International Technology Diffusion in a Sustainable Energy Trade Agreement (SETA)

September 2012
Issues and Options for Institutional Architectures

Thomas L. Brewer, Senior Fellow, ICTSD

ICTSD
International Centre for Trade and Sustainable Development

A joint initiative with

Global Green Growth Institute

Peterson Institute for International Economics

International Technology Diffusion in a Sustainable Energy Trade Agreement (SETA)

September 2012
Issues and Options for Institutional Architectures

Thomas L. Brewer, Senior Fellow, ICTSD

ICTSD
International Centre for Trade and Sustainable Development

Published by

International Centre for Trade and Sustainable Development (ICTSD)
International Environment House 2
7 Chemin de Balexert, 1219 Geneva, Switzerland
Tel: +41 22 917 8492   Fax: +41 22 917 8093
E-mail: ictsd@ictsd.org   Internet: www.ictsd.org

Publisher and Director: Ricardo Meléndez-Ortiz
Programme Manager: Ingrid Jegou
Programme Officer: Joachim Monkelbaan

Acknowledgments

This paper is produced by the Global Platform on Climate Change, Trade and Sustainable Energy of the International Centre for Trade and Sustainable Development (ICTSD). The concept of the research has been informed by ICTSD policy dialogues during the past year, in particular a dialogue organised in Washington DC in November 2011 by the Peterson Institute for International Economics (PIIE) with support of the Global Green Growth Institute (GGGI) and ICTSD, as well as high-level Roundtables- in Geneva in December 2011, on the occasion of the Eighth Ministerial Conference of the WTO, an ICTSD Panel Session on SETA at Global Green Growth Forum Stocktaking meeting, Copenhagen in March 2012 and an ICTSD Session at the Global Green Growth Summit in May 2012 in Seoul, Korea. The author thanks Ricardo Meléndez-Ortiz, Ingrid Jegou, Mahesh Sugathan, Joachim Monkelbaan, Ahmed Latif, and Pedro Roffe from ICTSD for their guidance and inputs during the production of the paper. The author is also grateful for the valuable comments provided by Heleen de Coninck of ECN.

This project has benefited from the generous support of the Ministry of Foreign Affairs of Denmark (DANIDA) and the Global Green Growth Institute. In addition, ICTSD is grateful for the support of its main donors including the UK Department for International Development (DFID); the Swedish International Development Cooperation Agency (SIDA); the Netherlands Directorate-General of Development Cooperation (DGIS); the Ministry of Foreign Affairs of Denmark (Danida); the Ministry for Foreign Affairs of Finland; the Ministry of Foreign Affairs of Norway; Australia's AusAID; the Inter American Development Bank (IADB); Oxfam Novib and the Deutsche Gesellschaftfür Internationale Zusammenarbeit (GIZ).

ICTSD welcomes feedback on this document. These can be forwarded to Joachim Monkelbaan at jmonkelbaan@ictsd.ch

For more information about ICTSD's work on trade and climate change, visit our website: www.ictsd.org

Citation: Brewer, Thomas (2012); *International Technology Diffusion in a Sustainable Energy Trade Agreement: Issues and Options for Institutional Architectures.* International Centre for Trade and Sustainable Development, Geneva,Switzerland, www.ictsd.org

ISSN 2225-6679

About the International Centre for Trade and Sustainable Development, www.ictsd.org
Founded in 1996, the International Centre for Trade and Sustainable Development (ICTSD) is an independent think-and-do-tank based in Geneva, Switzerland and with operations throughout the world, including out-posted staff in Brazil, Mexico, Costa Rica, Senegal, Canada, Russia, and China. By enabling stakeholders in trade policy through information, networking, dialogue, well-targeted research and capacity-building, ICTSD aims to influence the international trade system so that it advances the goal of sustainable development. ICTSD co-implements all of its programme through partners and a global network of hundreds of scholars, researchers, NGOs, policymakers and think-tanks around the world.

About the Peterson Institute for International Economics, www.piie.com
The Peter G. Peterson Institute for International Economics is a private, nonprofit, nonpartisan research institution devoted to the study of international economic policy. Since 1981 the Institute has provided timely and objective analysis of, and concrete solutions to, a wide range of international economic problems. Its agenda emphasises global macroeconomic topics, international money and finance, trade and related social issues, energy and the environment, investment, and domestic adjustment policies. Current priority is attached to the global financial and economic crisis, globalisation (including its financial aspects) and the backlash against it, international trade imbalances and currency relationships, the creation of an international regime to address global warming and especially its trade dimension, the competitiveness of the United States and other major countries, reform of the international economic and financial architecture, sovereign wealth funds, and trade negotiations at the multilateral, regional, and bilateral levels.It celebrated its 25th anniversary in 2006 and adopted its new name at that time, having previously been the Institute for International Economics.

About the Global Green Growth Institute, www.gggi.org
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, and is scheduled to be converted into an international organisation in October 2012.

TABLE OF CONTENTS

List of Tables and Boxes

Abbreviations and Acronyms

ACEEE	American Council for an Energy-Efficient Economy
APEC	Asia Pacific Economic Cooperation [forum]
APP	Asia Pacific Partnership for Clean Energy and Climate
BIT	Bilateral Investment Treaty
CERC	Clean Energy Research Centre
CFL	Compact fluorescent lamp
COP	Conference of the Parties of the UNFCCC
CO_2	Carbon dioxide
DEA	Danish Energy Agency
DS	Dispute settlement
EC	European Commission
ECEEE	European Council for an Energy Efficient Economy
ECJ	European Court of Justice
EGS	Environmental Goods and Services
EJ	Exajoule
ETP	Energy Technology Perspectives (published by the IEA)
ETS	Emissions Trading Scheme
EU	European Union
FAO	Food and Agriculture Organisation
GGGI	Global Green Growth Institute
GHG	Greenhouse gas
Gt	Gigatonne (billion tonnes)
GW	Gigawatt (1000 MW)
IBRD	International Bank for Reconstruction and Development
ICJ	International Court of Justice
ICTSD	International Centre for Trade and Sustainable Development
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
kWh	kilowatt hour
MW	Megawatt
OECD	Organisation for Economic Cooperation and Development
PIIE	Peterson Institute for International Economics
SETA	Sustainable Energy Trade Agreement
SETI	Sustainable Energy Trade Initiative
TRIPs	Trade Related Intellectual Property Rights [agreement at the WTO]
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
USITC	United States International Trade Commission
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 their reliance on fossil-fuel imports. Developing sustainable energy through a switch 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 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. Alternatively, renewable energy costs are enduring a rapid global decline that will likely continue for some time. In certain locations renewable energy generation has already attained 'grid-parity', equalling the cost of fossil fuel-based power generation.

While incentives such as feed-in tariffs and tax breaks help, lowering the costs of equipment and services used to produce sustainable power can facilitate the scale-up process, enabling economies of scale and cost optimisation for renewable energy projects. Addressing barriers to trade in sustainable energy goods and services can also contribute to scale economies and cost-optimisation, as trade in sustainable-energy goods can be hampered by tariffs, subsidies, diverse or conflicting technical standards, and lack of harmonisation or mutual recognition efforts.

In striving to lower production costs, policymakers often seek to promote domestic manufacturing of renewable energy 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. Canada and Japan are in the midst of the World Trade Organization's (WTO) first ever trade dispute over renewable energy feed-in tariffs and local content measures. 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 liberalise 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 – unclarified, given the Doha mandate's lack of a holistic perspective on energy.

With such a scenario, sustainable energy trade initiatives 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 "multilateralised." 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 to immediately undertake ambitious liberalisation in sustainable energy goods and services. A SETA could also help clarify existing ambiguities in various trade rules and agreements as they pertain to sustainable energy and provide focalised governance through effective, operational provisions.

The international diffusion of sustainable energy technologies is not only important for climate change mitigation, but also for low-carbon growth and trade. The network of barriers to widespread diffusion of renewable energy technology, including the lack of effective mechanisms and incentives for technology transfer, trade barriers to new technology imports, and trade distortions created by government subsidies, standards and procurement practices have limited the widespread diffusion of sustainable energy capacity. As nations strive to adopt new technologies, the complex and varied nature of the international institutions' aid mechanisms and the obstacles to change embedded within domestic governance make widespread technological diffusion increasingly expensive and difficult to achieve.

This paper assesses issues and options for enhancing climate-friendly technology diffusion in the development of a SETA and makes a case for the creation of a new international institutional architecture built around a sustainable energy trade agreement. There is no single institutional setting, nor even only one type of institutional architecture, that can fully exploit the gains from increasing the international diffusion of sustainable energy technologies. The complexities of the issues at hand require a clear and coherent governance regime for sustainable energy and related goods and services supported by trade rules and robust markets.

In order to clarify issues and options for a SETA, this paper adopts several levels of analysis, including products, industries, countries, and private firms' modes of technology transfer in international business. This multi-level approach gives the reader a comprehensive understanding of issues at the micro-levels of technologies and firms, in addition to the macro-levels of countries and groups of countries. At each of these levels, international technology diffusion is inherently embedded in international trade, investment and licensing flows. The paper considers a wide range of related topics that need to be addressed in designing and negotiating a SETA, especially four key elements: subsidies, government procurement, standards and intellectual property rights. It emphasizes the importance of including energy efficiency goods and services in the coverage of a SETA in view of the relative cost effectiveness of energy efficiency measures as ways to reduce greenhouse gas emissions.

The paper was conceived by the International Centre for Trade and Sustainable Development (ICTSD) and written by Thomas Brewer, Senior Fellow at ICTSD.

The paper is produced as part of a joint initiative of ICTSD's Global Platform on Climate Change, Trade and Sustainable Energy, the Global Green Growth Institute (GGGI) and the Peterson Institute for International Economics (PIIE).

The concept of the research has been informed by ICTSD policy dialogues, in particular a dialogue organised in Washington, DC in November 2011 by the PIIE with support of the Global Green Growth Institute (GGGI) and ICTSD; a high-level Roundtable in Geneva organised 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; and at a session organised at the Global Green Growth Summit 2012 in Seoul, Korea. 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

International diffusion of sustainable energy technologies is widely acknowledged by policymakers and researchers as potentially making substantial contributions to climate change mitigation as well as sustainable development. Facilitating such diffusion is an objective of proposals to negotiate a Sustainable Energy Trade Agreement (SETA), which could be developed in multilateral, regional and/or other venues. In order to clarify issues and options for a SETA, this paper adopts several levels of analysis, including products, industries and countries, as well as firms' modes of technology transfer in international business.

It is particularly important to address the issues associated with **all the modes of technology transfer used by firms**, namely international direct investments, licensing, and trade in services and goods. Because international direct investments and international services transactions are integral to technology diffusion processes, a SETA agenda should include **non-tariff barriers** to these modes of international technology diffusion, in addition to tariffs on goods and barriers to licensing.

From a macro perspective as well as a micro perspective, international technology diffusion is inherently embedded in international trade, investment and licensing flows. Further, trade, investment and licensing together with technology diffusion are central to sustainable development processes. Altogether, they represent a tightly integrated economic package.

A SETA should also take into account the following key features of sustainable energy technologies:

Energy efficiency technologies are among the most cost-effective ways to reduce greenhouse gas emissions, as well as gain other benefits from reducing dependence on fossil fuels. A SETA agenda should therefore include the numerous, diverse and expanding lists of energy efficiency technologies that could make a significant contribution to sustainable development.

Government procurement practices are important factors in the demand for sustainable energy technologies and international diffusion of them. Although some sustainable energy technologies are covered by some countries in the existing WTO Agreement on Government Procurement, there are significant gaps in its coverage in terms of both technologies and countries.

Standards and testing, which are also inherently problematic in the context of trade policy issues because of concerns about disguised protectionism, are even more problematic for sustainable energy technology diffusion issues because the technologies themselves are rapidly evolving. Standards and testing procedures are also therefore in a state of flux in many instances.

Government subsidies of sustainable energy projects by technology exporting and importing countries can be justifiable on economic efficiency grounds because of market failures. A SETA agenda should therefore not only be about trade liberalization; it should also be about finding a balance between the roles of governments and markets. Achieving such a balance is one of the most analytically and politically challenging topics for SETA dialogues. A new paradigm about the role of government in economies, including international trade, is needed in order to adequately accommodate the legitimate role of subsidies in facilitating economic efficiency where there are market failures.

Many emerging and "developing" countries are **significant exporters as well as importers of sustainable energy technologies**. As a result, the political economy of the patterns of interests and influence in international negotiations of a SETA are changing. Developing countries' increasing interests as technology exporters create incentives to participate in agreements that would reduce barriers to international diffusion of sustainable energy technologies. At the same time, those countries' expanding role in the world economy enhances their influence in international negotiations.

The evolving energy technology revolution is also changing the international political economy of sustainable energy technology diffusion. New and evolving technologies are changing international trade, investment and technology diffusion patterns. As such patterns change, it is important that a SETA agenda be flexible so that it can expand to include new technologies.

In sum, what is needed is a new international institutional architecture. While some opportunities for increased international cooperation can be exploited in existing institutional venues, others may require the creation of new international institutional arrangements. There is no single institutional setting, nor even only one type of institutional architecture, that can fully exploit the gains from increasing the international diffusion of sustainable energy technologies.

Chapter 1

Purpose, Scope and Structure

Facilitating the international diffusion of climate-friendly technologies is a central objective of proposals to develop a Sustainable Energy Trade Agreement (SETA). The purpose of this paper is to assess issues and options for enhancing climate-friendly technology diffusion in the development of a SETA. The paper explicitly considers a wide range of related topics that need to be addressed in designing and negotiating a SETA.

Throughout the paper the term "trade" refers to international trade in services as well as goods, and also to international direct investment and international licensing. Similarly, the term "technology" is used in its broad sense to refer to knowhow and thus trade, investment and licensing in services, as well as hardware. The approach of the paper is furthermore multi-level, in that it considers issues at the micro-levels of technologies and firms, in addition to the macro-levels of countries and groups of countries.

1.1 Country Groups

As a result of discussions before, during and after recent climate change conferences, the terminology of country groups in international diplomacy has been changing. The changes were perhaps most significant during the Durban COP-17, when references to "Annex I" and "non-Annex I" countries and references to "developing" and "developed" countries and "economies in transition" were not included in the Durban Platform for Enhanced Action.[1]

Although such references nevertheless continue to be embedded in some official documents and in much common discourse, it is often more precisely descriptive of current and prospective realities to use different terms. This is particularly so when referring to international technology issues because the key features of countries are whether they are *sources* or *recipient*s in specific international technology diffusion processes.

