INTERGOVERNMENTAL PANEL ON climate change
Working Group III – Mitigation of Climate Change

Chapter 15

National and Sub-national Policies and Institutions

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Chapter:	15	
Title:	National and Sub-national Policies and Institutions	
(Sub)Section:	All	
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Remarks:	Second Order Draft (SOD)	
Version:	1	
File name:	WGIII_AR5_Draft2_Ch15.docx	
Date:	22 February 2013	Template Version: 8

Table of changes

No	Date	Version	Place	Description	Editor
1	09.01.2013	01		Initial Version	RRB

Chapter 15: National and Sub-National Policies and Institutions

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Executive Summary

This chapter assesses national and sub-national mitigation policies and institutions. It focuses mainly on common, crosscutting issues across sectors. Sector-specific policies are assessed in greater detail in the individual sector chapters. The chapter examines the strengths and weaknesses of various mitigation policies in terms of environmental effectiveness, cost-effectiveness, distributional incidence, and public acceptability. It offers guidance for how they may best be combined and when they may be in conflict. Our major findings are summarized as follows.

Institutions and Governance [15.2, 15.7, 15.9]

Policies are implemented through institutions and their processes of governance. They colour the way in which problems are perceived; they can influence decisions about appropriate policy goals or objectives, and shape which instruments are considered to be most acceptable in attaining a policy goal. Choice of institutions is therefore an important first step for climate change mitigation [15.2]

There has, in most but not all regions, been a considerable increase in national plans and strategies to address climate change since AR4. These are far ranging in scope and adopt multiple approaches. Mitigation of climate change is increasingly occurring in the context of multiple-objective policy-making. A key example is the integration of climate policy with development planning in developing countries (*robust evidence, high agreement*). [15.2, 15.7]

Assessment of the Performance of Policy and Measures

Three broad categories of policies can be implemented by governments: A price signal on emissions; policies to remove barriers to acting on the price signal; and policies for long term change. The last two categories could include fiscal measures related to taxes, charges, subsidy removal; public financing policies such as low-interest loans; regulations such as quantity driven policies like quotas, price driven regulations like feed-in tariffs for renewables or heat. They can be sector specific and can be implemented at the local, state, provincial, and national levels.

There is no best policy. Different policies play different roles. A combination of policies that meets all three roles mentioned above will be most effective. Policies should be designed and adjusted so as to complement rather than substitute for other policies in the same and other jurisdictions [15.7.3, 15.8]. Appropriate designs depend on national and local circumstances and institutional capacity. These categories are complementary when policy packages are designed to take advantage of synergies and avoid negative interactions. [15.8]

Economic Instruments

Emissions taxes and cap-and-trade systems are cost-effective policy instruments; by raising the price of carbon, they induce consumers and firms to reduce emissions in the least costly way (*medium evidence, high agreement*). Elimination or reduction of subsidies to fossil energy can result in major emission reductions at negative cost *(robust evidence, high agreement)*. In most countries (particularly low and middle-income countries), carbon and fuel taxes are progressive or neutral with the rich paying an equal or greater proportion of their income than the poor. Kerosene in low-income countries is an exception, with taxation being regressive *(robust evidence, high agreement)* Carbon and fuel taxes have often been initially resisted but once introduced, the level has often been raised and this has been acceptable *(medium evidence, medium agreement)*. Hypothecated instruments such as refunded emission payments make a higher fee level possible and thus may make possible more environmental improvement *(medium evidence, medium agreement).* [15.5.2]

Emission trading systems are still a new instrument in the climate arena, the caps have typically been fairly lax, and thus permit prices moderate or low *(robust evidence, high agreement)*. Like carbon taxation, emissions trading establishes a price on emissions; in this case the price is the price of emissions allowances. Grandfathering permits makes them more politically acceptable but this has to be designed so as to avoid perverse incentives to increase emission *(medium agreement, medium evidence)*. [15.5.3]

Linking or harmonizing initially separate climate policies can reduce costs, but there are significant challenges involved in linking systems internationally. Linking two cap and trade systems may substantially alter the distribution of wealth among entities involved, and it might be necessary to negotiate a side-payment for compensation *(medium evidence, high agreement).* [15.8]

Barrier removal policies

Carbon pricing alone is not always enough to encourage firms and individuals' to take actions because their behavior is often hampered by "barriers" such as costs of acquiring and processing information. A range of barrier-removal policies for energy efficiency improvement including regulations, information measures, energy management systems, energy audits and so forth, often bring about energy efficiency improvement and greenhouse gas emission cuts at negative to low cost to society when assessed at individual policy instrument level *(robust evidence, high agreement)*. Rebound effects partially offset the environmental effectiveness of such policies, but the policies can still be valuable since they allow economic growth with low carbon intensity *(medium evidence, high agreement)*. [15.5.4]

Voluntary agreements may also serve as a barrier-removal policy. Successful voluntary agreements are characterized by a strong institutional framework, consisting of capable industrial associations, and governmental will, capacity, and involvement in review processes. The strengths of voluntary agreements are speed and flexibility in phasing measures, and facilitation of barrier removal activities. Regulatory threats, even though the threats are not always explicit, are also an important factor for firms to be motivated. On the other hand, there are few environmental impacts without a proper institutional framework *(medium evidence , high agreement).* [15.5.5]

Long-term policies for new technology and infrastructure

Price instruments are insufficient to stimulate sufficient investment in new technologies. Complementary technology specific policies are therefore required new technologies and system practices that lower emissions are to be developed and deployed to their full potential. The main reason for this is that there is a second market failure in addition to the failure to internalize damages from greenhouse gases. This failure is that of the market for protection of intellectual property rights (for example the patent market). Because of this failure, private investments in non-fossil energy production and in efficiency of energy use are less than socially optimal and there is an argument in favour of subsidies. Technology policy is more than government subsidies to R&D – it includes assistance for commercialization and technology transfer. For example, such policies have fostered cost reductions in renewables like wind energy and solar PV. *(robust evidence, high agreement)* [15.6].

Policy Packages and Interaction among Policy Instruments

Appropriate policy package of regulations, information measure, voluntary agreements, and public provision of infrastructure can address market failures and thus complement economic instruments. Research into new technologies may be necessary to create the political acceptability for a carbon pricing policy. *(medium evidence , high agreement)* [15.5-8].

Without coordination, policy instruments may not work as expected. Environmental effectiveness of regulations may be undermined by the rebound effect unless carbon pricing is used in conjunction with regulations. Without regulations there may be barriers to internalizing carbon prices. In the land use sector, appropriate government planning and provision of infrastructure is crucial. Otherwise, the additional costs of achieving significant emission reduction might be prohibitive. *(medium evidence , high agreement)* [15.5].

Tradable permit policies, unlike taxes and other policies, can cancel the emission reduction from other policies within the capped sectors. For example, the additional emission reduction from carbon taxes in a EU party may be offset by increased emission in the rest of the EU due to the EU ETS). One possible way of addressing this problem in cap-and-trade schemes is to create an institutional mechanism to tighten the cap in response to other policies so that their effects are not offset by permit trading. (*medium evidence , high agreement*) [15.7.4.2, 15.8.3]

National, State and Local Linkages

Climate relevant actions at the sub-national level are increasing, often in the context of local development choices *(robust evidence, high agreement)*. When there is synergy between these actions and development goals, they can result in effective outcomes that inspire the national level. However, care needs to be taken to avoid carbon leakage and collective action problems *(medium evidence, high agreement)*. [15.8] There is increasing evidence of activities by NGOs and civil society, with varied impacts on policy formation and implementation (*medium evidence, medium agreement*). [15.9]

Capacity Building [15.10]

Since environmental considerations cannot be appreciated without information, knowledge, tools and skills, capacity building is central to the sustainable development agenda. The needs for capacity building include: leadership capacity, capacity to formulate, implement and evaluate policies, public sector and private sector capacity, and capacity on both non-conventional and conventional energy sources *(medium evidence, high agreement)*. [15.10]

Links of Mitigation to Adaptation [15.11]

Mitigation and adaptation policies are largely independent of each other, given that mitigation requires global cooperation on public goods while adaptation takes place in local context. Still, there are areas of human activity with profound effects on both of them. An example is land-use planning. Urban sprawl and monoculture in farming are examples of poor land use planning process with significant impacts on climate change and adaptation capacity *(medium evidence, medium agreement)*. [15.11]

Investment and Finance [15.12]

Financing climate adaptation and mitigation in developing countries is crucial from the viewpoint of welfare and equity. In an attempt to cope with the increasing multiplicity of sources, agents and channels offering financial resources for adaptation and mitigation activities, a number of developing countries have established national funding entities to coordinate domestic and international funding with this development funding *(medium evidence, high agreement).* [15.12]

15.1 Introduction

This chapter assesses national and subnational mitigation policies and the institutional setting in which they may be implemented. It begins by examining the development of institution and governance of climate change issues by nations (15.2). The next sections lay out the classification of polity instruments and packages (15.3) and methodologies used to evaluate policy and institutions (15.4).

After these introductory sections, the performance of policy and measures, including technology policy, are individually assessed (15.5, 15.6). The following sections further assess the interaction among policy instruments (15.7, 15.8), as they are not usually used in isolation and the impact of particular instruments depend on the entire package of policies and the institutional context.

Other key issues are further discussed in dedicated sections. They are: the role of stakeholders including NGOs (15.9), capacity building (15.10), links between adaptation and mitigation (15.11), investment and finance (15.12).

15.2 Institutions and Governance

15.2.1 Why institutions and governance matter

Policies are implemented through institutions and their processes of governance. Different countries have different policy paradigms, as understood as a dominant sets of ideas, policy goals and instruments that influence the way in which policy is formulated in a given policy area (Hall, 1993). They colour the way in which problems are perceived; can influence decisions about appropriate policy goals or objectives, and shape which instruments are considered to be most acceptable in attaining those goals (Hall, 1993, pp. 278–9). Policy paradigms and their institutions can also serve to limit the entry of new ideas (Radaelli and Schmidt, 2004; Mitchell, 2010); the way in which institutions are constituted can determine the set of policies that are discussed at all (Radaelli and Schmidt, 2004, p. 197). In these ways, the existing energy system exerts a strong momentum for its own continuation (Hughes, 1987), locking in existing technologies and policies in place and locking out new technologies and ways of doing things (Unruh, 2000, 2002; Walker, 2000) (Hay, 2002, p. 215). Changing perceptions and incentives, inducing new ideas, and avoiding harmful lock-in all require changes in institutions and governance so that appropriate policies for mitigation can be made and implemented (Ekstrom and Young, 2009). This section explores various mechanisms through which this shift is being and can be brought about, and draws some general lessons for the governance of climate mitigation policy.

15.2.2 Increase in government institutionalization of climate mitigation actions

Although, as seen in Chapter 5, the increase in global emissions since AR4 has shown no sign of slowing, there has been a discernible increase in formal national governmental efforts to promote climate mitigation as measured through introduction of legislation, policies, and coordination mechanisms. See **Figure 15.1**. These maps illustrate two categories of action: formal, legally binding climate strategy, and political, non-binding climate strategy at the national level (the definitions of these categories are in Annex 1). The data notably do not cover sub-national action, which is discussed further in 15.2.4 and 15.3. The map covers 185 countries, about 96% of all countries; data was unavailable for the remaining countries. The number of countries that have either legally binding or political non-binding national climate strategies has increased since the 4th Assessment Report was published. By 2012, 40% countries of the countries studied fell in one of these categories, while in 2007 only 23% did so. There has been a slight increase in the number of countries with formal legislation (18% in 2007 to 22% in 2012), and a larger increase in the number of countries with climate policies (5% in 2007 and 18% in 2012). There are also significant regional effects, with many additional countries from Latin America and Asia in particular adopting legislation or strategies during this period. Shifts in rules and norms brought about by such institutional and governance changes at the national level are worth documenting since, as discussed in 15.2.1, these changes change policy paradigms, provide openings to new ideas, and decrease the momentum toward continuation of existing systems, even if they are not always sufficient to bring about change.

Of 19 large economies in a recent study, two-thirds were found to have put in place both regulations and economic incentives for greenhouse gas mitigation, while one-third have in place some form of carbon price (Lachapelle and Paterson, Forthcoming; Townshend et al., 2011).

While widely discussed in the literature (See Section 15.5.3), in practice there are only a few efforts at imposition of carbon prices through a centralized cap and trade mechanisms such as the EU Emissions Trading Scheme (See Ch 14) or carbon taxes (see Section 15.5.2). Only 32% of major emitting countries have any carbon price in place.[1] By contrast 74% of these states have regulatory mechanisms such as standards in place. Common explanations for this variation are in terms of the novelty of these policy tools, especially emissions trading, the legitimacy problems faced by emissions trading (Paterson, 2010), popular opposition to increased taxation (see for example (Jagers and Hammar, 2009; Laurent, 2010)) and lobbying by fossil or energy-intense industry lobbies. More common are a variety of plans and strategies that stimulate and enable national and sub-national action, often organized by sector as discussed in 15.2.3.2.

In all countries, the local co-benefits of climate mitigation (reductions in air pollution, congestion, energy insecurity, and resource depletion), have been an important driving force for institution building and policy-making (Rogers et al forthcoming; (Gore et al., 2009; Rabe, 2009). This is especially so for developing countries (Dubash, forthcoming, 2011a; Kostka and Hobbs, Forthcoming; Teng and Gu, 2007; Richerzhagen and Scholz, 2008a; Tsang and Kolk, 2010; Hochstetler and Viola, 2012; Atteridge, 2013; Held et al., 2013). This means that institutions for climate policy-making usually have multiple objectives, that, while often synergistic, may sometimes be in conflict (see 15.7.2 below).

[1] Major emitting countries refers countries that were ranked the top 19 major emitters by absolute emissions in 2008 using World Bank data. (Lachapelle and Paterson *forthcoming*)

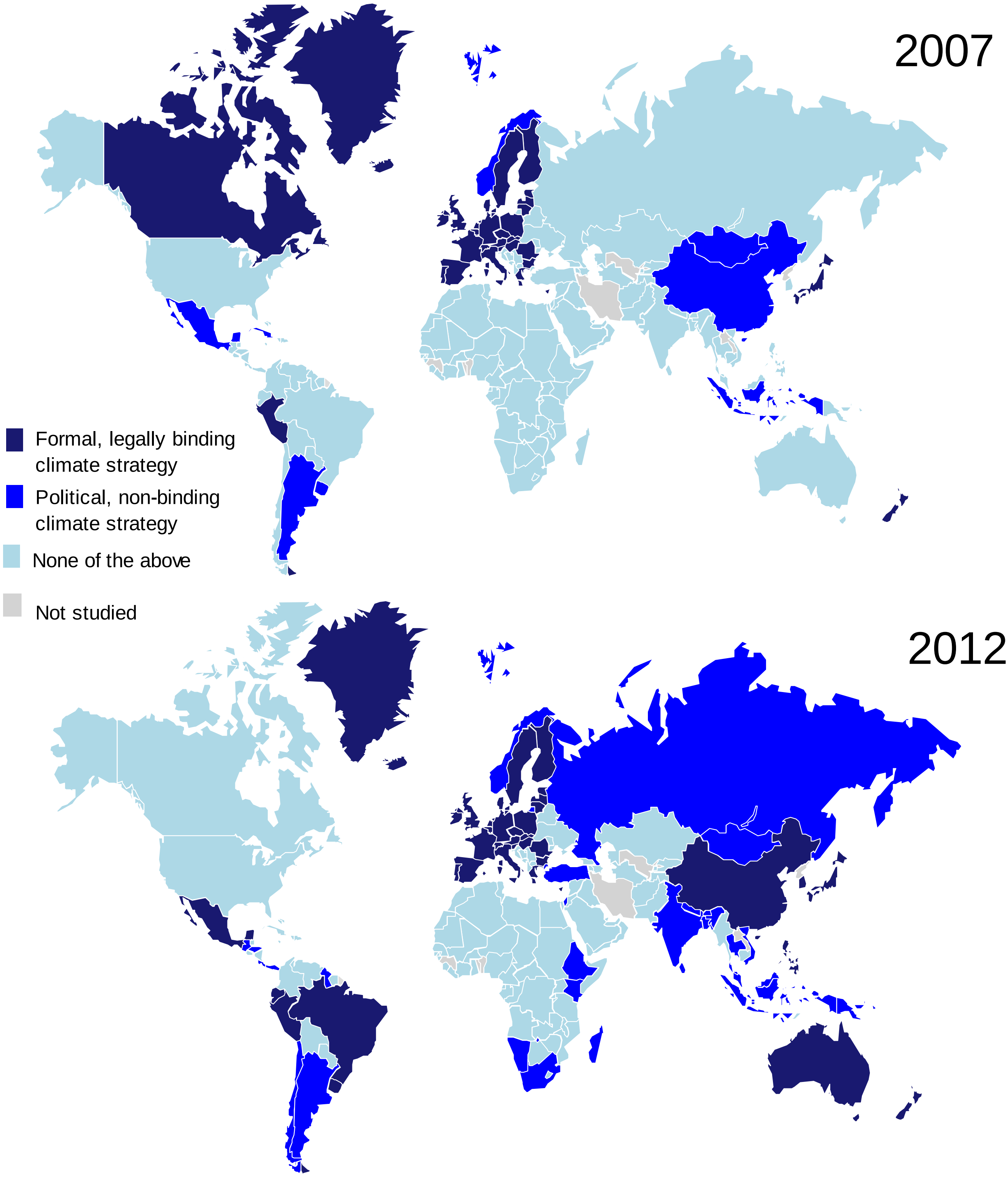

Figure 15.1. Comparison of change in policy and legislation over time.

