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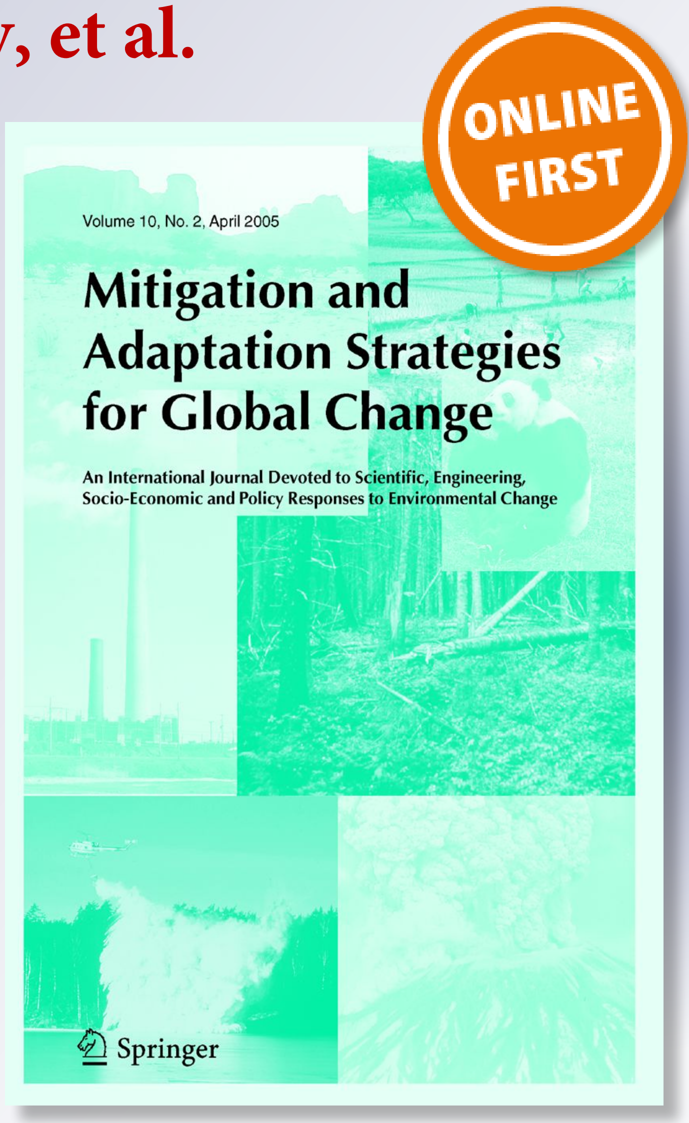

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ORIGINAL ARTICLE

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Kirsten Halsnæs · Amit Garg · John Christensen · Helene Ystanes Føyn · Maryna Karavai · Emilio La Rovere · Matthew Bramley · Xianli Zhu · Catherine Mitchell · Joyashree Roy · Kanako Tanaka · Hidefumi Katayama · Carlos Mena · Imoh Obioh · Igor Bashmakov · Stanford Mwakasonda · Myong-Kyoon Lee · Marlene Vinluan · Yu Joe Huang · Laura Segafredo

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Abstract The aim of this paper is to assess how policy goals in relation to the promotion of green growth, energy security, pollution control and greenhouse gas (GHG) emissions reductions have been aligned in policies that have been implemented in selected countries during the last decades as a basis for discussing how a multi objective policy paradigm can contribute to future climate change mitigation. The paper includes country case studies from Brazil, Canada,

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China, the European Union (EU), India, Japan, Mexico, Nigeria, South Africa, South Korea and the United States covering renewable energy options, industry, transportation, the residential sector and cross-sectoral policies. These countries and regions together contribute more than two thirds of global GHG emissions. The paper finds that policies that are nationally driven and that have multiple objectives, including climate-change mitigation, have been widely applied for decades in both developing countries and industrialised countries. Many of these policies have a long history, and adjustments have taken place based on experience and cost effectiveness concerns. Various energy and climate-change policy goals have worked together in these countries, and in practice a mix of policies reflecting specific priorities and contexts have been pursued. In this way, climate-change mitigation has been aligned with other policy objectives and integrated into broader policy packages, though in many cases specific attention has not been given to the achievement of large GHG emission reductions. Based on these experiences with policy implementation, the paper highlights a number of key coordination and design issues that are pertinent to the successful joint implementation of several energy and climate-change policy goals.

Keywords Climate change policies · Developing and industrialised countries · Coordination of multiple energy and climate change policy goals

1 Introduction

The aim of this paper is to assess the effectiveness of policies with significant climate-change mitigation benefits which countries around the world have been implementing. These policies have been introduced for various reasons, such as the promotion of green growth, energy security, pollution control and greenhouse gas (GHG) emissions reductions. Policy experiences have demonstrated that in many cases sustainable development goals can go hand in hand with climate change mitigation. Performance standards for appliances, equipment, buildings and vehicles, for example, have proven effective and have reduced energy consumption and costs, while economic instruments such as fossil fuel subsidy removal have reduced energy consumption. While the international climate change negotiations have focussed on top-down commitments, national experiences demonstrate that there is a large potential for influencing investments in energy efficiency, renewable energy,

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infrastructure and equipment through complementary national bottom-up, sector-specific policies that help reduce GHG emissions.

The methodological approach adopted in this paper is to draw general conclusions about policy instrument coordination based on a bottom-up study of experiences from national policies related to energy and climate change. As far as possible the emphasis here is to present quantitative estimates for how the particular instruments have contributed to energy and climate-change policy objectives and to review how they have performed in the complex multidimensional regulatory environment.

Many of the national policy experiences reviewed in this article offer valuable lessons and are potentially replicable. One of the key findings is that a combination of many national initiatives, even in the absence of a global climate deal, could be a key element in climate change stabilization policies. However, the empirical results also suggest that meeting low-temperature stabilization targets and thereby implementing very large GHG emission reductions might require a specific focus on climate change mitigation within national sustainable development and energy policies beyond what follows from alignment with broader national policy goals.

The national policy experiences also demonstrate that climate change mitigation policy objectives until now have not alone worked as a strong driver of energy efficiency options and renewable energy. These policy measures need support from a long-term stable policy environment, including transparent economic support mechanisms, which international climate policies as yet have not offered. Since energy efficiency and renewable energy policy measures can potentially deliver several benefits such as job creation, clean industry development, pollution control, and improved energy and mobility services, policies must be designed in such a way that they take all these aspects into consideration.

The examples used throughout the paper are illustrative cases selected from a pool of 11 countries which represent the biggest GHG emitters in all regions of the world and thus represent a balance between different regions and stages of development. The countries covered are Brazil, Canada, China, the European Union (EU), India, Japan, Mexico, Nigeria, South Africa, South Korea and the US. These countries and regions together contribute more than two thirds of global carbon dioxide (CO_2) and other GHG emissions. This is a supplement to modelling based climate change mitigation costing studies that rather focus on future optimal technology choices and the cost effectiveness of climate change mitigation policies. The added value of the current assessment of experiences with policy implementation then is to review how policies that are identified to be cost effective in the modelling studies in practice have worked and been taken up as part of a broader set of national energy and climate change policies.

The paper discusses different policy instruments for several sectors, including energy supply, industry, transportation, buildings and appliances, and cross-sectoral options. While some of the policy instruments discussed aim at reducing emissions by curbing energy demand, others are designed to change the energy supply side with a focus on renewable energy. The instruments are generally most successful when they manage to align technologies, markets and behavioural change, thus combining several policy goals. This is often achieved by implementing several policies in a single coherent package.

2 Energy supply sector—renewable energy deployment

There is a wide range of existing technologies all over the world that reduce GHG emissions from energy supply, including nuclear power, efficient coal combustion and renewable energy technologies. Policies in these areas are being implemented for various reasons, such as the establishment of effective and reliable supply, energy security, efficiency improvements, developing a green economy, the promotion of industry interests and not least addressing various environmental concerns, including climate change.

In terms of climate-change mitigation, renewable energy is among the options with medium to high mitigation costs relative to other supply options. However, ambitious climate change-stabilization scenarios will require renewable energy to play a key role. This, for instance, is confirmed by Azar et al. (2010), whose study reveals that a broad energy portfolio is needed to attain low CO_2 concentrations. In this paper, a specific focus is therefore placed on the examples of specific and well-targeted penetration policies for renewable energy. It is recognised that the implementation of many other energy-supply mitigation options that are more competitive is easier (IPCC 2011).

Renewable energy policies that promote wind, solar and biomass power are being deployed globally, and the share of renewable energy in energy supply has increased by more than 150 % during the last decade (IPCC 2011). Out of the about 300 gigawatts (GW) before (GW) of new electricity generating capacity added globally from 2008 to 2009, 140 GW came from renewable energy. There are therefore key experiences to be gained with renewable energy policies, some examples of which are covered below, including a brief overview of implementation in China, Mexico, EU, Japan, USA and Canada.

2.1 Policy overview

In recent decades, renewable energy policies have been dominated by instruments that address market failure and promote cost effectiveness. These include the introduction of feed-in tariffs (FITs) on a fixed price or tender basis, producer subsidies and quota obligations.

According to Bloomberg New Energy Finance, FITs have proved extremely effective in encouraging wind and solar energy deployment, given that about 64 % of global wind capacity and 85 % of solar PV capacity have been built in markets subject to these regimes (Bloomberg New Energy Finance 2011). Over 50 countries had implemented FIT policies as of 2010 (REN21 2011). FITs have been the primary mechanism for supporting development in the renewable energy sector.

FITs have been successful in promoting investment in renewable energy sectors in many OECD countries with mature electricity markets, such as in Denmark, Germany and Spain, which have more than 10 years of experience with FITs and the highest shares of renewable energy generation in Europe (Reiche and Bechberger 2004). Furthermore, FITs have also been implemented successfully in other EU member states and in China and Mexico, as explained in more detail below. The FITs in China and the EU have been coupled with binding national, multi-national or regional renewable energy targets, which have improved the efficiency of the policies.

Despite the success of FITs, there is a tendency to shift to tender-based systems because guaranteed tariffs without a limit on the total subsidy are difficult to handle in government budgets. Conversely a system with competitive bidding for a specified amount of electricity limits the total amount of subsidy required.

Quota-type mechanisms have been adopted in several countries, including Britain, Italy, Poland, Sweden, Belgium, India, China and Chile, as well as in 30 out of the 50 states in the US. Renewable quota obligations imply that an electricity supplier is required to procure a certain amount of electricity from renewable sources over a given period. Their success depends on the extent to which the risk of investment is reduced by guaranteed off-takes of a proportion of the renewable power generated in the system, and this in turn relates to the extent to which the obligation is enforced and sets minimum payments and contract lengths.

