loans for infrastructure; area payments for growing energy crops; and funding for research and development. Some member states that have regulated minimum market shares for biofuels have started to move away from exempting them from fuel-excise taxes. The cost-effectiveness of biofuels to meet these objectives is questionable. For example, the cost of obtaining a unit of CO2-

equivalent reduction through biofuel subsidies is estimated to be EUR 575 to EUR 800 for ethanol made from sugar beet, about EUR 215 for biodiesel made from used cooking oil, and more than EUR 600 for biodiesel made from rapeseed. Governments could achieve far more reductions for the same amount of public funds by simply purchasing the reductions in the marketplace. For the price of one tonne of CO2 reduction through EU biofuel subsidies, more than 20 tonnes of CO2-equivalent offsets could be purchased on the European Climate Exchange. (GSI-IISD Report, 2011)

Also in the US biofuels are an extremely high-cost means for reducing GHG emissions. Under optimistic projections, it costs roughly USD 500 in federal and state subsidies to reduce one metric tonne of CO2-equivalent through the production and use of corn-based ethanol. Moreover, the sheer levels of government support to biofuels appear to be out of proportion to their ability to satisfy domestic transport-fuel requirements. Biofuels accounted for less than 5 percent of total transport fuel use in 2010. (GSI-IISD Report, 2011)

Table 22: Effects of Removing Subsidies on Ethanol and Reducing Import Tariffs To 5 Percent

Ethanol	China	Japan	Germany	France	Italy	USA	Canada
Output	-0.76	1.55	-9.98	-7.62	4.42	-78.77	-36.00
Employment	-1.13	1.74	-10.43	-8.13	4.48	-82.43	-39.89
Exports	34.52	24.11	-10.78	-5.13	29.56	-100.0	-51.27
Imports	6.04	-46.14	-1.44	4.07	-6.52	31.64	-16.68
Ethanol	**Taiwan**	**Korea**	**India**	**Brazil**	**S.Africa**	**R.O.W**	
Output	1.78	2.06	0.19	-91.01	5.99	6.04	
Employment	1.82	2.47	0.22	-98.84	6.15	6.13	
Exports	56.60	62.98	86.36	-100.0	44.25	32.06	
Imports	-2.87	6.02	48.97	202.00	-7.34	-4.21	

The effects of removing subsidies on ethanol production show the largest fall in output, employment, and exports in the case of Brazil. There is a substantial increase in imports. Increased sugar prices as well as the discovery of gasoline would both have a negative effect on the profitability of ethanol in Brazil. Hence, reducing subsidies would have a significant depressive effect on production and exports of ethanol. Canada, the EU, and the US would also see similar effects, owing to the lack of competitiveness explained above. Italy, however, had no support policies for the production of ethanol and hence there is no subsidy effect but a slight tariff effect. China also experiences a slight decrease in output and employment, while the other countries have slight increases, owing to the reduction in protectionist policies in Brazil, Canada, the EU, and the US. However, the mandate for blending necessitates an increase in imports in most of these countries. The imports will be met with competitive countries, though apart from Brazil the imports of other countries are not high.

The effects on emissions of eliminating tariffs and subsidies of ethanol are negligible. This implies that the overall production of ethanol will probably decrease with the elimination of subsidies and tariffs. The effects on welfare were negative for most countries. The effects on GDP were negligible and in all cases well under 1 percent.

Table 23: Welfare Changes From Reducing Import Tariffs To 5 Percent and Removing Subsidies (in millions of US dollars)

Countries	Welfare changes	Welfare changes due to import tariff reductions to 5%	Welfare reductions because of elimination of subsidies
1 China	-607.38	11.56	-618.94
2 Japan	686.44	-11.18	675.26
3 Germany	-1123.88	-0.02	-1123.9
4 France	-716.99	-5.57	-711.42
5 Italy	-289.6	-2.6	292.21
6 USA	-40323.01	-10.2	-40312.81
7 Canada	-3370.29	4.68	-3374.98
8 Taiwan	11.66	10.3	1.37
9 Korea	286.93	84.68	202.25
10 India	188.98	25.57	163.42
11 Brazil	-9281.52	25.48	-9307
12 South Africa	46.04	6.72	39.32
13 Rest of World	1145.97	581.85	564.12

The results change slightly, although not significantly when import tariffs on ethanol are reduced to zero. The import tariff effects are slightly higher as shown below. Thus, when import tariffs are reduced to zero, countries such as Brazil, Canada, the EU, and the USA gain in terms of output and employment. Thus, reducing import tariffs to zero is more beneficial to ethanol-producing countries, although reducing subsidies would depress output, employment, and exports in these countries.

Table 24: Effects of Removing Subsidies on Ethanol and Reducing Import Tariffs To Zero

Ethanol	China	Japan	Ger	France	Italy	USA	Can
Output	-0.75	1.51	-9.43	-6.79	4.91	-78.68	-36.42
Employment	0.28	-0.09	0.08	0.59	0.28	0.44	-0.18
Exports	38.68	28.49	-7.36	-1.70	32.83	-100.0	-50.94
Imports	11.13	-42.45	-0.57	4.91	-6.23	32.83	-12.26
Ethanol	**Taiwan**	**Korea**	**India**	**Brazil**	**S.Africa**	**R.O.W**	
Output	1.32	2.08	0.19	-90.94	6.42	6.04	
Employment	-0.51	-0.68	-0.65	3.22	2.92	-0.02	
Exports	61.89	67.74	89.43	-100.0	49.25	35.47	
Imports	1.51	10.00	51.89	207.55	-2.08	0.38	

Emissions reductions are only significant for Brazil and the US, but even for them it is well below 1 percent.

Table 25: Emission Reductions from removing Subsidies on Ethanol and Reducing Import Tariffs to Zero

Country	% reduction
1 China	0.02
2 Japan	-0.02
3 Germany	0.01
4 France	0.00
5 Italy	-0.02
6 USA	0.14
7 Canada	0.06
8 Taiwan	0.00
9 Korea	-0.02
10 India	0.00
11 Brazil	0.37
12 South Africa	0.03
13 Rest of World	-0.01

The GDP and welfare effects do not change significantly with an import tariff reduction to zero. Overall, the subsidy effect overwhelms the tariff effects and has a much more significant effect on output, employment, and trade.

Chapter 8

Conclusions

This paper has focused on a small list of products for which the link with RE can be clearly traced. It has also focused on analysing the general equilibrium impacts of trade reforms. It is hoped that such an analysis would provide the rationale and the direction for undertaking trade reform and highlight policies that would give the greatest benefits in terms of RE deployment.

What impacts do import tariff reductions have?

By narrowing the range of RE products and through the use of a general equilibrium analysis, the paper finds that import tariff reduction would increase trade in these products and that production and employment would shift to the countries that have a comparative advantage in the production of industrial goods. These would include countries such as China, Japan, Korea, and Taiwan. Not surprisingly the countries that are top traders of RE equipment would remain so. There is little effect on carbon emissions or on electricity prices from liberalization of import tariffs on these products. Import tariff liberalization is, however, welfare enhancing and can lead to income augmentation for most countries. In our CGE model, however, unlike in partial equilibrium, we have not been able to rank the various factors, such as regulation, government procurement, and other enabling polices that would be more effective in improving the deployment of RE products.

What are the consequences of fossil-fuel subsidy removal?

The most dramatic improvements in emissions result from the removal of first, fossil-fuel subsidies provided directly to coal, petroleum, gas, etc., which impact the transportation sector and affect the downstream industrial (eg: steel-manufacturing) and power generation sector and second, subsidies provided directly to the electricity sector as a whole. We have tried to distinguish between electricity subsidies generated from fossil-fuel use and those generated from RE, and the electricity sector subsidy estimated is net of RE subsidies. While there are several RE subsidies, this study has focused on FITs as they are most widely used.

The effects of the removal of fossil-fuel subsidies are dramatic. Emissions drop significantly for all countries, but obviously much more for India, China, Korea, and South Africa. Brazil sees a less than 1 percent drop in emissions, perhaps because its subsidies on fossil fuels are minimal. Among the OECD countries, France and Italy see a big drop in emissions. However, the economic costs of removing fossil-fuel subsidies are quite high. This can be traced to the increase in electricity prices (which in the case of India and South Africa are nearly 11 percent and 41 percent). These countries both predominantly use coal for power generation. Removal of fossil-fuel subsidies also leads to a general increase in energy prices including transport fuels. Most other countries see a rise in energy prices. Most developed countries see a rise in energy prices of between 0.5 and 1 percent. These rises are very significant for countries whose entire populations have not as yet been connected to electricity grids. In India, for example, the coverage is about 75 percent, and in South Africa about 65 percent. Extending the coverage to the entire population would be beyond the scope of these countries if fossil-fuel subsidies were removed, as the increased electricity prices would be beyond the budget of most poor people.