In many countries, the formulation and implementation of national mitigation approaches are further delegated to sub-national levels, with differing levels of central coordination, depending on national contexts and institutions. Comparative analysis of cross-country climate action is insufficiently developed to allow generalization and explanation of different approaches to climate policy. Instead, country examples provide indications of broad trends.

In China, national action is defined by the central government, and continues to be closely monitored, even as implementation is delegated to provinces. Targets set in the subsequent National Climate Change Programme, such as a target to enhance energy efficiency by 20% by 2012, are implemented through a mechanism of provincial communiqués to track compliance with the target, and provincial leading groups to implement the target were established (Kosktka and Hobbs, Forthcoming; Teng and Gu, 2007; Qi et al., 2008; Tsang and Kolk, 2010; Held et al., 2011).

Belgium provides an example of a federated system with strong sub-national authority. In this case, Belgium's Kyoto targets were re-allocated to the regional level through a process of negotiation, followed by the preparation of regional climate plans to implement its targets (Happaerts et al., 2011).

India and Germany represent intermediate cases between central control and decentralization. In addition to its federal policies, the Government of India has directed states to develop State Action Plans on Climate Change. While they are predominantly focused on implementing national level directives, there is also sufficient flexibility to pursue state-level concerns, and a few states have created new mechanisms, such as the establishment of a Climate Change department in the state of Gujarat, and the establishment of a green fund in Kerala (Atteridge, Shrivastava, et al., 2012). In Germany, while the federal government initiates and leads climate action, the states or "Länder" have a veto power against central initiatives through representation in the upper house of parliament (Weidner and Mez, 2008a). In addition, however, the Länder may also take additional action in areas such as energy efficiency measures, renewable energy development on state property and even through state-wide targets (Biedermann, 2011).

In some countries sub-national actions in some cases have well exceeded national mitigation efforts. In Japan, local governments have developed action plans with targets that, in 40% of cases surveyed, went beyond national targets (Sugiyama and Takeuchi, 2008). For example, Tokyo has independently established Japan's first emission trading system, while Kyoto introduced an appliance labelling requirement that subsequently affected national policy. California has consistently led the rest of the United States in formulating and implementing both climate mitigation and environmental policy (Mazmanian et al., 2008; Farrell and Hanemann, 2009), 15.5.3.

In many countries, cities are particularly vibrant sites of subnational action, often operating in networks, and involving a range of actors at multiple scales (Betsill and Bulkeley, 2006a; Gore and Robinson, 2009). For example, in the Netherlands, the central government has established a programme that provides subsidies to municipalities to undertake various measures such as improvements in municipal buildings and housing, improved traffic flow, sustainable energy and so on (Gupta et al., 2007). In Brazil, important cities such as Rio de Janeiro and Sao Paulo have taken specific measures that go beyond national policies. For example, a 2009 Sao Paulo law commits the state to undertake mandatory economy-wide GHG emission reduction targets of 20% by 2020 from 2005 levels. 'Horizontal' forms of multi-level governance through networks and partnerships have been prominent in producing urban climate change policy (Hodson and Marvin, 2010; While et al., 2010; Bulkeley and Schroeder, 2011; Bulkeley and Castán Broto, 2012).. In contrast, there is more limited evidence that 'vertical' multi-level governance (in the form of regional, national, and international agencies) has been explicitly engaged in promoting urban responses but rather that this has rather created the 'permissive' or 'restrictive' context within which urban responses have developed (Betsill and Bulkeley, 2006b; Betsill and Rabe, 2009). In some cases countries have set in place explicit mechanisms for coordination of national and sub-national action, such as in China and India, but there is insufficient evidence to assess the effectiveness of these mechanisms. More typical is relatively uncoordinated action and experimentation at sub-national level, particularly focused on cities. These issues are discussed further in Section 15.8.

15.2.3 Approaches to climate governance

National and provincial climate change governance takes a variety of forms, partly in response to existing political, economic and institutional contexts. These approaches, as discussed above, may be articulated in the form of legislation or as policy plans and strategies. Some countries have explicitly passed national climate change legislation, such as Japan (Sugiyama and Takeuchi, 2008) and the United Kingdom [Author note: need cite] with explicit reduction targets as enshrined in the Kyoto Protocol. Other countries, notably EU countries such as Germany (Weidner and Mez, 2008b), France (Mathy, 2007) and Italy (Massetti et al., 2007) have no overarching national legal climate framework, but operate within the framework of EU directives. Many countries have opted for a patchwork of arrangements that delegate and enable, with various levels of precision and specificity, emission mitigation actions to subnational levels or to sectors.

Many countries have approached the development of national plans and strategies on a *sector by sector* basis. One important metric by which such efforts may be measured is the extent to which they successfully integrate economic development and climate change in sectoral planning. Countries have a variety of different approaches to this process of integration. For example, in France, sectoral approaches are devised at the central level through negotiation and consultation between multiple ministries, experts, business and NGOs. According to at least one analysis, this approach risks a dilution of measures through the influence of lobbies that may lose from mitigation actions (Mathy, 2007). In Germany, mitigation efforts were broken down by sectors for the period between 2008 to 2012, with the national "Allocation Act 2007" specifying emissions budgets for sectors participating in the EU Emissions Trading Scheme as well as the remaining sectors (Mehling, 2005).

Brazil's climate approach is based on national sector-specific plans to reduce emissions by stipulated absolute amounts so as to add up to the overall planned reduction, with a particular importance given to the forest sector (Da Motta, 2011; La Rovere, 2011). Responsibility for sector specific approaches rests with sectoral ministries complemented by a multi-stakeholder forum to solicit views and forge consensus. Progress on the Brazilian plan was enabled by prior domestic political consensus around a far-reaching Forest Code, suggesting the importance of specific sector politics in shaping national climate policies (Hochstetler and Viola, 2011)

The Indian National Action Plan on Climate Change was built around the establishment of eight national 'missions' aimed at integrating mitigation and adaptation aspects of climate change into national policies across a range of sectors (Dubash, forthcoming, 2011b; Prime Minister's Council on Climate Change, 2007; Atteridge, Srivastava, et al., 2012). The significant design challenge faced was winning buy in from existing bureaucracies while still retaining sufficient flexibility to generate new ideas.

The South African policy White Paper envisages sectorally focused actions (Marquard, 2006). The integration of climate considerations into electricity planning, backed by a process of stakeholder consultation provides a particularly instructive example of the tensions associated with mainstreaming climate change into a major economic sector (See Box 15.1).

Box 15.1 Mainstreaming carbon constraints in electricity planning in South Africa

Electricity planning in South Africa illustrates how considerations of carbon constraints have been increasingly integrated into sectoral planning. Energy policy in South Africa provides for integrated resource planning (IRP) in the electricity sector (DME, 1998) based on an approach that begins with assessment of demand for energy services and balancing and integrating those considerations with planning of supply (Marquard, 2006).

The Integrated Resource Plan of 2010 (IRP2010) was different in important respects. In earlier plans, cost minimization had been the single objective of optimization models informing (Department of

Energy, 2011). IRP2010 considered multiple criteria much more completely, with carbon prominent among these. Several scenarios explicitly considered a constraint of 275 Mt CO2–eq for the electricity sector by 2025. Other possible plans modeled in the process of developing IRP2010 considered a carbon tax, and all plans reported on emissions implications. This shift was informed politically by the pledge made by South Africa in Copenhagen, for emissions to peak, plateau and decline, with an assumption that electricity would take half of the implicit limit of 550 Mt. While different views remain whether this fully aligns electricity planning with subsequent climate policy in South Africa (Republic of South Africa, 2011), IRP2010 mainstreamed carbon into electricity planning to a significant extent. This shift in approach was also accompanied by a change of process, with more extensive consultations through an inter-departmental task team convened by the DoE.

The Chinese case provides an example of a sectoral approach that is overseen by a strong central authority. The creation of a 'National Leading Group on Climate Change' in June 2007, housed in the apex National Development and Reform Commission and chaired by the premier (Tsang and Kolk, 2010) signaled high political profile and authority for coordination of climate change policies. Through this coordinating institution, targets set in the subsequent National Climate Change Programme, such as a target to enhance energy efficiency by 20% by 2012, were converted to sectoral targets. In addition, a mechanism of provincial communiqués to track compliance with the target, and provincial leading groups to implement the target were established (Kosktka and Hobbs, Forthcoming; Teng and Gu, 2007; Qi et al., 2008; Tsang and Kolk, 2010; Held et al., 2011). A range of policy mechanisms were used to implement this target, such as differential energy prices based on energy efficiency performance, promotion of energy audits, and financial incentives for performance (Held et al., 2011).

As discussed further in Section 15.8.3 below, an *exclusively* sectoral approach misses the opportunity to increase the scope, environmental effectiveness, and cost-effectiveness of mitigation policy and its co-benefits, by also using economic instruments – taxes or emission trading systems.

In several countries and provinces, the involvement of finance ministries in mitigation policy or the creation of an authority for emissions trading, has made the use of these instruments possible. While several jurisdictions, the EU, California, Australia, New Zealand, and Korea being prominent examples, have opted for creating an authority to implement carbon trading, others, such as the UK, British Columbia, the Netherlands, and several Scandinavian countries have adapted existing finance ministries and revenue collection machinery to implement carbon or other broad taxes on fossil fuels.

Countries that follow the exclusively sector-based approach and wish to avail of the opportunity of expanding coverage and cost-effectiveness need to consider whether to make use of the existing tax collection system and use taxes, or to set up a new institution for carbon trading. From an institutional perspective, the former is, of course, simpler.

15.2.4 Conclusion

The evidence on institutional change and new patterns of climate governance is limited, as many countries are in the process of establishing new institutions and systems of governance. However, a few trends are visible. First, there is a considerable increase in government-led institutionalization of climate action through both legislation and policy since AR4. Second, there is considerable diversity in the forms of action. While there are only a few cases of national or regional economy-wide carbon price setting efforts, more common are sectoral approaches to climate mitigation or delegated action to sub-national levels, often embedded within national climate policy frameworks. Third, there is a profusion of activity at sub-national levels, particularly urban areas, much of which is only loosely coordinated with national actions. Fourth, the existence of co-benefits is a particularly strong rationale for climate action. Finally, achieving mitigation and its co-benefits requires institutional innovation and adaptation of institutions that have been heavily moulded by the fossil fuel economy. For example, adding carbon pricing to the policy mix via taxation requires the integration of finance ministries into climate policy making, while adding it via emissions trading requires a new institution.

15.3 Characteristics and classification of policy instruments and packages

This subsection presents a brief and non-exhaustive description of the main policy instruments and packages, using the common classification set by Section 3.8 (Chapter 3). Most of these instruments will be assessed with the common evaluation criteria set by Chapter 3 (see Section 15.5 through 15.8) in most of the remaining parts of this chapter. As indicated in Section 15.2, these instruments are introduced within an institutional context that obviously influences their design and implementation.

15.3.1 Economic instruments

Economic instruments are sometimes termed “market-based” approaches because they use pricing approaches in environmental and climate change policies. There are several categories of economic instruments for climate change mitigation, mainly: taxes (including charges and border adjustments), emissions trading schemes and subsidies/subsidy removal.

Taxes and charges are defined as a payment for each unit of greenhouse gas released into the atmosphere and in the case of climate change are usually unrelated to the provision of a service (taxes). They can be levied on different tax bases, mostly GHG emissions or the consumption of products that are highly linked to GHG emissions. Tax rates, given the global and uniform characteristics of the taxed emissions, usually do not show spatial variation (OECD, 2001). In the last years many GHG or energy taxes have devoted part of their revenues to the reduction of other distortionary taxes (green tax reforms), although other revenue uses (distributional offsets, energy efficiency, etc.) are playing an increasing role (Ekins and Speck, 2011).

Border tax adjustments are related instruments that intend to solve the dysfunctions of variable climate change regulations across the world. Although some authors see them as a solution to the problem of leakage and a contribution to a wider application of climate change policies (Ismer and Neuhoff, 2007), others see potential threats to the functioning of the global trade system in their application (Cendra, 2006).

In ‘cap and trade’ *emission trading systems* regulators establish an overall target of emissions and issue an equivalent number of emissions permits. Permits are subsequently allocated among polluters and trade leads to a market price. The allocation of emission permits can be done through free distribution (by either grandfathering, output allocation or benchmarking) or through auctioning, which could allow the use of revenues (see above: taxes). In ‘baseline and credit’ emission trading systems, polluters may create emission reduction credits (often project-based) by emitting below a baseline level of emissions (Stavins, 2003).

15.3.2 Regulatory approaches

Regulatory approaches are widely used in climate policies all around the world. They establish a rule and/or objective that must be fulfilled by firms and individualist can be used as a part of a technology policy to create niche markets for new technologies or more generally to increase the scale of production in these areas. Another role of the regulatory approach is to help firms and individuals to overcome various behavioural and other barriers to low cost mitigation.

The second role is of particular importance since carbon pricing alone is not enough. For various reasons, including the private cost of acquiring and processing information, firms and individuals are often far from being collectively economically rational given the price structure. As a consequence, significant theoretical potential for reduction of greenhouse gas emissions at low cost has been reported, particularly in the area of energy efficiency. Governments can influence firms and individuals to behave more rationally by providing an appropriate choice architecture to assist rational choice with regard to efficient energy use. Regulatory measures, as the key elements of such an architecture, have been widely used by governments in such context.

15.3.3 Information programs

As mentioned above, a typical market failure in the environmental domain is the lack of relevant information among firms and individuals. Good quality information is essential for identifying environmental challenges, better designing and monitoring the impacts of environmental policies, and providing relevant information to inform consumption and production decisions. Examples of information instruments include eco-labelling or certification schemes for products or technologies and collection and disclosure of data on GHG emissions by significant polluters (Krarup and Russell, 2005).

15.3.4 Government provision of public goods or services

Conventional actions and programs by governments, in many cases without climate change concerns, may have profound effects on GHG emissions. This is the case of physical and infrastructure planning, provision of public transportation services (Grazi and Van den Bergh, 2008), and funding and provision of research activities (Metz, 2010). Moreover, the removal of institutional and legal barriers that promote GHG emissions (or preclude mitigation) should be included in this policy type.