At the aggregate level, it is especially important to note that many "developing" countries are *sources* as well as recipients in international technology diffusion processes; it is also important to note that "developed" countries are *recipients* as well as sources. The policy-relevant empirical issues are to what extent in which technologies an individual country is a source or recipient; there are thus significant empirical questions in addition to the definitional issues about country groupings. Issues about the *scope* of a country's capabilities as a technology exporter and the *level* of its current and prospective capabilities are also often pertinent. The paper considers empirical issues further below in relation to the *changing techno-economic geography* of international technology diffusion.

1.2 Structure of the Paper

Section 2 of the paper puts the focal issues about international diffusion of sustainable energy technologies in the broader context of the interactions among sustainable development, technological change and trade. It includes definitions of key terms, as well as discussions of the scale of deployment of sustainable energy technologies needed and the modes and geographic patterns of international technology diffusion. Section 2 is thus about technology and economics.

Section 3 focuses on government policies – domestic as well as international – that need to be taken into account in SETA design and policymaking processes. That section also briefly describes the panoply of international institutional arrangements concerning energy, climate, trade and development where SETA issues are or will be on the agenda.

In Section 4 the paper considers ways forward and discusses issues and options for change – including not only the issues and options that are SETA-specific, but also more broadly the political economy of participation and compliance issues.

Chapter 2

Context: Sustainable Energy Technologies, Low Carbon Economies And Trade

2.1 Sustainable Energy in Low Carbon Economies: Technologies and Terms

Sustainable development, energy technology diffusion and trade are inevitably integrated in economic and technological processes. Furthermore, technology spillovers – including sustainable technologies in the energy sector which is central to economic development – are important benefits of international technology diffusion, including developing countries in particular. The significance and role of technology spillovers are discussed, for instance, in Grossman and Helpman (1991) and Coe and Helpman (1995).

In order to understand better international technology diffusion processes, it is helpful to clarify key terms. The dialogue on technology transfer issues from the 1992 to the 2012 Rio conferences are discussed in Abdel Latif (2012b), and fifty years of technology transfer negotiations and the associated terminology are discussed in Sampath and Roffe (forthcoming).

The accepted notions of *technology* have been expanded and refined as the technology diffusion dialogue has progressed in technology transfer and climate change mitigation policymaking circles. In particular, it refers to "knowhow" and thus intangible, as well as tangible goods. *Technology diffusion* refers to a process that includes transfer but with the additional connotation of absorption of the technology into the recipient economy.

Renewable energy is "any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. Renewable energy is obtained from the continuing or repetitive flows of energy occurring in the natural environment and includes low-carbon technologies such as solar energy, hydropower, wind, tide and waves and ocean thermal energy, as well as renewable fuels such as biomass" (IPCC, 2011: Annex 1, 9). *Sustainable energy* is "inexhaustible and [does] not damage the delivery of environmental goods and services including the climate system" (IPCC, 2011: Chapter 1, 18).

The meanings of these and related terms are discussed further in Box 1.

International diffusion

The international diffusion of sustainable energy technologies is not only important for climate change mitigation, but also for low-carbon growth and trade, including in developing countries. Since Solow (1956), economists have emphasized the importance of technological change in increasing productivity and economic growth. In order to improve understanding of these opportunities, ICTSD completed technology mapping studies of the energy supply sector and of climate-friendly technologies in two key end-use sectors: transport and buildings. The mapping studies identify products, including components, associated with these technologies; the studies provide bases for analyses of market access conditions and market opportunities that arise from the deployment of such technologies, including for producers in developing countries. (See especially Lako, 2008; Kejun, 2010; Vossenaar, 2010; Vossenaar and Jha, 2010; Goswami, Dasgupta and Nanda, 2009. An extensive list of relevant ICTSD studies appears at the end of the References section.)

The mapping studies also illustrate the large potential for climate change mitigation that can be achieved by deploying climate-friendly technologies. See Box 2 for a list of the many ways that technologies can reduce greenhouse gas emissions.

Although technology is sometimes equated with hardware and thus as *goods* in international trade, a broader notion of technology as "knowhow" - and thus *services*- is now more widely accepted, as noted above. Engineering services, consulting services, and construction services are obvious examples (see esp. Kim, 2011). The list of services in Box 3 is indicative of the number and variety of services potentially involved, for example, in an offshore wind farm.

In order to understand the diffusion of sustainable energy technologies, it is important to recognize that international technology transfers are often undertaken by firms as elements in complex "bundles" of transactions involving services, the movement of personnel, and the movement of financial capital, as well as goods. It is typically *firms' direct investment projects* that drive the composition of these bundles. Moreover, direct investment projects are often central to the key strategic choices of firms as they expand internationally within particular regions. For instance, in the wind industry, transportation economics create pressures to locate production of large towers, blades and turbines near wind farm installation sites. These pressures, in combination with economies of scale that create pressures to centralize production, lead to international regional hubs being strategically important for serving multiple international markets. A key ingredient of the hub is an international direct investment project, the success of which depends on market access to the countries of the region.

In many cases, technology can be transferred internationally through joint ventures, involving a direct investment by the foreign firm as well as an investment by a local partner. For example, Japanese firms have partnered with local Indian firms in joint ventures involving high-efficiency, low-emission coal technologies (IEA, 2010: 575).

Access to technology can also be facilitated by international licensing. For example, one of China's largest wind technology manufacturers, Goldwind, gained access to wind technology by purchasing licences from German wind turbine maker Vensys. Chinese firms have also acquired licences to produce boilers, turbines, and generators for advanced technology coal-fired power plants.

The importance of sustainable energy technologies and energy efficiency

Two fundamental facts about the significance of energy production and consumption as contributors to greenhouse gas (GHG) emissions need to be recognized In order to understand the potential contributions of sustainable energy technologies to climate change mitigation (IEA, 2010):

- Nearly two-thirds (65 percent) of all greenhouse gas emissions world-wide can be attributed to energy supply and energy use.
- More than four-fifths (84 percent) of global CO_2 emissions in particular are energy-related.

Addressing energy production and consumption issues is thus essential to mitigate climate change. As for technological *solutions:*

- "There is currently no single technology solution that can lead to a sustainable energy future…" (IEA, 2010: 75; also see this paper Annex I).

But of course, not all energy technologies are equally cost-effective; nor are they similarly suitable for all locations. Yet, there are some consistent patterns in their relative attractiveness; one such pattern is that energy efficiency has been consistently found to be the most cost-effective approach to reducing GHG emissions associated with energy production and consumption.

The relative cost-effectiveness of energy efficiency technologies has been a recurrent theme in analyses by the International Energy Agency (IEA); this has been true at the global level in general and for particular countries. The following are indicative of the theme:

- "End-use [energy] efficiency accounts for 36 percent of all savings in the BLUE scenario" (IEA, 2008). The BLUE scenario assumes that global energy-related CO_2 emissions are reduced to one-half their current levels by 2050.

- In the BLUE scenario for India, "improved energy efficiency across both supply and end-use sectors is the single largest source of CO_2 reductions" (IEA, 2010: 452).

- Similarly for China, "higher rates of energy efficiency result in a 27 percent reduction in [energy related emissions]in 2050 compared to Baseline levels" (IEA, 2010: 382).

- In its study of paths for reaching a global greenhouse gas concentration level of 450ppm by 2100, the IEA (2010) found that the cost-effective opportunities for energy-related abatement of CO_2 were especially pronounced in energy efficiency measures, particularly in the early years. Thus, in 2020 the share of abatement from energy efficiency is projected to be 72 percent in that path, and in 2035 44 percent. Energy efficiency's share of the *cumulative abatement* during the period from 2010 to 2035 was 50 percent. These and the relative contributions by renewable energy technologies and other sources are detailed in Table 1.

- "The average energy efficiency in 2050 needs to be twice the level of today, a significant acceleration compared to the developments in the last 25 years" (IEA, 2008).

In the building and transport sectors there are particularly significant potential gains in reducing greenhouse gas emissions from increased energy efficiency and thus there has been much technical and policy research conducted in these sectors over the past many years. The significant potential for energy efficiency gains in the industrial sector has also been widely noted and researched, partly because firms have a clear incentive to reduce costs.

The *IPCC Special Report on Renewable Energies and Climate Change Mitigation* (IPCC, 2011) is a useful source for assessing the relative importance and prospects of various types of sustainable energies. It lists six broad categories of technologies at the industry level: bioenergy, geothermal, hydro, ocean, solar, wind. Pacala and Socolow (2004) also have identified a wide range of sustainable energy technologies – including energy efficiency measures – that could significantly reduce greenhouse gas emissions. The IEA (2010) has identified 17 "key groups" of technologies that could reduce greenhouse gas emissions 50 percent by 2050, compared to current levels (see Box 4).

While such lists are useful for appreciating the breadth of the technologies and sectors that can contribute to climate change mitigation, it is also useful to gain a more in-depth understanding of the technologies available in a particular sector. Box 5 identifies emerging technologies for heating, ventilating and air conditioning in the building sector.

The illustrative list in Annex II of this paper presents the results of a scanning of these and other such lists in a preliminary effort to identify the universe of *energy efficiency* technologies with greater breadth and depth.

2.2 The Challenges of Scale and Price in the Evolving Energy Technology Revolution

It is well known that the estimated technical potentials of world sustainable energy production are more than adequate to meet increasing energy demands for many decades, as the data of Table 2 indicates in detail.[2] The global technical potential of solar energy in particular has been estimated to be between 3 times and 101 times recent world energy demand (IPCC, 2011:10). Though the technical potentials of other energy sources are not so enormous, they are individually and collectively substantial. Yet, the technical potential has to be *physically* harnessed and distributed - at significant *economic* costs.

The physical challenge is evident in an IEA estimate: "the average year-by-year investments between 2010 and 2050 needed to achieve a virtual decarbonisation of the power sector include, amongst others, 55 fossil-fuelled power plants with [carbon capture and storage], 32 nuclear plants, 17, 500 large wind turbines, and 215 million square metres of solar panels. [The BLUE scenario] also requires widespread adoption of near-zero emission buildings and, on one set of assumptions, deployment of nearly a billion electric or hydrogen fuel cell vehicles" (IEA, 2008: 1).

As for the *economic* challenge and the importance of technological innovation, "using technologies available in 2005, the present value cost of achieving stabilization at 550 ppm CO_2 would be over USD20 trillion greater than with expected developments in energy efficiency, hydrogen energy technologies, advanced bioenergy, and wind and solar technologies" (IPCC, 2011). The trends in comparative costs are thus centrally important in the evolving energy revolution. The IPCC (2011: 10) presents a summary of the "levelized costs" of a variety of sustainable energy sources.[3] It concludes that "Some [renewable energy] technologies are broadly competitive with existing market energy prices. … [However, in] most regions of the world, policy measures are still required to ensure rapid deployment of many [renewable energy] sources."

2.3 International Technology Flows: Changing Geographic Patterns

The precise patterns and trends in the changing techno-economic geography of sustainable development vary according to the particular indicators used from among a wide range of possibilities. One is patents. Previous ICTSD studies (Abdel Latif, 2012b; Abdel Latif, et al., 2011) have found that firms in Organisation for Economic Cooperation and Development (OECD) countries continue to dominate the issuance of patents.[4] Although developed countries remain predominant in patent applications and the granting of licenses, there is a trend of increasing innovation and sourcing of production in developing countries.[5] In some key industries and technologies, firms in a few large developing countries are world leaders in climate friendly sustainable energy technologies. Moreover, some large multinational firms based in developed countries have significant global R&D centres in developing countries (Brewer, 2008a; 2008b; 2008c; 2009).

The increasing importance of developing countries as suppliers of new technologies in general and climate-friendly technologies in particular is evident, for instance, in China for solar and in India for wind (IEA, 2010: 573). Data computed for the 21 economies in Asia Pacific Economic Cooperation forum (APEC) (Kuriyama, 2012: 2) revealed that over the period from 2002 to 2010, the developing countries' shares went from one-third to two-thirds of APEC *exports* of climate friendly technology products. The shift in *imports* was less substantial: the industrialized countries' share declined from slightly more than a half to about four-tenths, while the developing countries' share went from slightly less than a half to nearly six-tenths (see Table 3).

China is the largest exporter of static converters that change solar energy into electricity, solar batteries for energy storage in off-grid photovoltaic systems, the concentrators used to intensify solar power in solar energy systems and wind turbine towers (IEA, 2010: 574). An APEC policy brief (Kuriyama, 2012) presents abundant data on the patterns and trends in environmental goods and services trade for the 21 APEC economies. The data include specific categories concerned with sustainable energy – including renewable energy plants, power generation, heat energy and management, resource efficient technologies, and environmental monitoring, analysis and assessment equipment. "Developing economies" in APEC have become significant technology exporters as well as importers, and the trend is for them to become increasingly net exporters. In these data, of course, the "developing country" patterns and trends reflect particularly China's emergence as a major exporting economy.

Trends in climate-friendly products have been especially notable: "[W]orld trade for the climate-friendly technology products increased at an average annual rate of 16 percent during the period 2002- 2010, reaching USD 224.4 billion in 2010. Over the same period, APEC exports of climate-friendly technology products to the world increased at a faster pace of 17.2 percent per year, totaling USD 123.7 billion; whereas APEC imports grew at a slower rate of 13.6 percent per year, reaching USD 100 billion." Furthermore, "intra-APEC trade of climate-friendly technology products nearly tripled from USD 23 billion to USD 63 billion between 2002 and 2010. Intra-APEC trade in 2010 was equivalent to 28.4 percent of the world total…" (Kuriyama, 2012: 2).

Data compiled by ICTSD (2011a) also reveal the increasing importance of many developing countries as exporters of sustainable energy products. Furthermore, data on international direct investment flows reveal increasing *outward* flows from developing countries (Hanni, van Giffen, Kruger and Mirza, 2011; also see UNCTAD, 2010). Firm-level cases illustrate the nature of these flows in greater detail than is possible with the aggregated data. The Indian wind turbine manufacturer Suzlon is a particularly compelling example. Suzlon is the fifth largest turbine manufacturer in the world with sales in nearly all regions. Its expansion has been achieved through a combination of increasing exports from India and direct investment projects in foreign countries. The foreign direct investment projects have enabled it to gain access to technologies in other countries, especially in existing firms in Europe. Thus, it bought all or major portions of: AE-Rotor Techniek, a rotor-blade design firm in Germany; Hansen International, a gearbox manufacturer in Belgium; and RePower, a manufacturer of onshore and offshore wind turbines in Germany (IEA, 2010: 575; also see Lewis, 2007).