Losses in overall welfare and GDP are also very high. Except for Brazil, all the countries examined experienced a decline in welfare and GDP. The GDP losses for France, India, and South Africa are most important, with India suffering a GDP loss of more than 4 percent, France more than 2 percent, and South Africa about 1.5 percent. For most other developed countries, the loss in GDP is less than 1 percent, but considering the declining growth overall, this loss cannot be considered insignificant. The same goes for welfare losses. While the effect of tariff liberalization cannot be felt on growth, it does generate some positive welfare gains for most countries. However, these positive welfare gains are overshadowed by the welfare losses resulting from the removal of fossil-fuel subsidies.

What is even more interesting to note, and little appreciated in other studies, is that with the removal of fossil-fuel subsidies there is no commensurate increase in the production, employment, and trade of RE products. Thus, the idea that levelling the playing field by removing fossil-fuel subsidies would encourage RE is not necessarily true. Where RE has achieved grid parity, as in the case of distributed solar in a number of locations around the world, deployment will increase and in some cases significantly. In fact, fossil fuel and electricity prices have risen so much in recent years that grid parity has already been achieved, particularly rooftop and off-grid solar energy in a number of countries, such as Germany, India, Italy. The deployment of solar energy goes up in China, India, and South Africa while the other sectors, such as wind and components see small declines but in terms of percentages they are very low. The analysis also shows that increasing the price of fossil-fuel energy may not by itself encourage investment in the RE sector; there may be a need for better targeted policies, such as FITs and LCRs in the RE sector. As removal of fossil-fuel subsidies, especially in the present recessionary climate is a long-term goal, this paper focuses on trade reforms that could lead to a deployment of RE.

Import tariff reform vs. subsidy reform

One of the easiest trade reforms is import tariff liberalization. Unlike the case of subsidy reform for fossil fuel and electricity, the direct effects of import tariff reform are felt on production, employment, and trade in wind energy equipment. Comparing these results with those for fossil-fuel subsidy reduction shows that when fossil-fuel subsidies are removed, the most advanced and the cheapest RE for a number of locations and for off-grid electricity generation, i.e. solar PVs, would substitute fossil-fuel based energy. However, import tariff reduction has a much more significant effect on wind energy and its components. Two reasons can be put forward to explain this. The first is that import tariffs on these products are high, and the second is that trade in these products is large.

Reducing import tariffs to zero and removing FITs

Deployment of RE and the consequent production, employment, and trade is reduced with the removal of FITs. However, this result does not hold for solar, which as stated above has reached grid parity in some cases. However, it must be noted that grid parity is a moving target and can be more easily achieved when fossil-fuel prices themselves are rising. This has been the case for the past decade or so.

FITs are also distributed unevenly according to the source of RE. They tend to be higher for solar and lower for wind. However, there is a shift toward solar and hydro, but a fall in wind energy deployment when FITs are reduced to zero. The shift toward solar is not completely unexpected, given the rapidly falling cost of solar PV modules, and grid parity has already been attained in a number of locations. Furthermore, solar can be deployed in a greater range of locations than wind, as solar systems can operate off the grid as well and on a distributed scale without the need for investments in expensive grid-connection infrastructure. There is a small drop in emissions for some countries. The combined effect of removing tariffs and FITs has a positive effect on output, employment, and trade of solar- energy products.

The price of RE increases dramatically for countries that currently provide high FITs once FITs are removed. These include the European countries and Canada. Hence, while the removal of fossil-fuel subsidies did not affect them much, the removal of FITs would impact more significantly the developed countries. Developing countries, such as China, India, and South Africa show an increase in RE prices from the removal of FITs.

GDP and welfare losses are roughly the same. The ranking remains the same as for fossil-fuel subsidies, but developed countries – except for the US, which does not use FITs – experience a slight worsening in GDP and welfare. While the losses amount to a fraction of a percentage point, the changes in GDP and welfare cannot be seen as insignificant given the fact that growth of GDP is already low.

The deployment of some forms of RE, especially wind energy goes down further with the removal of FITs. There is an increased shift towards hydro and solar, but overall employment in these products as a whole increases. This points to the fact that the removal of FITs would probably result in a realignment of the industry towards solar, hydro, and ethanol to the benefit of the countries as a whole. The same goes for the removal of fossil-fuel subsidies. While there will be a shift toward renewables, the countries that are intensive in the use of energy, such as wind energy equipment, and require investments in grid connections to serve population centres, will see a decline in production and employment.

Comparing results of reducing import tariffs to zero accompanied by: (a) removing FITs only (b) removing LCRs only and (c) removing FITs and LCRs together

As far as measures that accompany import tariff reduction (to zero) are concerned, the removal of LCRs only (in contrast to removing FITs only) affects the wind energy sector more. Removing LCRs would not affect solar or hydro significantly, but would increase the output, employment, and trade of wind turbines from competitive countries, such as Brazil, China, and India. This is because LCRs in the wind sector would force companies from competitive countries, like India, to invest in manufacturing facilities within countries like Canada, rather than supplying these countries through exports. Removing LCRs would mean that production would take place in developing countries, and components and turbines would be exported from them.

The effects of removing both LCRs and FITs together in addition to reducing import tariffs to zero is generally positive for solar and hydro and generally negative for wind energy. This shows that FITs may be more important for wind energy, and their removal in the short run could adversely affect this industry. However, the removal of LCRs would be beneficial as shown above for the competitive countries.

Removing import tariffs and subsidies for ethanol

The case of ethanol is straightforward. The removal of import tariffs would lead to a realignment of production toward more competitive countries, in this case, Brazil and to some extent South Africa. However, other developing countries could get a share of the trade pie if they have refining capacities. The effects of removing subsidies on ethanol are most severely felt by a decline in output, employment, and trade of Brazil, Canada, and the US. This is because their output, employment and trade as well as their subsidies are the highest in the world. The removal of EU subsidies also affects their output, but these effects are much lower than those for the larger ethanol producing countries. This shows that without subsidies the sector may be difficult to sustain.

Chapter 9

Recommendations

Based on the model presented, emissions were reduced significantly as a result of the removal of fossil-fuel subsidies, but the macroeconomic cost, in terms of lost GDP and welfare was high. The costs were higher for developing countries rather than developed countries, as the former provide much larger fossil-fuel subsidies. Moreover, the deployment of renewables is by no means ensured with the removal of fossil-fuel subsidies, as the cost of installation of wind energy, in particular would be prohibitively expensive. Renewables have not achieved grid parity, even if we take into account the externality cost of fossil fuels. Moreover, their installation costs are very high; hence, reducing many prevalent fossil-fuel subsidies may not be an option for energy scarce developing countries in the short run. Removing fossil-fuel subsidies is a desirable objective though over the longer term, because of the positive impact on reducing GHG emissions and the localized benefits, such as reduced pollution and health protection. What may be feasible in the short to medium term is a partial phase-out of fossil-fuel subsidies. For many developing countries this should be done in a carefully targeted manner, depending on the specific situations and socio-economic considerations in different countries. However, such reform may not be sufficient to enable renewables to achieve grid parity, although it could contribute to reducing the price differential to a certain extent.

In this situation, other options should also be explored in addition to efforts to deploy renewables. For example, carbon storage and sequestration of both coal and gas could help meet environmental objectives while keeping energy costs low. Several studies have shown that coal is the cheapest energy source at this point, and hence investing in carbon capture and storage (CCS) would be a good option to explore, especially for developing countries. This option would also have to be explored for gas, and the substitution of gas for coal where feasible should also be explored.

Improving energy efficiency in the economy is another option that needs to be tested, particularly in developing countries. In a scenario study released recently by the IEA as part of the *2013 Redrawing the Energy Climate Map* report (IEA, 2013) energy efficiency is one of four readily available measures that that can contribute to almost half of the emission cuts that are necessary to limit global warming to 2 degrees Celsius at no net economic cost.

Other measures include limiting the construction and use of the least-efficient coal-fired power plants (21 percent of potential cuts), minimizing methane (CH4) emissions from upstream oil and gas production (18 percent of potential cuts) and accelerating the (partial) phase-out of subsidies to fossil-fuel consumption (12 percent of potential cuts).