15.3.5 Voluntary actions

Voluntary actions include totally voluntary business activities and voluntary agreement. Voluntary agreements are agreements between a government authority and one or more private parties to achieve environmental objectives or to improve environmental performance beyond compliance to regulated obligations. Voluntary agreements can take on many forms. Some may involve incentives (rewards or penalties) for participation. Firms may agree to direct emissions reductions or to indirect reductions through changes in product design. Agreements may be stand-alone, but they are often used in conjunction with other policy instruments.

15.4 Approaches and tools used to evaluate policies and institutions

15.4.1 Evaluation Criteria

Several criteria have been usually employed to assess the effects of climate change policies and these have been laid out in Chapter 3. The criteria that have been used are environmental effectiveness, economic effectiveness (cost-effectiveness and economic efficiency), distributional equity and broader social impacts, institutional, political, and administrative feasibility and flexibility.

15.4.2 Methods

The implementation of mitigation policy is a multi-decade undertaking, therefore lessons learned about the relative effectiveness of different policy instruments and implementation methods can be used to improve the efficacy of policy over time. This requires a systematic approach to the evaluation, assessment and comparison of policies as they are implemented. In order to evaluate a policy instrument, one wishes to assess what impact the instrument or method had. This requires comparing the observed evolution of the situation the policy was intended to affect with what would have occurred in the absence of the policy.

Statistical methods can be used to attempt to control for the evolution of the world in the absence of the policy. The most reliable basis for estimating counterfactual developments is to build program evaluation into the design of programs from their inception (Jaffe, 2002). If the planning of such evaluation is undertaken at the beginning of a program, then data can be developed and maintained that greatly increase the power of statistical methods to quantify the true impact of a program by controlling for but-for developments.

The ex-post data analyses would be useful if data is available (also see Chapter 3). However, it is essential to use theory in some cases because the data that we require are not available. Economic theory is useful to the understanding of economic policies and instruments. The policies and instruments discussed in this chapter are modelled theoretically and advantage and disadvantage are analyzed.

Several simulation analyses are utilized and one technique is Computable General Equilibrium (CGE) models. Climate change policies are likely to have important macroeconomic effects due to their impacts on different markets. Therefore, general equilibrium approaches are necessary to provide a comprehensive and reliable analysis of such effects. CGEs have become a standard operational tool to evaluate climate change policies at subnational, national or supranational levels, measuring their effects on resource allocation and distribution as relative changes with respect to a benchmark (see, for e.g. Bohringer et al., 2006).

There are also cases several policies had been proved to be effective theoretically, but it was difficult to evaluate the effectiveness in the real world before and immediately after those schemes were introduced. Laboratory experimental is one of the useful methods to help understand how markets function as they are expected (Falk and Heckman, 2009). Laboratory experiment is the application of experimental economics methods to study economic questions related to emissions trading scheme and other public bads (Kotani et al., 2011). Laboratory experiments are useful in testing theoretical results and evaluating newly devised schemes. Cash-motivated subjects are used to create real-world incentives in the experiment.

Many policies often take place simultaneously. Example includes air pollution and CO_2 emission. Therefore, it may be necessary to sort out interaction among policies to understand the effect of each policy. In general, abatement decisions cannot be made separately for each emission level (Kumar and Managi, 2011). Quantifying the interactions among polices is, therefore, not straightforward.

Qualitative analyses or case studies are used when specific cases need to be analyzed. Commonly, the goal of case studies is to permit analytic generalisations about the subject of interest.

FAQ 15.1 What kind of evidence and analysis will help us design effective policies?

Economic theories and numeric model calculations are useful to understand the concept and the scale of the impact of alternative mitigation policies. However, as they use a set of simple assumptions, it is desirable that they are complemented by ex-post policy evaluations whenever feasible. For example, theories and bottom up models predict that some energy efficiency policy can deliver CO2 cut at negative costs, but we need ex-post policy evaluation to know when they really do. Moreover, it is useful to build evaluation into the design of a program or policy in order to evaluate its success and improve it.

15.5 Assessment of the Performance of Policies and Measures

15.5.1 Introduction

In this section we assess the performance of a series of policy instruments and measures, starting with economic instruments (taxes in 15.5.2, emissions trading in 15.5.3), regulatory approaches (15.5.4), information programs (15.5.5), government provision of public goods (15.5.6) and voluntary agreements (15.5.7). The assessment is not completed in this section, however. We go on to assess aspects of these and other policies in Section 15.6 on technology and R&D policy, and in Section 15.7

that deals with interactions between policies. We provide a summary of the conclusions of these three sections (15.5 to 15.7) jointly in Section 15.7.4.

15.5.2 Taxes, Charges, and Subsidy Removal

15.5.2.1 Overview

Taxes on carbon (together with emission trading systems) are called economic instruments because in the presence of rational consumers, firms and complete markets, they achieve any given level of emissions reduction in the least costly way possible. A carbon tax is attractive because of its broad scope, which covers all technologies and fuels (Section 3.8). A carbon tax will evoke the cost-minimising combination of actions such as changing inputs in production and technologies to changing behaviour as manifested in consumption choices. This is the reason a carbon tax will normally be more efficient than directly regulating technology, products or behaviour[2]. To minimize administrative costs, a carbon tax can be levied "upstream" (at the points of production or entry into the country). Finally, unlike an emission trading system that requires new administrative machinery, a tax can piggyback off existing revenue collection systems.

Despite these attractive properties, carbon taxes are not nearly as prevalent a policy instrument as one might expect. As yet, the Scandinavian countries, the Netherlands, the UK, Australia (temporarily until it switches to an ETS), and the Canadian province of British Columbia are the only large jurisdictions with significant carbon taxes of at least \$10/tCO2. The reasons for this are not entirely clear. It may be that a carbon tax, unlike a narrower sectoral regulation, attracts more hostile lobbying from fossil fuel interests[3] for whom the stakes it creates are high (Hunter and Nelson, 1989; Potters and Sloof, 1996; Goel and Nelson, 1999; Skjærseth and Skodvin, 2001; Godal and Holtsmark, 2001; van den Hove et al., 2002; Kolk and Levy, 2002; McCright and Dunlap, 2003; Markussen and Svendsen, 2005; Beuermann and Santarius, 2006; Pearce, 2006; Deroubaix and Leveque, 2006; Pinkse and Kolk, 2007; Bridgman et al., 2007; Jones and Levy, 2007; Bjertnæs and Fæhn, 2008; Blackman et al., 2010; Sterner and Coria, 2012). Secondly, the payments required by a tax are transparent, unlike the less visible costs of regulations. The general public, not being aware of the above-mentioned properties of a tax, may be less than enthused by this instrument (Brännlund and Persson, 2010). Finally, policy may be driven by perceived risks to competitiveness and employment as well as the distribution of costs rather than on considerations of pure efficiency (Decker and Wohar, 2007).

Countries that have sizeable general carbon taxes are fewer still – mainly a few Northern European countries. The carbon tax in Sweden is 1100 SEK or 165 USD/ton, which is an order of magnitude higher than the price of permits on the EU ETS market or than the carbon taxes discussed in many other countries. Such high taxes typically have some exemptions motivated by the fact that other (competing) countries have no taxes and industry only has to buy EU ETS permits. Sweden, for example, exempted the large energy users who participate in the EU ETS from also paying the carbon tax on the ground that there would otherwise be some form of "double" taxation (See Section 15.5.2.4 for a more thorough discussion on exemptions).

Although carbon taxes are so far uncommon, taxes on fuels, especially transport fuels are very common. While narrower in scope, they nevertheless cover a significant fraction of emissions in many countries. These can be interpreted as sectoral carbon taxes; in some countries this is clearly stated as an objective of fuel taxes, in others it is not. They may be politically easier to implement in

[2] If psychological or institutional barriers to adoption are the main factor impeding choice then regulations or other instruments may be an efficient complement or stand-alone instrument to deal with this (15.4).

[3] These can be either producers (for instance of fossil fuels) or users of energy, ranging from energy intensive industries to truck drivers.

some countries since (private) transport is hardly subject to international competition and hence leakage rates are low. A large share of all revenues from environmentally related taxes in fact come from fuel taxes which were introduced in various countries, beginning with Europe and Japan, though they are also common in low income, oil-importing countries. One of their main stated purposes is to finance road building, although additional arguments include expensive imports, government revenue raising, and reducing environmental impacts. Irrespective of the motivation, the effect of carbon taxes on fuel is to raise prices to consumers and restrict demand. This is important since the transport sector represents a big and increasing share of carbon emissions (22% of global energy-related CO_2 emissions in 2010 - see chapter 8). Theory and simulation studies suggest strongly that taxing fuel is a lower cost method of reducing emissions compared to policies such as fuel efficiency mandates, driving restrictions, or subsidies to new technologies (Austin and Dinan, 2005). A possible counterargument is that consumers who buy vehicles are unable to correctly internalize the long-run savings of more fuel-efficient vehicles. This would be "a barrier" and provide motivation for having fuel efficiency standards in addition to fuel taxes (see 15.5.4).

Variation in fuel prices is generated by subsidies as well as taxes. Fossil fuel subsidies are prevalent in many countries, being most common in oil and coal producing countries. In 2008, fossil fuel subsidies – for transport fuels, electricity, tax breaks for oil and gas production, and for research and development into coal generation – exceeded $500 billion globally – exceeded $500 billion globally (International Energy Agency and Organisation for Economic Co-operation and Development, 2011). In at least ten countries, fossil fuel subsidies exceeded 5 percent of GDP, and constituted substantial fractions of government budgets (International Energy Agency and Organisation for Economic Co-operation and Development, 2010). Subsidies for oil product consumption are the largest of these, followed by subsidies for the electricity and coal sectors.

For transitional economies such as China, energy subsidies are a part of the historical legacy of planning. However it is clear that such subsidies are detrimental to climate objectives and costly for the economy. (Lin and Jiang, 2011) have shown that China's energy subsidies amounted to 1.4% of GDP in 2007.

15.5.2.2 Environmental effectiveness

Assessing the environmental effectiveness of carbon taxation is not straightforward because multiple instruments and many other factors co-evolve in each country to produce policy mixes with different outcomes in terms of emissions. For example, energy taxes varying by sector have been prominent in the Nordic countries since the 1970's with carbon taxes being added on in the early 1990's. Ex-post analyses have found varying reductions in CO2 emission from carbon taxes in Norway, Sweden, Denmark, and Iceland, compared to business-as-usual (see (Andersen, 2004) for an extensive review of these studies and their estimation techniques).

During 1990 to 2007, the CO2 equivalent emissions in Sweden were reduced by 9% while the country experienced an economic growth of +51%[4] (OECD, 2000; Hammar and Akerfeldt, 2011). Per capita emissions in Denmark were reduced by 15% from 1990 to 2005; The experience in Scandinavia, the UK and the Netherlands was similar (Enevoldsen, 2005; Enevoldsen et al., 2007), (Bruvoll and Larsen, 2004)), (Cambridge Econometrics, 2005), (Berkhout et al., 2004; Sumner et al., 2011a; Lin and Li, 2011). In Sweden, which had the highest carbon tax (albeit with exemptions for some industrial sectors), we see a strong decoupling of carbon emissions and growth. **Figure 15.2** demonstrates that while there is a general trend to decreasing carbon intensity, the levels are much lower in Sweden and the UK compared to the whole OECD. Despite the low levels, the rate of decrease since 1990 has been lower – 40 to 45% in Sweden and the UK, respectively, compared to

[4] Figures are not identical to those in Figure 15.2 since the latter are in constant USD for comparison across countries while the numbers in the text for Sweden are in national currency.

slightly more than 25% for the whole OECD. Of course, many factors may be at play, and these differences cannot be attributed solely to differences in taxation.

UK's Climate Change Levy (CCL), introduced in 2001 on manufacturing plants and non-residential energy users (such as offices, supermarkets, public buildings, etc.), was found to have a strong impact on energy intensity (Martin et al., 2011). Electricity use, taxed at a rate of about 10%, declined by over 22% at plants subject to the levy as compared to plants that were eligible to opt out by entering into a voluntary agreement to reduce energy use. Exogenous eligibility to opt out was used to identify the causal effect of the tax. (Martin et al., 2011)) also provide evidence related to the cost of the tax. Remarkably, there was no evidence that the tax had any detrimental effect on economic performance or led plants to exit from the industry.

Overall, the evidence suggests that carbon taxes, as part of an environmental tax reform, can deliver real greenhouse gas emission reductions and raise revenues to finance government spending and lower income tax rates without threatening employment.

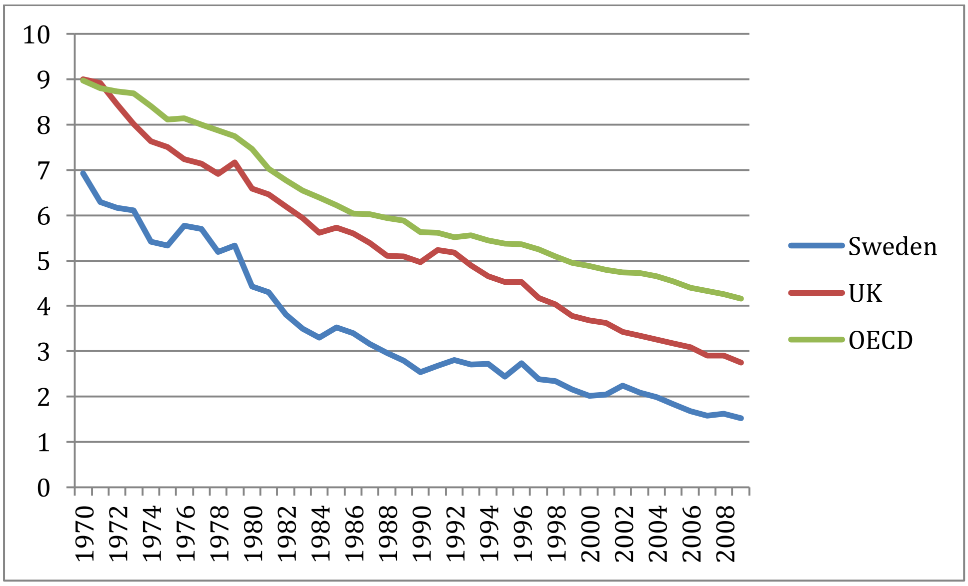

Figure 15.2 Carbon intensity of GDP Sweden, UK and OECD, Kg CO2/$ GDP

There is much more evidence available on the environmental efficacy of fuel as compared to carbon taxation. This is sometimes questioned in the popular press, since consumers are thought of as locked into patterns of use by habit, culture, vehicle characteristics, urban infrastructure and architecture. The slow speed of adaptation may also be mistaken for an absence of effect. The short-run response to higher fuel prices is indeed often small – price elasticity estimates range between -0.1 to -0.25. However long-run price elasticities are quite high: in the range of -0.7 to -0.8 (this is supported by a range of surveys of hundreds of studies that use both market based variations in fuel price as well as policy induced variations and exploit both temporal and cross-sectional variations in the data; (Oum, 1989; Goodwin, 1992; Graham and Glaister, 2002; Goodwin et al., 2004). This means that in the long run, 10% higher fuel prices will lead to a 7-8% reduction in fuel use and emissions.

The potential long-run effects of transport fuel taxation are large: the whole OECD would have had *30% higher* fuel use had not the EU and some other members imposed high fuel taxes (i.e., if all the OECD countries had instead chosen as low fuel taxes as in the US). Similarly, the OECD could have decreased fuel use by more than *35%* if all member countries (including notably the USA) would have chosen as high taxes as the UK. The accumulated difference in emissions over the years is enough to be noticed at the level of quite a few ppm in CO2 concentration, making fuel taxes arguably the government policy that has had the largest impact on the climate (Sterner, 2007).