In the EU the quota obligations based on Tradable Green Certificates (TGCs) are generation-based, quantity-driven instruments. The government defines targets for renewable energy deployment and obliges particular parties in the electricity supply chain (e.g. generator, wholesaler or consumer) to meet the target. Once defined, a parallel market for renewable energy certificates is established and prices are set (Resch et al. 2007).

A major reason for the wide application of economic instruments for the promotion of renewable energy is that the policy instruments that can be used by governments directly to influence the choice of new power plants or to stop the operation of existing plants are limited due to the privatisation of energy supply in many countries. Even with such privatisations, energy supply in the EU, for example, is still regulated by national energy strategies with penetration targets. In addition to national strategies, the EU also has common targets overall for shares of renewable energy.

In cases where power companies are state-owned, decisions on fuel choice and plant termination can be made on political grounds, as is illustrated below by the phasing out of coal-fired electricity in Ontario. The Ontario, Canada example also illustrates the major role that sub-national governments can play in climate and energy policy.

Another set of policies, which can be framed as enabling policies to support technology research, development and demonstration, are also important in improving and reducing the costs of low-emission energy-supply technologies over time. Other important enabling policies are make it easier for clean-energy developers obtain land for their projects, removing barriers for access to electricity grids, increasing education and awareness, and enabling technology transfer (IPCC 2011).

2.2 National policy examples

China has introduced very effective policies and measures for promoting renewable energy, especially wind energy. China has the biggest installed capacity of wind energy in the world (REN21 2011). In 2007 the National Development and Reform Commission of China (NDRC) set the objective of raising the share of renewable energy among total primary energy consumption to 10 % in 2010 and to 15 % in 2020, including large-scale hydro power. The NDRC reports that modern biomass (including biogas, biofuels and biopellets), geothermal energy, hydro power, solar power (including solar thermal, solar photovoltaic (PV) and solar heating systems) tidal energy and wind energy will be promoted (Urban et al. 2009). Total wind-power capacity in 2010 was 44.7 GW, which was much higher than the target of 30 GW by 2020 set in 2006. Moreover, China has also become a main producer of wind-power equipment. About 90 % of the newly added wind-generating capacity in China today is from Chinese-produced wind turbines (China Wind Energy Association 2011).

The government policies and measures that have led to this success include the enactment of the China Renewable Energy Law in 2006, which laid the foundations for renewable energy development. It stated that renewable energy projects can receive preferential tariffs and taxation, that grid companies have to buy all the electricity generated from renewable sources, and that the extra costs of renewable energy compared to coal-based electricity can be added to the electricity price. Subsidies and grants were given to local enterprises for progress with technology and pilot wind projects, and foreign wind turbine-makers were encouraged to set up joint ventures in China, to set up local production facilities and to buy from local suppliers. The government also gave a long-term policy signal, setting capacity targets for wind and other renewables by 2020, with mid-term targets included in China's five-year development plans.

Mexico may not currently be one of the major renewable energy producers, but it has rapidly increased its wind energy capacity by setting up a Special Climate Change Program, a major component of which is to increase wind energy capacity in the Tehuantepec region, which has very good wind resources (Inter-Ministerial Climate Change Commission 2009). The Energy Ministry and the Energy Regulatory Commission have designed an innovative framework to systematically address the financial and regulatory barriers that have inhibited its development. The framework includes a small feed-in tariff determined through a competitive bidding process and a modification to the tax law that allows wind-power investments to be deducted in the first year. Furthermore, the transmission capacity from the Isthmus of Tehuantepec was enlarged through a bidding process where private generators paid for new transmission lines and were entitled to access new high-tension transmission lines to be built by the state power company, those making the best offers receiving the transmission capacity (Barnés 2011). The Mexican program has been very successful and wind power-installed capacity in Mexico, just 2 megawatt (MW) in 2007, was already 880 MW in 2011 and there are 350 MW more under construction. During implementation, the solution to the transmission bottleneck problem was the more important policy aspect. There is now a thriving wind-energy industry largely driven by private companies in Mexico, and they plan to install 5,500 MW wind-power capacity in addition to the 350 MW under construction.

The overarching EU climate and energy package, the so-called 20-20-20 targets, implies a specific 20 % renewable energy target in 2020 (Europa 2009). Although the EU is one entity within the United Nations Framework Convention on Climate Change (UN FCCC) Kyoto Protocol, it is the responsibility and choice of the individual member states to implement renewable energy and other policies to address the Kyoto commitment. The contribution of GHG emissions reductions from renewable energy according to the European Renewable Energy Council implied a 7 % reduction in CO_2 emissions in 2009 compared with 1990 levels (EREC 2011).

The combination of renewable energy targets and the European Emission Trading System (ETS) has given rise to discussions about the cost effectiveness and environmental effectiveness of having targets in both areas. The argument is that having renewable energy targets that force more renewable energy implementation beyond what is cost-effective in the ETS system undermines the emissions reductions achieved under the ETS, because larger emissions reductions than required by one country under the ETS just make emission permits cheaper for other countries without any additional GHG emissions reductions. A counter argument to this is that a country that sets targets for renewable energy is doing this for several reasons in addition to the benefits in terms of GHG emissions reductions, providing a very clear example of the need for policy coordination between ETS and other policies.

The way that countries support renewable energy has changed over time in the EU. In particular the reasons for the choice and effectiveness of a quota- versus price-driven mechanism has been widely examined (Held et al. 2010; Haas et al. 2011; de Jager et al. 2010; Kitzing 2011; Ragwitz et al. 2010, 2011). These studies have concluded that some FITs have been more effective and efficient at promoting renewable energy electricity than quotas, mainly due to the combination of long-term fixed-price or premium payments, network connections and the guaranteed purchase of all electricity generated by renewable forms of energy. Quota policies, however, can be effective and efficient if they are designed to reduce risk, for example, with long-term contracts (IPCC 2011).

For instance, introduced in 1993, FITs were key to the diffusion of wind energy in Denmark (Maagard 2006; Lipp 2007). Utilities were obliged to purchase wind-generated electricity at a rate that equalled 85 % of the consumer price (Lipp 2007). FITs were complemented with other policies such as direct subsidies and tax exemptions to private turbine owners, including a 30 % investment subsidy and tax exemption for electricity generation up to 7,000 kilowatt hour kWh per year (Meyer 2006). Through intense collaboration among the public research testing centres, research institutions and private sector, extensive capacity was created (Andersen and Drejer 2012).

Another good example of the FIT's success is the German Renewable Energy Sources Act, which gives sources of renewable energy priority access to the grid, obliges grid operators to purchase electricity from renewable sources, sets the price for renewable energy electricity for long, fixed periods, and sets no limit to the amount of renewable energy feeding into the grid (German Renewable Energies Agency 2012). While a decision to fix FITs in 2000 is argued to be a key factor in the deployment of renewable energy, a number of studies conclude that other policies, together with a broader market structure, were equally significant (Haselip 2011). Furthermore, research and development investments have increased remarkably over the period from 1970s to almost two billion Euros between 1990 and 1998 (Lauber and Mez 2004). As a result wind-power capacity has increased from a total of 56 MW in 1990 to 14,600 MW in 2003, supplying 6 % of national electricity demand (UNEP 2007a). In a similar way, the solar industry has been strongly supported in Germany through an extensive solar roof programme that started with 1,000 roofs in 1989 and increased to 100,000 in 1999 (Lipp 2007), making PV commercially viable for the first time, particularly in combination with the new Renewable Energy Act (EEG) (Wüstenhagen and Bilharz 2004).

In the UK, FITs were introduced by the government's Energy Bill in 2008, with the policy coming into effect in April 2010 (Haselip 2011). This was a major departure from the previous reliance on a micro-generation grant scheme and the 'Renewables Obligation' (RO), a quota-based mechanism introduced in 2002 (Haselip 2011). RO failed to achieve significant reductions in the cost of renewables, and in 2005 only 3.9 % of electricity was generated from RO-related sources rather than the targeted 4.9 % (DTI 2006). The new Energy Bill reversed the rules of the former Non-Fossil Fuel Obligation (NFFO) by placing the obligation on operators to purchase and supply a certain amount of renewable-generated electricity (Lipp 2007). The UK also supports renewable technology deployment in other ways, such as through the Climate Change Levy for commercial and industrial customers if they purchase electricity generated from renewable energy (DTI 2006).

Spain is another good example of the policy role in renewable energy deployment. In 2008 the PV market in Spain was the largest worldwide and had an installed capacity of over 3,500 MW as of 2008, of which 2,700 MW had been installed in that year (Dusonchet and Telaretti 2010). Regulation before 2008 was based on the producer's ability to choose whether to sell electricity with a fixed tariff or in the free market. Thus, FITs were supplied for an undefined number of years with a reduction after 25 years. The new regulatory framework established in Royal Decree 1578/2008 introduced changes in two main lines. FIT's value increased by about 30 % with better values for PV installation in roofs and facades (Dusonchet and Telaretti 2010). In order to control the total cost of the FITs in the national economic situation, a quota of 500 MW in 2009 and similar quotas for the next 3 years have been set (Dusonchet and Telaretti 2010).

Japan's Renewable Portfolio Standard Law 2003 lays down the goal of raising the share of the nation's electricity supply generated by renewable energy by placing regulations on energy supply corporations (Valentine 2011). These companies can reach their imposed quota in three different ways: by generating their own electricity from renewable sources, purchasing renewable energy-generated electricity from another party or purchasing the so-called New Energy Certificates (REN21 2011).

In the United States, installed wind capacity grew rapidly from 2.6 GW in 2000 to more than 40 GW in 2010 (AWEA 2011). Federal tax incentives, state Renewable Portfolio Standards (RPSs) and the improving economics of wind power drove this development. The RPSs oblige the purchase of renewable electricity, although the details of the obligation can vary from state to state. However, from 1994 to 2004, the federal production tax credit (PTC) (which provided about 2 US cents extra per kilowatt from wind facilities for the first 10 years of operation) created a boom and bust cycle for wind development (Bird and Summer 2010). However, in 2005–2010, wind development rose steadily as the PTC were re-authorised. US, unlike Europe, has, around 30 state with RPSs, while in the EU the application of FITs is much wider. Overall, the US wind industry experience indicates the importance of a mix of stable, consistent long-term policies that address both economic and socio-technical barriers such as siting issues. The state RPSs provide market certainty, while the PTC improves the cost-effectiveness of wind and other renewable energy technologies (Wiser and Bolinger 2010).