The IEA's expectation that a partial phase-out of fossil-fuel consumption subsidies could be carried out by 2020 with no net economic cost is relevant, as it appears to give credence to the fact that a complete fossil-fuel subsidy reduction will require economic sacrifice. This study's modelling results show that the economic impact of fossil fuel subsidy reform requires a phased and targeted transition, while taking the urgency of emission cuts into account.

Increased energy prices can provide an incentive for improving energy efficiency, which can, in fact, contribute to economic growth. (also see Climate Institute, 2013) As this modelling study shows, Japan and Germany suffer minimal welfare losses compared with other countries when energy prices rise following fossil-fuel subsidy reform. The higher levels of energy efficiency in these countries could be a major reason for this finding. While efficiency will deliver long-term net benefits, it will also involve some degree of initial investment in improved technologies and infrastructure.

When energy prices rise, policymakers in every country, but particularly in many developing countries, will therefore need to maintain a good balance between spurring economic growth through improved energy efficiency and safeguarding the supply of energy services to vulnerable sectors of society. One way to provide energy and related services more efficiently is by ensuring that financing of upfront investments in more efficient appliances is accessible and that the wider population is aware of the economic return of those appliances in the long run. The process of fossil-fuel subsidy reform may require carefully designed and targeted policies that take the needs of the local population into account over the longer term. Again, all of these nuances cannot be captured by a general equilibrium model.

What the model does show are clear welfare increases from trade-policy reforms, although the impact of trade liberalization on emissions may be less than that arising from fossil-fuel subsidy reform. Trade policy reforms are easily available and accessible to policymakers and can be implemented fairly rapidly, so they should be pursued as a 'low-hanging fruit.' In addition, trade liberalization is of systemic importance as it can have positive spillover effects on investment, innovation, and increased opportunities for cooperation and coordination of policies.

Of course, innovations in RE should continue until it reaches grid parity. However, a realistic picture of the overall effect of deployment of RE should be admitted into policy discourse.

As far as RE is concerned, trade reforms must be explored as an option to improve their deployment. Beginning with a small list of products that can be directly linked to RE deployment, import tariff reform should be explored. Most countries see a welfare gain with import tariff reform for RE products as well as an income gain. While the effects will not be spread uniformly across all RE sectors or all countries, there is little to suggest that any particular group of countries would be consistent losers. Hence, import tariff reform would be a first policy of choice for this limited group of products.

Both FITs and LCRs have been used by countries as policies to deploy RE. LCRs, however, were trade distorting, and FITs based on their design could have trade impacts. FITs by themselves have minor effects on trade except in the case of solar energy, where removing FITS was generally positive for the industry. When combined with LCRs, they may have a trade distortive effect. LCRs by themselves have a stronger effect, especially in the wind energy industry. In terms of options, countries could consider retaining FITs while phasing out LCRs, except with respect to solar energy, where there is a good case in a number of locations for phasing out FITs. However, given the fiscal deficits in the global economy, the reverse is likely to be the case. This would imply that RE objectives would be pursued in an inefficient and trade distortive manner. Phasing out LCRs would shift production to countries that are more competitive in the production of RE products.

LCRs are trade distortive and are in direct violation of the WTO TRIMs Agreement. FITs are in a grey area, as the way they are implemented will determine their trade neutrality. They are also expensive to implement. LCRs, on the one hand, may help create jobs in the RE sector, but they may take jobs elsewhere in the economy, for instance in downstream industries. By raising costs of RE deployment, LCRs may increase costs for the downstream services industry, resulting in the loss of more jobs there than are created in upstream sectors. Other similarly trade-restrictive policies, such as anti-dumping duties, have been shown to have this effect. For instance, according to a study carried out by the German consultancy Prognos and flagged by the Alliance for Affordable Solar Energy, a coalition of mainly European companies, a 60 per-cent duty on Chinese solar panels could cost 240,000 European jobs over 3 years. Therefore, RE measures with potential trade impacts need to be implemented carefully, keeping long-term environmental, economic, and trade goals in mind.

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2. Swanson's law, named after Richard Swanson, the founder of SunPower, a big American solar-cell manufacturer, suggests that the cost of the photovoltaic cells needed to generate solar power falls by 20% with each doubling of global manufacturing capacity.

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Annex I

Methodology Outline For The Study

In the near future climate change will be more and more perceptible all over the world. The impacts will vary substantially across countries and even across different regions within a country. In order to evaluate the costs and benefits of climate protection and prevention measures at a country level, it is necessary to construct a specific model that corresponds to its economic structure. This will help assess the impact of specific policy variables on future changes in socioeconomic variables at the national and global level. The increasing risks arising from climate change impose enormous pressure on politicians and government authorities. They have to take measures to adapt to climate change while having minimal adverse effects on their economies and on trade. To arrive at an estimate of the environmental and economic effects of specific policy variables, it would be useful to construct a general equilibrium model that shows the different linkages in an economy's input-output structures.

Energy is an important input in several economic activities. Its usage affects the environment via CO2 emissions and the greenhouse effect. Modelling the energy-economy-environment-trade linkages is an important objective in applied economic policy analysis. Energy substitution from fossil to renewable sources is a key factor in the chain of economic linkages that can help reduce GHGs and especially carbon emissions. The model used in this paper is a GTAP-E model, which specifically incorporates both electricity and energy sources as inputs and outputs in a computable general equilibrium (CGE) model.

Computable general equilibrium (CGE) models allow simulating any kind of shock on exogenous variables (in this case tariffs and subsidies) and their effects on different endogenous variables, like output, employment, prices, emissions, and trade. The basic idea of CGE is to implement theoretical economic models empirically. In order to simulate the economic effects of tariff and subsidy reduction, a general equilibrium approach is combined with empirical data. The CGE model is based on the Walrasian general equilibrium theory, which implies that all markets clear simultaneously. An equation system representing the demand for goods by consumers, the supply of goods by producers, and the equilibrium condition where supply equals demand on every market is solved simultaneously (Arrow and Debreu 1954, p. 265). However, the CGE model allows for some modifications like imperfect markets and externalities.

CGE can be understood by defining it word by word. Computable stands for numerical calculations by computer. The term equilibrium refers to the concept of market equilibrium. This concept includes the micro foundation of profit-maximizing norms and utility-maximizing households. Hence, agents have no incentive to revise their decisions once they reach their equilibrium position. Finally, the approach is general since all markets are interconnected and not considered separately as in a partial equilibrium analysis.

The Walrasian equation system represents the interdependencies between markets via commodities and corresponding payment flows between market agents. These circular flows represent a closed system. Closed means that there cannot be a payment or commodity flow from one agent that has no recipient. The budgets of all agents have to be balanced. Agents obtain a certain income that can be spent on goods (Wing, 2004, pp. 4-5 and Shoven and Whalley 1984). CGE first delineates agents like consumers, producers, and states and markets for products. It then organizes the data for a computer programme in a social accounting matrix in which each economic agent appears twice. (Brocker, 2004, pp. 273-277).

A market form (usually perfect competition) is assumed. A benchmark price for each product and factors of production is chosen on the basis of available data at that point of time for each country. The functional forms of supply and demand are specified through a set of equations to set up the model. The next step is to compute the policy effects. The last step is the sensitivity analysis. To reduce the arbitrariness of the chosen elasticity from other research results, sensitivity analysis with varying elasticity is implemented in a CGE procedure. GTAP-E uses an Armington elasticity assumption, which implies quite reasonably that the elasticity of demand of products produced domestically is not the same as that of imports for the same product.

In CGE models, like in all general equilibrium models, price changes cause simultaneous reactions in all other markets. This property is important for the micro foundation and the inclusion of economic feedback processes. The micro foundation consists of three conditions, namely market clearance, zero profit of firms, and income balance of households. Because of the inclusion of economic feedback processes (due to price changes that lead to quantity changes) CGE can be used for long-term perspective analysis (Walz and Schleich, 2009, pp. 33-34).

A significant weakness of CGE is the poor empirical foundation of the calibration. Only observations from one year are used to calibrate shift parameters. For example, from the current GTAP-E model the observations on elasticities date back to 2007. The production and utility functions are constrained to constant elasticity of substitution (CES). The parameters for these functional forms come exogenously from empirical estimation of elasticites and not from the calibration process. These 'best guess' values add a large uncertainty into the model. In particular, the chosen elasticity has a significant effect on the results. (West 1995, p. 217)

The GTAP framework model and its assumptions

Hertel (1997) gives an overview of the GTAP model. This is a CGE model, involving many regions and sectors. Demand and supply are balanced in all markets, which implies that the price received by the producer is the same as the producer's marginal cost. By imposing taxes and subsidies on commodities and primary factors, a government can drive wedges between prices paid by purchasers and prices received by producers. These policy interventions are modelled as ad valorem taxes, tariffs, and subsidies, or quantitative restrictions. International trade is linked through Armington substitution among goods differentiated by country of origin. Therefore, in markets for traded commodities, buyers differentiate between domestically produced products and imported products with the same name. Product differentiation between imports by region of origin allows for two-way trade across regions in each tradable product.