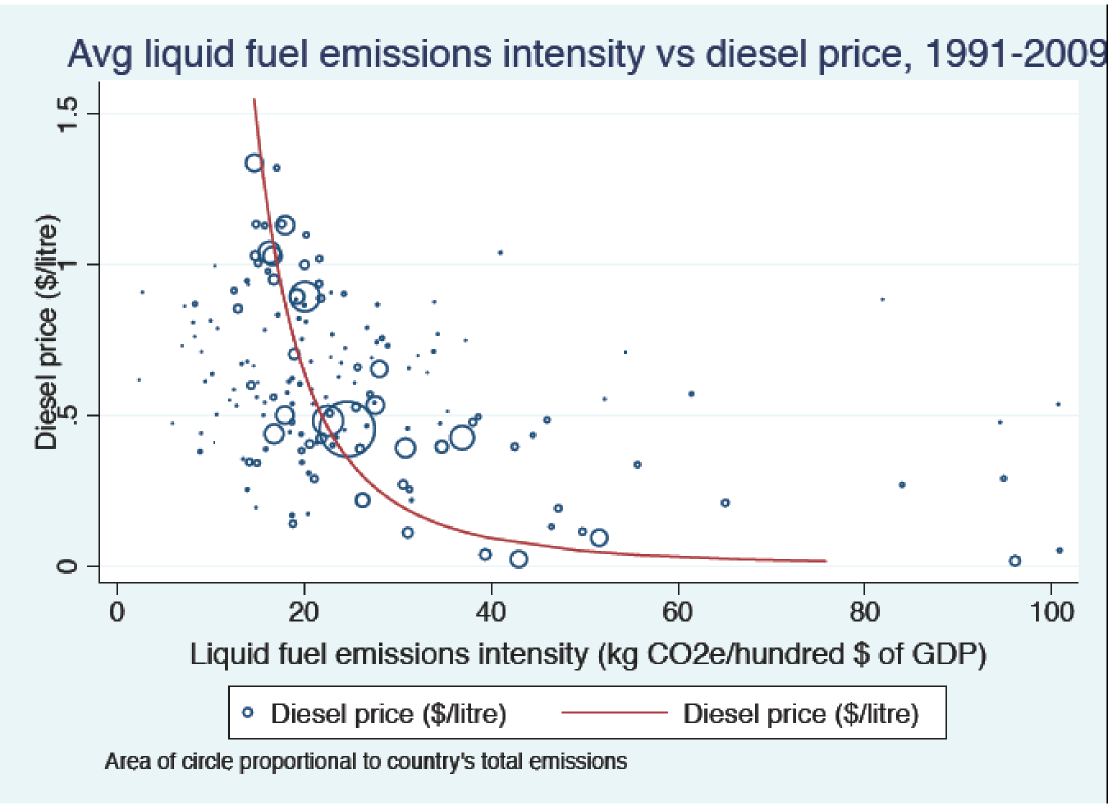

Figure 15.3. The impact of average diesel prices across the world on the emissions intensity of liquid fuels.

The environmental effect of a fuel tax is illustrated in Figure 15.3 where the fitted curve is from a log-linear regression of the emission intensity of liquid fuels on the price of diesel. The cross-country variation in diesel prices is mostly due to variation in taxes (and in countries with low prices, subsidies).

Though there are few clean experiments, the market often creates “quasi-experiments” which are analogous to the introduction of policies. Increased fuel prices in the USA in 2008, for instance, led to a shift in the composition of vehicles sold increasing fuel-efficiency, while also reducing miles travelled (Ramey and Vine, 2010; Aldy and Stavins, 2012).

Other price instruments that have been used in the transport sector are congestion charges, area pricing, parking fees, and tolls on roads or in cities. These have been used to reduce congestion; emission reduction is a co-benefit. The stiff £10 congestion fee in London led to reductions in incoming private cars by 34% when introduced. Overall congestion was also estimated to have been reduced by 30%, and emissions fell (Leape, 2006). Even a less substantial congestion fee (2€) in Stockholm was able to successfully reduce total road usage by 15% (Johansson et al., 2009).

Figure 15.3 suggests that the effect of a change in the price of a fuel on emissions is greater when the price is low. This is intuitive, since fuel will be consumed wastefully when it is cheap, allowing for greater demand reductions when the price rises. Reducing subsidies to fossil energy will thus have a significant impact on emissions. Reducing subsidies to fossil energy will thus have a significant impact on emissions. Removing them could reduce world Greenhouse Gases (GHG) emissions *by 10% at negative cost* (Burniaux and Chateau, 2011). Recognizing this, the G20 and APEC blocks agreed in 2009 to phase out fossil fuel subsidies (G20 Leaders, 2009).

In China, the energy saving policies adopted in 1991, the 1998 Law on Energy Conservation, and the 2004 Medium and Long Term Specific Schema on Energy Saving, all led to higher energy prices and have helped decrease energy intensity (Yuan et al., 2009). Around half the decline in energy intensity of Chinese industries between 1997 and 1999 can be explained by the price effects of these policies, while R&D has accounted for only 17% of this decline (Fisher-Vanden et al., 2006).

15.5.2.3 Distributional Incidence

A criterion of considerable importance when evaluating instruments is that of equity or fairness in cost distribution. Although fuel taxes are often attacked with the argument that they are regressive (that is, impose a proportionally higher burden on the poor), this is generally not true. There are large variations in distributional impacts both within and between social groups, but the effects do not have to be overall regressive or progressive (Rausch et al., 2010, 2011); see also chapter 6.3.5.2.

A recent collection of studies on the distributional incidence of fuel taxes shows that they may be neutral or weakly regressive (before revenue recycling) in rich countries, but that they are generally progressive in poor countries. In many large and important least developed and developing countries such as India, Indonesia, China, and many African countries, the progressivity of fuel taxes is in fact quite strong. In Europe they are approximately neutral (Sterner, 2012).

(Benjamin, 2011) analyses the distributional effects of carbon taxes on transportation fuels in France 2003 to 2006, incorporating individual household price responsiveness to different income groups into a consumer surplus measure of tax burden. Carbon taxation is found to be regressive before revenue recycling. However, taking into account the benefits from congestion reduction mitigates the regressivity, while recycling tax revenues makes the poorest households better off.

Naturally, the distributional effects of other fuels also vary significantly. Taxes on kerosene in developing countries do tend to be regressive since kerosene is used predominantly by the poor (Younger et al., 1999; Gangopadhyay et al., 2005; Datta, 2010). In some countries, this may also apply to taxes on electricity or coal (Sterner, 2012).

15.5.2.4 Design Issues: Exemptions, revenue recycling, border adjustments

As mentioned above in 15.5.2.1, despite the attractive efficiency properties of a broad carbon tax, and even its progressivity in many circumstances, it may face political resistance. To have a big effect on emissions a tax must however be high. Carbon and fuel taxes have often been initially resisted but once introduced it seems the fee level has often been increased, (Sumner et al., 2011b).One reason might be people realize the taxes are not damaging the economy. Another may be a path dependence since the taxes reduce the use of fossil fuel and lower fuel use means less opposition to fuel taxes, (Hammar et al., 2004). This may be the rationale for raising the fuel or carbon taxes slowly and steadily as done by the Thatcher government with the Fuel Price Escalator starting in 1993, a policy that was continued under the successor Labour government until the proceeds were sufficient to cover the cost of road building and maintenance in the country.

An emissions tax involves a transfer from parties to the state, namely the tax revenue from the residual emissions that are not abated. Private parties have to make this transfer in addition to bearing the cost of actually reducing emissions. There are a number of approaches to designing a tax (or fee) so that the transfer does not take place and resistance from incumbent polluters is reduced.

One approach that has been taken is simply to exempt certain carbon-intensive industries – such as heavy industry in Sweden as mentioned earlier. Such policies with incomplete coverage are often more costly than general policies (see Montgomery, 1972) and chapter 6.3.5.1) in addition to having a smaller environmental effect. This applies not only to carbon emissions in industry, residential and transport sectors – it applies even more broadly to agriculture, forestry and to other climate gases such as methane or nitrous oxide (Bosetti et al., 2011). However, narrow sectoral policies may be politically more feasible, partly because of the structure of winners and losers and consequent lobbying (Holland et al., 2011).

A related approach that tries to avoid the loss of coverage is to exempt some firms from taxes conditional on their undertaking emission reduction commitments. In Denmark, companies signing an energy savings agreement with the government received a 25% tax reduction (OECD, 2001; Agnolucci, 2009; Sumner et al., 2011a; Ekins and Speck, 2011; Aldy and Stavins, 2012). A similar approach has been adopted in the UK where firms in some industries are allowed to sign Climate Change Agreements to reduce emissions that exempt them from the Climate Change Levy. This experience offers a cautionary tale: on average the agreements did not require firms to reduce emissions beyond what they would have done anyway (Martin et al., 2011). Conditional exemptions amount to unconditional ones if the conditions are lax.

Another approach to avoiding a large transfer to the state is to recycle all or part of the tax revenue to those who pay it. This does not compromise efficiency. In the Canadian province of British Columbia, revenue from the broad carbon tax of $30/tCO2 is fully rebated to the general population via income tax cuts and transfers to low-income people who do not pay income tax. British Columbia raised the tax gradually in increments of $5/tCO2 annually to its current level (Jaccard, 2012).

Sometimes revenues are recycled to firms in emission-intensive industries. Again, this relies on identifying the recipients so it is usually confined to a few sectors with the attendant disadvantages mentioned above. Refunded emission payments and other combinations of taxes and subsidies may be designed to be neutral so that, for example, the industry pays the cost of abatement but does not pay a tax for the allowed or reference level of pollution (Fischer, 2011). One expression of this is fees, which are collected in environmental funds and subsequently used in ways that benefit the polluters. An interesting example from the management of NOx emissions in Sweden is that a refunded emission payment may be politically much more acceptable and thus environmentally more effective than simply a tax. Since the fee is refunded (in proportion to output), there is considerably less resistance to the fee and it can be set much higher than what would have been acceptable for a pure tax. Norway has pioneered another instrument for the management of NOx emissions – the government refunds the tax to cover abatement expenses. This implies a combination of a tax on emissions with a subsidy on abatement. Experience shows that a lower fee can achieve the same result with this instrument design than with the output-based refunding described above (Fischer, 2011). Norway is considering promoting similar solutions for carbon emissions (Hagem et al 2011). The drawback of such schemes for reducing carbon emissions is that their sectoral nature reduces coverage and raises costs.

A similar problem arises when the issue is one of removal or reduction of energy subsidies for the general population. Many governments motivate their hesitancy to remove subsidies because of fear of social unrest. Protests over reduced petrol subsidies are common; recently riots erupted in Nigeria when President Goodluck Jonathan tried to eliminate very costly petrol subsidies with only partial success. Some countries such as Iran and Indonesia have recognized that fuel subsidies actually accrue to the relatively wealthy and have managed to successfully reduce them without much unrest, by making sure that revenues saved are spent fairly – for instance through general lump-sum cash transfers (Coady et al., 2010; Sterner, 2012; Aldy and Stavins, 2012).

Subsidies for emission reducing investments, also known as abatement subsidies, have also been financed out of general revenues. They are not as efficient as a tax due to their sectoral nature. If applied to firms, they may create perverse incentives to enter or to fail to exit from, a polluting industry, and raise costs (Polinsky, 1979). Perhaps for such reasons, they are seen in residential and commercial sectors, for instance, tax breaks are provided for building insulation or refurbishing. There are also white certificates and innovative financing schemes that allow loans to be repaid as part of electricity bills (see chapter 9 for further discussion).

Another reason for tax exemptions is to avoid a loss of competitiveness in industries exposed to foreign competition that is not subject to taxation or to equivalent policies. A pure tax (at a high level) may also incentivize industries to move to neighbouring countries. This is known as leakage, since emissions `leak' to jurisdictions not subject to taxation. It is generally hard to find decisive empirical effects of environmental taxation on carbon leakage and reduced competitiveness, though this may be partly because high carbon taxes have not been tried for trade-exposed sectors in significant geographic areas or for significant amounts of time. Simulations do indicate there could be sizeable effects, as shown by (Elliott et al., 2010), who find that increased carbon emissions in developing countries due to leakage could undo a fifth of the reductions achieved by the industrialized countries imposing a carbon tax of $105 per ton C. They also show that adding full border tax adjustments would eliminate this leakage. Border tax adjustments are taxes levied on imported goods that impose equivalent taxes on emissions `embedded' in the goods. (Aichele and Felbermayr, 2011) find that sectoral carbon imports for a committed (i.e. taxed) country from an uncommitted exporter are approximately 8% higher than if the country had no commitments and that the carbon intensity of those imports is about 3% higher. Since the measurement of embedded emissions is uncertain, border tax adjustments have been criticized for violating trade agreements in environmental guise (Holmes et al., 2011).

15.5.3 Emissions Trading

15.5.3.1 Introduction

Over the past three decades, emissions trading or cap-and-trade has evolved from just a textbook idea (Dales, 1968) to its current role as a major policy instrument for pollution control.[5] Earlier experiences with emissions trading include for the most part subnational and national attempts at dealing with local or national problems such as the California RECLAIM program and the US Acid Rain program (Tietenberg, 2006; Ellerman et al., 2010). But since the start of the EU carbon trading system (see Chapter 14 for an overview of this regional policy), several countries and subnational jurisdictions (e.g., New Zealand, Australia, California, northeastern United States, South Korea, Tokyo, and different cities in China) have also put in place or proposed trading schemes to control their carbon emissions. This section provides a brief overview of the literature from these experiences and draws lessons for the design of trading programs with particular attention to carbon markets.[6]

The section is organized around key components in the design of an emissions trading scheme (ETS), namely, sector coverage, point of obligation for regulated sources, level of ambition and how it is adjusted over time, linking to other markets, use of offsets, allocation of permits, and use of banking and borrowing. The section also touches on design issues dealing with price volatility, market power and leakage. But we start the section with a more basic question that is not only relevant for instrument design but also for instrument choice: Has emissions trading worked?

15.5.3.2 Has emissions trading worked?

A comprehensive answer to this question is beyond the scope of the section given the large number of existing programs and the different evaluation criteria that can be used (i.e., environmental effectiveness, economic effectiveness, distributional equity, institutional feasibility and flexibility, etc). The short answer, however, is that emissions trading, when implemented, has worked reasonably well at least from the viewpoint of ex post environmental and economic effectiveness perspectives (Tietenberg, 2006). Another different question is getting a program through the political decision making process, particularly, when it comes to stringent caps and other program

[5] We do not cover emissions-reductions-credit systems, which is another form of emissions trading. A good example is the EPA Emissions Trading Program ---established in the mid-70s to control criteria pollutants under the US Clean Air Act. See Tietenberg (2006) for more.

[6] We will offer only a brief description of some of the carbon programs here; for more see (Perdan and Azapagic, 2011; Aldy and Stavins, 2012).

features. In several trading programs the allocation has been lax (and hence prices low); yet, other programs that have been suggested have not made it through the parliamentary or political process.

According to (Harrison, Jr and Nichols, 1992) and (Johnson and Pekelney, 1996) cost savings in the RECLAIM program ---a trading scheme established in 1994 to control SO2 and NOx in Southern California--- have been around 40% relative to an equivalent command-and-control approach.

This is consistent, although not a necessary condition, with the large volume of trade reported by (Ellerman et al., 2000). Cost savings in the US Acid Rain program ---an allowance trading system established in 1995 to control SO2 emissions from coal-fired plants in the continental US--- have also been substantial according to several studies (e.g., (Carlson et al., 2000; Ellerman et al., 2000). Cost savings in this program came not only from equalizing marginal costs across affected electric utility units on a period-by-period basis but also from equalizing (present value) marginal costs intertemporally as firms have saved current permits for future used in what is known as banking of permits. According to (Ellerman and Montero, 2007), the use of banking has been substantial and remarkably close to what would be expected in a well-functioning market.