Other examples of the internationalization of sustainable energy industries are evident in Box 6.

Chapter 3

Government Policies And International Institutional Arrangements

Within the broad array of governments' sustainable energy policies and trade policies, subsidies and other support policies are especially problematic in terms of their trade implications.

3.1 Government Support Policies for Sustainable Energy and Trade Policies

There are two categories of market failures that justify government policy supports for sustainable energy on the grounds of increasing economic efficiency – namely the market failures represented by (1) the negative externalities associated with the widespread use of fossil fuels and other activities that release greenhouse gases, and (2) the positive externalities associated with investment in energy efficiency and renewable energy or carbon sequestration projects with significant "public goods" payoffs. Negative externalities are thus inherent in the cause of the problem, and positive externalities are inherent in the constraints on the solutions. There can therefore be economic efficiency rationales for governments to undertake subsidies to incentivize investment in and use of sustainable energy sources and practices (see e.g. Brewer, forthcoming: ch. 1).

The extensive use of support policies is documented in Table 4. Their use is common across all country groups. Feed-in tariffs and a variety of types of tax reductions are especially frequent. In some countries – the US in particular – several types of support policies are in effect only at the sub-national level.

From a trade policy perspective, of course, sustainable energy support policies prompt concerns about the possibility of disguised protectionism. Such concerns and possibilities have already been involved in trade disputes – some of which have reached the WTO dispute settlement process and some of which festered without being formally submitted to the WTO for resolution. Some are the subject of on-going dispute panel cases in mid-2012 as this paper is being written. See Annex 3 for summaries of these and other instances in which climate change and trade issues have collided.

Extensive analyses of subsidies issues are available in ICTSD studies by Ghosh (forthcoming) and Howse (2010).

3.2 Standards and Testing

Standards and testing procedures - like support policies - are widespread and diverse; and like support policies, they are potentially problematic when they become enmeshed in trade relations because they can be easily perceived as disguised trade protectionism, as indeed they sometime are. Yet, they can also be legitimate sustainable energy policies, which can be justified on economic efficiency grounds since they can be used to address market failures.

The extent and diversity of them are evident in the results of a "Survey of Market Compliance Mechanisms for Energy Efficiency Programs," undertaken by the APEC Expert Group on Energy Efficiency & Conservation (APEC, 2012b), which reported that "Within the APEC region there are a total of 32 energy labeling and 16 minimum energy efficiency standards programs operated by 18 economies. These include programs that have been running since 1978 [and] those that are in their infancy; programs covering up to 50 product types [and] those spanning only one or two."

In the EU, there are several Directives and many programmes that address sustainable energy standards and testing issues. Of particular importance is the Renewable Energy Directive (2009/28) which has spawned a variety of activities. For instance, the European Committee for Standardization (CEN) has been developing a set of standards for sustainably produced biomass for energy applications, which is expected to be made public in late 2012.

The usual trade policy problems concerning technical standards are significantly exacerbated for sustainable energy technologies because many of the technologies are relatively new and/or in a state of flux (see, for instance, ICTSD, forthcoming-a; IEA, 2009; REN21, 2011; Storm, 2012; UNCTAD, 2011).

3.3 International Venues: Who Does What

The expansion of the development-energy-climate-trade agendas in recent years is reflected in the wide range of international institutional venues where those issues have been under consideration (for context, see Brewer, 2008a; 2008b; 2008c; 2009). Much of the climate change diplomatic dialogue has been in the United Nations Framework Convention on Climate Change (UNFCCC) process (see esp. Aldy and Stavins, 2007; 2009; 2010a; 2010b; 2010c).

The UNFCCC's Technology Mechanism, Centre and Network, and Executive Committee

Since its beginning twenty years ago, the UNFCCC has included international technology diffusion as one of its central objectives.As a result of a series of COPs in Bali, Cancun and Durban a new institutionalization is being put into place in the form of a Technology Mechanism, which consists of a policy body, the Technology Executive Committee (TEC), and a Climate Technology Centre and Network (CTCN). Although the latter is not yet operational, the priorities of the Mechanism have been established by the various COP decisions and followup meetings. The priorities include the promotion of public-private partnerships and strengthening international R&D cooperation, as well as the development of national innovations systems and technology actions plans. Discussions of the tangible implications of these priorities and numerous suggestions for how the Mechanism can "realize its potential" are available in an ICTSD report by Sampath et al. (2012).

UNFCCC and WTO

The UNFCCC and the WTO - as the premier multilateral arrangements for climate and trade, respectively - have gotten the most attention from researchers, policymakers and other stakeholders, as well as the media. The attention has been mostly focused on legal-institutional issues, with a special concern about conflicts between trade and climate, but with a recognition of their compatibilities and complementarities (Cottier et al., 2009; Epps and Green, 2010; Frankel, 2010; WTO and UNEP, 2009).

Other fora

The panoply of relevant international institutional arrangements, however, is much more extensive than only the UNFCCC and WTO. Among the specialized agencies of the UN system, the United Nations Environment Programme (UNEP) has been particularly active, including in particular the co-authorship with the WTO of a major study of issues at the intersection of trade and climate change (WTO and UNEP, 2009). Two other UN agencies with industry-specific missions have become more salient in recent years, after many years of quiescence on climate-trade issues. The International Civil Aviation Organization (ICAO) has received much attention, particularly since the advent of the international controversy about the inclusion of aviation in the EU Emissions Trading Scheme (ETS); but it has done little on climate change issues as of this writing. The International Maritime Organisation (IMO) has also become more active in recent years.

Outside the UN system, several for a specifically for large economies have given periodic attention to climate and sustainable energy issues as well as trade and sustainable development, though typically not all of them at the same time. The annual G-8 summit has sometimes focused on climate change issues, while the G-20 has focused on sustainable energy; but in both cases international financial issues have become dominant in recent years. The Major Economies Forum on Energy and Climate (MEF), with 17 members, was initiated in 2009 as a venue where major emitters of greenhouse gases might make progress on negotiating a climate change agreement without the complications of nearly 200 participants in UNFCCC negotiations. Although the MEF has stimulated and discussed major studies on a wide range of key issues, it has not taken any decisions of substance.

These and other international institutional arrangements for addressing the issues of this paper can be described along several dimensions, including issue clusters, economic sectors and scope of membership. There are four directly relevant - and overlapping - issue clusters: energy, climate, trade and development. The economic sectors – and subsectors – can be summarized as energy production, energy distribution, buildings, transportation, industry, agriculture - and their subsectors - as represented in several boxes in section 2 above. The scope of membership extends from bilateral to regional to plurilateral to multilateral (i.e. nearly global).

Although it is not feasible to present a comprehensive listing of all the relevant international institutional arrangements and their key features in terms of issue clusters, economic sectors and membership, it is possible to list a few in a comparative format that illustrates their extent and diversity (see Table 5).

It is easy to imagine at least five quite different venues where a SETA could be negotiated: a forum such as the G20 of large economies and large GHG emitters, a regional forum such as APEC or the Trans-Pacific Partnership (TPP) or perhaps a Trans-Atlantic Partnership, or bilateral FTAs such as those being negotiated between the EU and several countries, particularly in Asia. Each of course presents its own distinctive issues as a result of the differences in trade patterns, GHG emissions trajectories and development paths, and it is not feasible to examine each one in detail. However, because SETA issues are already on the active agendas of APEC and EU bilateral FTA negotiations, they warrant special attention.

3.4 Sustainable energy issues in APEC[6,7]

A SETA-like agenda is already progressing in the Asia Pacific Economic Cooperation (APEC) forum, whose 21 economies account for about 60 percent of world energy demand. Interest in those economies in sustainable energy issues is evident in official statements by leaders and ministers of the 21 APEC economies. The November 2011 Leaders' Honolulu Declaration is particularly notable in its ambitions (APEC, 2011):

> In 2012, [our] economies will work to develop an APEC list of environmental goods that directly and positively contribute to our green growth and sustainable development objectives, on which we are resolved to reduce by the end of 2015 our applied tariff rates to 5 [percent] or less, taking into account economies' economic circumstances, without prejudice to APEC economies' positions in the WTO. Economies will also eliminate non-tariff barriers, including local content requirements that distort environmental goods and services trade….

Their commitments are further summarized in Box 8.

APEC trade ministers (APEC, 2012) subsequently reaffirmed their "commitment to promote trade and investment in environmental goods and services (EGS) in order to address environmental challenges, … [their commitment] to strengthen regional cooperation on trade and environmental matters, ... [and their] commitments to advance shared green growth objectives and to address both the region's economic and environmental challenges by accelerating the transition towards a global low-carbon economy, which will contribute to energy security and reduce APEC's aggregate energy intensity."

Of course, the geographic scope of participation in APEC is limited by its regional focus, and thus major economies and GHG emitters such as Brazil and Argentina and European countries are excluded, as compared with the G20. Yet, at the same time, the inclusion of China and Russia as well as a large number of Southeast Asian countries nevertheless give it much diversity in terms of the structure of the economies represented in it (see Table 6).

EU bilateral FTAs

The EU has engaged in a large number of bilateral Free Trade Area (FTA) negotiations in recent years, several of them involving countries in east, south and southeast Asia (European Commission, 2012). The first to enter into force was the FTA with South Korea (European Union, 2011). The EU aims for each of the FTAs with Singapore, Malaysia, Vietnam to have an annex on sustainable energy technology issues, including pro-visions concerning GHG emissions, and non-tariff barriers to services trade and direct investments as well as tariffs on goods. Prospective EU FTAs with Japan and the US are expected to include similar provisions. The FTA with India, however, is not expected to include such an annex (as of this writing in July 2012).

Chapter 4

Ways Forward: Issues And Options For Change

Carefully crafted trade policies could contribute to a more widespread and rapid deployment of efficient, sustainable technologies that promote sustainable growth. Within that context, trade can also provide incentives for innovation and investment in climate-friendly technologies. However, there are a variety of international institutional governance issues that need to be addressed in order to facilitate more effectively the contributions of trade to sustainable growth and climate change mitigation.

4.1 International Governance Issues

Despite the wide array of existing international institutional arrangements, there are nevertheless some gaps in the institutional structure; and because of the number and diversity of the substantive development-energy-climate-trade issues involved, there are inevitably some inter-agency coordination issues, as well.

Assessing international arrangements[8]

There are of course many ways to assess the adequacy of existing international institutional arrangements – political, economic, legal, and administrative. Each is a legitimate approach, with its own concepts and criteria, and each yields its own distinctive descriptive and prescriptive results. *Politically*, at the most fundamental level, the memberships of current institutions differ – and thus the patterns of interests and influence within them differ. A challenge for the development of a SETA, therefore, is to find a combination of countries that can form a politically viable arrangement; it seems unlikely that that will happen in a multilateral climate or trade venue, where the impasses between developing and industrial countries are so formidable. *Economically,* the current configurations obviously differ enormously in the sizes of the economies, individually and collectively – and in the quantities of their GHG emissions. A challenge for developing a SETA therefore is to find a venue that is large enough in economic terms and emissions terms to be significant, but small enough to be politically feasible. *Legally,* at a basic level, there are differences in the places of the institutions in international law – for instance, older international agreements have privileged positions relative to more recent ones; yet another challenge for a SETA is thus to fit it into an existing array of institutions and agreements. Finally, in simple *administrative* terms, there are already many multilateral institutions with overlapping missions and program responsibilities, and therefore coordination and redundancy issues are inevitable. Coordination issues have been especially noteworthy in UNFCCC-WTO relations.

UNFCCC and WTO at the multilateral level

The UNFCCC and the Kyoto Protocol have specific provisions which recognise the need to encourage international technology transfer. These include financial mechanisms such as specialized funds and market-based initiatives. The restructuring and expansion of the technology innovation and transfer programs as a result of Durban COP-17 decisions is in progress. Thus, the institutionalization of issues concerning climate friendly technologies within the UNFCCC framework continues to evolve. The institutionalization of intellectual property rights issues within the WTO is well established.

How to coordinate the two is an open question. The continuing exchanges of information between the two secretariats and periodic attendance at one another's meetings are useful steps in the right direction. A potentially useful further institutionalization of relations at the multilateral level of UNFCCC-WTO interactions would be formalized *mutual notification processes* whereby (a) climate friendly policies such as sustainable energy subsidies would be notified to the WTO and (b) WTO dispute cases and the results of

WTO Policy Reviews would be notified to the UNFCCC.

Intellectual property rights issues pose yet other questions about international governance, including the roles of the UNFCCC, WIPO and the WTO. It has been suggested, for example, that "…multilateral discussions on sustainable development and climate change are not the appropriate venues for proposals that would modify international IP norms. Efforts to enhance the transfer and diffusion of green technologies in these discussions should take place in the framework of existing international rules established by the TRIPS Agreement, and flexibilities are an integral part of the balance of rights and obligations in these rules" (Abdel Latif, 2012a).

4.2 Elements of a SETA

A previous ICTSD (2011a: esp. 62-67) report oA previous ICTSD (2011a: esp. 62-67) report on SETA-related issues identifies a wide range of diverse questions about potential elements of a SETA, and all of them are directly or indirectly relevant to the specific focus of the present paper on technology diffusion issues. The present discussion builds on that report by highlighting some items in the previous report that are especially important for technology transfer issues and by supplementing them with a few additional observations.

A SETA should have a *broad scope in terms of its coverage of industries and technologies.* They should definitely include energy efficiency technologies - perhaps through a second track in addition to first track negotiations concerning energy supply technologies. See ICTSD (2011a: 62) concerning the possibility of two-phase negotiations.

Policies that act as either *barriers* or *facilitators* of sustainable energy technology diffusion need to be addressed in a SETA. As for *barriers,* a SETA that would eliminate tariff and non-tariff barriers on climate friendly energy technologies could increase their traded volume by an average of 14 percent in 18 developing countries that emit high levels of greenhouse gases, according to estimates in a World Bank study (2009). Reducing *non-tariff barriers on international services and direct investments* could have much bigger effects on technology transfers in the form of knowhow.