In Canada the Ontario is phasing out all coal-fired electricity generation in the province, which is home to nearly 40 % of Canada's population. Coal-fired generation reached a peak in the year 2000, when it accounted for 27 % of the output of Ontario's electricity generation sector, and 36 Mt out of the sector's total emissions of 41 Mt CO_2equivalents (Environment Canada 2010, p. 513). In 2001, the province government adopted a regulation to close the Lakeview generating station, which entered into service in the 1960s, by April 30, 2005 (Government of Ontario 2001). In 2007, the government adopted a regulation to close the other four coal-fired power stations, which had entered service between 1970 and 1985, by December 31, 2014 (Government of Ontario 2007). Coal-fired power is being replaced by a mix of gas-fired, wind, other renewable and nuclear power, as well as by reduced demand (Ontario Power Authority 2011, pp. 3–5). The government has undertaken a series of electricity procurement and conservation programs to shape the future electricity mix and demand (ibid.). Notable among these are feed-in tariffs for renewable power (Ontario Power Authority 2011b) enabled by the province's Green Energy and Green Economy Act, which entered into force in 2009 (Ontario Ministry of Energy 2011).

In 2015, once Ontario's coal phase-out is complete, annual GHG emissions from electricity generation in the province will be about 15 Mt CO_2equivalents (Environment Canada 2008). The phase-out can therefore be estimated to reduce annual GHG emissions by about 25 MtCO_2e. Reduction in smog-forming pollutants was an important motivation for the phase-out (see, e.g., Ontario: Office of the Premier 2005). In 2011 the Ontario Power Authority projected that, as a result of the various investments needed to balance the province's electricity supply and demand—which include managing the coal phase-out but also many other changes such as addressing increased demand, upgrading and replacing other generation and transmission capacity—'residential bills are expected to rise by 3.5 % per year over the next 20 years. Industrial prices are expected to rise by 2.7 % per year over the next 20 years' (Ontario Power Authority 2011). It would certainly be misleading to attribute these increased prices solely to the coal phase-out. It should also be noted that current electricity prices are low by international standards: the average wholesale price is less than 4 cents per kWh.

The coal phase-out's political feasibility has been high because all the coal-fired power plants belonged to a state-owned company (Ontario Power Generation) and all the major political parties in the province have consistently agreed with the phase-out (Clean Air Alliance 2011).

3 Industry sector

The industry sector contributed almost 20 % to global CO_2 emissions in 2009 and is a fast-growing sector with a large mitigation potential for both industrialized countries and developing economies (IEA 2011). There is a wide range of technologies for GHG emissions reductions available, including energy efficiency, removal of non-CO_2 gases from industrial processes, CO_2 capture and storage from iron and steel industries, fertilizer and cement production, and changes in industrial processes.

Experiences show that both low-cost options and measures with high up-front investment costs are not being taken up spontaneously in the industry sector at present, and policy instruments are therefore essential for the successful uptake of low emissions technologies and efficiency improvements. The policies include performance standards, tax credits, subsidies, tradable permits and voluntary agreements (IPCC 2007, Chapter 7; World Energy Council 2008; IEA 2005).

Energy efficiency has been a major goal for the industrial sector in many countries, and there are therefore many examples of national policy measures in this area, as shown in Table 1 (based on Tanaka 2011). It shows that support policies to establish a favourable environment for energy efficiency measures on a more voluntary basis are the instruments most widely applied by the sample countries, followed by economic measures and then by prescriptive measures. A brief overview of the industry policy categories is given below, followed by country case examples of policy applications from India, Japan and China.

3.1 Energy management standards

Industrial company energy-management standards have been implemented since late 1970s. These policies include setting binding targets and standards for enterprises and imposing various penalties for those who fail to comply with them. Various penalties, from fines to suspension or closure of production, have been used in this context. The advantage of targets and standards is environmental effectiveness in meeting given targets, but reduction costs are uncertain. Another disadvantage is that standards restrict enterprise choices, meaning that emissions reductions are unlikely to be achieved with the least cost.

Japan has been one of the frontrunners in this area, with regulations in terms of energy consumption targets, equipment standards and fuel-technology mix management. Regulations for equipment efficiency have also been widely applied in Europe since 1992, when the European Council Directive on boiler efficiency standards entered into force (Council Directive 92/42/EEC of 21 May 1992). China has also successfully introduced energy management standards for industry, but the instrument would not easily be replicable in other countries with a stronger market economy, as explained in more detail below.

The introduction of energy efficiency policies is coordinated and promoted by the International Partnership for Energy Efficiency Cooperation (IPEEC), established in 2008. In October 2010, IPEEC members included Australia, Brazil, Canada, China, the EU France, Germany, India, Italy, Mexico, Russia, South Korea, the United Kingdom and the United States, which collectively account for over 75 % of global GDP and energy use.

3.2 Financial instruments

Among financial instruments, subsidies and preferential loans have been used in industry since the mid- and late-1970s. Carbon taxes and energy tax reductions tied to energy

Table 1 Energy efficiency policies for industry in selected countries

Policy type	Prescriptive measures				Economic measures					Supportive measures			
Policy category	Regulation for efficiency of equipment, process	Regulation for energy management	Control retrofit/ replace	Negotiated agreements	Energy taxes	Directed energy tax reductions	Directed financial incentives—loans	Directed financial incentives subsidy	Cap and trade scheme	Identification opportunity	Cooperative measures	Capacity building	Publicity
Brazil	X									X	X	X	
Canada	X					X		X	P	X	X	X	X
China	X		X	X				X	P	X		X	
EU	X	X		X	X	X	X	X	X	X	X	X	
India	X	X					X	X	P	X	X	X	X
Japan		X		X		X	X	X	X	X	X		
Mexico				X			X			X	X		
Russia								X		X			
South Africa	X	X		X						X	X	X	
South Korea				X			X	X	P	X	X		
United States		X		X			X	X	X	X	X	X	

Modified from Tanaka 2011

X policies being implemented; *P* policies planned efficiency actions have been introduced. Soft loans, tax incentives and subsidies have been implemented in the industry sector by many countries to encourage energy efficiency investments and abatement measures for non-CO_2 gases such as N_2O-Nitrous Oxide, HFCs–hydrofluorocarbons and PFCs-perfluorocarbons, but carbon or GHG emissions taxes have been introduced only occasionally (Tanaka 2011; World Energy Council 2008).

The EU directive on Energy Products and Electricity (2003/96/EC) sets the minimum tax levels on fossil fuels for the coming 10 years, starting in 2004, but many countries have specific exemptions for up to 5 years. It broadens the scope of EU energy tax rates to cover coal, gas and electricity. China is also in the process of imposing energy taxes in the eight industrial sectors with highest energy consumption (Reuters 2011). This includes iron and steel, aluminium and cement. The units which lag behind others in energy efficiency and have very high energy usage will be taxed 20 Yuan, 1USD = 6.29 Chinese Yuan (CNY) per kWh of electricity consumed, while the second category of relatively more efficient units will face a tax of five yuan per kWh of electricity consumed.

3.3 Voluntary agreements

Use of voluntary agreements between governments and industry increased rapidly in the early 2000s, but few new programmes have been implemented since, as emissions cap-and-trade schemes were being developed as part of the (UN FCCC) Kyoto Protocol. Many countries started with voluntary industrial-energy efficiency policies, and later shifted to mandatory schemes with specific targets (UNEP 2006; Price 2005; UNIDO 2008; Tanaka 2011). As United Nations Intergovernmental Panel on Climate Change (IPCC) AR4 (IPCC 2007) showed, voluntary agreements had a positive effect on energy efficiency improvements, but results in terms of GHG emissions reductions have been modest, with the exception of Japan, where the status of these voluntary agreements has also been much more 'binding' than in other countries in line with Japanese cultural traditions. More details about policy instrument applications are given below for India, Japan and China.

The latest estimates show that industry contributed 22 % of total GHG emissions in India, equal to 1,728 $MtCO_2$eq. (India INCCA 2010). Many Indian industries have installed specific pollution-abatement, energy-saving and renewable-energy devices promoted by depreciation allowances. Customs duty rebates also exist such as 5 % to 15 % reductions on components of membrane cell technology used in the caustic soda industry, and customs exemptions on imports of equipment, machinery and capital goods for making products using fly-ash and phospho-gypsum etc. Fly-ash usage also receives a duty exemption.

Since 2006, the Indian Bureau of Energy Efficiency (BEE) has provided incentives to industries, and required them, to undertake Specific Energy Consumption audits and to report the results. This information is used to determine specified efficiency enhancement targets for an upcoming Perform, Achieve and Trade (PAT) scheme, which will be implemented during 2012–2014. The PAT is projected to reduce CO_2 emissions by 25 Mt per year relative to business-as-usual, equal to about 1.4 % of overall Indian GHG emissions (INCCA 2010). Industry would have to invest around US$ 6 billion to enhance its energy efficiency, resulting in energy and GHG emissions savings.

The major emitters in Japan, including industry and energy supply, have set up plans to reduce CO_2 emissions on their own initiative. These plans now cover 83 % of emissions from the industrial and energy conversion sectors, and around 44 % of those from all sectors (Government of Japan 2010).

The policy challenge of energy management in Japan is also noteworthy as an example of a regulatory, but flexible policy for industry. Japan has been implementing the Energy

Conservation Act since the 1970s, which originally started after the oil shock in order to reduce energy consumption. The law includes energy management regulation, which requires industry to reduce energy intensity and to monitor and report progress to the government. The regulation has helped industry to self-check its internal energy use to reduce energy costs. Through these measures, the CO_2 emissions of industries participating in the Action Plan in 2009 decreased by 16.8 % compared to 1990. Reductions in CO_2 emissions per unit of production and per unit of energy respectively contributed to decreases of 13.2 % and 1.4 % in CO_2 emissions (Keidanren 2010) The regulation has occasionally been modified in order to strengthen the regulatory scope, and the last amendment in 2008 shifted its legal basis from the factory or workplace to a system of comprehensive energy management on an enterprise basis, including not only the factory for manufacturing but also the office and logistics system in an industrial entity (Government of Japan 2010).