Banking has also been responsible for a large part of the significant cost savings in the US Lead Phasedown program ---a trading scheme established in 1982 to provide refineries with flexibility to gradually remove lead from gasoline. In addition to banking, cost savings in this program have been driven by dynamic efficiencies, i.e., the faster adoption and/or development of more efficient refining technologies (Kerr and Newell, 2003). In contrast, dynamic efficiency has played a minor role in explaining cost savings in the US SO2 allowance program (e.g., Ellerman et al., 2000; Fowlie, 2010; Kumar and Managi, 2010).

Cost savings in the more recent (national and subnational) carbon trading programs are yet to be documented (except for the EU ETS which are documented in Chapter 14); although simulation exercises show that they can be important. In addition to overall cost savings, there are other lessons for the design of carbon markets that can help improve their performance or make them politically more feasible to which we now turn.

15.5.3.3 Sector coverage and scope of the cap

A key component in a trading scheme is establishing the pollutants (e.g., greenhouse gases) and entities that will be regulated or subject to a cap. There are several factors that may affect this decision and their weight varies from program to program as the evidence below shows: the availability of emissions data and monitoring capabilities, targeting sectors with the greatest mitigation potential, the desire to achieve least-cost mitigation by extending coverage as widely as possible, the political acceptability of including some sectors, including the interaction with existing policies, etc.

The reality is that in most trading schemes the affected sources, the entities that have to surrender permits, have included relatively large emitting sources whose emissions have been closely monitored (smaller emitting sources are often regulated with alternative instruments that may include command-and-control approaches or taxes). This has been the case in the earlier programs (e.g., Acid Rain, RECLAIM, Lead Phasedown)[7] but also in carbon markets that are in operation or about to. In other words, there are few cases in which the point of obligation has been upstream, i.e., different than the emitting point.

The trading scheme in Australia, launched in 2012, covers around 500 large emitters and approximately 60 percent of Australia's GHG emissions. Electricity generation, industrial processes,

[7] An exception is the market for particulates established in Santiago-Chile in 1992 for industrial sources (Montero et al, 2002). The trading commodity was not actual emissions, which were difficult to monitor on a daily basis, but a firm's maximum capacity to emit.

fugitive emissions and non-legacy waste are under permit liability. Small-scale stationary fossil fuel use (especially gas) is covered by upstream permit liability on fuel distributors who pass on their costs. Fuels for heavy road transport, aviation and synthetic GHGs are subject to an equivalent emissions price, through changes in existing taxes and levies. Agriculture and forestry can produce offset credits (Macintosh and Waugh, 2012; Caripis et al., 2012). The carbon market in South Korea, to start in 2015, is also expected to cover about 60% of the country's GHG emissions by targeting around 450 large facilities (Kim, 2011).

Coverage in the carbon trading scheme in New Zealand, established in 2008, is the most comprehensive in that it covers all GHGs and all sectors. It has expanded in stages from the forestry sector (in January 2008) to fossil fuels and industrial emissions (in July 2010), with the waste and agricultural sectors to be included from 2013 and 2015 respectively. It is the only national emissions trading scheme to include agriculture and forestry, and is expected to shift land-use change decisions towards greater carbon sequestration and less deforestation (Karpas and Kerr, 2011; Adams and Turner, 2012). Coverage is also scheduled to expand in stages in the recently launched carbon market in California (Hanemann, 2009). The first compliance period (2013–2014) will cover electricity generating and industrial facilities exceeding 25,000 tonnes of CO2e per year; the second period (2015–2017) adds distributors of transportation, natural gas, and other fuels; and the third period (2018–2020) adds transportation fuels. Over time it will cover all major sources, representing 85% of California's GHG emissions (CARB, 2011). Offset projects are foreseen in forestry management, urban forestry, dairy methane digesters, and the destruction of ozone-depleting substances.

There are other carbon markets that are much less ambitious in scope. The trading scheme in Tokyo, launched in April 2012, includes 1,000 commercial and institutional buildings and 300 industrial facilities (with annual energy consumption of at least 1,500 kl of crude oil equivalent) that amounts only to 20% of Tokyo's total CO2 emissions. Though the program may be limited in scope, it is one of the first programs in the world to address emissions from urban buildings, which can be quite significant (Nishida and Hua, 2011). The Regional Greenhouse Gas Initiative (RGGI), a cap−and−trade program initiated in 2009 and that covers nine Northeast and Mid−Atlantic states in the U.S. (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont), only regulates CO2 emissions from power plants.

15.5.3.4 Setting the level of the cap

The cap, the number of permits allocated to affected sources, defines the stringency of the trading scheme. Caps are rarely fixed; they are usually tightened up gradually and are subject to changes. Earlier programs have adopted relatively lax or generous caps in the short run but to varying extents, they have included mechanisms for tightening the cap gradually. The RECLAIM program started with caps for two pollutants, NOx and SO2, above expected emissions to steady decrease until, by 2003, they would be about 50% below early 1990s levels. The caps would remain constant from 2003 onward. Similarly, the cap in the SO2 allowance program was relatively generous in Phase I (1995-2000) but the dropped to about 50% of 1990 levels in Phase II (2000 and after). The same gradual approach was used in the Lead Program until the total phase out was reached. More recently the price of permits has fallen drastically as the EPA chose to use other instruments to speed up the phase out of sulphur thus sidestepping the program in a way that appears to suggest difficulty in reducing the number of permits sufficiently fast.

Caps in the different carbon markets have followed gradual evolution as well; although less ambitious in terms of their emission goals (which does not need to be in terms of costs if abatement possibilities are more limited). In the Australian scheme, for example, there is no cap on emissions during the initial so-called "fixed-price phase" of the scheme (2012-2014) but a price that will change from Aus$23.00 per tonne in 2012/2013 to Aus$25.40 in 2014/2015. The fixed price scheme offered advantages in the specific political circumstances that failed to agree on emissions target but not on a price (Jotzo et al., 2012) despite the uncertainty on emissions that a price creates (Pearce, 2012). Starting with the first flexible-price phase (2015-2018), the government will set annual caps for five-year periods, extending the cap by one year every year. A default cap (associated to a GHG emissions reduction of 5% from 2000 levels by 2020) will apply in the event the parliament cannot agree on a cap (CAUS 2012).

New Zealand, on the other hand, has operated within the Kyoto cap for 2008–2012 by requiring every unit of emission to be matched by a Kyoto unit at the end of the Protocol's true-up period (in that sense it does not have a separate domestic cap on allocation or emissions). For 2012 and forward, the government has proposed legislative amendments to introduce a domestic cap and remove the requirement to back domestic emission with Kyoto units (NZME 2012).

Programs on the other side of the Pacific are not different. The cap in the California scheme is set in 2013 at about 2% below the emissions level forecast for 2012, and then declines about 2% in 2014 and about 3% annually from 2015 to 2020 (four percent of allowances will be held in reserve to contain costs). Similarly, RGGI has introduced a "soft" fixed cap from 2009 to 2014 to decline by 2.5% per year for a total reduction of 10% from 2009 levels by 2020. Economic growth (hence, electricity demand) has been slower than expected and natural gas prices lower than expected, resulting in less coal power use, so it is unlikely that the cap becomes binding through 2020 (Aldy and Stavins, 2012).

15.5.3.5 Allocations

There are basically three ways in which permits are allocated to affected sources: free through grandfathering or output allocation, and auctioning. Earlier programs relied almost exclusively on grandfathering. The SO2 allowance program, for example, allocated only a small fraction of the total cap, less than 3%, through revenue-neutral auctions; mainly to provide an earlier and more reliable price signal to participants (Ellerman et al., 2010). Recent carbon markets are not that different and more so because of concerns about emissions-intensive trade-exposed industries. In fact, the programs in New Zealand and Australia consider a very limited amount of auctioning (although increasing over time) unlike RGGI which allocates everything through auctions (the softer cap in RGGI explains large part of the difference). California is somewhere in the middle in terms of auctioning.

The California scheme is also interesting because it makes explicit an output-based (free) allocation rule for energy-intensive, trade-exposed sectors. An equivalent to an output-based allocation is also considered in the Australian scheme to similar sectors but in the form of a financial transfer, although limited (Clarke and Waschik, 2012), linked to the emissions price and output. The Australian experience has also shown the influence that industry lobby groups can have in policy design (Garnaut, 2008; Pezzey et al., 2010) and how politically involved this can become (Macintosh et al., 2010).

15.5.3.6 Linking of schemes

Linking occurs when a trading scheme recognizes permits from a foreign system as valid currency for complying with its domestic requirements and, possibly, vice versa. It is similar to allowing for offsets from domestic uncapped sectors. Linking can be mutually beneficial by lowering costs or increasing profits, depending on whether the country is a net buyer or seller of permits. Linking, however, involves certain trade-offs in terms of exposure to international prices and loss of flexibility to unilaterally change features in the domestic design once links are established. In addition, international linkage of trading schemes might be simpler than attempting to align carbon taxes through political agreements internationally (Karpas and Kerr, 2011). There is however not general agreement on this point; see for instance (Nordhaus, 2007).

The experience with linking is limited because carbon markets are relatively recent. One example of a linking process is the ongoing collaboration, since 2007, between California and the Canadian province of Quebec, which will both place compliance obligations on large emitters under trading schemes beginning in January 2013 (CARB, 2011, p. 201). Another example is in Australia's last year announcement that it was linking its system to the EU ETS to start trading in 2015. Interestingly, Australia is also exploring ways for establishing links with schemes in South Korea and California, which, by de facto, would create links between all these trading schemes.[8] We do not yet know if linking schemes without prior commitment on overall caps will facilitate or complicate future negotiations on the caps.

15.5.3.7 Other design issues: banking, offsets, leakage, price volatility and market power

There are additional aspects of policy design on which we can only briefly touch here, which does not mean they are not equally important. Unlike borrowing, banking, the possibility to store current permits for future use, is a feature that has been present in most trading schemes with good results in terms of both additional cost savings and environmental benefits (i.e., absence of emission spikes and acceleration of emission reductions). A well-documented example is the US SO2 allowance program (Ellerman and Montero, 2007). Offsets, the possibility of using emission credits outside the capped sectors either domestically or internationally (e.g., CDM, linking of schemes), is another design feature common in most trading schemes but of much concern because of the well-known tension between cost-effectiveness (i.e., extending the range of cheaper abatement possibilities) and additional emission reductions (i.e., additionality). One way to somewhat assuage this tension is to move away from a project-based crediting approaches (e.g., CDM) to scaled-up approaches ---to the level of the sector, jurisdiction or country--- that can preserve the economic benefits while minimizing the adverse selection problems of additionality. Offset provisions, if well designed, can also help alleviate the "leakage" problem of moving emissions from capped to uncapped sectors. An alternative design option to address leakage is to use output-based allocation rules. Since future allocations should not be influenced by a firm's behaviour, the design of an output-based allocation must balance the distortions in output with the control of leakage.

Like in any commodity market, price volatility and market power have also been present in the discussion of permit trading. The main concern with price volatility is that prolonged periods of high prices can inflict unbearable costs on affected firms and prolonged periods of too low prices can discourage firms to develop and adopt cleaner technologies. Other than banking, earlier trading schemes were not equipped with specific design features to deal with volatility, although it was clearly present. Recent carbon schemes are more responsive to it. Australia is a good example. In 2015, the Australian scheme will abandon its fixed price and move to a true trading scheme but with a pre-defined price band (Jotzo and Betz, 2009; Jotzo and Hatfield-Dodds, 2011). On the other hand, market power specific to permit trading has also been the subject of much research since the work of (Hahn, 1984). The reality, however, is that market power seems to be less of a problem than anticipated (Liski and Montero, 2011), which is also consistent with findings from laboratory experiments (Sturm, 2008).

15.5.4 Regulatory Approaches

Various kinds of regulatory approaches are widely used throughout different parts of the economy, and described in detail in the sectoral chapters (Ch7 through 12). However, research assessing their effectiveness is scarcer. This section focuses mainly on energy efficiency instruments. Energy efficiency regulations are, generally speaking, rules for the maximum amount of energy used (or carbon emitted) in relation to the provision of a certain service (travelling a mile in a private car or

[8] The firm intentions of New Zealand and Australia about linking their systems came to a sudden end after the latter announced it was linking its system to the EU ETS.

cooling a certain quantity of food). Their overt purpose is to restrict the behaviour of firms and individuals and lead them to use less energy per unit of useful service. The regulations may also be seen as a way to remove barriers, thereby saving the money of firms and individuals and reducing social costs. Seen in the latter way, well-designed regulations can be important complements to carbon pricing policies.

Barriers to the adoption of energy efficiency can arise for various reasons. We mention three commonly cited ways in which they can arise.

First, consumers may have less information about the efficiency and cost of a device than sellers. They may not be able to assess the energy savings from an appliance even after using it. This can lead to a situation in which low-efficiency devices drive more expensive high-efficiency ones out of the market. Efficiency standards in this setting can improve consumer welfare (Leland, 1979).

Second, when competition is imperfect and sellers compete on both quality (efficiency) and price, then a minimum quality standard eliminates low-quality sellers from the market. This narrows the range of quality in the market, making different sellers' products closer substitutes for each other. In turn, this forces sellers to compete more in the price dimension, leading to a fall in the distribution of prices for the remaining high-quality goods. This can make all consumers better off (Ronnen, 1991).

Third, cognitive costs may result in some consumers simply not taking operating (energy) costs into account at all while making their purchase decisions, as was the case with 40% of US car buyers in a recent survey (Allcott, 2011). This can lead sellers to offer less energy efficient products than these consumers would buy if they could compute the consequences.

15.5.4.1 Case studies on the environmental and economic effectiveness

Energy Efficiency Standards

Appliance standards can help address a number of energy efficiency barriers (Gillingham et al., 2009). In particular, landlords may buy cheap energy-inefficient appliances when tenants pay the utility bill even though the discounted value of savings from more efficient appliances would more than make up for their cost. The magnitude of the distortion due to this landlord-tenant problem was analyzed by (Davis, 2010). He compared appliance ownership patterns between homeowners and renters using household-level data from the Residential Energy Consumption Survey in US. The results showed that renters were significantly less likely to have energy efficient refrigerators, clothes washers and dishwashers.

In order to overcome such barriers, Minimum Efficiency Performance Standards (MEPS) and mandatory labels have been used by many countries since the 1980s on a range of residential equipment including refrigerators and freezers, clothes washer and driers, and air conditioners. (Ellis, 2007) analyzed the programs in Europe, UK, US, Australia and Japan and showed that all products examined have experienced an increase in energy efficiency by 10% to 60%, while the real prices declined by 10% to 45% over the periods when data were collected.

On the impacts of building codes for insulations of households, the evidence is mixed. In 1979-1988, building codes across states were not found to have made an observable difference in building practices (Jaffe and Stavins, 1995). However, an increase in the stringency in Florida's energy code two decades later resulted in a decrease in the consumption of electricity by 4% and natural gas by 6%, compared to residences structured before the code came into effect, with average social and private payback periods between 3.5 and 6.4 years (Jacobsen and Kotchen, 2010). Furthermore, states that adopted building codes followed by a significant amount of new construction have experienced detectable decreases in per capita residential electricity consumption, ranging from 0.3 to 5% in the year 2006, with larger impacts in states with more stringent and strictly enforced codes (Aroonruengsawat et al., 2011).

Energy Management Systems and Energy Audits

A number of analyses continue to show that significant energy efficiency improvement opportunities exist in the industrial and building sectors, many of which are cost-effective even at current prices. However, industrial facilities and buildings are not always aware of their overall energy efficiency improvement potential or specific technologies and measures that can be implemented (Price and Lu, 2011; Akimoto, 2012; Backlund et al., 2012; Thollander and Palm, 2013).