As for *facilitation* policies, the issues are more complex. Government policies that facilitate innovation and investment in sustainable energy technologies are important because of the market failures associated with technology research, development and diffusion. Market forces alone are insufficient to bring about a rapid deployment of sustainable energy technologies; government regulations and incentives are also important. How to resolve the conflicts between sustainable energy subsidies and trade liberalization is thus an urgent challenge. There are two approaches to the challenge: *formulating principles*, which has the potential advantage of creating clarity and reducing uncertainty, and *resolving dispute cases*, which has the advantage of pragmatic adaptation to the circumstances of tangible circumstances. Perhaps a mix of the two can be devised.

In any case, given the potential for conflicts between trade and sustainable energy/climate change issues, it is important that a SETA include provisions for *dispute resolution* – through either existing WTO or other arrangements.

There should be provisions concerning *government procurement* (at the subnational as well as national levels) – given its importance in sustainable energy technology markets and given the inadequacy of the coverage of the current WTO Agreement on Government Procurement(ICTSD, forthcoming).

Competition policy – which is not included in the WTO, but which has been broached as a possible agenda item in international negotiations in the past – should be on the agenda as a possible element of a SETA. Anti-competitive industry structure and/or firm behaviour are issues in sustainable energy industries, as they are in any industry, where there are frequent international mergers and acquisitions. A SETA that is sensitive to technology diffusion issues should also reflect the following: "Sustainable energy is a rapidly changing field, characterised by new technologies, innovation and market developments. Therefore, an open-ended SETA, where new issues could be added… would enable the agreement to be dynamic and responsive to changing needs and circumstances" (ICTSD, 2011a: 64).

These and other potential elements are itemized in the "checklist" of Box 9.

4.3 Key political economy issues

Two key issues about the political economy of a SETA concern: (1) how the patterns and trends in *countries' technology exports and imports affect their interests* at stake in SETA negotiations, and (2) the ways in which and the extent to which a SETA may be able to circumvent the global public goods, free rider problem of existing climate change agreements by creating club goods with incentives for countries to *participate in a trade agreement and comply with its norms*.[9]

Changing import/export patterns

The political economy of trade liberalization has changed substantially in recent years, including for sustainable energy trade technologies in particular, as noted above in section 3.2.The IEA (2010: 586) has observed that "The removal of [import trade] barriers is important for developing countries. China, Hong Kong (China), Mexico, Singapore and Thailand are among the top ten exporters of renewable energy technologies and, therefore, have significant export interests in trade liberalisation in the sector." An APEC policy brief (Kuriyama, 2012) concludes that "Given the growing importance of [the EGS] market, removing barriers would be beneficial to both industrialized and developing APEC member economies. Barriers are not limited to tariffs and cover a wide array of issues, such as over-stringent technical regulations that go beyond what is reasonable to allow the commercialization of a product; cumbersome certification procedures; quantitative restrictions to imports and exports; local content requirements; low enforcement to prevent infringement of intellectual property rights; subsidies to goods and services with higher levels of carbon footprint; and sectoral restrictions to foreign investment, among others."

As is generally true in international trade issues, sustainable energy technology importing countries and exporting countries have different interests. Though there are many examples of the interests of corporate and individual consumers of imports having sufficient influence to overcome the political pressures of protectionist firms and industry associations,[10] it is nevertheless true that technology-importing countries – especially those with producers and/or aspirations to become homes to producers - are more prone to resist liberalization of trade barriers while exporting countries are likely to support them. The patterns and trends in imports and exports are therefore obviously significant determinants of countries' negotiating positions.

As noted above, services trade and direct investment are both centrally involved in international technology diffusion processes, in addition to goods trade. Thus, although patterns in goods trade are certainly indicative of some interests in international technology diffusion issues, they are not necessarily conclusive. In fact, the interests of economies are much more complex. The implications for negotiating a SETA are significant: governments' calculations of economic incentives and domestic economic groups' political pressures on governments tend to be more conflicted and their positions on issues in negotiations less clear cut. Consider, for instance, wind power issues for India. While India may be inclined to impede imports of wind turbines through tariffs and/or non-tariff barriers in order to protect its domestic producer Suzlon, it also true that Suzlon has an interest in access to foreign markets for its exports from India and for establishing foreign production and servicing facilities in foreign markets, and access to foreign technology through outward direct investment. Thus, like multinational firms with geographically diverse interests, Suzlon has mixed interests on trade issues, as does its home country.

A SETA, then, does *not* pose a simple conflict between the interests of industrialized countries as sustainable energy technology exporters and developing country importers. Indeed, many developing countries are already significant exporters of sustainable energy technology goods and services – and source countries of international direct investments. Therefore, they have incentives to support trade and investment liberalization agreements.

Club goods - and incentives for participation and compliance

Among the central challenges of developing any international environmental or trade agreement is to create an arrangement with sufficient incentives for countries – and perhaps other entities – to participate in its activities and to comply with its norms. Indeed, multilateral climate change agreements to date have been weak in precisely these two respects. The underlying problem, of course, is that there are incentives for countries to be "free riders" in the presence of global "public goods" – an endemic problem with international environmental agreements.

International trade agreements, on the other hand, can create "club goods" such that only participants derive the benefits of the arrangement and such that non-compliance entails penalties. See especially, Victor (2011: 254-259), who emphasizes how a "club approach," as used in the WTO, can be adopted in climate change negotiations; also see Hoekman and Kostecki (2009: 158). Linking climate and trade issues is possible, of course, as when the EU made its support of Russian accession to the WTO conditional on the latter's participation in the Kyoto Protocol. Such a linkage made Russia's access to the WTO's "club goods" dependent on its willingness not to be a "free rider" on the Kyoto Protocol.

As a trade agreement, a SETA can create "club goods" and thereby incentives for countries to participate in it and comply with its norms. By focusing directly on trade in sustainable energy goods and services – and thus indirectly on climate change mitigation – a SETA can incorporate the club goods features of a trade agreement, and circumvent (at least partially) the free rider, public goods problem of climate change agreements. Also, a SETA could include provisions on capacity building and technical assistance, and could refer to existing agreements on technology cooperation. (For example, see CERC, 2012; Africa-EU RECP, 2010; NREL, 2010 and DEA, 2012.)

There are yet other ways to increase the incentives for developing countries to participate in a SETA, particularly through linking SETA negotiations to other closely-related issues. For instance, bilateral SETAs could be linked to existing bilateral international technology cooperation arrangements, in which developing countries already have a stake. SETAs can also be linked to capacity building and to related development financing programs. The many ways in which sustainable energy technologies can play crucial roles in sustainable development are discussed, for instance, in a World Bank (2012) report on *Inclusive Green Growth.*

4.4 Prospects and Importance of a SETA

Proposals for a SETA are appearing at a critical but potentially propitious time in the evolution of both the international climate change regime and the international trade regime: both are undergoing strong fragmentation tendencies that are producing highly pluralistic regimes with diverse institutional manifestations at all levels, with multilateral institutions at their core – i.e. the UNFCCC and the WTO. A SETA that can be integrated into these expanding climate and trade institutional landscapes could make significant contributions to both.

The climate and trade issues converge in the sustainable energy issues that are at the core of a SETA. It has been said (Schmalensee, 2010: 897) that "The most important and difficult [climate change] task is to move toward a policy architecture that can induce the world's poor nations to travel a much more climate-friendly path to prosperity than the one today's rich nations have travelled." Such a climate-friendly alternative path could lead to a better quality of life, compared with a traditional carbon-intensive path. The development of a SETA - by whatever name - offers the prospect of being a milestone along that path. Indeed it may be an international institutional design that offers the rare combination of being a "scientifically sound, economically rational, and politically pragmatic" (Aldy and Stavins, 2010:2) contribution to the array of international climate change agreements, as well as a contribution to the trade-and-development agenda.

A SETA offers developing countries, in particular, opportunities to participate more fully in the "third industrial revolution" (Rifkin, 2011) and in the "remaking of the modern world" (Yergin, 2011).

Existing international institutional arrangements for trade, energy, sustainable development and climate change are arguably inadequate to the challenges needing urgent attention. These are historically significant times needing historically significant diplomatic creativity. It is time for a burst of diplomatic creativity akin to that half a century ago when new international institutions were put into place to address the development and trade issues of that era. Now, new problems in new circumstances involving a broader and more diverse array of "players" require new solutions based on new paradigms.

How to begin

As negotiators sit down for their initial meetings to address the sustainable energy agenda, they should be articulating and acting upon the following key points about the issues and the context in which they will be considered:

As for the specific content of a SETA, the negotiators need to be direct about the challenge of addressing four especially important but difficult elements: subsidies, government procurement, standards and intellectual property rights. They all need a fresh look. For instance, negotiators should take a pragmatic approach to IPR issues – an approach that reflect the following observation: "…it is not mutually exclusive to recognise and encourage the important role of IPRs in promoting green innovation, while at the same time considering more closely their impact on technology transfer and dissemination, against the factor of 'affordability'. In this regard, it is difficult to reach categorical generalisations as the impact of IPRs varies according to many factors such as the technology in question, the sector, and country circumstances. Thus an examination of the role of IPRs in relation to diffusion of green technologies needs to be conducted on a case-by-case basis and in light of specific evidence" (Abdel Latif, 2012b).

Negotiators' fresh look should reflect three new paradigms:

- A new paradigm of **international technology diffusion** that includes South-North and South-South transfers and other new techno-economic geographic realities at the macro-level and the diverse modes of firms' technology transfers at the micro-level. There must be realism about the new techno-economic geography: many economically significant "developing" countries are also significant sources of sustainable energy technologies, not only in manufacturing goods but also in R&D and in services.

- A new paradigm of **economic growth** that incorporates the roles of sustainable energy and energy efficiency and that also recognizes the potential contributions of private international technology transfers to climate change mitigation and sustainable development – transfers that occur through trade in services and direct investments as well as licensing and trade in goods.

- A new paradigm of the **role of government in economies** that recognizes the market failures that are at the core of the climate change problem and that are embedded in technological solutions.

Finally, the negotiators should emphasize that the negotiations are not only about reaching agreements that take into account differences in countries' and industries' interests; they are also about the common interests of the international community in addressing effectively the global commons problems associated with climate change and about the global benefits of the widespread diffusion of sustainable energy technologies.

Endnotes

1. Aldy and Stavins (2010: 5) have noted that "approximately fifty non-Annex I countries – that is, developing countries and some others – now have higher incomes than the poorest of the Annex I countries with commitments under the Kyoto Protocol. Likewise, forty non-Annex I countries ranked higher on the Human Development K Index in 2007 than the lowest ranked Annex I country."

2. "Technical potential" refers to the amount of [renewable energy] output obtainable by full implementation of demonstrated technologies or practices (IPCC, 2011: 6).

3. The "levelized cost" of energy refers to "the cost of an energy generating system over its lifetime; it is calculated as the per-unit price at which energy must be generated from a specific source over its lifetime to break even. It usually includes all private costs that accrue upstream in the value chain, but does not include the downstream cost of delivery to the final customer; the cost of integration, or external environmental or other costs. Subsidies and tax credits are also not included" (IPCC, 2011: 10).

4. An extreme example is Siemens, which averages approximately 40 new patents per day.

5. Porter and van der Linde (1995) observed that domestic firms' compliance with environmental regulations can trigger technological innovations, since such inventions lower firms' cost of compliance. The existence of spillovers in climate change technology (i.e. transfers of technological knowhow from one country to another) provides one mechanism by which developing countries' efforts to combat climate change can benefit from innovations in OECD countries.

6. Compared with APEC, the Trans Pacific Partnership (TPP) has an overlapping membership of only nine countries but a more wide ranging agenda of issues.

7. The Asia Pacific Partnership (APP) on Clean Development and Climate, which was specifically created to address issues of sustainable development, energy and climate, was disbanded in April 2011, with a transfer of its programs to other venues.

8. A less conventional - but potentially fruitful - alternative approach to assessing current or proposed arrangements from a technological or engineering perspective is to regard the arrangements as problem-solving and learning networks that overlap and adapt to changing circumstances. Such an approach is more akin to organizational behavior and open systems approaches – or to a cybernetics approach emphasizing communications and control. The key questions of this approach are: What are the hubs and nodes of the networks for specific problems? Are there problems that are being ignored? Are there networks for specific issues that need more resources?

9. Yet a third, related set of political economy issues concerns the ways in which varying arrangements for technology innovation and diffusion can address public goods and club goods issues – a set of issues under consideration for further research.

10. E.g. the opposition of the automotive industry in the US to steel import restrictions, and the opposition of retailers of CFLs in the EU to restrictions on imports from Asia. In both instances, it should be noted, however, that the restrictions were in place for many years before they were removed under pressure from the affected domestic corporate consumers.

References

ABB (2012). Obtained from: www.abb.com, accessed on 1 June 2012.

Abdel Latif, A. (2012a). *Intellectual Property Rights and Green Technologies from Rio to Rio,* Policy Brief No. 14; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Abdel Latif, A. (2012b).The UNEP–EPO–ICTSD Study on Patents and Clean Energy: Key Findings and Policy Implications," in *Low-Carbon Technology Transfer – from Rhetoric to Reality,* edited by D. Ockwell and A. Mallett. London and New York: Routledge.

Abdel Latif, A., K. Maskus, R. Okediji, J. Reichman and P. Roffe (2011). *Overcoming the Impasse on Intellectual Property and Climate Change at the UNFCCC: A Way Forward*, Policy Brief No. 11; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

ACEEE (2012). Obtained from: www.aceee.org, accessed on 1 June 2012.

Africa-EU Energy Partnership (2010). *Africa-EU Renewable Energy Cooperation Programme.* Obtained from: http://www.africa-union.org accessed on 19 September 2012.

Aldy, J.E., and R.N. Stavins, editors (2007). *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World.* Cambridge, UK: Cambridge University Press.

Aldy, J.E., and R.N. Stavins, editors (2009). *Post-Kyoto International Climate Policy: Summary for Policymakers.* Cambridge, UK: Cambridge University Press.

Aldy, J.E., and R.N. Stavins, editors (2010). P*ost-Kyoto International Climate Policy: Implementing Architectures for Agreement*. Cambridge, UK: Cambridge University Press.

APEC (2011). 2011 Leaders' Declaration, The Honolulu Declaration - *Toward a Seamless Regional Economy."* Obtained from: www.apec.org accessed on 12 March 2012.

APEC (2012). 2012 meeting of APEC ministers responsible for trade, Obtained from: www.apec.org accessed on 10 July 2012.