There are two types of inputs: intermediate inputs and primary factors used for production. In each region, each sector is assumed to mix the inputs to minimize total cost at a given output level. A three-level nested production technology constrains the sectors' inputs choice. At the first level, intermediate input bundles and primary-factor bundles are used in fixed proportions according to a Leontief function. At the second level, intermediate input bundles are formed as combinations of imported bundles and domestic goods with the same input-output name, and primary-factor bundles are obtained as combinations of labour, capital, and land. In both cases, the aggregator function has a constant elasticity of substitution (CES) form. At the third level, imported bundles are formed as CES composites of imported goods with the same name from each region.

Each country in a GTAP model has a single representative household that collects all the national income. This representative household aggregate income is exhausted through constant share to private household consumption, government expenditures, and national savings. The private household buys bundles of commodities to maximize utility subject to its expenditure constraint. The constrained optimizing behaviour of the private household is represented by a constant difference elasticity (CDE) demand system. The CDE function is not as general as the commonly used CES and linear expenditure system (LES), but it is more flexible and easy to calibrate with different price and income elasticities of consumption by region. The bundles are CES combinations of domestic goods and import bundles, with the import bundles being CES aggregations of imports from each region.

The share of aggregate government expenditure in each country's income is held fixed. Government expenditure is allocated across commodities by a Cobb-Douglas distribution. The allocation of total expenditure on each good to domestically produced and imported versions is based on the same nesting scheme used to allocate total household expenditure on each good.

Investment in each region is financed from a global pool of savings. Each country contributes a fixed proportion of its income to the savings pool. Two alternative ways can be used to allocate the savings pool. The first is where each region's share increases by the proportion in which the aggregate pool increases. The second is where the investment allocation is done according to the relative rates of return. Countries, which experience increases in their rate of return relative to the global average, receive increased shares of the investment budget, while countries experiencing reductions in their rate of return relative to the global average receive reduced shares.

In each country there are five types of factors of production. First, the model recognizes two types of labour (skilled and unskilled) and a single, homogenous, capital good. Then there is land and other natural resources that also form part of the set of the factors of production. In the typical closure of the model, total supplies of labour and land are fixed for each country, but capital can cross regional borders to equalize changes in rates of return. In other words, there is clear distinction between those factors that are perfectly mobile and those that are sluggish to adjust. In the case of the mobile factors, they earn the same market return regardless of the use location. As for the sluggish factors, returns in equilibrium may be different across sectors.

Examining the effects of tariff cuts on countries listed in Annex II on climate-friendly products

We now look at some of the most relevant equations required for our analysis. Following equation represents market clearing. Index variables in the brackets of the variables indicate the dimensions of the variable and the sets that they are defined upon. With tariff-cuts in region (could denote Annex 2 countries), qxs (exports from, i.e rest of the world to Annex 2 countries) may rise, implying a rise in output (qo) in region s. Higher the share of exports in output (SHRXMD) and higher the export growth (qxs), higher is the rise in output. Depending on the magnitude and sign of the change in domestic consumption (qds) and its share in output (SHRDM), output may rise or fall. Depending on the domestic consumption and import shares, these figures, in conjunction with changes in imports (qxs) cause the changes in real output, as seen from the following equation of market clearing for sectors.

qo(i,r) = SHRDM(i,r) * qds(i,r) + sum(s,REG, SHRXMD(i,r,s) * qxs(i,r,s)) + tradslack(i,r);

(where i: Sector; r: Region; s: Destination)..(1)

In the above equation, market prices also adjust to ensure that changes in real output equal the weighted sum of changes in real domestic consumption and exports. Thus changes in prices and quantities of output can be explained by (1).

The following equation (2) establishes the link between source-wise import prices (pms) relative to aggregate import prices (pim), aggregate imports (qim) and source-wise exports (qxs). Armington elasticity (ESUBM) affects the degree of influence of prices on exports. Tariff-cut on imports from a source r reduces the source-wise price (pms) from region r. To the extent to which the source r is important in terms of total trade with region s, it also reduces the aggregate import price (pim). The extent to which the prices from r to s are different from the aggregate price in s basically constitutes the substitution effect, captured by the last term in equation 2, which is multiplied by ESUBM. Aggregate imports in country s (qim) gives us the domestic penetration effect, or the extent to which the country s has increased its overall imports. The variable ams (import-augmented technological change due imports from r to s) captures any technological change that occurs in region r by virtue of exporting to region s. While this may be interpreted and implemented in different ways for different research objectives, we do not use this variable in this study.

qxs(i,r,s) = -ams(i,r,s) + qim(i,s) - ESUBM(i) * [pms(i,r,s) - ams(i,r,s) - pim(i,s)] –(2)

Value-added in GTAP model is a composite entity that consists of various endowment commodities or primary factors – labour, land, capital and natural resources. While most of the changes in value-added (qva) and its price (pva) is driven by those in the output (qo and pm), demand for each factor is determined by qva and pva in turn. Equation (3) below shows how this happens. To the extent that the endowment prices (pfe – can be interpreted as wages for labour) are higher than the value-added prices, demand for that particular endowment will be low, given the substitution elasticity ESUBVA for this CES (Constant Elasticity of Substitution) nest. In addition, any increases in total value-added are directly translated into those in the endowment demand. This is how labour demand or employment is determined for different sectors, for both skilled and unskilled labour. Technological change in factor use of factor i in sector j in region r (afe) has a negative impact on factor demand, as expected, and also a positive effect through the price channel. Changes in wages for both skilled and unskilled labour are directly influenced by those in overall output (market) prices (pm) and any tax changes on labour.

qfe(i,j,r) = - afe(i,j,r) + qva(j,r) - ESUBVA(j) * [pfe(i,j,r) - afe(i,j,r) - pva(j,r)] –(3)

Welfare in this model is measured in terms of Equivalent Variations (EV). Welfare is decomposed into various components - most importantly, allocative efficiency, terms of trade and capital goods price changes needed to maintain the investment-savings balance.

Eliminating FITS and fossil-fuel subsidies in G-20 countries

This was factored into the GTAP-E model. In the past several years, there has been seen growing concern on the scarcity of energy resources, the volatility of energy prices and the impact of energy sector on climate change. In this context, energy environment models designed for analysis of energy systems have become more important. The issue related to environmental and energy policies have attracted a lot of studies both in term of technological and economy-wide impacts. The GTAP-E model is an extension of a standard GTAP model constructed by the Global Trade Analysis Project (GTAP) team. The model incorporated energy substitution both for inter-fuel and fuel-factor substitution into the Standard GTAP model. The new features allow the estimation of sectoral energy consumptions by fuel type - one important step to estimate carbon emission from fuel combustion.

The GTAP-E model will utilize the structure of the original paper of GTAP-E which was developed by Burniaux and Truong (2002) and then revised by McDougall and A. Golub (2007). The determination of the number of sectors and regions to be aggregated is another step in the process of building a GTAP-Eversion. According to the GTAP-E approach, energy sectors should be presented, including coal, crude oil, gas (natural gas and gas distribution and transportation), petroleum and refined oil products, and electricity. Electricity will be split into two- one renewables which include a feed in tariff and the other from non-renewables. Since RE, when fed into the grid enjoys a subsidy called FIT, this variable can enter as a price decrease for the consumer of renewable electricity. Energy intensive sectors, non-intensive sectors or sectors which might emit relatively more CO2 as described on the International Energy Agency (IEA) Energy Balances can also be categorized. Specifically, 57 old sectors are mapped over to 17 new sectors. As for regional aggregation, regions similar to the mapped regions in the original

GTAP-E model can be used. Alternatively regional aggregation suggested by the ICTSD can be used.

Expected results

Several scenarios are envisaged as shown above. One is the elimination of fossil fuel subsidies in the categories specified in the GTAP-E model. The second scenario is to build the effects of feed in tariffs for renewables through electricity prices considering energy intensive and non-intensive sectors. The same goes for elimination of FITs. The third is the effect of elimination of LCRs with and without FITs. The model will also allow us to get an estimation of carbon emissions when these shocks are introduced in the model. The effects of these shocks on macroeconomic variables such as output, employment, exports, imports, and emissions will be estimated. Country groupings could be those specified in Annex 2. Inter country trade is also captured by this model.