Energy Management Systems (EMS) are a collection of business processes, carried out at plants and firms, designed to encourage and facilitate systematic, continuous improvement in energy efficiency. They help managers and staff to identify, carry out, monitor and learn from technical actions. The typical elements of EMS include the following: maintenance checklists; measurement processes; performance indicators and benchmarks; progress reporting; energy coordinators; energy purchase, use and disposal procedures, strategic plans, energy audits, and so forth (McKane, 2007). Energy audits often provide a key step for identifying the energy efficiency improvement potential (Vreuls, 2005; ECCJ, 2007; Price and Lu, 2011).

Historically both EMS and energy audits originate in energy intensive private firms, and the government has helped disseminate the knowledge to a broader range of economic agents (Kajiki and Sugiyama, 2010). Governments have implemented diverse policies to encourage plants and firms to employ EMS processes. Some require an energy manager for plants of a certain size; others require the reporting of audit results, some set standards for how EMS should be carried out. Some provide technical and financial assistance for EMS activities. The policies do not prescribe particular energy saving actions, but instead promote the use of EMS processes that will likely lead to technical actions. This gives industry flexibility in the choice of energy saving measures (Tanaka, 2009). The legal status and coverage of EMS varies across countries. In the US it is voluntary and coverage is less than 5%. In the UK and the Netherland EMS systems were required under negotiated agreements with the government (Price, Lynn et al., 2008). In Japan EMS are mandated by law. (Tanaka, 2008).

At least 15 governments have implemented 22 industrial energy auditing programs around the world to encourage, facilitate, or mandate industrial facilities to undertake energy audits (Price and Lu, 2011; Shen et al., 2012).

There are a number of case studies that argue for the environmental and economic effectiveness of EMS and energy audits. (Ogawa et al., 2011) concluded, by interviews to industries, that almost all factories and other workplaces see the mandatory EMS as generally effective in Japan. The system worked to accelerate in-house decision making on energy conservation measures. In the US, (Anderson and Newell, 2004) found that plants adopted about half the recommended energy-efficiency projects. Others have found have found positive impacts on energy efficiency in China. Energy auditing has not only helped enterprises identify energy-efficiency improvement opportunities but has also helped them improve their energy management structure including the evaluation of the efficiency of energy systems, collection and analysis of energy usage data, identification of opportunities for efficiency improvement, and implementation of energy-efficiency projects (Shen et al., 2012). Several papers report very quick payback or high profitability for energy efficiency investments identified during such assessments; such was the case in a project supported by the Department of Energy in the US (Price, Lynn et al., 2008). In Germany a program offering partial subsidies to SMEs for energy audits was found to have saved energy at a rate equivalent to 1.6-2.1 USD/tCO2, (Gruber et al., 2011). Even cheaper savings were found in an energy audit program in Finland (Khan, 2006). On the other hand, the energy audit program by the Energy Conservation Centre of Japan (ECCJ), which provided on-site energy diagnosis service to 2409 small to medium facilities in 2004-2007, was found to provide positive net benefits for society, defined as the net benefit to private firms minus the costs to government, of USD61/t-CO2. For the energy audit program of the New Energy Development Organization (NEDO) the net benefit was equivalent to USD38/t-CO2 (Kimura, 2009). The two studies also show that the benefit to the society is higher when the target facilities are larger. (Kimura and Noda, 2010) found that the somewhat higher costs in other cases were due to the fact that firms implemented costly options such as photovoltaic in addition to low cost energy efficiency options.

On the other hand, there are also studies that reported mixed results of *mandatory* EMS and energy audits. Some companies actually used EMS to improve their energy efficiency, but others only paid lip service to EMS by going through the motions of implementation. The latter did not achieve any energy efficiency improvements (Kimura and Noda 2010b). Other mixed results were reported from Italy where a number of companies were not in compliance (Di Santo and Labanca, 2006).

Crosscutting Evaluations and Caveats

There are also a number of studies carrying out a more crosscutting Evaluation of Government Energy Efficiency Programs. (Ellis, 2009) evaluated 8 energy efficiency programs with different target sectors and with different policy types (financial incentives, voluntary agreements, procurement, utility regulation, regulation, information) from the Netherlands, Germany, Britain, New York, Thailand, Denmark and California. The eight programmes clearly delivered significant energy savings, and most were extremely cost effective.

It should also be noted that there is also evidence that energy efficiency policies do not always bring about energy saving at low to negative costs, particularly when the argument is scaled up to sector or national economy level. (Stavins et al., 2007) critically reviewed three studies claiming that California could meet its ambitious greenhouse gas reduction target by 2020 at no net economic costs. They found that although some opportunities might exist for energy saving policies at low to negative costs, the studies substantially underestimated the overall cost of meeting the target.

15.5.4.2 Rebound Effect

Energy efficiency improvement will cause a reduction in the real per unit cost of energy services and result in an increase in the demand of energy services. Therefore, potential energy consumption reduction by the improvement may be offset partially in response to this cost reduction. This effect is referred as "rebound effect".

The rebound effect comes in four forms. The first two of these are fairly "*direct*": 1) If a car or appliance is more efficient, people may use it more thus raising energy use, or 2) they may use the savings to buy other products that consume energy. Moreover, there are also 2 "*indirect"* or general equilibrium effects. These include: 3) the energy price drops due to reduced energy demand in one sector, leading to increased energy use elsewhere, and 4) more efficient technologies spur industrial growth, again leading to energy increases. There are a number of estimates of the direct rebound effect.

(Sorrell et al., 2009) reviewed the literature and concluded that, for personal automotive transport, household heating and household cooling in OECD countries, the mean value of the long-run direct rebound effect is likely to be less than 30% and may be closer to 10% for transport. (Jenkins et al., 2011) conclude that direct rebound effect are in the range of 10-30% of projected technical energy savings in developed countries. However, they argued that direct rebound effects are likely to be greater in developing economies and also appear to be more significant in the productive sectors of economy, where direct rebound may range from 20-60% or higher, particularly for energy intensive sectors where energy services are easily substituted for other factors of production.

There are also a number of studies estimating the Macro-economic rebound effect. (Barker et al., 2007) find an effect of 11% for the UK using a macroeconomic model. (Mizobuchi, 2008) finds a 37% effect for the Japanese household sector using a simulation model. (Jenkins et al., 2011) survey a number of CGE modelling studies and find a 30-50% effect or greater, with a surprising number of studies projecting backfire (rebound greater than 100%). All of the studies above acknowledge that the estimates of rebound effects are associated with considerable uncertainty and depend on assumptions and models used.

(Sorrell, 2009) argued that the rebound effect may be particularly large for the energy efficiency improvements associated with so-called 'general purpose technologies (GPT)’, such as steam engines and computers. GPT have a wide scope for improvement and for use in a wider variety of products and processes and have strong complementarities with existing or potential new technologies. Steam engines provide a paradigmatic illustration of a GPT in the 19th century, while electric motors provide a comparable illustration for the early 20th century. (The former was used by Jevons to support the original case for over 100% rebound – so called “backfire”).

The total rebound effect appears to be in a rather broad interval that goes from a low of 10% to a high of at least 60% depending on various factors including, model used, type of innovation, country institutions and the time horizon studied (it will tend to grow over time) (Gillingham et al., 2013).

The existence of a rebound effect clearly does not mean that efficiency policies are useless. Efficiency policies enable economic growth with less energy intensity. But a rebound effect has to be accounted for and addressed. Since 2010, the UK government has begun to account for a direct rebound effect in energy policies (Maxwell et al., 2011). The rebound effect also implies that energy efficiency policy alone may not be enough to achieve economy-wide ambitious emission reductions. The regulations have to be part of a broader policy package including decarbonisation of energy supply and carbon pricing (Jenkins et al., 2011).

15.5.5 Information Measures

Information measures are used in all sectors in various forms as shown in the sectoral chapters (ch7 through 12). The literature on the assessment of effectiveness of information policies is rather scarce compared to the wide use of this policy instrument, partly because the information measures are often implemented as part of wider policy package. However, there is some literature evaluating information programs. For example, (Gillingham et al., 2006) reviewed several information programs including ENERGY STAR and identified environmental effectiveness. (Ellis, 2009) evaluated the Netherlands appliance labelling and New York ENERGY STAR market support programs and concluded that the information measures brought about energy savings at low costs.

15.5.6 Government Provision of Public Goods or Services

While formal assessment is difficult, it is clear that public provision and planning can and have played a prominent role in the mitigation of climate change at the national and sub-national levels, and in a wide range of industries including energy, transport, agriculture, forestry, and others. At the national level, government provision or funding is crucial for basic research into low and zero-emission technologies (see 15.7 below).

In the energy sector, the provision and planning of infrastructure, whether for electricity transmission and distribution or district heating networks, interconnectors, storage facilities etc., is complementary to the development of renewable energy sources such as wind and solar energy (7.6.1.3). A modal shift from air to rail transport also requires public planning or provision by national and local governments as a part of the policy mix and in best-case scenarios could reduce associated emissions by 65-80% (8.4.2).

Urban planning that incorporates climate mitigation can have a major impact on emissions; therefore, municipal governments have a very important role to play. Since climate mitigation policies have many co-benefits at the local level, including reduced local pollution and congestion, and improved quality of urban space, cities have an interest in mitigation policies in addition to the largely external climate benefits they provide. Land-use and transport policies can considerably influence the share of non-motorized transport, public transport, and associated emissions (8.4.2.3). Buildings and associated energy supply infrastructure are very long-lasting (9.4.5) so public planning to encourage the rapid adoption of new low-carbon technologies and avoid lock-in to high-emission infrastructure assumes importance. Such planning would need to take into account transport pricing relative to land prices, building, parking, and other zoning regulation, city heating and cooling systems, and green areas (see section 12.5, and (Baeumler et al., 2012). Capacity building at the municipal level may be needed for incorporating GHG mitigation and its co-benefits into the planning process, especially in developing countries (see 15.10.3 below).

Government planning and infrastructure provision can complement a carbon or fuel tax, increasing the quantity response to the price instrument by making substitution towards less energy and carbon-intensive lifestyles easier. Conversely, whether or not a public transit system will generate sufficient demand to be economical, depends on whether private transit is suitably priced. By contrast, as noted below in 15.8, a tradeable permit system for emissions would be a substitute, rather than a complement for emission reduction through public provision. In conjunction with a tradeable permit system, local actions would affect the cost of reducing emissions, but not overall emissions themselves. This raises the possibility that local governments may be de-motivated to integrate GHG mitigation in their planning if they are located in a national or international jurisdiction with a tradeable permit system. In that case, their actions would not be `additional' in GHG emission reduction. Rather they would reduce the cost of meeting the overall cap. Furthermore, the cost reduction would not be captured entirely by the residents of the local jurisdiction in which the actions took place.

Since most of the world's forests are publicly owned, provision of sequestration services as part of forest conservation is largely in the public sector. Forest protected areas make up 13.5 % of the worlds' forests, and 20.8% for tropical lowland evergreen broadleaf forests (rainforests) (Schmitt et al., 2009). During the period 2000-2005, strictly protected forest areas experienced 70% less deforestation than all tropical forests (Campbell et al., 2008), but impact studies must also control for 'passive protection' (protected areas being located in remote and inaccessible areas), and 'leakage' (more deforestation outside the protected area). The understanding of how protected areas can contribute to forest conservation, and thereby be a means of climate mitigation, has advanced much since AR4, due to better spatial data and methods.

(Andam et al., 2008) find substantial passive protection for protected areas in Costa Rica. While a simple comparison suggests that protected areas reduce deforestation by 65%, the impact drops to 10% after controlling for differences in location and other characteristics. (Gaveau et al., 2009) estimate the difference between deforestation rates in protected areas and wider areas in Sumatra, Indonesia during the 1990s to be 58.6%; this difference falls to 24% after propensity score matching which accounts for passive protection. In a global study, also using matching techniques, (Joppa and Pfaff, 2011) finds that for about 75% of the countries, protected areas reduce forest conversion, but that in 80 % of these controlling for land characteristics reduces the impact by 50% or more. Thus, an emerging consensus is that protected areas reduce deforestation (Chomitz et al., 2007), even though protection is not perfect, and there is a medium to high degree of passive protection. Estimates of leakage are more challenging, as the channels of leakage are diverse and harder to quantify.

Local governance of forests can be an effective way of reducing emissions from deforestation and forest degradation, as at least some of the public goods provided by forest are included in the decision-making. A meta-analysis of 69 cases of community forest management finds that 58% of these were successful in meeting ecological sustainability criteria, e.g. "improved forest condition" (Pagdee et al., 2006). Another large comparative study of 80 forest commons in 10 countries found that greater rule-making autonomy at the local level is positively correlated with high forest carbon levels (Chhatre and Agrawal, 2009). However, an analysis of central Himalaya in India that controls for confounders finds no statistical difference in forest cover between village and state-managed forest, although the costs per Ha are seven times higher for the latter (Somanathan et al., 2009).

Where property rights are insecure, strengthening land rights is often put forward as a way to contain deforestation, though the effects are ambiguous. Insecure tenure might lead to less land investment and more soil exhaustion, thus increasing the need and/or incentives for cutting down more forest to replace degraded land. Unclear tenure can also lead to unproductive and violent land conflicts (Alston et al., 2000). But land reforms which give higher tenure security increase the value of land clearing and could therefore spur deforestation when property rights to forest are insecure (Angelsen, 1999).

15.5.7 Voluntary Actions

15.5.7.1 Introduction

Voluntary agreements have been developed in very different ways in different nations, depending on their institutional or political culture background. In what follows the literature will be reviewed by three categories provided by (Pinkse and Kolk, 2009).

15.5.7.2 Government-sponsored voluntary programs for firms

Government-sponsored programs for firms, where participation is completely voluntary and there are no penalties for not participating in the agreement, have been implemented in several countries, including US and Australia.

The literature has been quite critical of this type of program. Several studies say little reduction was achieved (see (Brouhle et al., 2009) analyzing a voluntary program in the U.S. metal-finishing industry) or the impacts were short lived, as was the case for the US Climate Wise Program (Morgenstern, Richard et al., 2007). See also (Griffiths et al., 2007) and (Lyon and Maxwell, 2004) who conclude the US Climate Leaders program had little effect on firm behaviour.

15.5.7.3 Voluntary agreements as a complement to mandatory regulations

Voluntary agreements have been implemented as part of broader climate policy mix that contains mandatory policy instruments such as a tax or emissions trading scheme. Voluntary agreements conducted jointly with mandatory regulations have been widely implemented in Europe (Rezessy and Bertoldi, 2011).

This approach allows the regulated industries to use the voluntary agreement as a partial fulfilment of the mandatory regulation. For example, through participation in the Climate Change Agreements (CCA) in the UK, energy intensive industrial sectors established energy efficiency improvement targets; companies that met their agreed upon target were given an 80% discount from the Climate Change Levy (CCL). Likewise, the Dutch government ensured industries participating in Long-Term Agreements (LTA) were not subject to additional government policies regulating CO2 emission reductions or energy conservation and that the new energy tax would not be levied on the participating industries. In both cases participants established a long term plan to save energy and reduce CO2, and implemented energy management systems (Price, Lynn et al., 2008); (Stenqvist and Nilsson, 2012).

Some studies found that the voluntary agreements were environmentally and economically effective. (Bressers et al., 2009), using an expert interviews approach in the Netherlands, found positive results in terms of ambition, compliance, goal attainment and behavioural change. Opinions were mixed on the costs, but a large majority acknowledged the efficiency advantages of flexibility in phasing technical measures. They were, however, less positive on the transactions costs, due to the continuous consultation processes with the government. (Ekins and Etheridge, 2006) analysed the UK CCA and found that, while the targets were not very stringent and were generally achieved well before the due date, the CCAs appeared to have had an awareness effect in stimulating energy savings. This had resulted in overall environmental benefits above those that would have resulted from the imposition of a flat-rate tax with no rebate and no CCAs, as well as economic benefits for the sectors and companies with which CCAs were negotiated. (Rezessy and Bertoldi, 2011) assessed the effectiveness of voluntary agreements in 9 EU member countries. They emphasized that by engaging signatories in energy audits, consumption monitoring, energy management systems and energy efficiency project implementation, the voluntary agreements helped overcome the barrier for energy efficiency improvement in a systematic manner.