Barton, J. (2007). *Intellectual Property and Access to Clean Energy Technologies in Developing Countries: An Analysis of Solar Photovoltaic.*

Brewer, T. L. (2008a). "Climate Change Technology Transfer: A New Paradigm and Policy Agenda," *Climate Policy*, 8 (2008): 516-526.

Brewer, T. L. (2008b), "International Energy Technology Transfers for Climate Change Mitigation: What, who, how, why, when, where, how much … and the implications for international institutional architecture." Paper prepared for CESifo Venice Summer Institute Workshop: Europe and Global Environmental Issues. Venice, Italy - 14-15 July; CESifo Working Paper No. 2408.

Brewer, T. L. (2008c), "The Technology Agenda for International Climate Change Policy: A Taxonomy for Structuring Analyses and Negotiations." In Christian Egenhofer, ed. *Beyond Bali: Strategic Issues for the Post-2012 Climate Change Regime.* Brussels: Centre for European Policy Studies; pp. 134-145.

Brewer, T. L. (2009), "Technology Transfer and Climate Change: International Flows, Barriers and Frameworks," in Lael Brainard, ed., *Climate Change, Trade and Competitiveness* (Washington, DC: The Brookings Institution).

Brewer, T.L. (forthcoming). *The United States in a Warming World: The Political Economy of Government, Business and Public Responses to Climate Change* (under review).

Brewer, T. L., and A. Falke (2012). "International Transfers of Climate-friendly Technologies: How the World Trade System Matters," in *Low-Carbon Technology Transfer – from Rhetoric to Reality,* edited by D. Ockwell and A. Mallett. London and New York: Routledge.

Coe, D.T., and R. Helpman (1995). "International R&D Spillovers", European Economic Review 39:5:859-887.

Cottier, T., O. Nartova and S.Z. Bigdeli, eds. (2009). *International Trade Regulation and the Mitigation of Climate Change.* Cambridge: Cambridge University Press.

de Coninck, H. 2009. *Technology rules! Can technology-oriented agreements help address climate change?* Amsterdam: Vrije Universiteit Amsterdam.

Danish Energy Agency (2012). *Renewable Energy Cooperation with China.* Obtained from: http://www.ens.dk accessed on 19 September 2012.

ECEEE (2012). Obtained from: www.eceee.org, accessed on 1 June 2012.

Epps, T., and A. Green (2010). *Reconciling Trade and Climate: How the WTO Can Help Address Climate Change.* Cheltenham, UK: Edward Elgar.

European Commission (2012). International Affairs: Free Trade Agreements, accessed at www.ec.europa.eu/enterprise/policies/international on 22 July 2012.

European Union (2011). Official Journal, International Agreements, 2011/265/EU, Council Decision of 16 September 2010 on the signing, on behalf of the European Union, and provisional application of the Free Trade Agreement between the European Union and its Member States, of the one part, and the Republic of Korea, of the other part. Accessed at www.eu.europa.eu on 24 July 2012.

Frankel, J. (2010). "Global environment and trade policy," in J.E. Aldy and R.N. Stavins, eds., *Post-Kyoto International Climate Policy: Implementing Architectures for Agreement.* Cambridge, UK: Cambridge University Press.

Gehl Sampath, P.G., J. Mugabe and J. Barton (2012). *Realizing the Potential of the UNFCCC Technology Mechanism: Perspectives on the Way Forward;* Issue Paper 35; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Gehl Sampath, P.G., and P. Roffe (forthcoming). *Unpacking the International Technology Controversy: Fifty Years and Beyond*. International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Ghosh, A. (forthcoming). [Subsidies Study]; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Goswami, A., M. Dasgupta and N. Nanda (2009). *Mapping Climate Mitigation Technologiesand Associated Goods within the Buildings Sector.* ICTSD Programme on Trade and Environment. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Grossman, G.M. and Helpman, E. (1991). *Innovation and Growth in the Global Economy.* Cambridge, MA.: MIT Press.

Hanni, M.S., T. van Giffen, R. Kruger and H. Mirza (2011). "Foreign direct investment in renewable energy: trends, drivers and determinants," *Transnational Corporations*, 20, 2: 29-65.

Hoekman, B.M., and M.M. Kostecki (2009). *The Political Economy of the World Trading System: The WTO and Beyond,* Third Edition. Oxford: Oxford University Press.

Howse, R. (2010). *Climate Mitigation Subsidies and the WTO Legal Framework: A Policy Analysis.* International Centre for Trade and Sustainable Development, Geneva, Switzerland, Obtained from: www.ictsd.org.

Intergovernmental Panel on Climate Change [IPCC] (2011). *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T.Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds.)]. Cambridge and New York: Cambridge University Press.

International Centre for Trade and Sustainable Development [ICTSD] (2010). *Climate-related Single-use Environmental Goods.* Environmental Goods and Services Series, Issue Paper no. 13. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2010b). "Japan Challenges Canadian Sustainable Energy Incentives at WTO." *Bridges Trade BioRes,* Vol. 10, no. 17 (24 September): 3-5.

International Centre for Trade and Sustainable Development [ICTSD] (2011a). *Fostering Low Carbon Growth: The Case for a Sustainable Energy Trade Agreement.* Issue Paper; International Centre for Trade and Sustainable Development, Geneva, Switzerland, Obtained from: www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2011b). *The Climate Technology Mechanism: Issues and Challenges*, Information Note No. 18; International Centre for Trade and Sustainable Development, Geneva, Switzerland, Obtained from: www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2011c). "Tensions Build between EU, China over Rare Earths in Aftermath of Raw Materials Decision." *Bridges Weekly Trade News Digest,* Vol. 15, no. 27 (20 July): 7-8.

International Centre for Trade and Sustainable Development [ICTSD] (2011d). "WTO Panel Rules against China"s Export Restrictions on Raw Materials." *Bridges Weekly Trade News Digest,* Vol. 15, no. 25 (6 July): 1-3.

International Centre for Trade and Sustainable Development [ICTSD] (2011e). "US Proclaims Victory in Wind Power Case; China Ends Challenged Subsidies", *Bridges Weekly Trade News Digest,* Vol. 15, no. 21 (8 June): 3-4.

International Centre for Trade and Sustainable Development [ICTSD] (2011f). "Beijing, Washington Lock Horns over Chinese Wind Power Fund." *Bridges Trade BioRes*, Vol. 11, no. 1 (24 January): 1-3.

International Centre for Trade and Sustainable Development [ICTSD] (forthcoming). [gov procurement paper]; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (forthcoming). [Trade and Standards paper]; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (forthcoming). [Subsidies paper]; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Energy Agency [IEA] (2008). “Energy Technology Perspectives 2008: Fact Sheet – The Blue Scenario.” Paris: IEA.

International Energy Agency [IEA] (2009). *Technology Roadmap*. Paris: IEA.

International Energy Agency [IEA] (2010). *Energy Technology Perspectives, 2010.* Paris: IEA.

Karp, L., and J. Zhao (2010). “A proposal for the design of the successor to the Kyoto Protocol,” in J.E. Aldy and R.N. Stavins, eds., *Post-Kyoto International Climate Policy: Implementing Architectures for Agreement.* Cambridge, UK: Cambridge University Press.

Keeler, A., and A. Thompson (2010). “Mitigation through resource transfers to developing countries: expanding greenhouse gas offsets,” in J.E. Aldy and R.N. Stavins, eds., *Post-Kyoto International Climate Policy: Implementing Architectures for Agreement.* Cambridge, UK: Cambridge University Press.

Kejun, J. (2010). *Mapping Climate Mitigation Technologies and Associated Goods within the Transport Sector.* ICTSD Programme on Trade and Environment. Geneva: International Centre for Trade and Sustainable Development, Obtained from: www.ictsd.org.

Kuriyama, C. (2012). “A Snapsot of Durrent Trends in Potential Environmental Goods and Services.” APEC Policy Support United, Policy Brief Number 3, Obtained from: www.apec.org accessed on 10 July 2012.

Lako, P. (2008). *Mapping Climate Mitigation Technologies and Associated Goods within the Renewable Energy Supply Sector.* ICTSD Programme on Trade and Environment. Geneva: International Centre for Trade and Sustainable Development, Obtained from: www.ictsd.org.

Lewis, Joanna I. (2007). “Technology Acquisition and Innovation in the Developing World: Wind Turbine Development in China and India,” *Studies in Comparative International Development*, 10.

Macgregor, J. (2010). *Carbon Concerns: How Standards and Labelling Initiatives Must Not Limit Agricultural Trade from Developing Countries,* ICTSD–IPC Platform on Climate Change, Agriculture and Trade, Issue Brief No.3, International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org, and International Food & Agricultural Trade Policy Council, Washington DC, USA.

McKinsey (2012). Web site at www.mckinsey.com, accessed on 1 June 2012.

Mitsubishi (2012). Web site at www.mitsubishi.com, accessed on 1 June 2012.

Newell, R. (2010). “International climate technology strategies,” in J.E. Aldy and R.N. Stavins, eds., *Post-Kyoto International Climate Policy: Implementing Architectures for Agreement.* Cambridge, UK: Cambridge University Press.

National Renewable Energy Laboratory. (2010). *Strengthening Clean Energy Technology Cooperation under the UNFCCC: Steps toward Implementation.* Obtained from: http://osti.gov/bridge accessed 19 September 2012.

Ockwell, D., and A. Mallett, eds. (2012a). *Low-Carbon Technology Transfer – from Rhetoric to Reality.* London and New York: Routledge.

Pacala, Stephen W., and Robert H. Socolow, 2004. "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies," *Science*, 305 (August 13): 968-972.

REN21 (2011). *Global Status Report*. Paris: REN21.

Rifkin, J. (2011). *The Third Industrial Revolution.* New York: Palgrave Macmillan.

Sachs, H., A. Lowenberger and W. Lin (2009). Emerging Energy-Saving HVAC Technologies and Practices for the Buildings Sector. ACEEE Research Report A092; Obtained from: www.aceee.org accessed on 7 May 2012.

Sampath, P.G., J. Mugabe and J. Barton (2012). *Realizing the Potential of the UNFCCC Technology Mechanism: Perspectives on the Way Forward.* Issue Paper 35; International Centre for Trade and Sustainable Development, Geneva, Switzerland, Obtained from: www.ictsd.org.

Sampath, P.G., and P. Roffe (forthcoming). *Unpacking the International Technology Controversy: Fifty Years and Beyond.* International Centre for Trade and Sustainable Development, Geneva, Switzerland, Obtained from: www.ictsd.org.

Schmalensee, R. (2020). "Epilogue," in J.E. Aldy and R.N. Stavins, eds., *Post-Kyoto International Climate Policy: Implementing Architectures for Agreement.* Cambridge, UK: Cambridge University Press.

Solow, R.M. (1956). "A contribution to the theory of economic growth", Quarterly journal of economics Vol., no. 70:1: 65-94.

Storm, L., ed. (2012). "Sustainia100." Copenhagen: Sustainia.

Teng, F., Chen, W. and J He (2010). "Possible development of a technology clean development mechanism in a post-2012 regime," in J.E. Aldy and R.N. Stavins, eds., P*ost-Kyoto International Climate Policy: Implementing Architectures for Agreement*. Cambridge, UK: Cambridge University Press.

UNCTAD (2010). *World Investment Report.* Geneva: United Nations.

UNCTAD (2011). *Technology and Innovation Report.* Geneva: United Nations.

US-China Clean Energy Research Center (2011). Annual Report. Obtained from: http://www.us-china-cerc.org accessed on 19 September 2012.

Victor, D. G. (2011). *Global Warming Gridlock: Creating More Effective Strategies for Protecting the Planet.* Cambridge, UK: Cambridge University Press.

Vossenaar, R. (2010). *Deploying Climate-Related Technologies in the Transport Sector: Exploring Trade Links.* Environmental Goods and Services, Issue Paper no. 15. Geneva: International Centre for Trade and Sustainable Development, Obtained from: www.ictsd.org.

Vossenaar, R., and V. Jha (2010). *Technology Mapping of the Renewable Energy, Buildings, and Transport Sectors: Policy Drivers and International Trade Aspects,* Programme on Trade and Environment, Environmental Goods and Services Series, Issue Paper No. 12; International Centre for Trade and Sustainable Development, Geneva, Switzerland,Obtained from: www.ictsd.org.

World Bank (2009). *International Trade and Climate Change.* Washington, DC: World Bank.

World Bank (2012). *Inclusive Green Growth: The Pathway to Sustainable Development. Washington, DC. World Bank*. World Trade Organization [WTO] (1998a). Committee on Trade and Encironment. "United Nations Framework Convention on Climate Change," Note by the Secretariat (Geneva: WTO).

World Trade Organization [WTO] (1998b). Council for Trade in Services. "Environmental Services," Background Note by the Secretariat.

World Trade Organization [WTO] (1999). "An Introduction to the GATS," revised version, October 1999, prepared by the Secretariat, Trade in Services Division; Downloaded January 30, 2000.

World Trade Organization [WTO] (2001). Committee on Trade and Environment. Note by the Secretariat. "Matrix on Trade Measures Pursuant to Selected MEAs" (Geneva: WTO).

World Trade Organization [WTO] (2005). Committee on Trade and the Environment. Synthesis of Submissions on Environmental Goods, Informal Note by the Secretariat. Geneva: WTO.

World Trade Organization and United Nations Environment Programme (2009). *Trade and Climate Change.* Geneva: WTO.

Yergin, D. (2011). *The Quest: Energy, Security, and the Remaking of the Modern World.* New York: Penguin Press.

Related ICTSD publications

Abbott,F. M. (2009). *Innovation and Technology Transfer to Address Climate Change: Lessons from the Global Debate on Intellectual Property and Public Health*, ICTSD Programme on Intellectual Property Rights and Sustainable Development, Intellectual Property and Sustainable Development Series, Issue Paper No. 24; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Abdel Latif, A. (2012). *Intellectual Property Rights and Green Technologies from Rio to Rio,* Policy Brief No. 14; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Abdel Latif, A., K. Maskus, R. Okediji, J. Reichman and P. Roffe (2011). *Overcoming the Impasse on Intellectual Property and Climate Change at the UNFCCC: A Way Forward*, Policy Brief No. 11; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Ancharaz, V. D., and Riad A. Sultan (2010). *Aid for Trade and Climate Change Financing Mechanisms: Best Practices and Lessons Learned for LDCs and SVEs in Africa*; Trade-Supported Strategies for Sustainable Development Series; Issue Paper No. 10; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Babcock, B. (2011). The Impact of US Biofuel Policies on Agricultural Price Levels and Volatility; ICTSD Programme on Agricultural Trade and Sustainable Development; Issue Paper No. 35; ICTSD International Centre for Trade and Sustainable Development, Geneva, Switzerland. www.ictsd.org.