Annex II

List of Countries Subject to CGE Modelling Exercise

Criteria (Based on Prominent Exporters/ Importers of Single-End Use Environmental Goods-2010 and Top 5 CO_2 Emitting Countries plus any member of the BASIC group of countries (Brazil, South Africa, India and China) remaining. Russia is excluded for now.

China
Japan
Germany
France
Italy
US
Canada
Chinese Taipei
Korea
India
Brazil
South Africa

Annex III

List Of Products To Be Subject To CGE Analysis

Single-end Use Product	HS Tariff Code
Wind-powered Generating Sets -(Wind Turbines)	HS 850231 **(Wind Energy Equipment)**
Solar PV devices and light-emitting diodes	HS 854140 **(Renewable energy equipment)**
Solar water heaters	HS ex-841919
Hydraulic turbines (micro < 1 MW)	HS 841011
Hydraulic turbines (small 1 -10 MW)	HS 841012
Hydraulic turbines (large >10 MW)	HS 841013
Heat pumps	HS 841861
Thermostats	HS 903210
Un-denatured Ethyl Alcohol	HS 220710
De-natured Ethyl Alcohol	HS 220720
Energy Access Relevant Products	
Solar Cooking Stoves	HS 732119 (2007) HS 732111 (2002)
Wood Pellet Cooking Stoves	HS 732189 (2007)
Solar Water Heaters	HS 841919
Other Products with Dual-Use but with Large Trade Volumes-including for Developing Countries	**(Other)**
Parts for Hydraulic Turbines	HS 841090
Heat Exchange Units	HS 841950
Tapered Roller bearings (Wind Turbine Components)	HS 848220
Spherical Roller bearings (Wind Turbine Components)	HS 848230
Needle Roller bearings(Wind Turbine Components)	HS 848240
Other Cylindrical Roller bearings (Wind Turbine Components)	HS 848250
Other Ball or Roller Bearings(Wind Turbine Components)	HS 848280
Gears and Gearing (Other than Tooth) (Wind Turbine Components)	HS 848340
Static Converters	HS 850440
Towers and Lattice Masts (Wind Energy)	HS 730820

Annex IV

Fossil-Fuel Subsidies in Selected Countries

Table A.1. Subsidies for the Electricity Sector as a percentage of total price of electricity consumption (2009)

Country	Industrial Electricity Tariff (USD/ MWh)	Electricity Consumption (Million MWh)	Subsidies (m USD)	Subsidies (%)
Argentina	59	104	2 650,00	43%
Australia	45	229	-	0%
Belgium	139	79	-	0%
Canada	59	505	-	0%
China	124	3 253	7 130,00	2%
France	107	451	13,25	0%
Germany	140	510	338,33	0%
India	108	638	6 210,00	9%
Indonesia	62	132	3 570,00	44%
Italy	276	296	-	0%
Japan	158	934	7,98	0%
Korea	58	408	-	0%
Mexico	86	204	260,00	1%
Russia	47	808	14 400,00	38%
Saudi Arabia	32	186	10 480,00	176%
South Africa	50	206	2 840,00	28%
Taiwan	75	204	0,34	0%
US	68	3 724	321,33	0%

Notes:

** For a country like India, where industrial electricity tariffs are higher to subsidise consumption in the residential and agricultural sectors, the subsidy (%) might appear lower than what it actually is. The subsidies in EIA are calculated for all sets of consumers, but here we assume that all electricity is sold at industrial rates only.*

Source:

Transportation and Electricity Subsidies

** This includes subsidies that can be clearly identified as benefitting the electricity or transportation sector from the consumption of fossil fuels*

** All other subsidies which benefit all end-uses (Production Support) or other sectors (heating, industry, farming, etc) are clubbed under their respective fuels.*

For OECD countries, subsidies include only producer support or consumer support subsidies

** This is descibed in the OECD methodology document at: www.oecd.org/site/tadffss/48867583.pdf*

** Subsidies that are assumed not to have a direct price impact such as those related to R&D activities, are not included in the final tally.*

For non-OECD countries, subsidies are sourced from IEA. These are calculated using the price-gap methodology.

** The estimates of subsidies in USD are accessible at: http://www.oecd.org/site/tadffss/48802785.pdf*

** While the methodology document is at: http://www.worldenergyoutlook.org/resources/energysubsidies/methodologyforcalculatingsubsidies/*

Table A.2. Subsidies (in Million USD)-2009

Country	Coal	Oil	Gas	Electricity	Transportation	Grand Total
Argentina	-	520	2 700	2 650	-	5 870
Australia	30	5 626	44	-	908	6 607
Belgium	-	2 159	45	-	-	2 204
Canada	7	1 472	787	-	-	2 266
China	3 730	5 290	370	7 130	-	16 520
France	4	2 070	323	13	1 063	3 473
Germany	30	113	96	338	153	730
India	-	11 490	2 720	6 210	-	20 420
Indonesia	-	8 990	-	3 570	-	12 560
Italy	-	1 151	79	-	804	2 034
Japan	-	165	9	8	-	183
Korea	180	1 621	-	-	-	1 801
Mexico	-	3 170	-	260	-	3 430
Russia	-	-	18 570	14 400	-	32 970
Saudi Arabia	-	22 060	-	10 480	-	32 540
South Africa	-	120	-	2 840	-	2 960
Taiwan	-	0	-	0	-	1
US	356	3 574	5 898	321	93	10 243

Source:

Transportation and Electricity Subsidies

** This includes subsidies that can be clearly identified as benefitting the electricity or transportation sector from the consumption of fossil fuels*

** All other subsidies which benefit all end-uses (Production Support) or other sectors (heating, industry, farming, etc) are clubbed under their respective fuels.*

For OECD countries, subsidies include only producer support or consumer support subsidies

** This is descibed in the OECD methodology document at: www.oecd.org/site/tadffss/48867583.pdf*

** Subsidies that are assumed not to have a direct price impact such as those related to R&D activities, are not included in the final tally.*

For non-OECD countries, subsidies are sourced from IEA. These are calculated using the price-gap methodology.

** The estimates of subsidies in USD are accessible at: http://www.oecd.org/site/tadffss/48802785.pdf*

** While the methodology document is at: http://www.worldenergyoutlook.org/resources/energysubsidies/methodologyfor-calculatingsubsidies/*

Table A.3. Subsidies (in Million USD)-2010

Country	Coal	Oil	Gas	Electricity	Transp-ortation	Grand Total
Argentina	-	520,00	2 700,00	2 650,00	-	5 870,00
Australia	30,03	5 625,51	43,69	-	907,74	6 606,97
Belgium	-	2 158,61	45,21	-	-	2 203,81
Canada	7,13	1 471,92	787,43	-	-	2 266,48
China	3 730,00	5 290,00	370,00	7 130,00	-	16 520,00
France	3,97	2 069,85	323,05	13,25	1 063,15	3 473,27
Germany	29,99	112,74	95,55	338,33	152,90	729,51
India	-	11 490,00	2 720,00	6 210,00	-	20 420,00
Indonesia	-	8 990,00	-	3 570,00	-	12 560,00
Italy	-	1 150,60	79,47	-	803,58	2 033,64
Japan	-	165,45	9,12	7,98	-	182,54
Korea	180,05	1 621,02	-	-	-	1 801,07
Mexico	-	3 170,00	-	260,00	-	3 430,00
Russia	-	-	18 570,00	14 400,00	-	32 970,00
Saudi Arabia	-	22 060,00	-	10 480,00	-	32 540,00
South Africa	-	120,00	-	2 840,00	-	2 960,00
Taiwan	-	0,24		0,34	-	0,58
US	356,18	3 573,67	5 898,17	321,33	93,30	10 242,65
Grand Total	4 337,35	69 589,62	31 641,67	48 221,22	3 020,67	156 810,53

Source:

Transportation and Electricity Subsidies

* *This includes subsidies that can be clearly identified as benefitting the electricity or transportation sector from the consumption of fossil fuels*

* *All other subsidies which benefit all end-uses (Production Support) or other sectors (heating, industry, farming, etc) are clubbed under their respective fuels.*

For OECD countries, subsidies include only producer support or consumer support subsidies

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* *Subsidies that are assumed not to have a direct price impact such as those related to R&D activities, are not included in the final tally.*

For non-OECD countries, subsidies are sourced from IEA. These are calculated using the price-gap methodology.