Industry contributes to around half of China's gross domestic product (GDP) and two thirds of China's primary energy consumption (CNSB 2010), and energy-intensive industries alone account for around half of the country's total energy consumption. Therefore, the industrial sector, especially companies with high energy consumption and GHG emissions, are being targeted as a key national policy area. A key policy measure is the introduction of specific targets in the government's 2020 energy efficiency program and in its five-year development plans. Based on these targets, annual energy efficiency benchmarks are set that are tightened gradually for the biggest 1,000+ energy consumers among industrial enterprises, key industrial products and processes. Customs duties for import and export, loan approval, differentiated electricity prices, tax reductions for energy efficiency renovation and subsidies for the closure of low-efficiency industrial production capacity are all being used in order to encourage and ensure improvements in energy efficiency (General Office of the Chinese State Council 2010). For example, during 2006–2010, China charged higher electricity prices for enterprises from energy-intensive sectors using technologies listed in the elimination or restriction catalogue based on energy efficiency performances. Higher tax rates and interest rates for bank loans were also used as instruments to discourage the operation of enterprises using such technologies. The government also offers subsidies and grants to encourage improvements in energy efficiency.

China has established energy efficiency benchmarks for key products and processes in its iron and steel, non-ferrous metals, building materials and chemical industries. Enterprises are required to meet these benchmarks, and their performance is subject to strict monitoring and supervision. Local governments can force enterprises failing to meet the benchmarks into immediate production suspension and energy efficiency renovation. Enterprises that are beyond renovation or cannot meet the benchmark even after such renovations will be forced to close. Deadlines are set for enterprises to replace their machinery and electrical equipment that are on the prohibited list for low-energy efficiency. One powerful measure is the mandatory closure of production capacity from out-of-date technologies before the end of their operational lives. For example, in August 2010, the Chinese Ministry of Industry and Information Technology published a list of 2,087 industrial enterprises whose outdated industrial capacity had to be removed before the end of 2010. If the enterprises failed to close as requested, they would not receive government approval for new investments, nor access to additional land, and would face the withdrawal of their production licenses and pollution permits (*China Daily*, April 21, 2011).

In case of company closures, supplementary measures are introduced such as helping workers losing their jobs through the forced closure to find new jobs and offering them unemployment benefits. The extreme measures taken by the government authorities at different levels to achieve the targets, in some cases shutting down power supply, make enterprises believe that the government is serious about achieving the targets, and this has increased the compliance rate. Especially since 2002, the rapid growth of such energy-intensive sectors has led to robust growth in energy consumption. In the 5 years to 2010, China reversed this trend: its overall energy intensity in the industrial sector fell 25 %, with even faster improvements in some energy intensive industries. China is continuing these effective policies and measures in its current five-year period (2011–2015) (Lewis 2011).

4 Transportation policies

Vehicle performance standards have a proven track record as one of the most effective regulatory instruments to reduce GHG emissions (PEW 2004) while at the same time reaping extensive economic and health benefits have also triggered a radical transformation in motor vehicle design and environmental performance (Bellagio 2001; Krier and Ursin 1997). Regulations in the EU, the United States, and Japan have reduced vehicle emissions of conventional pollutants by about 99 % with respect to the 1970s, at user cost to the consumer of roughly $500 compared with the average cost of a new gasoline-fueled car (Lee et al. 2010). According to the US Environmental Protection Agency, the social benefits have been larger than the costs of these measures (EPA 1999), and this is a remarkable example of how government standards transformed the environmental performance of passenger vehicles by setting performance-based goals to drive new technologies.

Similar government policies are now also being introduced in order to reduce GHG emissions in several countries, including South Korea, China, the United States, the EU, Japan, Australia and Canada, that have adopted vehicle performance standards in some form, thus bringing about 70 % of global transportation GHG emissions under regulation (Feng et al. 2007).

While initially devised to reduce the amount of conventional pollution associated with internal combustion engines, vehicle efficiency standards have proved very effective in reducing fuel use and CO_2 emissions. Germany's standards, for example, yielded a drop in CO_2 emissions of up to 10 % per year compared with business-as-usual trends between 1978 and 2005. Similarly, the fuel economy of new vehicles in China has improved by 10 % since a weight-based fuel economy standard for automobiles and light trucks was adopted nationwide in 2005. In the United States, fuel economy standards reduced oil consumption by about 3 million barrels per day and lowered annual CO_2 emissions by 28 % between 1975 and 2005.

Experience shows that vehicle performance standards must be well designed to be effective. In the United States, for example, the federal government increased the stringency of its standards every year from 1975 to 1985. As a result, automobile and light truck fuel economy nearly doubled during that decade, but from 1985 to 2008, the standards remained static and fuel economy improvement halted, stagnating at about 28 miles per gallon (mpg) for cars and 20 mpg for light trucks (ICCT 2007).

The United States experience illustrates that, if the stringency of performance standards is not regularly increased, and in the absence of other forms of economic incentives such as high fuel taxes, previous efficiency gains will be absorbed by increases in average vehicle weight and engine size (EPA 2009). Additionally, vehicle performance standards should encompass the entire vehicle fleet, as exempting some categories of vehicles will necessarily create unforeseen loopholes. For instance, the 'gas-guzzler tax', introduced in the US in 1978, which imposed penalties on car manufacturers which failed to meet a minimum level of fuel economy, excluded minivans, SUVs–sport utility vehicles and pick-up trucks. Critics contend that the dominance of the modern SUV is a direct result of this flawed policy design. Binding, increasingly stringent and comprehensive fuel efficiency legislation is therefore a key energy efficiency and climate policy instrument.

An additional layer of economic incentives can be provided by higher fuel taxes, which can complement vehicle performance standards in three ways. First, consumers respond to higher fuel prices by driving less and favouring public transit, cycling and walking. Secondly, fuel taxes influence consumers' vehicle purchases and reduce the carbon intensity of vehicle fleets by stimulating improvements in fuel economy. Thirdly, fuel taxes can help counteract what is known as the 'rebound effect' associated with fuel economy standards regulation, i.e. the fact that standards make driving cheaper, thereby encouraging consumers to drive longer distances.

Additionally, if fuel taxes are set at a level approximating external costs (including pollution, price volatility, disruptions in oil imports and national security concerns), they can also help make the whole economy more efficient.

High transportation fuel taxes can reduce fuel consumption and CO_2 emissions significantly. This has been proved in EU and Japan, where taxes are significantly higher than in the U.S., and passenger vehicle fleets display average fuel economy levels that are 50 % higher, at 5.6 l per 100 km (42 mpg) for EU vs. 8.4 l/100 km (28 mpg) for the United States in 2010. Although their effectiveness may drop as incomes increase, fuel taxes remain a very important and effective climate policy instrument.

Shifting passengers from cars to public transit and non-motorized transport in cities is also of crucial importance to improving the energy efficiency of transportation systems (ITDP 2011). Smart urban planning regulations include neighbourhoods that promote walking, priority bicycle paths, dense networks of streets, support for high-quality transit zones for mixed-use neighbourhoods, matching density to transit capacity, the creation of compact regions with short commutes, and increased mobility by regulating parking and road use (ClimateWorks 2011). This is also a unique opportunity to create smart and inexpensive transportation systems such as bus rapid transit (BRT), a collective transportation system using buses running on dedicated lanes to provide a faster and more efficient service than ordinary bus lines. BRTs are a much cheaper and quicker way to provide express public transport services than metro expansion, which can take many years to construct and requires much more capital.

One successful example is the Seoul, South Korea Metropolitan Area BRT system, which started in 2004 and is now expanding to several major cities in Korea. The main motivation for the implementation of this system was to relieve traffic congestion, increase mobility options for commuters, and ultimately to reduce greenhouse gas emissions and other air pollutants. Among the notable results of the Seoul BRT is the improvement in bus speeds, which range on average from 16.6 to 21.6 km/h, hence increasing bus punctuality and reliability. Total bus accidents and injuries on all routes combined have fallen by about a third. Rising bus passenger levels outnumbered that of the subway system by more than 100,000 passengers per day. Moreover, private car usage dramatically decreased on the average from 2,942 to 2,402 vehicles per hour (Ministry of Land, Transport and Maritime Affairs 2009). Additionally, some of the co-benefits resulting from this policy are less pollution (CO_2, PM-particulate matter, NOx reductions), congestion and social costs, such as decreases in accidents and fuel savings among others (Cervero and Kang 2009).

China has achieved similar success with its newest BRT system. The Guangzhou, China BRT, opened in early 2010, took just 9 months to build. It is clean, fast, modern, and convenient, and already carries 800,000 passengers per day (Hughes and Zhu 2009).

In the last decade, four BRT systems have also been successfully developed and implemented in Mexico, contributing significantly to improve public transportation and bringing significant benefits for both people and the environment. Compared with regular buses, the BRT systems in Mexico are aimed at reducing congestion, improving public transportation, reducing travel time and accidents, increasing fuel savings and decreasing air pollution. BRT has also reduced GHG emissions: the system operating now in Mexico City (METROBUS) removes 100,000 tonnes of CO_2e emissions per year compared with what would have been emitted in the absence of the system because both old polluting buses and cars have been replaced (CTS-Mexico 2011).

The Mexican government aims to implement BRT's more widely, and this is supported by the Public Transportation Federal Support Program, which offers grants to local governments to cover up to 100 % of studies and 50 % of infrastructure costs for public transportation projects that meet certain criteria. There are already 16 BRT projects for other cities in Mexico (CTS-Mexico 2011).

The current rapid transport system in South Africa is recognizably a significant step forward towards reductions in fossil fuel consumption and social development as a whole. For Johannesburg only, the rapid bus system project is estimated to have contributed to saving of more than 382,940 tonnes CO_2eq by end of 2010, with a further reduction of 6 million tons of CO2 equivalents estimated by 2020. Similar emissions reductions could be expected for the city of Cape Town. The rapid bus system in South Africa is conspicuous in its ability to provide modern transport services to only a small segment of the vast country. The Gautrain, for example, has been seen to lack easy accessibility by low income groups. These are some of the gaps that need to be filled when considering replication of the project in other parts of South Africa.

Policies that encourage low carbon fuel use also have the potential to reduce GHG emissions in the transportation sector. However, in order to ensure that the carbon footprint of biofuels will not be higher than that of conventional fuels, a specific assessment of their impact is needed which differentiates between the carbon intensity of various fuel types and takes into account the effects of indirect land-use change, while also introducing thresholds that prevent the otherwise expected market penetration of high carbon fuels (e.g., tar sands). Several countries have implemented policies that directly or indirectly subsidize biofuels, among much controversy. Perhaps the least contentious example is that of Brazil, where since 1975 the government has been supporting the expansion of ethanol production (providing funding to new production capacity) and use (mandated 20/25 % blend of ethanol in gasoline, and fiscal exemptions for flex fuel cars using E20 (ethanol and gasoline blends containing 20% ethanol) to E100 (100% ethanol) blends), though since 2003 its main driving force is a private sector encouraged by high international oil prices and good prospects for exporting ethanol (and sugar). In 2010, Brazil used 23 billion litres of ethanol as fuel, avoiding the emission of 45 Mt CO_2. It is estimated that the Ethanol Plan alone has avoided around 740 Mt of CO_2 emissions since its launch in 1975 up to 2010 (La Rovere et al. 2011). Another biofuel was promoted in Brazil through FITs/tender systems, allowing for the production and use of biodiesel in a 5 % blend with diesel oil from 2010 (starting with an up to 2 % voluntary blend from 2004, and moving to a mandatory 3 % in 2008 and 4 % in 2009).