Bartels, L. (2012). *The Inclusion of Aviation in the EU ETS: WTO Law Considerations*; Trade and Sustainable Energy Series; Issue Paper No. 6; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Barton J. H. (2005). *New Trends in Technology Transfer: Implications for National and International Policy;* International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Barton, J. H. (2007). *Intellectual Property and Access to Clean Energy Technologies in Developing Countries: An Analysis of Solar Photovoltaic, Biofuel and Wind Technologies,* Programme on Trade and Environment, Trade and Sustainable Energy Series, Issue Paper No. 2; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Cannady, C. (2009). *Access to Climate Change Technology by Developing Countries: A Practical Strategy. By ICTSD Programme on Intellectual Property Rights and Sustainable Development,* Intellectual Property and Sustainable Development Series, Issue Paper No. 25; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Correa, C. M. (2009). *Fostering the Development and Diffusion of Technologies for Climate Change: Lessons from the CGIAR Model,* ICTSD Programme on Intellectual Property Rights and Sustainable Development, Policy Brief No. 6; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Echols, M. A. (2009) *Biofuels Certification and the Law of the World Trade Organization*. ICTSD Programme on Agricultural Trade and Sustainable Development, Issue Paper no. 19. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Faber, J., and L. Brinke (2011). *The Inclusion of Aviation in the EU Emissions Trading System: An Economic and Environmental Assessment;* Trade and Sustainable Energy Series; Issue Paper No. 5; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Gehl Sampath, P.G., J. Mugabe and J. Barton (2012). *Realizing the Potential of the UNFCCC Technology Mechanism: Perspectives on the Way Forward;* Issue Paper 35; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Gehl Sampath, P.G., and P. Roffe (forthcoming). *Unpacking the International Technology Controversy: Fifty Years and Beyond*. International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Ghosh, A. (forthcoming). [Subsidies Study]; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Goswami, A., M. Dasgupta and N. Nanda (2009). *Mapping Climate Mitigation Technologies and Associated Goods within the Buildings Sector.* ICTSD Programme on Trade and Environment. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Harmer, T. (2009). *Biofuels Subsidies and the Law of the World Trade Organization*. ICTSD Programme on Agricultural Trade and Sustainable Development, Issue Paper no. 20. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Howse, R. (2010). *Climate Mitigation Subsidies and the WTO Legal Framework: A Policy Analysis.* International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2006). *Linking Trade, Climate Change and Energy*. By Malena Sell and others. Geneva: ICTSD.

International Centre for Trade and Sustainable Development [ICTSD] (2007a). T*rade, Climate Change and Global Competitiveness: Opportunities and Challenges for Sustainable Development in China and Beyond.* By Moustapha Gueye Kamal and others. Geneva: ICTSD.

International Centre for Trade and Sustainable Development [ICTSD] (2007b). *The WTO and Energy.* By Yulia Selivanova. Geneva: ICTSD.

International Centre for Trade and Sustainable Development [ICTSD] (2007c). "Environmental groups target shipping emissions," *Bridges: Trade BioRes,* 2: 2 December. Geneva: ICTSD.

International Centre for Trade and Sustainable Development [ICTSD] (2008). *Climate Change, Technology Transfer and Intellectual Property Rights,* Background Paper to the Trade and Climate Change Seminar, 18–20 June 2008 in Copenhagen, Denmark; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2008a). *Liberalization of Trade in Environmental Goods for Climate Change Mitigation: The Sustainable Development Context,* Background Paper to the Trade and Climate Change Seminar, 18-20 June 2008 in Copenhagen, Denmark; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD]. (2008b). *Environmental Priorities and Trade Policy for Environmental Goods: A Reality Check*. Environmental Goods and Services Series, Issue Paper no. 7. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2008c). *HS Codes and the Renewable Energy Sector.* ICTSD Programme on Trade and Environment. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2009). *HS Codes and the Residential and Commercial Buildings Sector.* ICTSD Programme on Trade and Environment. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2010a). *Climate-related Single-use Environmental Goods*. Environmental Goods and Services Series, Issue Paper no. 13. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2010b). "Japan Challenges Canadian Sustainable Energy Incentives at WTO." *Bridges Trade BioRes*, Vol. 10, no. 17 (24 September): 3-5.

International Centre for Trade and Sustainable Development [ICTSD] (2011a). *Fostering Low Carbon Growth: The Case for a Sustainable Energy Trade Agreement*. Issue Paper; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2011b). *The Climate Technology Mechanism: Issues and Challenges*, Information Note No. 18; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (2011c). "Tensions Build between EU, China over Rare Earths in Aftermath of Raw Materials Decision." *Bridges Weekly Trade News Digest,* Vol. 15, no. 27 (20 July): 7-8.

International Centre for Trade and Sustainable Development [ICTSD] (2011d). “WTO Panel Rules against China”s Export Restrictions on Raw Materials.” *Bridges Weekly Trade News Digest*, Vol. 15, no. 25 (6 July): 1-3.

International Centre for Trade and Sustainable Development [ICTSD] (2011e). “US Proclaims Victory in Wind Power Case; China Ends Challenged Subsidies”, *Bridges Weekly Trade News Digest,* Vol. 15, no. 21 (8 June): 3-4.

International Centre for Trade and Sustainable Development [ICTSD] (2011f). “Beijing, Washington Lock Horns over Chinese Wind Power Fund.” *Bridges Trade BioRes*, Vol. 11, no. 1 (24 January): 1-3.

International Centre for Trade and Sustainable Development [ICTSD] (forthcoming-a). [Trade and Standards Study]; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (forthcoming-b). [Government Procurement Study]; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

International Centre for Trade and Sustainable Development [ICTSD] (forthcoming-c). [Subsidies Study]; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Janssen, R. (2010). *Harmonising Energy Efficiency Requirements - Building Foundations for Cooperative Action.* Environmental Goods and Services Series, Issue Paper no. 14. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Jha, V. (2009). T*rade Flows, Barriers and Market Drivers in Sustainable Energy Supply Goods: The Need to Level the Playing Field*. Environmental Goods and Services Series, Issue Paper no. 10. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Kejun, J. (2010). *Mapping Climate Mitigation Technologies and Associated Goods within the Transport Sector.* ICTSD Programme on Trade and Environment. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Kim, J. A. (2011). *Facilitating Trade in Services Complementary to Climate-friendly Technologies.* Environmental Goods and Services Series, Issue Paper no. 15. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Latif, A. A., K. Maskus, R. Okediji, J. Reichman and P. Roffe (2011). *Overcoming the Impasse on Intellectual Property and Climate Change at the UNFCCC: A Way Forward,* Policy Brief No. 11; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Lako, P. (2008). *Mapping Climate Mitigation Technologies and Associated Goods within the Renewable Energy Supply Sector.* ICTSD Programme on Trade and Environment. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Macgregor, J. (2010). *Carbon Concerns: How Standards and Labelling Initiatives Must Not Limit Agricultural Trade from Developing Countries,* ICTSD–IPC Platform on Climate Change, Agriculture and Trade, Issue Brief No.3, International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org, and International Food & Agricultural Trade Policy Council, Washington DC, USA.

Maskus,K. E. (2004). *Encouraging International Technology*. ICTSD Programme on IPRs and Sustainable Development, UNCTAD-ICTSD Project on IPRs and Sustainable Development, Issue Paper No. 7; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Maskus, K., and R. Okedij (2010). *Intellectual Property Rights and International Technology Transfer to Address Climate Change: Risks, Opportunities, and Policy Options,* Programme on Intellectual Property Rights and Sustainable Development, Intellectual Property and Sustainable Development Series, Issue Paper No. 32; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Mytelka, L. *Technology Transfer Issues in Environmental Goods and Services: An Illustrative Analysis of Sectors Relevant to Air-pollution and Renewable Energy;* International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Read, R. (2010). *Trade, Economic Vulnerability, Resilience and the Implications of Climate Nelson, G., Palazzo, A., Ringler, C., Sulser, T., and Batka, M. (2009). The Role of International Trade in Climate Change Adaptation*, ICTSD–IPC Platform on Climate Change, Agriculture and Trade, Issue Paper No.4, International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org, and International Food and Agricultural Trade Policy Council, Washington DC, USA.

Selivanova, Y. (2007). *The WTO and Energy: WTO Rules and Agreements of Relevance to the Energy Sector.* Trade and Sustainable Energy Series, Issue Paper no. 1. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

UNEP, Bloomberg New Energy Finance and Frankfurt School, UNEP Collaborating Centre for Climate and Sustainable Energy Finance (2011). *Global Trends In Renewable Energy Investment 2011.* [Geneva]: United Nations Environment Programme and Bloomberg New Energy Finance.

UNEP, EPO and ICTSD (2010). *Patents and Clean Energy: Bridging the Gap between Evidence and Policy, Final Report.*

Vossenaar, R. (2010). *Deploying Climate-Related Technologies in the Transport Sector: Exploring Trade Links.* Environmental Goods and Services, Issue Paper no. 15. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Vossenaar, R., and V. Jha (2010). *Technology Mapping of the Renewable Energy, Buildings, and Transport Sectors: Policy Drivers and International Trade Aspects,* Programme on Trade and Environment, Environmental Goods and Services Series, Issue Paper No. 12; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

Wind, I. (2010). *HS Codes and the Transport Sector.* ICTSD Programme on Trade and Environment. Geneva: International Centre for Trade and Sustainable Development, www.ictsd.org.

Annex I

Variations in energy scenarios among countries: China, Europe, India and the US

The IEA (2010) undertook a more detailed analysis of CO_2 trends and abatement options for four countries or regions that will have a major role in reducing global emissions: OECD Europe, the United States, China and India. Each faces unique challenges, reflecting current and future levels of economic development and diverse endowments of natural resources (represented in their energy mixes). Thus, each will have very different starting points and future trajectories in terms of their CO_2 emissions and develop in different ways in both the Baseline and the BLUE Map scenarios. Although many of the same technology options are needed to reduce emissions, the policy options associated with their application may be dramatically different.

In the Baseline scenario, CO_2 emissions in *India* show the largest relative increase, rising almost fivefold by 2050. *China* also shows a substantial rise, with emissions almost tripling between 2007 and 2050. *The United States* shows a much more modest rise, of 1 percent and emissions in OECD Europe decline by 8 percent. In the BLUE Map scenario, all countries show considerable reductions from the Baseline scenario: emissions in 2050 (compared to 2007) are 81 percent lower for the United States, 74 percent lower for OECD Europe and 30 percent lower in China, while India's emissions rise by 10 percent.

The BLUE Map scenario also brings significant security of supply benefits to all four countries or regions, particularly through reduced oil use. In the United States and OECD Europe, oil demand in 2050 is between 62 percent and 51 percent lower than 2007 levels (gas demand shows similar declines). In China and India, oil demand still grows in the BLUE Map scenario, but is between 51 percent and 56 percent lower by 2050 than in the Baseline scenario.

In OECD Europe, the electricity sector will need to be almost completely decarbonised by 2050. More than 50 percent of electricity generation is from renewable energy, with most of the remainder from nuclear and fossil fuels using CCS (the precise energy mix varies widely among individual countries, reflecting local conditions and opportunities). In industry, energy efficiency and CCS offer the main measures for reducing emissions. In buildings, efficiency improvements in space heating can provide the most significant energy savings and more than half of the sector's emissions reductions in the BLUE Map scenario. Other mitigation measures include solar thermal heating, heat pumps, CHP/ district heating and efficiency improvements for appliances. Transport volumes in OECD Europe are expected to remain relatively constant. Deep CO_2 emissions reductions in transport can be achieved through more efficient vehicles, a shift towards electricity and biofuels, and progressive adoption of natural gas followed by a transition to biogas and bio-syngas.

For the *United States*, energy efficiency and fuel switching will be important measures in reducing CO_2 emissions across all end-use sectors. Infrastructure investments will be vital to supporting the transition to a low-carbon economy, particularly in the national electricity grid and transportation networks. Most of the existing generation assets will be replaced by 2050 and low-carbon technologies such as wind, solar, biomass and nuclear offer substantial abatement opportunities. Many energy-intensive industries have substantial scope to increase energy efficiency through technological improvements. Similarly, the average energy intensity of LDVs is relatively high; doubling the fuel efficiency of new LDVs by 2030 can help reduce emissions. Advanced vehicle technologies can also play an important role in the LDV and commercial light and medium-duty truck sectors. In buildings, improving the efficiency of space cooling, together with more efficient appliances, offers the largest opportunity to reduce CO_2 emissions.

Given the dominance of coal, *China* must invest heavily in cleaner coal technologies (such as CCS) and improve efficiency of coal use in power generation and industry (which accounts for the largest share of China's energy use and CO_2 emissions). Priority should also be given to measures to improve energy efficiency and reduce CO_2 emissions in energy-intensive sectors such as iron and steel, cement and chemicals. The Chinese transport sector is evolving very rapidly, in terms of vehicle sales, infrastructure construction and the introduction of new technologies. The BLUE Map scenario shows that significant emissions reductions will depend on the electrification of transport modes and substantial decarbonisation of the electricity sector.

For *India*, the challenge will be to achieve rapid economic development — which implies a significant increase in energy demand for a growing population — with only a very small increase in CO_2 emissions. Electricity demand will grow strongly and the need for huge additional capacity creates a unique opportunity to build a low-carbon electricity system. While India has some of the most efficient industrial plants in the world, it also has a large share of small-scale and inefficient plants. Thus, improving overall industrial efficiency will be a significant challenge. Rising incomes and increased industrial production will spur greater demand for transport in India, making it imperative to promote public transport and new, low-carbon vehicle technologies. The buildings sector will also see strong growth in energy demand: efficiency improvements in space cooling and appliances will be critical to restraining growth in energy consumption and emissions.

Source: IEA (2010: 13-14); italics added by the author.