* *The estimates of subsidies in USD are accessible at: http://www.oecd.org/site/tadffss/48802785.pdf*

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Annex V

Tariffs on selected products from Annex III

Table A.1. Wind Energy: Applied MFN Tariffs-(Average Ad Valorem In Percent), For Select Climate Friendly Products (Reporting Year In Brackets)

Product HS Code	Product Description	China	Japan	Germany (EU-CET)	France (EU-CET)	Italy (EU-CET)	US
HS 850231	Wind-powered generating sets	8.0 (2011) Range 8.0-8.0	0 (2011)	2.7 (2012) Range 2.7-2.7	2.7 (2012) Range 2.7-2.7	2.7 (2012) Range 2.7-2.7	1.3 (2011) Range 0-2.5 50 percent of lines duty free
HS 848220	Tapered Roller Bearings (wind turbine components)	8.0 (2011) Range 8.0-8.0	0 (2011)	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	5.8 (2011) Range 5.8-5.8

Product HS Code	Canada	Chinese Taipei	Korea	India	Brazil	South Africa
HS 850231	0 (2011)	10.0 (2011) Range 10-10	8.0 (2011) Range 8.0-8.0	7.5 (2011) Range 7.5-7.5	0 (2011)	0 (2011)
HS 848220	0 (2011)	2.5 (2011) Range 2.5-2.5	8.0 (2011) Range 8.0-8.0	7.5 (2011) Range 7.5-7.5	16 .0 (2011) Range 16.0-16.0	13.3 (2011) Range 0-2033 percent of lines duty free

Product HS Code	Product Description	China	Japan	Germany (EU-CET)	France (EU-CET)	Italy (EU-CET)	US
HS 848230	Spherical Roller Bearings (wind turbine components)	8.0 (2011) Range 8.0-8.0	0 (2011)	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	5.8 (2011) Range 5.8-5.8
HS 848240	Needle Roller Bearings (wind turbine components)	8.0 (2011) Range 8.0-8.0	0 (2011)	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	5.8 (2011) Range 5.8-5.8

Product HS Code	Canada	Chinese Taipei	Korea	India	Brazil	South Africa
HS 848230	0 (2011)	1.8 (2011) Range 1.0-2.5	8.0 (2011) Range 8.0-8.0	7.5 (2011) Range 7.5-7.5	16.0 (2011) Range 16.0-16.0	0 (2011)
HS 848240	0 (2011)	6.5 (2011) Range 3.10-10.0	8.0 (2011) Range 8.0-8.0	7.5 (2011) Range 7.5-7.5	16.0 (2011) Range 16.0-16.0	0 (2011)

Product HS Code	Product Description	China	Japan	Germany (EU-CET)	France (EU-CET)	Italy (EU-CET)	US
HS 848250	Other Cylindrical Roller Bearings (wind turbine components)	8.0 (2011) Range 8.0-8.0	0 (2011)	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	5.8 (2011) Range 5.8-5.8
HS 848280	Other Balls or Roller Bearings (Wind Turbine component)	8.0 (2011) Range 8.0-8.0	0 (2011)	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	8.0 (2012) Range 8.0-8.0	5.8 (2011) Range 5.8-5.8

Product HS Code	Canada	Chinese Taipei	Korea	India	Brazil	South Africa
HS 848250	0 (2011)	2.5 (2011) Range 2.5-2.5	8.0 (2011) Range 8.0-8.0	7.5 (2011) Range 7.5-7.5	16.0 (2011) Range 16.0-16.0	0 (2011)
HS 848280	0 (2011)	2.5 (2011) Range 2.5-2.5	8.0 (2011) Range 8.0-8.0	7.5 (2011) Range 7.5-7.5	16.0 (2011) Range 16.0-16.0	0 (2011)

Product HS Code	Product Description	China	Japan	Germany (EU-CET)	France (EU-CET)	Italy (EU-CET)	US
HS 848340	Gears and Gearing (Other than Tooth) –Wind Turbine Component	8.0 (2011) Range 8.0-8.0	0 (2011)	3.7 (2012) Range 3.7-3.7	3.7 (2012) Range 3.7-3.7	3.7 (2012) Range 3.7-3.7	1.0 (2011) Range 0-3.8 60 per cent of lines duty free Also non-ad-valorem duty of 25 cents each +3.9 per cent
HS 730820	Towers and Lattice Masts (for wind turbines)	8.4 per cent (2011) Range 8.4-8.4	0 (2011)	0 (2012)	0 (2012)	0 (2012)	0 (2011)

Product HS Code	Canada	Chinese Taipei	Korea	India	Brazil	South Africa
HS 848340	0 (2011)	5.4 Range 2.5-10.0	6.8 (2011) Range 3.0-8.0	7.5 (2011) Range 7.5-7.5	14.0 (2011) Range 14.0-14.0	0 (2011
HS 730820	0 (2011)	10.0 (2011) Range 10.0-10.0	8.0 (2011) Range 8.0-8.0	10.0 (2011) Range 10.0-10.0	14.0 (2011) Range 14.0-14.0	7.5 (2011) Range 0-15.0 50 per-cent of tariff lines duty free

Source: WTO Tariffs Database accessible at http://tariffdata.wto.org/

Annex VI

Feed-In-Tariffs in Selected Countries (2003-2010)

Table A.1. Canada

	Canada	Solar	Wind	Geo-thermal	Biomass	Hydro*
	CAD	0,491	0,133	0	0,164333333	0
2003	USD	0,350714286	0,095	0	0,117380952	0
2004	USD	0,377401998	0,102229055	0	0,126313092	0
2005	USD	0,405115512	0,109735974	0	0,135588559	0
2006	USD	0,4329806	0,117283951	0	0,144914756	0
2007	USD	0,45716946	0,123836127	0	0,153010552	0
2008	USD	0,459737828	0,124531835	0	0,153870162	0
2009	USD	0,430324277	0,116564417	0	0,144025708	0
2010	USD	0,476699029	0,129126214	0	0,159546926	0

** Canada does have FITs for Hydro but they are for <50MW projects only. Without detailed data on that, it's very difficult to establish anything with certainty*

Policies
Feed-in tariff
0.138 CAD/kWh Provincial FIT for biomass =/< 10MW. 2011
(Ontario: Contracted 20 years.)
Technology: Solid Biomass
Sector: Electricity
Ontario Power Authority. "What is the Feed-in Tariff Program?" 2012

0.195 CAD/kWh Provincial FIT for biogas (on farm) = 100KW. 2011
(Ontario: Contracted 20 years.)
Technology: Biogas
Sector: Electricity
Ontario Power Authority. "What is the Feed-in Tariff Program?" 2012

0.135 CAD/kWh Provincial FIT for wind of any size. 2011
(Ontario: Contracted 20 years.)
Technology: Wind
Sector: Electricity
Ontario Power Authority. "What is the Feed-in Tariff Program?" 2012

FIT for solar PV exist. 2011
Technology: Solar PV
Sector: Electricity
Ontario Power Authority. "What is the Feed-in Tariff Program?" 2012

0.131 CAD/kWh Provincial FIT for hydropower = 10MW. 2011
(Ontario: Contracted 20 years.)
Technology: Hydropower
Sector: Electricity
Ontario Power Authority. "What is the Feed-in Tariff Program?" 2012

0.642 CAD/kWh Provincial microFIT for ground-mounted solar PV = 10KW. 2011
Technology: Solar PV
Sector: Electricity
Ontario Power Authority. "microFIT pricing" 2012

0.135 CAD/kWh Provincial microFIT for wind = 10KW. 2011
(Ontario: Contracted 20 years at 0% Escalation.)
Technology: Wind
Sector: Electricity
Ontario Power Authority. "microFIT pricing" 2012

0.131 CAD/kWh Provincial microFIT fo hydropower = 10KW. 2011
(Ontario: Contracted 20 years at 0% Escalation)
Technology: Hydropower
Sector: Electricity
Ontario Power Authority. "microFIT pricing" 2012

0.138 CAD/kWh Provinicial microFIT for biomass = 10KW. 2011
(Ontario: Contracted 20 years at 0% Escalation)
Technology: Solid Biomass
Sector: Electricity
Ontario Power Authority. "microFIT pricing" 2012

0.160 CAD/kWh Provincial microFIT for biogas = 10KW. 2011
(Ontario: Contracted 20 years at 20% escalation.)
Technology: Biogas
Sector: Electricity
Ontario Power Authority. "microFIT pricing" 2012

175.0 Canadian Dollars Provincial FIT for biomass CHP. 2011
Technology: Solid Biomass
Sector: Non-Sector specific
Nova Scotia Department of Energy 2011