Overall, no single policy will produce large GHG emissions reductions in the transport sector. Efficiency standards for private vehicles are widely considered to be a very effective policy instrument, but just like other types of prescriptive regulation, they are most effective when combined with some form of economic incentive. As cars become more efficient, driving becomes cheaper with respect to other alternatives, which may encourage people to drive longer distances. However, this effect can be eliminated by introducing some form of tax on driving, such as a fuel tax or a steep lump-sum tax on vehicle purchases. Thus, the combination of standards and taxes increases the efficiency of both instruments. The country case examples show that both developed and developing countries can achieve significant emissions reductions in the transportation sector by implementing a combination of the following policies with the focus on public transportation and private vehicles:

- Mandatory performance standards for vehicles and fuels, such as fuel economy standards or low-carbon fuel standards;
- Fiscal instruments aimed at discouraging driving such as taxes on fuels, vehicle purchase and annual registration, congestion charges, toll roads and parking pricing;
- Policies that influence mobility choices and encourage the use of mass transit or other forms of low-carbon transportation options.

5 Buildings sector

Buildings account for more than 30 % of the world's total energy consumption and a similar percentage of the world's GHG emissions (IPCC 2007; Zhengen et al. 2011). Many studies have shown that increasing the electricity and thermal efficiency of buildings is one of the cheapest and cleanest ways to reduce energy demand and thus carbon emissions (UNEP 2007b). At the same time, the building sector is very diverse and fragmented, making the implementation of building energy policies more difficult than in other, more centralized sectors, such as industry or transportation. In addition, building energy consumption is highly dependent on how buildings are used, particular in the residential sector, where their usage reflects lifestyles and standards of living. There are a number of measures that can be implemented to significantly reduce GHG emissions from the building sector.

Over the past 20 years, more countries have worked to curb energy use in the buildings sector through three basic types of policy: (1) minimum performance standards for buildings and appliances, (2) energy ratings and labels, and (3) voluntary programs to incentivize energy or environmental performance that go beyond the standards, e.g., green building certification. A recent study found that out of 81 countries surveyed, 61 have some form of mandatory or voluntary building energy standards, 11 have proposed standards, and only 9 have no standards at all (Janda 2009).

In the United States, for instance, efforts towards developing building energy standards started in the late 1970s, led by non-governmental organizations such as ASHRAE (the American Society of Heating, Refrigerating, and Air-Conditioning Engineers) for commercial buildings, and the International Codes Council (ICC) for residential buildings, and by 2011 all but 11 states had either adopted some version of ASHRAE 90.1 or have developed their own code that either meets or exceeds the ASHRAE standard. The situation with residential building energy codes is very similar. These standards establish a maximum allowable energy budget per floor area, without specific requirements for building components such as walls, windows, etc. This gives builders and architects flexibility in their designs, so long as these designs are shown to meet the required budget. For residential buildings, the focus has been more on promoting energy-efficiency retrofits of existing houses, such as providing zero-interest rate loans for adding more insulation, or replacing an old furnace or air-conditioner with a more efficient one.

Within the last decade, the concept of 'green buildings' has gained a great deal of attention globally with many certification programs. Since the 1970s, building energy regulations have been developed in EU, although for many years only heating energy consumption was considered, particularly in northern Europe, where building thermal requirements have been more rigorous than those in equivalent climates in the US or China. Starting in the mid-2000s, work also began on developing regulations for cooling energy efficiency. Moreover, the EU has demonstrated a remarkable political will in transposing the energy performance standards for buildings into mandatory obligations for member states (Directive 2002/91/EC, 2002). In 2003, a directive on the energy performance of buildings (EPBD) was passed by the european parliament and council requiring implementation by EU members states before 2006. A central element of the EPBD is the use throughout the EU of a common rating system for energy efficiency and environmental impact with seven rankings from A to G. Figure 1 shows the home performance rating developed in the United Kingdom in accordance with the directive. Furthermore, building energy performance certificates are required to be included in lease and purchase agreements in order to incentivize building owners to improve energy data and performance for buildings and to create awareness among users about energy savings and consumption.

In China, the building sector accounts for noticeably less of the national energy budget compared to the United States or EU (around 20 % in 2005), but for the past decade it has been the fastest growing sector, and further increases are inevitable. China has adopted building energy standards in stages, starting with an energy design standard for residential buildings in the heating zone in north China in 1986, revised in 1995. An energy standard for residential buildings in the hot-summer cold-winter region (central China) was developed in 2001, followed by one in the Hot-Summer Warm-Winter Region (south China) in 2003. A national energy design standard for public buildings (similar to commercial buildings) was adopted in 2004. Two of the older residential standards were updated in 2008, and plans are now underway to revise the public buildings standard in 2012. The first drafts of these standards were aimed at 50 % energy savings, while the latest drafts are aimed at 65 % energy savings.

The net result is that by the mid-2000's all major types of buildings in urban areas were covered by a building energy design standard. Implementation was very spotty in the early years after adoption, but through continued efforts, implementation rates are now reported to be in the 80–90 % range in the large urban areas, dropping off in the smaller cities and town (Wu 2006). In the last 5 years, China has given increasing attention to two newer policy efforts building on the successes of the energy standards—an Evaluation Standard for Green Buildings since 2006, and a national building energy rating and labelling program since 2008.

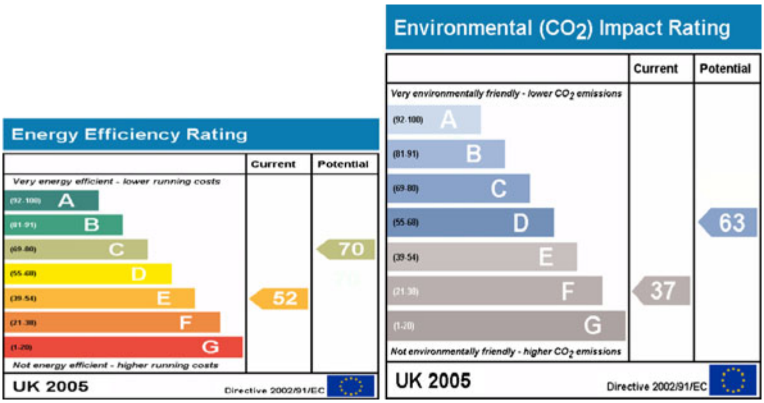

Fig. 1 United Kingdom home performance rating chart

There are numerous similarities in the building policies of the United States, China and EU. All three regions now have well-established building energy standards requiring a certain minimal level of energy performance for new buildings or for the retrofit of existing buildings. In addition, all three regions have programs that provide either incentives or recognition for buildings that outperform the building energy standard, most of which tend to be voluntary. Through such policies being maintained and revised over the years, there has been a dramatic improvement in the energy efficiencies of the overall building stock in the United States, China and EU. However, there remain limitations on all such technically based policies that aim to make buildings 'better', although ultimately the energy use of buildings to a large extent depends on the users and their using habits.

In both the United States and China, socio-economic factors have tended to minimize the actual reductions in building energy consumption. In the United States, house sizes have increased and occupant densities in commercial buildings have decreased, so that on a per capita basis, building energy use has stayed roughly constant or has even increased over the past two decades. In China, increasing wealth and higher demands for thermal comfort have had a similar effect in increasing per capita building energy use (especially for cooling) despite the physical improvements in the building stock and space-conditioning systems. A key question is what constitutes equitable effort in different parts of the world and how much should be expended on technical improvements versus the promotion or maintenance of more sustainable life-styles?

Policy measures for electricity appliances is another challenging aspect of mitigation measures in the residential sector. Many countries have been working for years in the development of appliance standards and labels (CLASP 2011). Similar to the situation with buildings, appliance standards set minimum requirements for energy efficiency that manufacturers must meet, while energy labels provide information to encourage consumers to select energy-efficient products and make high-efficiency appliances competitive in the market. Furthermore, disclosure of energy rankings creates incentives to manufacturers to develop more efficient products. There follow three snapshots of successful appliance programs in Japan, Nigeria, and South Africa.

In Japan since 1998 top-runner standards for electricity appliances have made the level of energy efficiency standards for 23 appliances better than that of the most energy-efficient product among commercialized products. The weighted harmonic average of the energy efficiency of tested appliances has been improved by 68 % for air conditioners and 55 % for electric refrigerators from 1998 to 2004 (METI 2011). By providing necessary information such as energy-saving labels, consumers are encouraged to select energy-efficient products. High-energy efficiency appliances are competitive in the market, and providing energy efficiency rankings works well as an incentive for manufacturers to develop more highly efficient products. In order to motivate retailers to promote distribution and control sales of energy efficient products appropriately, a retailer awards program has been implemented. In addition, a financial incentive for consumers, the Eco-Points scheme, is one of a number of subsidy programs aiming to boost purchasing more highly energy efficient products (METI 2010).

In Nigeria substitution of incandescent bulbs with compact flourescent lamps (CFL) bulbs for lighting homes, public institutions and street lights, as well as the substitution of traditional cooking stoves in homes with efficient cook stoves, are the main policies for efficient appliances. South Africa, in tandem with increasing access to electricity, also launched incandescent to CFL replacement programmes from 2000, estimating total energy savings of 4,000 GWh and 3.4 $MtCO_2$ per year.

6 Cross-sectoral policies

Policies that can support climate-change mitigation include a number of cross-sectoral instruments, where among the major categories are taxes and charges, and tradable emission permits. The cross-sectoral policies can be applied internationally, domestically, or among a specific group of countries. The basic idea of these instruments is that they are designed in order to give companies, private households, the public sector or other parts of the economy incentives to reduce GHG emissions. In this way the logic is that through taxes, quantitative restrictions or other economic incentives, GHG-emitting entities can decide whether they will invest in emissions reductions, pay taxes or buy credits. Through this flexibility in the allocation of climate-change mitigation across sources and sectors, the cross-sectoral instruments are expected to supply a high degree of cost effectiveness (IPCC 2007).

The UN FCCC Kyoto Protocol introduced (United Nations 1998) specific international cross-sectoral instruments for emissions trading among Annex I parties, joint implementation (JI) projects among Annex I parties, and clean development mechanism (CDM) projects among Annex I and Non Annex I parties.