However, other studies are more critical to this type of voluntary agreements. (Boehringer and Frondel, 2007) argued that they found little evidence that the commitment of the German cement industry was effective in reducing energy consumption significantly below the status quo. They concluded the voluntary approach would require more monitoring. (Martin et al., 2011) estimated the impacts of the Climate Change Levy (CCL) on manufacturing plants using panel data from the UK production census and concluded that the CCL had strong negative environmental impacts in terms of energy intensity and electricity use, but that CCA's did not. (Newell and Paterson, 2010) discuss a 1998 voluntary agreement between the European Commission and the car industry which set a mid-term target of 25% reduction on CO_2 emissions from automobiles by 2008. However, by February 2007, the European Commission had to insist on mandatory targets for CO_2 emissions from cars after it had become clear that the car industry was failing to meet its voluntary targets.

15.5.7.4 Voluntary agreements as a major policy instrument in governmental mitigation plans

Voluntary agreements may be used as a major policy instrument to ensure coverage and political salience within a national mitigation plan. This type of voluntary agreements has been implemented in Japan and Taiwan.

The Japanese Voluntary Action Plan (VAP) by Keidanren (Japan Business Federation) was initiated in 1997. The plan, led by Keidanren and joined by 114 industrial associations, covered about 80% of greenhouse gas emissions from Japan's industrial and energy transformation sectors. The plan is embedded in the regulatory culture in which the government constantly consults with industrial associations. It was reviewed annually in governmental committees, and an independent third party committee was also established to monitor its implementation; the included industries were required to be accountable with their environmental performance constantly. Industrial groups and firms established energy and CO_2 management systems, exchanged information, periodically reviewed and acted to improve energy efficiency and cut CO_2 emissions (Tanikawa Hiroya, 2004; Akimoto, 2012; Uchiyama Yoji et al., 2012; Wakabayashi Masayo, 2012)

(Sugino and Arimura, 2011) conducted a panel data econometric analysis at the firm level and found that voluntary actions by the manufacturing sector led to significant energy efficiency investments that helped reduce their environmental impact. In contrast, Kiko Network (2007), an environmental NGO, expressed critical views. They pointed out that targets are not ambitious and enforcement mechanisms are lacking in VAP. (Wakabayashi Masayo, 2012) reported on two successful case studies in VAP concerning cutting Perfluorocarbons (PFC), where 19 semiconductor industrial associations launched voluntary action plans in 1998. The government assisted the firms by subsidizing the gas destruction equipment, and by coordinating research and development programs for lower-emission processes. As a result, PFC emissions had been reduced by 58% by 2009.

In cutting stand-by power by electric appliances, three major industrial associations under Keidanren announced in 2001 an across-the-board 1W target for all appliances to be met by 2003. It was possible for them to commit to the ambitious targets – ambitious in terms of the level of target (1W), wide coverage of appliances, and early timing of goal – exactly because it was voluntary, not mandatory. In contrast, other countries that took a regulatory approach have implemented much weaker targets at later years, and the coverage of appliances had been small. By 2003, almost all appliances met the target in time in Japan (Wakabayashi Masayo, 2012).

(Chen and Hu, 2012) analyzed the voluntary GHG reduction agreements of six different industrial sectors in Taiwan, as well as the fluorinated gases (F-gas) reduction agreement of the semiconductor and LCD industries. They found that the plan launched in 2005 was largely successful.

15.5.7.5 Synthesis

The key benefits of voluntary agreements are: 1) quick planning and actions when technological solutions are largely known but still face uncertainties; 2) flexibility in phasing technical measures; and 3) facilitating coordination and information exchange among key stakeholders that are crucial to removing barriers to energy efficiency and CO2 reductions. The voluntary agreements have been successful particularly in countries with traditions of close cooperation between government and industry (IPCC, 2007; Rezessy and Bertoldi, 2011; Akimoto, 2012; Wakabayashi Masayo, 2012). However, several voluntary agreements have been criticized for not bringing about significant environmental impacts due to their limited scope or lack of proper institutional framework to ensure the actions to be taken.

Successful voluntary agreements are characterized by a proper institutional framework. This consists of, first, capable and influential industrial associations that serve as an arena for information exchange and development of common expectation among industries. Second, governmental involvement in implementation review is crucial. Third, accompanying measures such as technical assistance and subsidies for energy audits and equipment can also be instrumental. Finally, regulatory threats, even if they are not explicitly articulated, are an important motivating factor for firms to be active in the voluntary agreements.

On the environmental effectiveness, (Borck and Coglianese, 2009) reviewed US, EU and Japanese VAs on climate and other environmental issues and argued that voluntary agreements may be effective alternatives to mandatory regulations for achieving small environmental improvements at relatively low cost. (Morgenstern and Pizer, 2007) reviewed several studies of voluntary environmental programs in the US, Europe and Japan and found that these programs led to reductions in energy use and greenhouse gas emissions of around 5% on average.

As suggested above, the quantitative impact in terms of CO2 reductions may not be more than several per cents beyond the baseline. It should be noted, however, that it is difficult for any other policy instrument alone to drastically cut emissions at sector or national levels by more than a few percentage points (Akimoto, 2012). The major role of voluntary agreements is to facilitate cooperation among firms, industrial associations and governments in order to find and implement negative to low cost emissions reduction measures. Such a role is important because large mitigation potential at negative to low costs had been reported in AR4 yet was hampered by formidable energy efficiency and CO2 reduction barriers. In such context the voluntary agreements can play an important role as part of a policy package.

15.6 Technology Policy and R&D Policy

15.6.1 Introduction

It is clear from Chapters 5-12 that societies' ability to mitigate GHG emissions over time depends fundamentally on the rate and nature of development of new technologies. Further, as discussed in Chapter 3.12, there are market failures associated with research, technology development and technology diffusion that are distinct from and interact with the market failures associated with environmental harm of human activities, and there are specific policy instruments that can be used to address these market failures. These include the patent system and other forms of intellectual property ("IP"), public funding of research, tax subsidies for firms engaging in Research and Development ("R&D"), and various policies designed to foster deployment of new technologies. Chapter 11 of the SRREN presents an extensive discussion of these policies and institutions as they affect renewable energy technologies. This subsection will address more generally the implementation of policy intended specifically to foster the development and implementation of low-GHG technology.

Figure 15.4 illustrates schematically the interrelationships among markets and behaviour, technology, and policy and institutions. Policy affects technology *creation* through IP, public research, and incentives for private research. This is known as technology "push". Government policies also affect technology through market "pull" via deployment policies (e.g. feed-in tariffs or renewable technology mandates) directed at low and zero-emission technologies, as well as via the mitigation policies described above in Section 15.5. Technology deployment in turn affects markets and behaviour by affecting what investments are made, and also affects technology creation through learning curve and other dynamic effects. If properly coordinated, these multiple policy channels can be mutually reinforcing (Del Río et al., 2010). If carbon policy is encouraging markets to reduce GHG intensity, and technology policy is fostering the development of new low-GHG-technologies, then these effects will be amplified as market incentives also contribute to technology development, and new technology makes it easier for markets to achieve GHG reductions (Sanden and Azar, 2005; Jänicke, 2012). As low-emission technologies come to constitute a larger share of the market, they start to make their influence felt in the institutions that govern the policy process. This can help to overcome the institutional lock-in that favours existing carbon-intensive technologies in the policy process (Section 15.2).

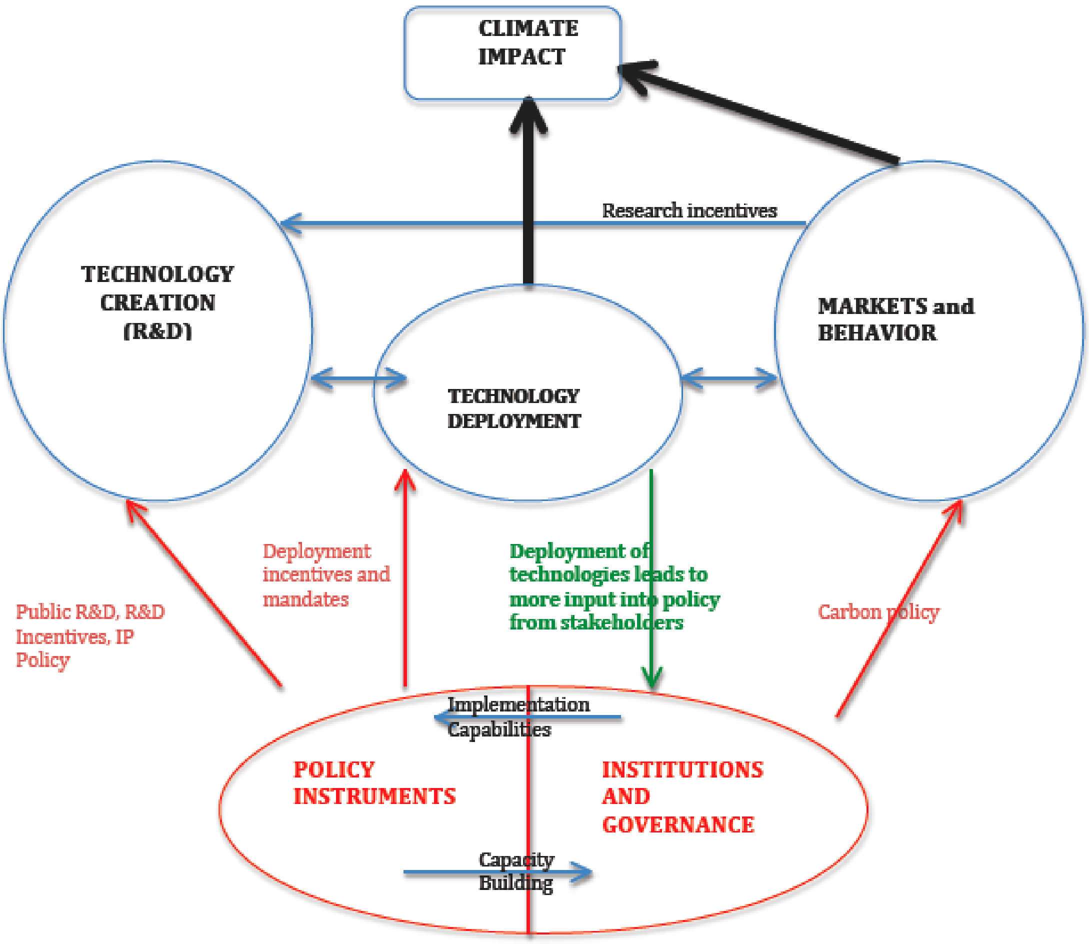

Figure 15.4. The Interaction of Technology, Markets, and Policies and Institutions

15.6.2 Public funding of research and development

The most direct and most widely implemented mechanism by which countries support the development of energy technology is through public funding of energy-related R&D. In 2011, total public expenditures for "Research, Development and Demonstration" ("RD&D") as reported to the International Energy Agency ("IEA") in its annual surveys were 19.1 billion USD.[9] The peak IEA RD&D expenditures reached a peak of 21.8 inflation-adjusted USD in 1980, fell to 11.1 in 1997, and has been rising gradually since (with a one-time spike in 2009 associated with economic-stimulus spending in the U.S.). Given that world GDP has more than doubled since 1980, world investment in energy RD&D is much smaller today as a fraction of economic activity. If the growth rate of world energy RD&D could be increased from the recent rate of about 5% to 10%/year, the world would achieve the 1980 energy RD&D/GDP ratio of 1980 in about 15 years (assuming real world GDP growth over the period of 2.5%/year).

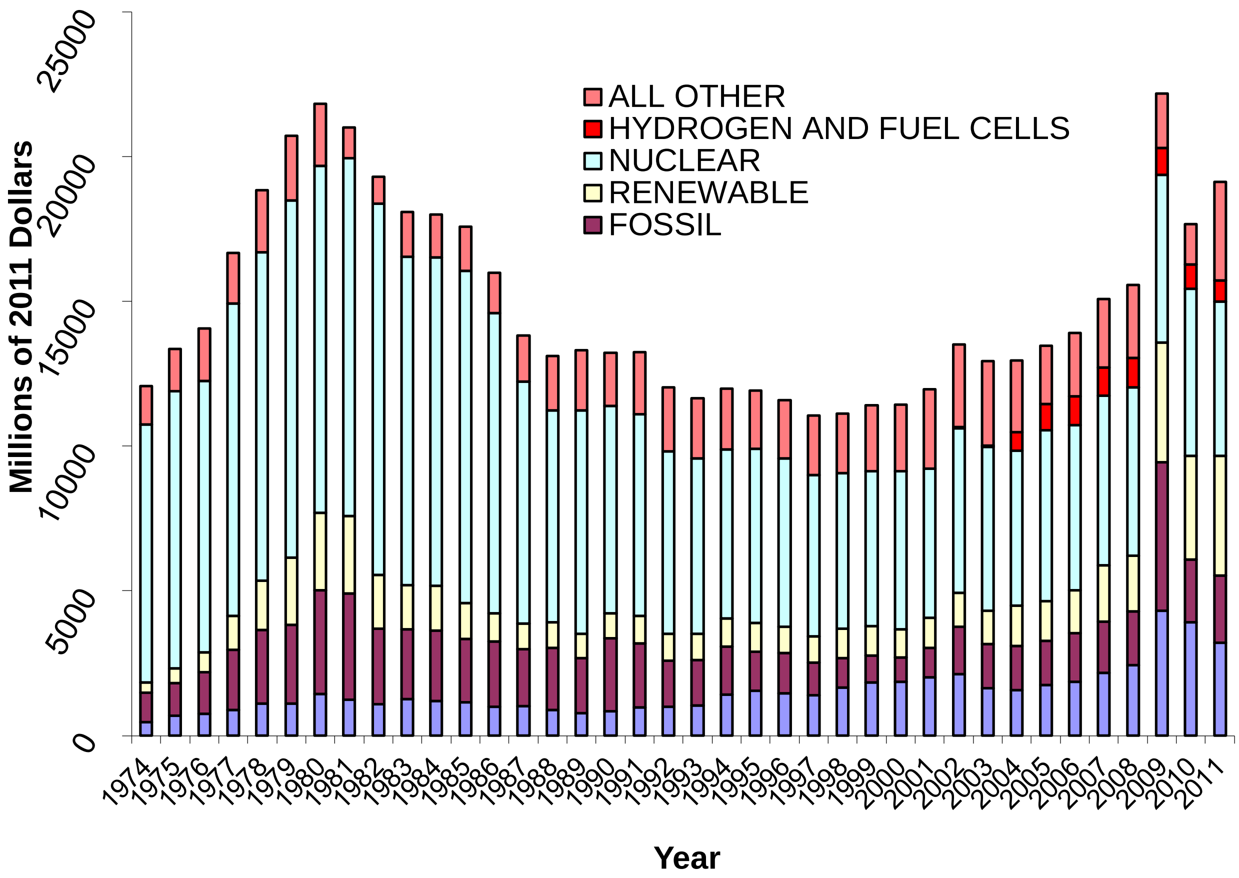

Figure 15.5. IEA Countries RD&D Expenditure over Time

[9] The IEA definition of RD&D includes applied research and experimental development, but excludes basic research unless it is clearly oriented towards the development of energy technologies. Demonstration projects are included, and are defined as projects intended to help prove technologies that are not yet commercial. IEA definitions exclude technology deployment activities. Data and definitions are available at http://www.iea.org/stats/rd.asp. For the Chart, the category "All Other" was constructed as the sum of IEA categories "Other power storage technologies" and "Other cross-cutting techs/research."