140.0 Canadian Dollars Provincial FIT for run of river hydro. 2011
Technology: Hydropower
Sector: Non-Sector specific
Nova Scotia Department of Energy 2011

652.0 Canadian Dollars Provincial FIT for small scale in-stream tidal. 2011
Technology: Ocean energy
Sector: Non-Sector specific
Nova Scotia Department of Energy 2011

499.0 Canadian Dollars Provincial FIT for wind >=50 kW. 2011
Technology: Wind
Sector: Non-Sector specific
Nova Scotia Department of Energy 2011

131.0 Canadian Dollars Provincial FIT for wind >50 kW. 2011
Technology: Wind
Sector: Non-Sector specific
Nova Scotia Department of Energy 2011

Table A.2. China

	China	Solar	Wind	Geo-thermal	Biomass	Hydro
	CY	1,075	0,56	0	0	0
2003	USD	0,129877975	0,067657364	0	0	0
2004	USD	0,129877975	0,067657364	0	0	0
2005	USD	0,131209569	0,068351031	0	0	0
2006	USD	0,134830051	0,07023705	0	0	0
2007	USD	0,141261498	0,073587385	0	0	0
2008	USD	0,154676259	0,08057554	0	0	0
2009	USD	0,157393851	0,081991215	0	0	0
2010	USD	0,157925665	0,082268253	0	0	0

Feed-in tariff
1.09 CAD/kWh For a 10 MW solar PV (non ground mounted). 2009
Technology: Solar PV
Sector: Electricity
Minister of Environmental Protection. "China Hikes 2011 Solar Power Target"2009

1.150 CNY/kWh FIT for solar PV introduced in August 2011. 2011
Technology: Solar PV
Sector: Non-Sector specific
European Commission. EurObserv´ER. "Photovoltaic Barometer" 2012

1.150 Renminbi National FIT for grid-connected photovoltaic in Tibet starting from January 2012. 2012
(These are 13.73 Euro cents/kWh.)
Technology: Solar PV
Sector: Non-Sector specific
Global Status Report (GSR) 2012. Country Profile China. Accessed by REN21 2012

1.0 Renminbi National FIT for grid-connected photovoltaic starting from January 2012. 2012
(These are 11.94 Euro cents/kWh.)
Technology: Solar PV
Sector: Non-Sector specific
Global Status Report (GSR) 2012. Country Profile China. Accessed by REN21 2012

0.56RMB/KWh
There are four different categories for the tariff, depending on the region's wind resources, ranging from 0.51 RMB/kWh (EUR 5.7 cents) to 0.61 RMB/kWh (EUR 6.8 cents).
http://www.gwec.net/index.php?id=125&L=0%25B4%3F80flag%3D

Table A.3. France

	France	Solar	Wind	Geo-thermal	Biomass	Hydro
	EUR	0,447	0,105	0,165	0	0
2003	USD	0,505084746	0,118644068	0,186440678	0	0
2004	USD	0,555279503	0,130434783	0,204968944	0	0
2005	USD	0,555279503	0,130434783	0,204968944	0	0
2006	USD	0,560853199	0,13174404	0,207026349	0	0
2007	USD	0,612328767	0,143835616	0,226027397	0	0
2008	USD	0,653508772	0,153508772	0,24122807	0	0
2009	USD	0,620833333	0,145833333	0,229166667	0	0
2010	USD	0,59205298	0,139072848	0,218543046	0	0

Feed-in tariff
0.02 to 0.13 EUR/kWh FIT for wind electricity. 2009
Technology: Wind
Sector: Electricity
Legifrance. "Arrêté du 1er mars 2007 fixant les conditions d'achat de l'électricité produite par les installations utilisant l'énergie hydraulique des lacs, cours d'eau et mers, telles que visées au 1° de l'article 2 du décret n° 2000-1196 du 6 décembre 2000" 2009

0.314 to 0.58 EUR/kWh FIT for solar PV electricity. 2009
Technology: Solar PV
Sector: Electricity
Ministry of Sustainable Development 2010

0.13 to 0.2 EUR/kWh FIT for geothermal energy. 2009
Technology: Geothermal
Sector: Non-Sector specific
Ministry of Sustainable Development 2010

0.125 EUR/kWh FIT for geothermal energy for installations from 5MW to 12MW. 2009
Technology: Solid Biomass
Sector: Non-Sector specific
Ministry of Sustainable Development 2010

0.15 EUR/kWh FIT for ocean energy electricity (wave, tidal and hydrokinetric). 2009
Technology: Ocean energy
Sector: Electricity
Legifrance. "Arrêté du 1er mars 2007 fixant les conditions d'achat de l'électricité produite par les installations utilisant l'énergie hydraulique des lacs, cours d'eau et mers, telles que visées au 1° de l'article 2 du décret n° 2000-1196 du 6 décembre 2000" 2009

0.0425 - 0.1772 EUR/kWh FIT for hydropower electricity (maritime and run-of-river energy). 2009
Technology: Hydropower
Sector: Electricity
Legifrance. "Arrêté du 1er mars 2007 fixant les conditions d'achat de l'électricité produite par les installations utilisant l'énergie hydraulique des lacs, cours d'eau et mers, telles que visées au 1° de l'article 2 du décret n° 2000-1196 du 6 décembre 2000" 2009

0.0425 - 0.1772 EUR/kWh FIT for CSP solar-only installations with less than 12 MW capacity and less than 1,500 hours a year operation. For production >12 MW the tariff is 0.05EUR/kWh. 2009
Technology: CSP
Sector: Non-Sector specific
Global Status Report (GSR) 2009. Country Contribution France. Accessed by REN212009

Table A.4. Germany

	Germany	Solar	Wind	Geothermal	Biomass	Hydro
	EUR	0,42	0	0,135	0,06	0,085
2003	USD	0,474576271	0	0,152542373	0,06779661	0,096045198
2004	USD	0,52173913	0	0,167701863	0,074534161	0,105590062
2005	USD	0,52173913	0	0,167701863	0,074534161	0,105590062
2006	USD	0,526976161	0	0,169385194	0,075282309	0,106649937
2007	USD	0,575342466	0	0,184931507	0,082191781	0,116438356
2008	USD	0,614035088	0	0,197368421	0,087719298	0,124269006
2009	USD	0,583333333	0	0,1875	0,083333333	0,118055556
2010	USD	0,556291391	0	0,178807947	0,079470199	0,112582781

Feed-in tariff
0.29 to 0.55 EUR/kWh FIT for solar PV. 2009
Technology: Solar PV
Sector: Electricity
Global Status Report (GSR) 2009. Country Contribution Germany. Accessed by REN21 2009

0.13 to 0.15 EUR/kWh FIT for offshore wind. 2009
Technology: Wind
Sector: Electricity
Global Status Report (GSR) 2009. Country Contribution Germany. Accessed by REN21 2009

0.11 to 016 EUR/kWh FIT for geothermal. 2009
Technology: Geothermal
Sector: Green Energy
Global Status Report (GSR) 2009. Country Contribution Germany. Accessed by REN21 2009

0.08 to 0.12 EUR/kWh FIT for solid biomass. 2009
Technology: Solid Biomass
Sector: Green Energy
Global Status Report (GSR) 2009. Country Contribution Germany. Accessed by REN21 2009

0.04 to 0.13 EUR/kWh FIT for hydropower. 2009
Technology: Hydropower
Sector: Electricity
Global Status Report (GSR) 2009. Country Contribution Germany. Accessed by REN21 2009

0.0779 - 0.1167 EUR/kWh Basic rate applied to biogas produced by methanisation plants. 2009
Technology: Biogas
Sector: Electricity
Observ´ER. "The State of Renewable Energies in Europe - 10th EurObserv'ER Report" 2010

Table A.5. India

	India	Solar	Wind	Geo-thermal	Biomass	Hydro
	INR	15,9125	4,7	0	0	0
2003	USD	0,341616574	0,100901675	0	0	0
2004	USD	0,351114298	0,103706973	0	0	0
2005	USD	0,360827664	0,106575964	0	0	0
2006	USD	0,35119179	0,103729861	0	0	0
2007	USD	0,384824667	0,113663845	0	0	0
2008	USD	0,365720524	0,108021145	0	0	0
2009	USD	0,328702747	0,097087379	0	0	0
2010	USD	0,345848729	0,102151706	0	0	0

Feed-in tariff
3.76 - 5.64 INR/kWh FIT fpr wind energy.
Technology: Wind
Sector: Non-Sector specific
Ministry of New and Renewable Energy, India (MNRE) 2010