Taxes and charges can be assigned to carbon or several GHGs and have high marks in terms of cost-effectiveness because they provide incentives to establish equal marginal reduction costs across all emission sources (IPCC 2007, Technical Summary). In economic studies the introduction of taxes is often recommended as being the most attractive instrument with the lowest mitigation costs. In practice, however, there are no examples of GHG emission taxes that have been implemented with uniform rates across emissions sources, despite the promising economic characteristics, and this is partly because some sectors have argued that taxes hurt competitiveness if they are not applied internationally. GHG emission taxes, however, have been widely applied unilaterally with different rates for different sectors, as, for example, in Scandinavian countries, in other European countries, and in British Columbia, Canada. The taxes have been popular partly because they have helped to generate significant public revenues.

Tradable permits set a limit to total emissions and allow flexibility among emitters and sources of emissions. Emission permits have proved very popular and are a key component of the UN FCCC Kyoto Protocol and of the EU's climate policy instruments for energy-intensive industry and large sources of emissions. Emission permits have been seen as attractive by the business sector compared with taxes and charges because they give companies an opportunity to sell excess charges or permits on the market if they are effective in emissions reductions, and some companies have also earned profits in these markets.

A number of countries have gained experiences with tradable emission permit systems, including a sub-regional system in China, a city-level system in Tokyo, Japan a tradable permit system for oil production and energy supply in Mexico, and a large internal EU emission permit system.

In October 2010 it was decided gradually to develop a regional emission trading system in China, with Guadong province to take the lead because of the very good energy data in this area (Wuppertal 2011). The goal is to reduce industrial emissions to 30 % below the 2005 level on a voluntary basis when the trading system is initialized in 2012 and 2013, and then to use these experiences to extend the system to cover other provinces and larger parts of the country. According to Climate South, 2011, China has also set up several other exchange platforms for carbon trading based on voluntary offsets: the Shanghai Environment and Energy Exchange, Tianjin Climate Exchange, and China Beijing Environmental Exchange were set up in 2008, the purpose of which was to help companies to create a green image, and also to be fast movers within the carbon trading business.

One of the policy instruments in the Mexican national strategy on climate change from 2007 has been the consolidation of different components of already established national emission trading systems (Wuppertal 2011). The development of a domestic carbon market has also been supported by a World Bank grant, but it is not clear how strong a role the system will have in future Mexican climate policies.

The Tokyo Metropolitan Government has developed the first cap and trade program at city level (World Bank 2010). It targets 1340 large facilities, including industrial factories, public facilities, educational facilities, etc. as well as, uniquely, commercial buildings, and it went into effect in April 2010. The city aims to reduce emissions by 25 % below 2000 levels by 2020. The system has benefited from a generally cooperative environment in the city, with a very high level of technical and financial management capacity. However, it must also be recognized that a very complex management system was needed, which is not very likely to exist in general in different cities.

The overarching EU climate and energy package is the so-called 20-20-20 targets, agreed in June 2009, and the EU-emission trading system, or ETS, is part of this system. The ETS system has suffered from instability in the carbon markets and the relatively generous emission permits given to energy-intensive industries and large sources of emissions, implying that carbon prices have been very low and unstable. One of the implications of this is that a proper long-term price signal to investments in clean technologies has not as yet been issued. Furthermore, the efficiency of the ETS system will strongly depend on whether a future international climate policy regime is established.

Several Organization for Economic Cooperation and Development (OECD) countries have gained experience with environmentally related taxes that have impacts on GHG emissions, either directly or indirectly. United Nations IPCC (2007) concludes that in OECD countries energy products had been taxed in 150 cases and motor vehicles had been taxed in 125 cases, which indirectly reduced GHG emissions.

Some countries have also implemented direct taxes on CO_2 emissions. Finland was the first country to introduce a carbon tax in 1990 and was followed by Sweden, Denmark, Norway, the Netherlands, Italy, New Zealand, Switzerland and British Columbia, Canada. The Swedish Ministry of Environment forecast in 1997 that by 2000 this tax policy would have reduced CO_2 emissions by 20 % to 25 % more than a conventional, regulatory-based policy package (Johansson 2000). The mitigation effects of carbon taxes in Denmark, the Netherlands and Sweden are recognized to be very limited as of now. According to the estimates of the Danish Ministry of Finance, the series of energy policies that have been implemented since 1995 would have reduced CO_2 emissions by 3.8 % by 2005, with the tax contributing 2 % to the reduction. In addition, the Swedish EPA (1997) showed that during the period 1991–1994, when the carbon tax was implemented, CO_2 emissions were reduced by 5 Mt, equivalent to 9 % of total CO_2 emissions in Sweden. However, the carbon tax rate was cut down in 1992, and in the period after 1992–1994 CO_2 emissions in Sweden increased by 25 %, which partly was a consequence of the tax cut.

The British Columbia (BC) levies a tax on the carbon content of virtually all fossil fuels burned in the province (Government of British Columbia, Canada 2008a, parts 3 and 4). The tax puts a price on about 73 % of the province's CO_2e emissions (Horne 2010). It began in July 2008 at $10/tonne CO_2e, and was to reach $30/tonne in July 2012; the government has not yet determined the tax rate for July 2013 onwards (Government of British Columbia, Canada 2008a, Schedule 1). Based on modelling, the BC carbon tax is expected to reduce annual emissions in 2020 by up to 3 $MtCO_2e$ relative to a scenario without the tax (Government of British Columbia 2008b, 20). However, since the tax is relatively new, real-world evidence for its success in redirecting investments to lower-emitting activities remains anecdotal. No other

Table 2 Clean development mechanism (CDM) projects distribution by sectors as of Dec 31, 2011

Type	Projects		Expected CERs				CERs issued	
			CERs/year (000)		2012 CERs (000)		(000)	%
Afforestation & reforestation	*63*	*0.9 %*	*4676*	*0.5 %*	*20708*	*0.8 %*		
- Hydropower	1763	26 %	207891	23 %	441040	16 %	52627	7 %
- Wind	1618	24 %	143153	16 %	327979	12 %	41634	6 %
- Biomass energy	771	11 %	49083	5 %	170073	6 %	19404	3 %
- Solar	133	2 %	4507	0.5 %	5573	0.2 %	107	0.02 %
- Tidal	4	0.1 %	116	0.0 %	287	0.01 %	10	0.001 %
- Geothermal	20	0.3 %	5632	0.6 %	13402	0 %	1977	0.3 %
Sub-total: renewables	*4306*	*64 %*	*410671*	*46 %*	*959170*	*35 %*	*115750*	*16 %*
- Transport	42	0.6 %	4743	0.5 %	10039	0.4 %	359	0.05 %
- Energy efficiency service	32	0.5 %	357	0.04 %	1044	0.04 %	6	0 %
- Energy distribution	22	0.3 %	5810	1 %	10471	0 %	316	0 %
- Energy efficiency industry	130	1.9 %	5257	1 %	17782	1 %	1650	0.2 %
- Energy efficiency households	73	1.1 %	2989	0.3 %	5248	0.2 %	28	0 %
- Energy efficiency own generation	472	7 %	58557	6 %	203604	7 %	31489	4 %
- Energy efficiency supply side (power plants)	108	1.6 %	59314	7 %	61067	2 %	667	0.1 %
Sub-total: energy efficiency	*879*	*13 %*	*137027*	*16 %*	*309255*	*11 %*	*34515*	*4 %*
- N_2O	76	1.1 %	51098	6 %	252749	9 %	155011	22 %
- PFCs and 'SF6'	18	0.3 %	5632	0.6 %	13402	0 %	1977	0.3 %
- HFCs	23	0.3 %	81727	9 %	476504	17 %	338879	48 %
Sub-total: HFCs, PFCs, SF6 and N_2O reduction	*117*	*1.7 %*	*137874*	*15 %*	*741049*	*27 %*	*494636*	*70 %*
- Cement	49	0.7 %	8549	1 %	33598	1 %	1615	0.2 %
Fugitive	47	0.7 %	24097	3 %	70005	3 %	8075	1.1 %
- Agriculture	1	0.01 %	10	0.0 %	18	0 %		
- Landfill gas	354	5 %	53725	6 %	202090	7 %	17080	2 %
- Methane avoidance	685	10 %	31719	4 %	108134	4 %	7923	1 %
- Coal bed/mine methane	86	1.3 %	38583	4 %	109648	4 %	6332	0.9 %
- CO_2 usage	4	0.1 %	116	0.0 %	287	0.01 %	10	0.001 %
Sub-total: CH_4 reduction & cement & coal mine/bed methane	*1226*	*18 %*	*156799*	*17 %*	*523779*	*19 %*	*41034*	*5.8 %*
Fossil fuel switch	*133*	*2 %*	*54877*	*6.1 %*	*174304*	*6.4 %*	*21866*	*3.1 %*
Total	6724	100 %	901925	100 %	2728265	100 %	707802	100 %

EE energy efficiency; *CERs* Certified Emission Reductions; CERs 2012–estimated CER generation by the end of 2012; *HFCs* hydrofluorocarbons; *PFCs* perfluorocarbons; N_2O Nitrous Oxide; CH_4 methane; *SF6* sulfurhexafluoride

UNEP Risoe CDM Pipeline Analysis and Database, January 1, 2012

jurisdictions in North America are currently expected to implement a carbon tax comparable to that of BC However, in the jurisdictions that are considering implementing cap-and-trade systems for GHGs, BC's tax could be influential in demonstrating that putting a significant price on emissions is economically feasible.

The CDM of the UN FCCC Kyoto Protocol aims to bring about real and measurable emissions reductions in various sectors, though the vast majority of projects developed under the CDM are in the energy sector. As of December 31, 2011, projects in renewable energy accounted for 64 % of total CDM projects (UNEP Risø Centre 2012). Projects reducing methane CH_4, projects in the cement industry and on coal-mine and coal-bed methane combined constitute 18 %, projects on HCFs, PFCs and N_2O reduction only 1.7 %, and the amount of CERs coming from renewable energy projects constitutes 46 %. This is followed by various projects achieving reductions of CH_4, projects in the cement industry and coal-mine and bed-mine methane combined (17 %) and projects in HCFs, PFCs and N_2O reduction (15 %) (see Table 2).