Annex II

Illustrative list of energy efficiency technologies[a]

Building sector

- Mineral wools (slag wool, rock wool)[b]
- Mineral insulating materials and articles[b]
- Multiple-walled insulating units of glass[b]
- Glass-filas insulation products[b]
- Phenolic resins, in primary forms[b]
- Plates, sheet etc, non-cellular and not reinforced, of polymers of styrene[b]
- Plates, sheet etc, cellular of polystyrene[b]
- Plates, sheet etc, cellular of polyurethane[b]
- Heat pumps[b]
- Heat exchange units[b]
- Automatic regulating thermostats[b]
- Compact flompact at lamps (CFLs)[b]
- Wood pellet burning stoves
- New plastic recycling methods for appliances
- Integrated building heating-air conditioning-lighting management systems

Transport sector

- Urban traffic control systems

Motor vehicles

- More efficient transmissions
- Recovery of energy from exhaust gases with turbo-charged engines
- More-efficient air conditioners, lighting
- High-strength steel; stainless steel; other advanced steels; aluminum; magnesium; plastic and plastic composites for lighter weight
- Efficient pumps, fans, air compressors, and heating, air conditioning and power-steering systems

Rail

- Fuel efficiency monitoring systems
- More efficient engines
- Use of aluminum instead of conventional steels
- More efficient air conditioning

Air

- Improved aerodynamics
- Open rotor engines for improved propulsion
- Lightweight materials: carbon-fire reinforced plastic airframes
- Lightweight materials: composite materials with high- temperature tolerances for engines
- More efficient air traffic control

Maritime shipping

- Flettner rotor (a spinning vertical rotor that converts wind into ship propulsion energy)
- Light weight alternatives for replacing steel
- Waste heat recovery

Industry sector

- Power semiconductor modules that turn electricity on and off

Agriculture, forestry and fishing sector

- Grassland management practices
- Rice production management practices

Water and water treatment

- Rehabilitating and retrofitting water treatment systems for greater energy efficiency
- Systems to reuse waste water from natural gas hydraulic fracturing drilling
- New materials for more efficient AC and DC inverters

[a] This is not intended to be an exhaustive, comprehensive list.

[b] See ICTSD (2011: Appendix A) for Harmonized System Codes.

Sources: ICTSD (2010a; 2011b), McKinsey (2012), Mitsubishi (2012).

Annex III

Trade conflicts involving sustainable energy technology and climate change mitigation issues

This annex provides an overview of cases in which sustainable energy, trade, climate change and technology diffusion issues have intersected publicly. Some of the cases have become subjects of formalized disputes in the WTO, while others have been addressed outside the WTO in bilateral negotiations.

Chinese Investigation of US Solar Panel Polysilicon Dumping. In July 2012, the Chinese government announced that its Ministry of Commerce would investigate US exports of solar-grade polysilicon with a view of potentially imposing anti-dumping duties. A decision was not expected until July 2013.

US Complaint in the WTO about Chinese Restrictions of Exports of Rare Earths. In 2012, the US launched a formal complaint at the WTO (DS Case 440) about China's policy to limit exports of rare earths. Although this is not explicitly a sustainable energy case, it has direct implications for sustainable energy industries. In particular, some of the 17 rare earth minerals are used in batteries and fluorescent lamps. The case was pending as of mid 2012.

US Complaint in the WTO about Chinese Solar Panel Manufacturing Subsidies and Dumping. On 9 November 2011, the US International Trade Commission began an investigation into issues concerning subsidies and dumping of Chinese-made solar cells. The subsidies are purported to include favored treatment in taxes, raw materials prices, land prices, electricity prices and water prices, as well as loans, insurance and other assistance for exports. The investigation was instituted at the behest of a group of seven solar cell manufacturers; among them was SolarWorld Industries Americas, an affiliate of its parent firm, SolarWorld of Germany. The identities of the six other firms were not made public. The petition filed by the seven firms on 19 October 2011 contended that solar cells being manufactured in China were being subsidized by the Chinese government and dumped internationally below production and transportation costs in violation of WTO rules. They asked that tariffs up to 100 percent be imposed on imports into the US. The investigation and possible further US actions against the Chinese government and firms were opposed by a group of 25 US firms that buy and install solar panels and by some US-based environmental groups. Many of the US importers of solar panels are US subsidiaries of Chinese firms. The US ITO is required to make preliminary decisions about the merits of the case during 2012. Additional background information includes the following: By 2011 China had more than half the world solar panel market, including more than half of the US market. Chinese imports into the US in 2009 were USD640 million and USD1.5 billion in 2010. Three US manufacturers went bankrupt in 2011 - one of them being Solyndra, which had received a US government loan guarantee for approximately USD500 million. Wholesale prices per watt of capacity declined from USD3.30 in 2008 to USD1.80 in early 2011 to USD1.00-1.20 by November 2011.

US Complaint in the WTO about Chinese Wind Power Subsidies. The US filed a request for WTO consultations in December 2010 about Chinese government renewable energy subsidies, including in particular its subsidies in the wind power industry and domestic content requirements (WTO Dispute Settlement case DS419). At stake were the quantity and mode of international technology transfer into China, as well as the competitive implications for firms inside and outside China. During the consultation phase of the dispute settlement process in the WTO, before the case reached the phase involving the establishment of a dispute settlement panel, the parties reached an agreement according to which the Chinese government would end the subsidies.

Japanese Complaint in the WTO about Canadian Domestic Content Requirements. After requesting consultations with Canada in September 2010, Japan filed a formal WTO complaint in June 2011 against Canadian treatment of imported equipment for renewable electricity generation in its feed-in-tariff program due to local content requirements. At issue specifically were the policies of the province of Ontario (the most populous in Canada). In view of the widespread interest in feed-in tariffs in many countries, the outcome of the case was potentially significant for several renewable industries. The case is pending as WTO dispute number DS412.

EU Tariffs on Compact Florescent Lights from China and Other Asian Countries. Although this case did not become a WTO dispute case, it is another example of how trade policy can limit international transfers of low carbon technologies. In this case, the EU imposed special tariffs on CFLs from China unilaterally on the grounds that Chinese exporters were engaged in dumping. The conflict progressed through several stages, dragged on for a decade, and involved several exporting countries in Asia. At stake in China - and in other Asian countries to which some manufacturing was relocated from China - was the fate of hundreds of manufacturers/exporters of CFLs; at stake in Europe was the energy efficiency of lighting in the commercial and residential sectors of 27 countries. After several years the tariffs were reduced, but they were not eliminated altogether until European retail firms complained to the Commission that their desire to sell more low-cost, energy efficient CFLs was being thwarted by the EU tariffs. The issue of whether there was dumping was not resolved by an independent process because the conflict did not become a WTO dispute.

US Limits on Rebates for Purchasers of Hybrid Automobiles from Certain Manufacturers. This case was unusual in that un-named firms (which were in fact Honda and Toyota and which of course happened to be Japanese) encountered volume-based caps put on US government rebates to US purchasers of hybrid cars in the US. Thus, the Japanese based firms, which were leaders in the increasingly popular hybrid technology, reached their caps before their US-based rivals, so the US customers of the Japanese firms could no longer receive the US government tax credits. In response, the Japanese firms shifted production of hybrids from Japanese plants to their facilities in the US in order to placate the US government. Over time, the effects of the rebates on international transfer of climate-friendly technology shifted: initially there was less transfer in the form of the *products* - i.e. the hybrid vehicles - but subsequently there was a transfer of the *production process* technology from the plants in Japan to the Japanese firms' plants in the US. The hybrid vehicles continue to be produced in the US by the Japanese firms. The US government rebate program eventually expired and was not renewed. The Japanese government did not file a complaint in the WTO.

EU Greenhouse Gas Emissions Standards on Imported Palm Oil Based Biodiesel Fuel from South East Asia. This case is different from the above cases in that the issue was the imposition of barriers to the importation of biofuels produced in greenhouse gas intensive production processes involving the clearing of rain forests (i.e. carbon sinks) in order to plant palm plantations. The trade barrier took the form of environmental standards because the imports were subjected to life cycle analyses in the EU.

US Tariffs on Ethanol Imports from Brazil. As has been typical with agricultural goods, US tariffs on imports were causally connected to domestic subsidies - in this instance, US domestic subsidies of corn production and corn-based ethanol refineries. The special tariff of 57 cents per gallon on sugar cane based ethanol from Brazil in addition to the regular 2 ½ percent was a particularly troublesome issue in Brazilian-US relations over many years, and it intruded into the WTO negotiating processes on trade in agricultural goods and trade in environmental goods. There was a surprising and unusual turn of events in this case in 2011, however, when the US Congress decided to end the tariffs as well as the domestic subsidies, as part of a broader movement against government spending in general and agricultural and energy subsidies in particular. As of 1 January 2012, both the special tariff and the subsidy program were no longer in effect.

EU Objections to US Exporters' Use of a 'Splash and Dash' Procedure to Subsidize US Exports of Biodiesel Fuel. The exploitation of a loophole in US legislation made it possible for US firms to import biodiesel fuel from southeast Asia, add a small portion of US petro diesel to it in order to qualify for a domestic US subsidy of the biodiesel portion of blended fuel, and then export it to Europe (Germany in particular, where it qualified for additional subsidies). The US firms were able to get US government subsidies for a product that was approximately 99 percent based on imports with only 1 percent US content and then export it without its entering the US market, even though the purpose of the subsidy program was to expand the US biodiesel industry and increase the use of biodiesel in the US market. The practice ended after coming under pressure from European diplomats and business leaders and after the US industry association acknowledged that the practice was inconsistent with the intention of the legislation.

Reactions to EU Inclusion of the Aviation Industry in the Emissions Trading Scheme. The inclusion in the European Emissions Trading Scheme (ETS) of commercial airline flights into and out of EU airspace became operational on 1 January 2012. When the EU decided to include the aviation sector in the ETS, in order to create a "level playing field for all carriers in the aviation industry, it covered international flights into and out of EU countries - not only the flights of EU-based carriers but also the flights of carriers based outside the EU. US airlines and the US Air Transport Association complained to the European Court of Justice (ECJ) and also threatened legal action in the International Court of Justice (ICJ) on the grounds that the Chicago Convention concerning international cooperation in civil aviation is being violated. The ECJ ruled against the US complaint. Whether there would be any further actions by the US and/or other governments was unclear as of mid-2012. The Chinese government also objected to its airlines' flights into EU airspace being covered by the EU ETS; the Chinese government put pressure on the EU by preventing a Chinese airline from entering into an agreement with the European manufacturer Airbus to buy nearly USD 4 billion worth of new A380 superjumbo planes. The case involved the use of a trade sanction by China on manufactured goods (airplanes produced in Europe), as well as the imposition of a restriction by the EU on international trade in services (commercial air transport services provided by Chinese airlines). At stake was not only the multi-billion dollar international trade transaction, but the effectiveness of the EU ETS as a stimulator of technological innovation and diffusion. Indeed, a rationale for the establishment of a cap-and-trade system and thus the creation of a price for greenhouse gas emissions is, of course, precisely to foster technological innovation and diffusion based on price incentives.

Source: Compiled by the author from *Bridges Weekly, Climate Wire* and *Financial Times* (London); also see www.TradeAndClimate.net for additional information, including updates.

Box 1: Definitions of key terms

Sustainable development

For development to be sustainable, delivery of energy services needs to be secure and have low environmental impacts. Sustainable social and economic development requires assured and affordable access to the energy resources necessary to provide essential and sustainable energy services. This may mean the application of different strategies at different stages of economic development. To be environmentally benign, energy services must be provided with low environmental impacts and low greenhouse gas … emissions (IPCC, 2011: Technical Summary, 5).

Renewable energy

[A]ny form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. Renewable energy is obtained from the continuing or repetitive flows of energy occurring in the natural environment and includes low-carbon technologies such as solar energy, hydropower, wind, tide and waves and ocean thermal energy, as well as renewable fuels such as biomass (IPCC, 2011: Annex 1, 9).

Sustainable energy

For a [renewable energy] resource to be sustainable, it must be inexhaustible and not damage the delivery of environmental goods and services including the climate system. For example, to be sustainable, biofuel production should not increase net CO_2 emissions, should not adversely affect food security, or require excessive use of water and chemicals or threaten biodiversity. To be sustainable, energy must also be economically affordable over the long term; it must meet societal needs and be compatible with social norms now and in the future. Indeed, as use of [renewable energy] technologies accelerates, a balance will have to be struck among the several dimensions of sustainable development (IPCC, 2011, Chapter 1, 18).

Energy efficiency

The ratio of useful energy or other useful physical outputs obtained from a system, conversion process, transmission or storage activity to the input of energy (measured as kWh/kWh, tonnes/kWh or any other physical measure of useful output like tonne-km transported, etc.) (IPCC, 2011, Annex 1, 10; italics added by the author).

Although the definition of energy efficiency is simple and straightforward as an increase in the ratio of energy services outputs to energy, there are some ambiguities arising from, for instance, fuel switching or other changes in energy systems. Further, sometimes energy efficiency and conservation are conflated, though conceptually there is a clear difference: conservation involves reductions in energy services, for instance turning down the temperature of a thermostat in the summer or up in the winter. Adding insulation, on the other hand, is an energy efficiency measure because it reduces energy consumption on the input/supply side without necessarily reducing energy services on the output/demand side. In addition, there are the challenges of identifying technologies in the form of services (“software”) and organizational systems (“orgware”) in addition to the familiar tangible (“hardware”) forms. This challenge, of course, is not unique to energy efficiency technologies; it is a challenge across the entire range of economic sectors in terms of both energy supply and energy demand.

Box 1: Definitions of key terms

Energy smart technologies

These do not count as renewable energy, since their aim is primarily the *more efficient use of electricity and fuel* rather than changing its source. However there are cross-overs – for instance plans to charge electric vehicles from renewable, rather than fossil-fuel powe. Bloomberg New Energy Finance defines energy-smart technologies as encompassing advanced transportation; the smart grid and digital energy; energy efficiency including lighting and building-integrated techniques; and energy storage including batteries and fuel cells (UNEP, Bloomberg New Energy Finance and Frankfurt School, UNEP Collaborating Centre for Climate and Sustainable Energy Finance, 2011: 29; italics added by the author; also see World Bank, 2012).

Author's note: In these definitions and examples – and in ICTSD reports - nuclear and large-scale hydropower are not generally included in notions of renewable or sustainable energy. In some other definitions of sustainable energy and renewable energy, however, nuclear and/or large-scale hydropower are included.