17.91 Indian Rupee FIT for solar PV in FY 2010-2011. 2011
Technology: Solar PV
Sector: Non-Sector specific
International Concentrated Solar Thermal Power Summit. "CSP FIT Guide - CSP today Sevilla 2011" 2011

15.39 Indian Rupee FIT for solar PV in FY 2010-2011. 2011
Technology: Solar PV
Sector: Non-Sector specific
International Concentrated Solar Thermal Power Summit. "CSP FIT Guide - CSP today Sevilla 2011" 2011

15.31 Indian Rupee FIT for solar thermal in FY 2010-2011. 2011
Technology: Solar heating/cooling
Sector: Non-Sector specific
International Concentrated Solar Thermal Power Summit. "CSP FIT Guide - CSP today Sevilla 2011" 2011

15.04 Indian Rupee FIT for solar thermal in FY 2010-2011. 2011
Technology: Solar heating/cooling
Sector: Non-Sector specific
International Concentrated Solar Thermal Power Summit. "CSP FIT Guide - CSP today Sevilla 2011" 2011

15.04 Indian Rupee FIT solar tariff for FY 2010-2011. 2011
Technology: Solar PV
Sector: Non-Sector specific
Ministry of New and Renewable Energy. "Achievements" 2011

Table A.6. Italy

	Italy	Solar	Wind	Geo-thermal	Biomass	Hydro
	EUR	0,353333333	0	0,2	0,25	0,22
2003	USD	0,353333333	0	0,2	0,25	0,22
2004	USD	0,353333333	0	0,2	0,25	0,22
2005	USD	0,353333333	0	0,2	0,25	0,22
2006	USD	0,353333333	0	0,2	0,25	0,22
2007	USD	0,353333333	0	0,2	0,25	0,22
2008	USD	0,353333333	0	0,2	0,25	0,22
2009	USD	0,353333333	0	0,2	0,25	0,22
2010	USD	0,353333333	0	0,2	0,25	0,22

Feed-in tariff
0.3 EUR/kWh FIT for wind (less than 200kW project).
Technology: Wind
Sector: Electricity
PV-Tech. "Italy" 2009

0.36 to 0.48 EUR/kWh FIT for solar PV.
Technology: Solar PV
Sector: Electricity
PV-Tech. "Italy" 2010

0.2 EUR/kWh FIT for geothermal.
Technology: Geothermal
Sector: Non-Sector specific
PV-Tech. "Italy" 2010

0.2 to 0.3 EUR/kWh FIT for solid biomass.
Technology: Solid Biomass
Sector: Non-Sector specific
PV-Tech. "Italy" 2010

0.22 EUR/kWh FIT for hydropower.
Technology: Hydropower
Sector: Electricity
PV-Tech. "Italy" 2010

0.34 EUR/kWh FIT for ocean energy. 2010
Technology: Ocean energy
Sector: Electricity
PV-Tech. "Italy" 2010

0.22 - 0.28 EUR/kWh FIT for CSP. 2009
Technology: CSP
Sector: Non-Sector specific
Global Status Report (GSR) 2009. Country Contribution Italy. Accessed by REN21 2009

0.22 - 0.28 EUR/kWh FIT for CSP existing. 2011
(0-15% = 0.28 Euro; 15-50% = 0.25 Euro; >50% = 0.22 Euro; The tariff depends on the net production (not attributable to solar).)
Technology: CSP
Sector: Non-Sector specific
Gestore dei Servizi Energetici (GSE). "Committed to renewables" 2012

Table A.7. Japan

	Japan	Solar	Wind	Geo-thermal	Biomass	Hydro
	ARS	23,5	0	0	0	0
2003	USD	0,202691047	0	0	0	0
2004	USD	0,2172908	0	0	0	0
2005	USD	0,213442325	0	0	0	0
2006	USD	0,201976794	0	0	0	0
2007	USD	0,199558424	0	0	0	0
2008	USD	0,227294709	0	0	0	0
2009	USD	0,251148873	0	0	0	0
2010	USD	0,267775752	0	0	0	0

Policies

Feed-in tariff
23.0 - 24.0 YEN/kWh FIT for solar PV electricity. 2009
Technology: Solar PV
Sector: Electricity
Global Status Report (GSR) 2009. Country Contribution Japan. Accessed by REN21 2009

http://www.meti.go.jp/english/policy/energy_environment/renewable/pdf/summary201207.pdf
Page 5 and 6 of this ppt has the details

Table A.8. South Africa

	South Africa	Solar	Wind	Geo-thermal	Biomass	Hydro
	RAND	2,053	0,952	0	0,9975	0
2003	USD	0,271381362	0,125842697	0	0,131857237	0
2004	USD	0,317801858	0,147368421	0	0,154411765	0
2005	USD	0,322849505	0,149709074	0	0,156864287	0
2006	USD	0,303249631	0,140620384	0	0,147341211	0
2007	USD	0,291205674	0,135035461	0	0,141489362	0
2008	USD	0,248547215	0,115254237	0	0,120762712	0
2009	USD	0,242384888	0,112396694	0	0,117768595	0
2010	USD	0,275274873	0,127648163	0	0,133748994	0

Feed-in tariff
0.837 South African Rand FIT for biogas >= 1 MW by 2011. 2011
Technology: Biogas
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.862 South African Rand FIT for biogas >= 1 MW by 2012. 2012
Technology: Biogas
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.887 South African Rand FIT for biogas >= 1 MW by 2013. 2013
Technology: Biogas
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.399 South African Rand FIT for CSP central receiver (tower) >= 1 MW with TES 6 hrs by 2011. 2011
Technology: CSP
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.408 South African Rand FIT for CSP central receiver (tower) >= 1 MW with TES 6 hrs by 2012. 2012
Technology: CSP
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.108 South African Rand FIT for CSP central receiver (tower) >= 1 MW with TES 6 hrs by 2013. 2013
Technology: CSP
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.836 South African Rand FIT for CSP through >=1 MW with 6 hours storage per day by 2011. 2011
Technology: CSP
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.845 South African Rand FIT for CSP through >=1 MW with 6 hours storage per day by 2012. 2012
Technology: CSP
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.854 South African Rand FIT for CSP through >=1 MW with 6 hours storage per day by 2013. 2011
Technology: CSP
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.938 South African Rand FIT for CSP through >=1 MW without storage by 2011. 2013
Technology: CSP
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.953 South African Rand FIT for CSP through >=1 MW without storage by 2012. 2012
Technology: CSP
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.967 South African Rand FIT for CSP through >=1 MW without storage by 2013. 2013
Technology: CSP
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.900 South African Rand FIT for landfill gas >=1 MW in 2009. 2009
Technology: Biogas
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.539 South African Rand FIT for landfill gas >=1 MW in 2011. 2011
Technology: Biogas
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.550 South African Rand FIT for landfill gas >=1 MW in 2012. 2012
Technology: Biogas
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.562 South African Rand FIT for landfill gas >=1 MW in 2013. 2013
Technology: Biogas
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.671 South African Rand FIT for small hydro >=1 MW in 2011. 2011
Technology: Hydropower
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.675 South African Rand FIT for small hydro >=1 MW in 2012. 2012
Technology: Hydropower
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.680 South African Rand FIT for small hydro >=1 MW in 2013. 2013
Technology: Hydropower
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

2.311 South African Rand FIT for solar PV >= 1 MW ground mounted by 2011. 2011
Technology: Solar PV
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

2.325 South African Rand FIT for solar PV >= 1 MW ground mounted by 2012. 2012
Technology: Solar PV
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

2.338 South African Rand FIT for solar PV >= 1 MW ground mounted by 2013. 2013
Technology: Solar PV
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.060 South African Rand FIT for solid biomass >= 1 MW (direct combustion) by 2011. 2011
Technology: Solid Biomass
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.084 South African Rand FIT for solid biomass >= 1 MW (direct combustion) by 2012. 2012
Technology: Solid Biomass
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

1.108 South African Rand FIT for solid biomass >= 1 MW (direct combustion) by 2013. 2013
Technology: Solid Biomass
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.938 South African Rand FIT for wind energy >1 MW in 2011. 2011
Technology: Wind
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.945 South African Rand FIT for wind energy >1 MW in 2012. 2012
Technology: Wind
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011

0.952 South African Rand FIT for wind energy >1 MW in 2013. 2013
Technology: Wind
Sector: Non-Sector specific
CSP Today Sevilla 2011. "CSP FIT Guide" 2011