Economic incentives in terms of carbon taxes, tradable permit systems and CDM projects have proved to be very popular, despite the fact that no binding international climate change agreement with strict targets has been established. Many actors on the market such as companies and stakeholders engaged in CDM projects have proved to be very interested in reacting to such economic incentives, despite the fact that they have been very weak up until now. This indicates that cross-sectoral instruments could be very popular and effective in future climate change policies in particular if more stable carbon prices were established. Carbon taxes can also offer cost-effective climate-change mitigation, and they have been popular in some countries since they can offer attractive tax revenues. However, in practice it is difficult to implement carbon taxes with uniform rates across all sources domestically since industry can potentially suffer from a loss of competitiveness, thus compromising cost effectiveness.

7 Conclusions

The country case examples presented in this paper confirm that policies that aim at improving energy efficiency and reducing local pollution with positive impacts on climate change mitigation too have been widely applied for decades. Many of these policies have a long history, and in many cases explicit climate change mitigation goals have not been directly addressed.

Renewable energy promotion is a very specific and strong driver of national policy in all the countries we have examined. In many cases policies have been developed and adjusted over a long time-frame based on experience and reflecting a wide range of goals related to energy security, clean technology promotion, industrial interests and climate change. The policies have been quite successful in achieving renewable energy penetration, and very fast penetration rates have been seen in countries that have introduced policies with strong economic incentives and regulation. In this way, there seems to be no problem in achieving rapid renewable energy implementation, the issue being rather to design cost-effective policies and avoid market distortions and excessive energy prices.

Specific climate-change mitigation policies such as the EU ETS system have helped to support the drive towards renewable energy implementation, but have not proved strong enough as a stand-alone effort. This is the case for many reasons. Development and innovation in renewable energy have taken place over very long periods beyond the commitment periods of international climate-change agreements, and price signals through the carbon market have been too small and too short-term to provide a proper incentive for the introduction of renewable energy. In some cases, there have even also been conflicts between climate-change policy frameworks such as the EU ETS system and renewable energy targets and support in terms of cost-effectiveness and the contribution to GHG emissions reductions gained by combining emission quotas with other regulations.

Energy efficiency in a number of countries has been fully been supported by the application of mandatory standards in industry, transportation and buildings, standards that have often been combined with economic instruments like fuel taxes, for example, in the transportation sector. In relation to industry, countries have different experiences in terms of introducing and enforcing compliance rules to specific standards. Dependent on culture, voluntary systems work well in some countries, while more compliance is needed in other countries. A number of countries have had positive experiences with vehicle fuel efficiency standards and with investments in BRTs, which have contributed to lower GHG emissions intensities for transportation. There is still the problem of a very high expected increase in mobility demand, however, so other measures will be needed to ensure large GHG emissions reductions in the transportation sector. Finally, the building sector is characterised by complicated implementation issues, in particular in relation to heat savings in existing buildings, despite the availability of economically very attractive options. Here limited finance and entrepreneurship, together with social issues related to behaviour and increasing demands, remain major constraints.

Cross-sectoral policies have been quite innovative in relation to climate change mitigation in their capacity as a facilitator of flexibility in emissions reductions, and successful examples of these policies include CO_2 taxes and the CDM. Despite the lack of GHG emission reductions requirements in the UN FCCC Kyoto Protocol, a number of developing countries have introduced cross-sectoral climate change-mitigation policies on their own initiative to support both general policy goals and an active engagement in international emissions trading markets and CDM.

In general, it can be concluded that various energy and climate-change policy goals work together in the countries discussed, and that a mix of policies that reflect specific priorities and contexts are needed. Climate change mitigation can be aligned with other policy objectives and integrated into broader policy packages, but special consideration of the policy goal is needed, in particular with low-temperature stabilization targets. Finally, the country case examples also demonstrate that flexibility in terms of a country's choice of policies and compliance rules is needed and must be facilitated in relation to international climate change agreements as recognition of differences in energy policy priorities and systems, culture and behaviour, market states and regulatory frameworks.

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References

Andersen PH, Drejer I (2012) Denmark – the wind power hub: transforming the supply chain. Sylvest T, Sevelsted J, Andersend MN, Boholm F (editors) May 2012, Published by the Danish Wind Industry Association in collaboration with Central Denmark Region, the University of Aarhus and Invest in Denmark. Retrieved from https://www.stateofgreen.com/Cache/StateOfGreen/2e/2e8f046f-6cad-439c-acd7-40013b7c6dae.pdf.

AWEA (2011) Fourth Quarter 2010 Market Report, Washington DC

Azar C, Lindgren K, Obersteiner M, Riahi K, Detlef P, van Vuuren K, Michel GJ, den Elzen Möllersten K, Larson ED (2010) The feasibility of low CO_2 concentration targets and the role of bio-energy with carbon capture and storage (BECCS). Clim Chang 100(1):195–202

Barnés F (2011) Evolution of Mexico's Renewable Energy Program. Presentation at Workshop: Regional Dialogue on the Initiative Mitigation Action Implementation Network (MAIN). Costa Rica

Bellagio (2001) Bellagio Memorandum on Motor Vehicle Policy Principles for Vehicles and Fuels in Response to Global Environmental and Health Imperatives Consensus Document: 19–21 June, 2001 Bellagio, Italy. Retrieved from http://www.theicct.org/sites/default/files/Bellagio_memorandum.pdf.

Bird L, Summer J (2010) Green Power Marketing in the US: A status report (2009 data) NREL/TP-6A20-49403, Washington DC

Bloomberg New Energy Finance (2011) Assessing the Effectiveness of Clean Energy Policy. Available from http://dt3.bnef.com. Cited 11 Oct 2011

Canada. Office of the Premier (2005) McGuinty Government Closes Lakeview Generating Station For Cleaner Air And Better Health, news release, April 28, 2005

Cervero R, Kang CD (2009) Bus Rapid Transit Impacts on Land Uses and Land Values in Seoul, Korea. UCB-ITS-VWP-2009-4. Retrieved from http://www.theicct.org/sites/default/files/Bellagio_memorandum.pdf

China Wind Energy Association (2011) China Wind Energy Installed Capacity Statistics 2010. Available from: www.cwea.org.cn Accessed 11 October 2011

CLASP (Collaborative Labeling and Appliance Standards Program) (2011) Worldwide Summary of S&L Programs. Available from: http://www.clasponline.org/clasp.online.worldwide.php. Cited 13 Oct 2011

Clean Air Alliance (2011) Coal: Dead Man Walking. http://www.cleanairalliance.org/node/1031 (bulletin of Ontario Clean Air Alliance) Accessed 4 October 2011

ClimateWorks Foundation (2011) Planning cities for people: a guide to prosperous, low-carbon urbanization. ClimateWorks Foundation

CNSB (China National Statistical Bureau) (2010) China Statistical Yearbook 2010. China Statistical Press, Beijing

Council Directive 92/42/EEC. Council Directive 92/42/EEC of 21 May 1992 on efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels. Official Journal L 167, 22/06/1992 P. 0017–0028

CTS-Mexico (2011) Mexico City Round Table: How to satisfy transport needs in fiscally constrained societies? Working Paper, Perspectives from Mexico to achieve more with less: Alternative transport modes and their social and Environmental benefits. World Resources Institute—EMBARQ May 2011. Retrieved from http://www.embarq.org/cts-mexico/sites/default/files/ITF_Documento_2011_vF.pdf

De Jager D, Klessman C, Stricker E, Winkel T, de Visser E, Koper M, Ragwitz M, Held A, Resch G, Busch S, Panzer C, Gazzo A, Roulleau T, Gousseland P, Henriet M, and Bouille A (2010) Financing Renewable Energy in the European Energy Market. Project No. PECPNL084659, A study led by Ecofys and funded by the European Commission, DG Energy, Brussels, Belgium

Directive 2002/91/EC (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings. Official Journal L 001, 04/01/2003 P. 0065–0071

DTI (2006) Department of Trade and Industry Energy Review Consultation, 2006. Submission by Open University Energy & Environment Research Unit. Milton Keynes, UK. Retrieved from www.claverton-energy.com/?dl_name=EERUEnergyReview.pdf

Dusonchet L, Telaretti E (2010) Economic analysis of different supporting policies for the production of electrical energy by solar photovoltaics in western European Union countries. Energy Policy 38(7):3297–3308

Environment Canada (2010) National Inventory Report 1990–2008: Greenhouse Gas Sources and Sinks in Canada, Government of Canada, Environment Canada, 2010

Environment Canada (2008) Canada's Energy and GHG Emissions Projections March 2008, Reference case: 2006–2020, provincial and territorial tables. Environment Canada, Gatineau

EPA (1999) Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements. Regulatory Impact Analysis, US Environmental Protection Agency

EPA (2009) Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2009

EREC (2011) Europe's Renewable Energy Policy. First Announcement. Brussels, 24 May 2011. Retrieved from http://www.erec.org/fileadmin/erec_docs/Events_Documents/EREC2011/EREC2011_1st_Announcement_01.pdf

Europa (2009) Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Official Journal. L 140/16. Retrieved from http://ec.europa.eu/energy/renewables/transparency_platform/doc/national_renewable_energy_action_plan_uk_en.pdf

Feng A, Gordon D, Hui H, Kodjak D, Rutheford D (2007) Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update, ICCT

General Office of the Chinese State Council (GOCSC) (2010) Guidance on Further Strengthening of Energy Saving and Greenhouse Gas Emission Reductions and Speeding up Restructuring in the Steel and Iron Industry, (No. 34, Document of GOCSC). Government Regulation in Chinese

German Renewable Energies Agency (2012) Companies Call for Investment Security - Feed-In Tariffs Guarantee Successful Expansion of Renewable Energy. Renews Kompakt 22/06/2012. German

Renewable Energies Agency, Berlin. Retrieved from http://www.unendlich-viel-energie.de/uploads/media/RenewsKompakt_Support-schemes_jun12.pdf

Government of B.C. (British Columbia) (2008a) Climate Action Plan. Retrieved May 1, 2010, from Live Smart BC Retrieved from www.livesmartbc.ca/attachments/climateaction_plan_web.pdf

Government of B.C. (British Columbia) (2008b) BC Air Action Plan. Retrieved May 1, 2010, from BC Air Smart Retrieved from www.bcairsmart.ca

Government of Japan (2010) Japan's Fifth National Communication Under the United Nations Framework Convention on Climate Change

Government of Ontario (2001) Ontario Regulation 396/01

Government of Ontario (2007) Ontario Regulation 496/07

Haas R, Panzer C, Resch G, Ragwitz M, Reece G, Held A (2011) A historical review of promotion strategies for electricity from renewable energy sources in EU countries. Renew Sustain Energy Rev 15:1003–1034