Box 2: How technology reduces greenhouse gas emissions

The ways in which technology reduces future GHG emissions in long-term emission scenarios include:

Improving technology efficiencies and thereby reducing emissions per unit service (output). These measures are enhanced when complemented by energy conservation and rational use of energy.

Replacing carbon-intensive sources of energy by less intensive ones, such as switching from coal to natural gas. These measures can also be complemented by efficiency improvements (e.g. combined cycle natural gas power plants are more efficient than modern coal power plants) thereby further reducing emissions.

Introducing carbon capture and storage to abate uncontrolled emissions. This option could be applied at some time in the future, in conjunction with essentially all electricity generation technologies, many other energy conversion technologies and energy-intensive processes using fossil energy sources as well as biomass (in which case it corresponds to net carbon removal from the atmosphere).

Introducing carbon-free renewable energy sources ranging from a larger role for hydro and wind power, photovoltaics and solar thermal power plants, modern biomass (that can be carbon-neutral, resulting in zero net carbon emissions) and other advanced renewable technologies.

Enhancing the role of nuclear power as another carbon-free source of energy. This would require a further increase in the nuclear share of global energy, depending on the development of 'inherently' safe reactors and fuel cycles, resolution of the technical issues associated with long-term storage of fissile materials and improvement of national and international non-proliferation agreements.

Box 2: How technology reduces greenhouse gas emissions

New technology configurations and systems, e.g. hydrogen as a carbon-free carrier to complement electricity, fuel cells and new storage technologies.

Reducing GHG and CO_2 emissions from agriculture and land use in general critically depends on the diffusion of new technologies and practices that could include less fertilizer-intensive production and improvement of tillage and livestock management.

Source: IPCC (2011: sec. 3.4); italics added by the author.

Box 3: Services involved in wind farm development and operation

- Assessment of wind resources - i.e. potential for producing electricity
- Site analysis
- Project development
- Real estate services
- Project management
- Project financing
- Project licensing and legal services
- Project engineering and design
- Environmental impact analysis
- Construction of wind power facilities
- Retail sale of turbines
- Installation of equipment
- Maintenance of equipment
- Operation of wind power facilities
- Transmission, distribution, and sale of electricity

Source: Brewer and Falke (2012; based on USITC, 2005: 43).

Box 4: "Key groups" of technologies in the IEA BLUE scenario[a]

Supply Side

- Onshore and offshore wind
- Photovoltaic systems
- Concentrating solar power
- 2nd generation biofuels
- Biomass IGCC & co-combustion
- Nuclear power plants
- CCS fossil-fuel power generation
- Coal: ultra-supercritical
- Coal: integrated-gasification combined cycle

Demand Side

- Energy efficiency in buildings and appliances
- Heat pumps
- Solar space and water heating
- Energy efficiency in transport
- Electric and plug-in vehicles
- Hydrogen fuel cell vehicles
- CCS industry, hydrogen and fuel transformation
- Industrial motor systems

a The BLUE scenarios assume that global energy-related CO_2 emissions are reduced to half their current levels by 2050.

Source: IEA (2010); the sequence of the entries has been changed by the author.

Box 5: Emerging heating, ventilating and air conditioning technologies

- Advanced rooftop packaged air conditioners
- Commercial energy recovery ventilation systems
- Residential hot-dry air conditioners
- Smart premium (robust) residential air conditioners
- Advanced northern heat pumps
- Commercial ground-source heat pumps
- Residential ductwork optimization
- Active chilled beam cooling
- Advanced modulating hvac compressor
- Automated fault detection and diagnostics for rooftop units
- Liquid desiccant air conditioner
- Residential boiler controls
- Dehumidification enhancements for air conditioners in hot-humid climates
- Air-side economizer control strategies

Source: Sachs, Lowenberger, and Lin (2009)

Box 6: Internationalization of renewable energy industries

Renewable energy has become, over the last few years, as internationally distributed as any other large, established industry.

Large projects are often highly international in terms of the parties involved. The USD1.7 billion *Thornton Bank wind project off the coast of Belgium*, will use turbines from Germany-based Repower, which is owned by Suzlon of India, has French and German utilities as shareholders, German and Danish export credit agencies as risk-guarantors for some of the debt, French, Dutch and German commercial banks and the European Investment Bank as lenders, and a Danish company as blade supplier.

The 212MW *Olkaria geothermal complex in Kenya* has Israeli and Kenyan plant operators, and is ordering drilling equipment from Chinese companies with the help of finance from Chinese and French development banks. It also has a loan from Japan to pay for a transmission line, and from the German government towards the expansion of the project. It has pre-qualified four engineering companies, three from Japan and one from France, as bidders for the work to increase capacity by 280MW.

In Latin America, multinational involvement is also the norm. Two *small hydroprojects in Rio Grande do Sul province in Brazil*, for instance, will use turbines made by French-owned Alstom and be developed by a Canadian-owned company. Two 40MW hydro projects in Chile, developed by a local company backed by funds from a New York investor, secured loans from Spanish, French and German banks.

Source: UNEP, Bloomberg New Energy Finance and Frankfurt School, UNEP Collaborating Centre for Climate and Sustainable Energy Finance (2011: 28; italics added by the author).

Box 7: Local content rules

Soon after the introduction of its first renewable energy law in 2005, [China] demanded that a certain proportion of the value-added of turbines had to be produced in China in order for them to qualify for the national wind tender programme. At one point in 2007 the local requirement reached 70 [percent; it was subsequently eliminated].

In Brazil the Proinfa wind feed-in tariff programme, which was replaced [in 2010] by a tendering system, also stipulated 70 percent local content, but the requirement was later dropped - at least for 1.5MW-plus turbines - after it became clear that there was insufficient local factory capacity to meet the programme target.

In 2009, the Canadian province of Ontario introduced a rule that its … feed-in tariff for solar PV projects of more than 10kW would only be available for developers using modules with at least 50 percent of their cost based on local goods and services. With effect from 1 January 2011, that proportion [increased] to 60 percent.

In July [2010], India announced that PV project developers participating in the first 150MW phase of its Solar Mission would only be eligible for support if they used locally assembled modules. For the main 296MW phase …, both cells and modules have to be produced locally.

Source: UNEP, Bloomberg New Energy Finance and Frankfurt School, UNEP Collaborating Centre for Climate and Sustainable Energy Finance (2011:29).

Box 8: APEC Leaders' Honolulu Declaration

We will also take the following steps to promote our green growth goals:

- Rationalize and phase out inefficient fossil-fuel subsidies that encourage wasteful consumption, while recognizing the importance of providing those in need with essential energy services, and set up a voluntary reporting mechanism on progress, which we will review annually;
- Aspire to reduce APEC's aggregate energy intensity by 45 percent by 2035;
- Promote energy efficiency by taking specific steps related to transport, buildings, power grids, jobs, knowledge sharing, and education in support of energy-smart low-carbon communities;
- Incorporate low-emissions development strategies into our economic growth plans and leverage APEC to push forward this agenda, including through the Low-Carbon Model Town and other projects;

Source: APEC (2011).

Box 9: A checklist of potential technology diffusion elements for a SETA[a]

- Industries covered:
  - Electric power supply (see Box 4)
    - Biomass
    - Geothermal
    - Hydro
    - Ocean
    - Solar
    - Wind
    - Carbon capture and storage
  - Transport (see Annex II)
    - Biofuels
  - Buildings (see Box 5, and Annex II)
  - Industry
  - Agriculture
- Technologies covered
  - Energy efficiency (see Box 4, and Annex II)
  - Existing, commercialized technologies
  - Prospective, emerging technologies
- Product (goods and services) code classifications, including dual use
- Modes of transfer covered
  - Goods trade
  - Services trade (see Box 4)
  - Licensing
  - Direct investments (see Box 7)
  - Personnel movements
- Types of barriers covered
  - Tariffs
  - Non-tariff barriers
- Subsidies
- Government procurement
- Standards
- Competition policy
- Dispute resolution

a *Not necessarily a comprehensive list.*

Sources: Compiled by the author from ICTSD (2011a: esp. 62-67) and the text and other indicated materials in the present paper.

Table 1: Energy efficiency and other sources of energy-related CO_2 abatement in IEA 450 scenario[a]

Source	Shares of abatement	
	In 2020	In 2035
Energy efficiency[b]	72%	44%
Renewables, incl. biofuels	19%	25%
Nuclear	5%	9%
Carbon Capture and Storage	3%	22%
Amounts of abatement (Gt CO_2)	2.5 Gt	14.8 Gt

a *IEA 450 Scenario refers to the scenario in which a mixture of energy technologies could achieve a CO_2GHG concentration level of 450 ppm. The abatement represented here is the difference between the emissions in the 450 Scenario and the New Policies Scenario, which refers to a scenario in which recent and prospective policies are adopted beyond the status quo represented by the Baseline scenario and the more ambitious 450 scenario.*

b *Energy efficiency's share of the cumulative abatement during the period 2010-2035 is 50 percent.*

Source: Compiled by the author from IEA (2011: 214, Fig. 6.4)

Table 2: Approximate ranges of technical potentials of world sustainable energy production relative to recent production[a]

Technology	Estimated technical potential supply (EJ)[b]	Ratio to recent world total demand	Recent world demand (EJ)
Geothermal electricity	118 - 1109	1.3 - 18.2	Total electricity = 61
Hydro electricity	50 - 52	0.8 - 0.9	
Ocean electricity	7 - 331	0.1 - 5.4	
Wind electricity	85 - 580	1.4 - 9.5	
Geothermal heat	10 - 312	0.1 - 1.9	Total heat = 164
Bio primary energy	50 - 500	0.1 - 1.0	Total primary = 492
Direct solar primary energy	1575 - 49,837	3.2 - 101.3	

a *Technical potentials reported here represent total worldwide potentials for annual renewable energy supply and do not deduct any potential that is already being utilized. Note that renewable energy electricity sources could also be used for heating applications, whereas biomass and solar resources are reported only in primary energy terms but could be used to meet various energy service needs. Ranges are based on various methods and apply to different future years; consequently, the resulting ranges are not strictly comparable across technologies.*

b *EJ refers to exajoule, which is 10^{18} joules. For comparison, the energy consumption of the US is approximately 100 EJ per year; in the table, total world primary energy consumption was 492 EJ.*

Source: Compiled by the author from data in IPCC (2011: Technical Summary, 13).

Table 3: APEC economies' changing shares of climate friendly technology exports and imports

Panel A. APEC economies' shares of exports (percent)

Year	2002	2010
APEC industrialized countries[a]	63.7	34.5
APEC developing countries[b]	36.3	65.5

Panel B. APEC economies shares of imports (percent)

Year	2002	2010
APEC industrialized countries[a]	51.9	42.8
APEC developing countries[b]	48.1	57.2

a APEC's five "industrialized countries" are: Australia, Canada, Japan, New Zealand, United States

b APEC's 16 "developing countries" are: Brunei Darussalam; Chile; People's Republic of China; Hong Kong, China; Indonesia; Republic of Korea; Malaysia; Mexico; Papua New Guinea; Peru; The Philippines; Russia; Singapore; Chinese Taipei; Thailand; Viet Nam

Source: Computed by the author from Kuriyama (2012: Figs. 5 and 6)

Table 4: Types and frequencies of government support policies for renewable energy

Policy types	High Income Countries[a] (36)	Upper Middle Income Countries[a] (26)	Lower Middle Income Countries[a] (24)	Low Income Countries[a] (13)
Regulatory				
Feed-in tariffs	26[b]	15	13	3
Renewable portfolio stds.	10[b]	3	3	1
Net metering	9[c]	1	4	0
Biofuels mandate	22[c]	8	4	2
Heat mandate	7[d]	0	1	0
Tradable REC	18	4	1	1
Fiscal incentives				
Capital sub., grant, rebate	31	8	8c	5
Invest. or prod. tax credits	17	5	8	1
Other tax reductions	25	10	15	11
Energy production payment	6	4	4	0
Public finance				
Gov. invest, loan, grant	21	10	12	5
Gov. competitive bidding	12	8	9	1

a The country groups are based on per capita income levels from World Bank (2010).

b Including 3 with only sub-national policies

c Including 1 with only sub-national policies

d Including 2 with only sub-national policies

Source: Computed by the author from Kuriyama (2012: Figs. 5 and 6)

Table 5: Examples of international institutional arrangements involved in energy, climate change, trade and/or development issues[a]

Institutions	**Numbers of members**[b]	**Issue clusters** Energy Climate Trade Development	**Economic sectors** Energy production Transportation Buildings Industry Agriculture
UNFCCC	195[c]	Climate +	All
Regional Development Banksd	48-77[d]	All	All
FAO	192	All	Agriculture
ICAO	191	Trade +	Transportation: aviation
World Bank (IBRD)	188	All	All
WTOe	155[e]	Trade +	All
APEC	21"economies"	Trade +	All
G-20	19 countries + EU (27)	All	All
Bilateral Investment Treaties (BITs)[f]	2[f]	Trade +	All

a *N.B.: This is not intended to be a comprehensive list.*

b *Based on information on official websites as of 6 June 2012.*

c *Parties to the Convention.*

d *African Development Bank = 77, Asian Development Bank = 67, Inter-American Development Bank = 48, European Bank for Reconstruction and Development = 61*

e *Not all WTO members are signatories to all WTO agreements. For instance, the "plurilateral" Government Procurement Agreement has 15 signatories (including the EU representing its 27 members).*

f *There are approximately 1800 BITs.*

Source: Compiled by the author from the websites of the organizations on 7 June 2012.

Table 6: Participation in three international fora[a]

	APEC(21)	TPP(9)	G20
Argentina			x
Australia	x	x	x
Brazil			x
Brunei-Darussalam	x	x	
Canada	x		x
Chile	x	x	
China	x		x
Chinese Taipei	x		
EU			x
France			x
Germany			x
Hong Kong	x		
India			x
Indonesia	x		x
Italy			x
Japan	x		x
Korea	x		x
Malaysia	x	x	
Mexico	x		x
New Zealand	x	x	
Papua New Guinea	x		
Peru	x	x	
Philippines	x		
Russia	x		x
Saudi Arabia			x
Singapore	x	x	
South Africa			x
Thailand	x		
Turkey			x
Vietnam	x	x	
United Kingdom			x
United States	x	x	x

a Participants in APEC are officially known as "economies" - not "members" or "governments."

Source: Compiled by the author from the organizations' web sites at www.apec.org, www.tpp.org and www.g20.org, accessed on 20 July 2012.