Haselip J (2011) Fit for use everywhere? Assessing experiences with renewable energy feed-in tariffs. In: Diffusion of renewable energy technologies: case studies of enabling frameworks in developing countries, technology transfer perspectives. UNEP-Risø Centre, Denmark: http://tech-action.org/Perspectives/FITuseEverywhere.pdf

Held A, Ragwitz M, Merkel E, Rathmann M, and Klessmann C (2010) Indicators Assessing the Performance of Renewable Energy Support Policies in 27 Member States. RE-Shaping project report to the European Commission under the Intelligent Energy for Europe Program (Grant agreement no. EIE/08/517/SI2.529243). Fraunhofer ISI and Ecofys, Karlsruhe, Germany and Utrecht, the Netherlands

Horne M (2010) Building a Low-Carbon Economy in British Columbia: Recommendations to Strengthen B.C.'s Carbon Tax, Retrieved from http://bc.pembina.org/pub/1961

Hughes C, Zhu X (2009) Guangzhou, China Bus Rapid Transit Emissions Impact Analysis. ITDP and Breakthrough Technologies Institute. Environmental Impacts of BRT in APEC Countries (BTI, 2011) May 2011. Retrieved from http://www.itdp.org/documents/20110810-ITDP-GZBRTImpacts.pdf

ICCT (2007) http://www.theicct.org/documents/ICCT_GlobalStandards_2007.pdf

IEA (2005) The Experience with Energy Efficiency Policies And Programmes In IEA Countries. Learning from the Critics. IEA Information Paper. http://www02.abb.com/db/db0003/db002698.nsf/ca7e93ab03030d22c12571380039e8fc/0912873430b22467c12571da0032d460/$FILE/The+Experience+With+Energy+Efficiency+Policies+and+Programmes+in+IEA+Countries.pdf

IEA (2011) CO_2 Emissions from Fuel Combustion – Highlights, 2011 Edition. IEA, Paris

INCCA (Indian Network for Climate Change Assessment) (2010) India: Greenhouse Gas Emissions 2007. New Dehli: Ministry of Environment and Forests. Available at: http://moef.nic.in/downloads/public-information/Report_INCCA.pdf (accessed 17 September 2010)

Inter-Ministerial Climate Change Commission (2009) National Climate Change Strategies: Comparative Analysis Of Developing Country Plans. World Resources Institute. Retrieved from http://pdf.wri.org/working_papers/developing_country_actions_table.pdf

IPCC (2007) Mitigation policies, report of WGIII. Cambridge University Press

IPCC (2011) Special Report on Renewable Energy Sources and Climate Change Mitigation. Prepared by Working Group III. Retrieved from http://srren.ipcc-wg3.de/report

IPCC (2011) IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [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 University Press, Cambridge, United Kingdom and New York, NY, USA, 1075 pp

ITDP (2011) Our Cities Ourselves: 10 Principles for Transport in Urban Life. Institute for Transport and Development Policy, New York

Janda KB (2009) Worldwide Status of Energy Standards for Buildings: A 2009 Update. In: Proceedings of the ECEEE Summer Study, June 1–6, 2009 (Colle Sur Loop, France). 1: 485–491. European Council for an Energy-Efficient Economy. Retrieved from http://www.eci.ox.ac.uk/publications/downloads/janda09worldwidestatus.pdf

Johansson B (2000) Economic Instruments in Practice 1: Carbon Tax in Sweden Swedish Environmental Protection Agency 2000. http://www.oecd.org/dataoecd/25/0/2108273.pdf

Keidanren (Japan Business Federation) (2010) Results of the Fiscal 2010 Follow-up to the Keidanen Voluntary Action Plan on the Environment

Kitzing L (2011) Trends in RE Support in Europe. Unpublished PhD thesis. Technical University of Denmark

Krier JE, Ursin E (1997) Pollution and policy: a case essay on California and Federal experience with motor vehicle air pollution, 1940–1975. University of California Press

La Rovere EL, Pereira AS, Simões AF (2011) Biofuels and sustainable energy development in Brazil. World Dev 39(6):1026–1036

Lauber V, Mez L (2004) Three decades of renewable electricity policies In Germany. Energy Environ 15 (4):599–623

Lee J, Veloso FM, Hounshell DA, Rubin ES (2010) Forcing technological change: a case of automobile emissions control technology development in the US. Technovation 30:249–264

Lewis J (2011) Energy and climate goals of China's 12th five-year plan. Pew Climate Centre, Washington

Lipp J (2007) Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom. Energy Policy 35:5481–5495

Maagard P (2006) Director of Nordic Folkcentre for Renewable Eenergy. Hurup Thy, Denmark. Personal communication, June

METI (2010) Energy white paper. Ministry of Economics, Trade, and Industry, Japan

METI (2011) The 16th meeting of the Energy Efficiency Standards Subcommittee of the Advisory Committee on Energy and Natural Resource http://www.meti.go.jp/english/press/2011/0124_01.html

Meyer N (2006) Learnings from wind energy policy in the EU, with focus on Denmark, Sweden and Spain. Draft Paper from the GIN Wind Stream Conference, Cardiff, July

Ministry of Land, Transport and Maritime Affairs (2009) The way to green BRT in Korea

Ontario Ministry of Energy (2011) Ontario's Green Energy Act, http://www.mei.gov.on.ca/en/energy/gea/. Cited Jul 16, 2011

Ontario Power Authority (2011) IPSP planning and consultation overview. Ontario Power Authority, Toronto

Ontario Power Authority (2011b) What is the Feed-in Tariff Program? [Internet] Toronto, Canada, Ontario Power Authority. Available from: <http://fit.powerauthority.on.ca/what-feed-tariff-program>. Cited16 Jul 2011

PEW (2004) Comparison of Passenger Vehicle Fuel Economy and GHG Emission Standards Around the World. By: Feng An, Energy and Transportation Technologies LLC and Amanda Sauer, World Resources Institute. December 2004. Retrieved from http://www.c2es.org/global-warming-in-depth/all_reports/fuel_economy

Price L (2005) Voluntary Agreements for energy efficiency or greenhouse gas emissions reduction in industry: an assessment of programs around the world. In: Proceedings of the 2005 ACEEE Summer Study on Energy Efficiency in Industry. Washington, DC: American Council for an Energy-Efficient Economy. Retrieved from http://ies.lbl.gov/iespubs/58138.pdf

Ragwitz M, Held A, Stricker E, Krechting A, Resch G, Panzer C (2010) Recent Experiences with Feed-in Tariff Systems in the EU: a research paper for the International Feed-In Cooperation. A report commissioned by the Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Bonn, Germany

Ragwitz M, Held A, Breitschopf B, Rathman M, Klessmann C, Reche G, Panzer C, Busch S, Neuhoff K, Junginger M, Hoefinagels R, Cusumano N, Lorenzoni A, Burgers J, Boots M, Konstantinaviciute I, and Weores B (2011) D8 Report Review on Support Schemes for Renewable Electricity and heating in Europe. A Report compiled for RE-Shaping, No. EIE/08/517/512.529243, Intelligent Energy Europe. Available from: www.reshaping-respolicy.eu/downloads/D8%20Review%20Report_final%20(RE-Shaping).pdf. Cited 11 Oct 2011

Reiche D, Bechberger M (2004) Renewable energy policy in Germany: pioneering and exemplary regulations. Energy Sustain Dev VIII(1):25–35

REN21 (2011) Renewables 2011 Global Status Report. REN21 Secretariat, Paris

Resch G, Ragwitz M, Held A, Faber T, Haas R (2007) FEED-in tariffs and Quotas for renewable Energy in Europe. CESifo DICE Report 4/2007 (accessed from http://www.cesifo-group.de/portal/pls/portal/docs/1/1193138.PDF on 11/11/2011)

Reuters (2011) China to Tax the Most Energy-Hungry of Industries, by Mridul Chadha

Swedish Environment Protection Agency (1997) Environment taxes in Sweden, Stockholm

Tanaka K (2011) Review of policies and measures for energy efficiency in industry sector. Energy Policy 39 (10):6532–6550

UNEP (2006) Improving Energy Efficiency in Industry in Asia: A Policy Review. Available at www.energyefficiencyasia.org

UNEP (2007a) Building and Climate Change: Status, Challenges and Opportunities. ISBN 978-92-807-2795-1, DTI/0916/PA. UNEP DTIE, Paris

UNEP (2007b) Handbook for drafting laws on Energy Efficiency and Renewable Energy Resources www.unep.org/law/PDF/UNEP_Energy_Handbook.pdf. Cited 20 Dec 2011

UNEP Risoe Center (2012) CDM/JI Pipeline Analysis and Database. 1 January, 2012 http://cdmpipeline.org/

UNIDO (2008) Advancing Industrial Energy Efficiency in the Post-2012 Framework. Expert Group Meeting Workshop Report. Lawrence Berkeley National Laboratory, Washington 22–23 September 2008. Retrieved from http://www.unido.org/fileadmin/user_media/Services/Energy_and_Climate_Change/EPP/Conferences/2008-09-22_EGM_Advancing_Industrial_Energy_Efficiency/Report_UN-Energy-EGM_Report_Final.pdf

United Nations (1998) Kyoto Protocol to the United Nations Framework Convention on Climate Change. Retrieved from http://unfccc.int/resource/docs/convkp/kpeng.pdf
Urban F, Benders RMJ, Moll HC (2009) Renewable and low-carbon energies as mitigation options of climate change for China. Clim Chang 94:169–188
Valentine SV (2011) Japanese wind energy development policy: grand plan or group think? Energy Policy 39:6842–6854
Wiser R, Bolinger M (2010) 2009 Wind Technologies Market Report LBNL-3716E USDoE
World Bank (2010) Cities and climate change mitigation: case study on Tokyo's Emission Trading System. Padeco
World Energy Council (2008) Energy Efficiency Policies around the World: Review and Evaluation Executive Summary. London: WEC. Retrieved from http://www.worldenergy.org/documents/energy_efficiency_es_final_online.pdf
Wu Yong (2006) Report based on Ministry of Construction surveys (incomplete)
Wuppertal Institute (2011) Domestic Emission Trading Systems in developing countries—State of Play and Future Prospects. JIKO Policy Paper 2/2011
Wüstenhagen R, Bilharz M (2004) Green energy market development in Germany: effective public policy and emerging customer demand. Energy Policy 34(2006):1681–1696
Zhengen R, Greg F, Wan-Yee C, Dong C, Mike S (2011) Auszeh design: software for low-emission and zero-emission house design in Australia. In: Proceedings of Building Simulation 2011: 12th Conference of International Building Performance Simulation Association, Sydney, 14–16 November. Retrieved from http://www.bounceinteractive.com/bs2011/bs2011/pdf/P_1121.pdf