In 1980, more than half of this expenditure was devoted to nuclear technology, with 16% devoted to fossil fuels, 12% on renewables and 7% on energy efficiently. In 2011, nuclear remains the largest category at 28%, followed by renewables at 22%, efficiency at 18% and fossil technology at 12%.

Support for research, development and commercialization of sustainable energy technologies has increased significantly in China in recent years. The National Basic Research Program (973 Program), the National High-tech R&D Program (863 Program), as well as the National Key Technology R&D Program, are the three key programs (TKPs) of China (Chai and Zhang, 2010).

The U.S. National Research Council evaluated Federal Energy RD&D investments in energy efficiency and fossil energy for the period 1978-2000. The NRC found that these investments "yielded significant benefits (economic, environmental, and national security-related), important technological options for potential application in a different (but possible) economic, political, and/or environmental setting, and important additions to the stock of engineering and scientific knowledge in a number of fields" (U.S. National Research Council, 2001). In terms of overall benefit-cost evaluation, the NRC found that the energy efficiency programs produced net realized economic benefits that "substantially exceeded" the investment in the programs. For the fossil energy programs, the net realized economic benefits were less than the cost of the programs for the period 1978-1986, but exceeded the cost of the programs for 1986-2000 (Chai and Zhang, 2010, p. 6).

In the short run, the availability of appropriately trained scientists and engineers is a constraint on a country's ability to increase its research output (Goolsbee, 1988). Therefore, sustained gradual increases in research are likely to be more effective than short-run rapid increases. In the long run, it is possible to expand the supply of scientific and technical labour available to perform energy-related research. This can occur through training that occurs when publicly funded research is carried out at universities and other combined research and teaching institutions, and/or via direct public funding of training. Success at increasing the technical workforce has been found to be a crucial factor in the long-run benefits of health-related research in the U.S. (Cockburn et al., 2011)

15.6.3 Policies to foster or accelerate deployment and diffusion of new technologies

Historical experience with other technologies points to the need for public policy to support purchase and diffusion of new technologies. Publicly funded research certainly played a role in the digital revolution, but active government involvement as a purchaser was also crucial (Mowery, 2011). Purchases were made of products meeting stated technical specifications, sometimes with little regard to cost, sometimes on a competitive basis with respect to cost, but typically with no maximum price set. These purchases helped moved products down the learning curve, eventually allowing civilian versions to be sold competitively. In addition to facilitating cost reduction by building cumulative volume, government procurement competition spurred private investment in R&D aimed at meeting the technical specifications requested by the government (Lichtenberg, 1988).

Table 11.2 of the SRREN provides a taxonomy of technology deployment policies. Although this table discusses the policies in terms of renewables, the same set of options generally applies to other technologies (e.g. energy efficiency). The SRREN groups these policies in three broad categories: fiscal incentives (e.g. tax credits or other tax adjustments, rebates or grants), public finance (e.g. loan or loan guarantee) and regulation. The regulation category is further subdivided into regulations that are quantity-based (e.g. Renewable Portfolio Standard (RPS)), those that are price-based (Feed in tariff (FIT)), and those that relate to access to the existing infrastructure.

FIT's, when set high enough, encourage deployment of renewable technologies as illustrated, for example, in Section 7.12 of this volume. As discussed above in connection with Figure 15.4, this increased utilization likely fostered cost reductions through learning-by-doing, economies of scale, and the increased incentive for R &D created by an expanding market.

There is a considerable and inconclusive literature comparing price-based (mostly FIT) and quantity-based (mostly RPS) policies to foster technology deployment. Some studies show that FITs are generally more efficient and effective policies for promoting renewable than RPS (see Butler and Neuhoff, 2008); (Mitchell et al., 2006), while others show RPS are relatively less expensive than FITs to achieving renewable energy target (see Palmer and Burtraw, 2005); (Böhringer and Rosendahl, 2010)).

FITs provide strong incentive for minimizing risk of renewables' project and can offer higher subsidy rates for more costly technologies (e.g. PV). (Butler and Neuhoff, 2008) and (Mitchell et al., 2006) show that UK's RPS is not inherently cheaper than German FIT and the FIT results in much larger wind power deployment. However, the high FITs for solar PV in Germany and Spain have attracted sharp criticism mainly for being too costly (Frondel et al., 2008, 2010; Constable, 2011).

In contrast, RPS encourages competition among various renewables and promoting the (currently) most economically attractive technologies. Although FITs remove risk from investors in renewable generation, removing risk from investors may serve mainly to shift the risk to other actors and hence not reduce the risk to society as a whole. (Schmalensee, 2012) shows in a simple theoretical model that the long-run societal risk may in fact generally be lower under the RPS approach than under a FIT regime.

Many developing countries face a somewhat different set of choices in encouraging technology deployment because of the dominance of state-owned or other monopoly enterprises in the energy sector. (Liu and Kokko, 2010) evaluate the factors related to the significant growth of wind power in China, and conclude that administrative rules stipulating levels of wind usage have been more effective than incentives operating through the pricing system. (Pegels, 2010) describes the introduction of a renewable FIT guaranteed for 20 years in South Africa, but notes that it is unclear what effect this will have on the investment decisions of the monopolist electricity supplier. (Solangi et al., 2011) provides a review of policies in many countries to promote solar energy. They also find that purchase mandates have had a greater impact than incentives. In a comparative study of off-grid solar power development in Kenya and Tanzania, Ondraczek (2013) identifies awareness among consumers as a critical element in market development and finds evidence for a "virtuous cycle" between dissemination and awareness. In addition to mitigating financial risks for entrepreneurs, Friebe et al. (2013) emphasize the need for including pre and post-sales services to sustain the uptake of solar home systems. (Glemarec, 2012) highlights the role for public-private partnerships to deliver energy access but underlines the need for public investment in capacity and market development.

(Jänicke, 2012) provides a number of case studies of national efforts to foster deployment of GHG-reducing technologies. Spain has moved to second worldwide in solar power capacity and forth in wind power, through the use of an attractive FIT. China has been very successful in rapidly increasing investment in renewable technologies, so much so that its development targets have been repeatedly revised upwards, demonstrating that the establishment of ambitious technology targets can be self-fulfilling in the Chinese context. India has launched an ambitious solar electric technology program, using ambitious deployment targets to simultaneously increase indigenous technological capacity, and promote electrification in rural areas with inadequate grid connections.

A contrasting and cautionary experience is the U.S. effort to develop synthetic liquid fuel from coal and other fossil sources in the 1970s and 1980s. Multi-billion dollar public investments were made in commercial-scale implementation projects. These projects probably did develop solutions to some of the technical problems facing these technologies, but they did not result in significant commercially viable outcomes. This is in part due to the collapse in world oil prices in the 1980s, but it appears that the projects were also wastefully implemented, and crowded out rather than complementing private investment in the technology (Cohen and Noll, 1991).

15.6.4 Intellectual Property

Patents and other forms of intellectual property ("IP") are intended to encourage the creation and development of new technologies, by granting to the creators of such knowledge a legal right to prevent its use or duplication by other parties. The public policy purpose for the grant of this right is to increase the economic reward, and thereby encourage investment in the creation and development of new technology.

Public policy towards intellectual property inherently involves a trade-off between the desire to create incentives for knowledge creators and developers, and the desire to have new knowledge used as widely as possible once it is created (Hall, 2007). It is therefore crucial to analyse the extent to which IP protection will foster climate change mitigation, by encouraging the creation and development of new GHG-reducing technologies, versus the extent to which it will hamper mitigation by raising the cost and limiting access to such new technologies as are developed. IP policy will affect climate mitigation both through its effects on the creation of new technology and on the international transfer of mitigation technology. The first of these mechanisms will be considered here; the effect of IP policy on technology transfer is discussed in Chapter 13.

In general, the empirical evidence that IP protection stimulates innovation is limited to the chemical and pharmaceutical sectors, and to developed economies (Park and Ginarte, 1997). It is unclear to what extent strong IP protection is necessary or conducive to the development of the kind of technologies that would mitigate climate change in advanced and middle income countries, and it appears unlikely to be relevant to indigenous technology development in the poorest countries (Hall and Helmers, 2010).

The international framework for IP policy is the Trade Related Aspects of Intellectual Property Rights ("TRIPS") agreement (Marakesh Agreement, 1994). The TRIPS agreement generally commits all countries to create and enforce standard IP protections, but it does allow for the possibility of exceptions to standard patent regulations for public policy reasons. Hence a major policy issue related to climate change is the extent to which less developed countries will be compelled within the TRIPS framework to enforce strong IP protection relative to GHG-reducing technologies, or whether an exception or exceptions will develop for these technologies on public policy grounds (Derclaye, 2008; Rimmer, 2009).

Because the evidence that strong IP protection increases domestic innovation is almost entirely limited to specific sectors in the developed world, there is little reason to believe that maintenance of strong IP protection in less developed countries will increase those countries' indigenous creation or adaptation of GHG-reducing technologies.[10] As discussed in Chapter 13, however, the evidence does suggest that the presence of an effective IP regime is a factor in fostering technology transfer into a country. There is therefore an inherent trade-off for less developed countries between the limitations on widespread deployment that may be created by strong IP protection, and the need for such protections as a market precondition for inbound technology transfer.

15.6.5 The effect of environmental policy instruments on technology

There is some empirical literature assessing the impact of generic environmental policy instruments (discussed in the previous subsection) on technological change. For surveys, see (Newell, 2010) and (Popp, Newell, et al., 2010). (Jaffe and Palmer, 1997) looking across industries in the U.S., found that more stringent regulation was associated with higher R&D expenditures (controlling for industry fixed effects), but did not find any impact on industry patents. Lanjouw and Moody (1996) did find that across the U.S. Germany and Japan, patenting rates were correlated at the industry level with pollution control expenditures.

[10] Developing countries contribute a small, but non-trivial share of world inventions related to climate change, with China and Brazil contributing 8.1% and 1.2% respectively since 1978 (Dechezleprêtre et al., 2011)

A number of studies have looked at the impact of energy prices on energy-saving technological change. These effects can be seen as indicative of the possible consequences of GHG policies that increase the effective price of emitting GHG. (Popp, 2002) found that rising energy prices increased the rate of patenting with respect to alternative energy sources and energy efficiency, with more than one-half the effect coming within five years of energy price changes. (Newell et al., 1999) found that rising energy prices increased the efficiency of the menu of household appliances available for purchase in the U.S. The Norwegian carbon tax appears to have triggered technology innovation in the form of carbon sequestration in the Sleipner gas field (Sumner et al., 2011a).

Energy efficiency standards also affected the efficiency of the menu, by eliminating less efficient choices. Labelling standards were found to increase the effectiveness of the price signal; the effect of energy prices on model substitution was increased when mandatory energy-efficient labels were implemented.

At a theoretical level, there are arguments why incentive-based policies such as carbon taxes or tradeable permits are more conducive to innovation that regulatory mandates (Popp, Newell, et al., 2010). After the 1990 Clean Air Act Amendments in the U.S. implemented a tradeable permit program for sulphur dioxide, (Popp, 2003) found that the rate of patenting on techniques for sulphur removal increased, and (Lange and Bellas, 2005) found that both capital and operating expenditures for scrubbers were reduced. In a survey of research on the effects of tradeable permit systems on technology innovation and diffusion, (Bellas, 2011) concluded “The general result is that tradable permit programs have improved the pollution control technology compared to the previous regulation used.”

More recently, a few studies have explored the effect of renewable energy policies on energy innovation. (Johnstone et al., 2010) found that policy had a significant impact on patent applications for renewable technologies, with different policy instruments being effective for different technologies. (Popp, Hascic, et al., 2010) found that the link between greater patenting and investment in specific technologies is weak, but there does seem to be an association between policy and investment.

15.6.6 Building program evaluation into government technology programs

Evaluation of government programs to foster new energy technologies has been hampered by a lack of complete and consistent evaluation data at the program level (U.S. National Research Council, 2001). This problem is common to many government technology programs. Proper evaluation requires that data on project selection and project performance be collected as programs commence and maintained after they are completed (Jaffe, 2002). Wider use of such evaluation methods would allow experience with relative effectiveness of different programs to be used to improve outcomes over time.

15.6.7 Conclusion

1. There is a distinct role for technology policy in GHG mitigation. This role is complementary to the role of policies aimed directly at reducing current GHG emissions.

2. Worldwide investment in research in support of GHG mitigation is small relative to the scale of the problem. The effectiveness of research support will be greatest if it is increased slowly and steadily rather than dramatically or erratically.

3. Policies aimed at fostering the diffusion and deployment of GHG-reducing technologies are likely to be complementary to policies in support of research and those aimed directly at reducing current emissions.

4. Government purchases, or government policy that generates purchases (e.g. utility renewable mandates) are necessary to accelerate the commercialization of potential

technologies. Both research and purchase policies should be designed to encourage and be complementary to private development efforts, to try to minimize crowding out of private development investment.

5. Data collection for program evaluation should be built into technology policy programs.

15.7 Synergies and Trade-offs among Policies

15.7.1 Introduction

This section discusses interactions between policies and policy objectives. Subsection 15.7.2 discusses interactions between policy objectives, 15.7.3 takes up interactions between different policies at different levels of government while 15.7.4 takes up interactions between policies enacted at the same level of government. The interactions in 15.7.3 and 15.7.4 reflect the absence of policy coordination, and they affect the environmental and economic outcomes. Deliberate linking of policies is discussed in the next section, 15.8. Finally, 15.7.4 sums up the lessons learned about policies and instruments in Sections 15.5, 15.6, and 15.7.

15.7.2 Interactions between policy objectives

Governments throughout the world have enacted various policies to support the mitigation of GHGs. This mitigation, along with the associated prevention of climate change, is the central objective of climate policy. However, climate-change policy also has benefits (or costs) beyond mitigation itself. Because these benefits are outside of the central objective of climate policy, these are labelled co-benefits (rather than primary benefits). Co-benefits may include social development, enhancement of energy security, technological development, and the reduction in local air pollution.

The co-benefits for climate-change policy are often primary benefits of other policies with other main objectives. Social development is a primary benefit of development policy, since such development is the main objective. Similarly, enhanced energy security, technological development, and reduced air pollution are primary benefits of energy security, technological development, and air-pollution policies, respectively. To the extent that these other policies (with other objectives) lead to mitigation of GHGs, such mitigation is a co-benefit of these other policies.

There are advantages to coordinating separate policies and their various benefits. The concept of “mainstreaming” climate policy refers to the linking of climate policy with other policy efforts, particularly policy efforts that have broad recognition. The prospects for successful climate policy can be enhanced through such mainstreaming.

Linking climate policy with other policies poses many challenges. Different policies do not automatically reinforce each other: there can be trade-offs.

The potential trade-offs can be significant between climate policy and development policy, in particular. Social and economic development can lead to higher GHG emissions, while climate change policy can potentially impose costs that retard social and economic development. Climate change policy can compete with development in terms of shifting financial resources away from promoting development. The complex relationship between development and climate change can benefit from a coordinated approach, one that integrates or mainstreams climate change within framework of sustainable development.

An integrated approach is especially important for developing countries. Developing country governments tend to address mitigation through developing comprehensive development plans. The sustainable development agenda of developing countries could be very wide, embracing goals including power eradication, energy access for all, environment sustainability, ensuring education and gender equity. Although mitigation goals are not major and immediate concerns for developing countries, many development policies indeed have side-impact on climate change. Properly designed policies can widen policy goals to more than one and capture these mitigation benefits. For example, the improvement of energy efficiency may reduce greenhouse gases and enhance security of energy supply.

Sustainable development provides a context that can be integrated with both mitigation and adaptation (Wilbanks and Sathaye, 2007). Mainstreaming climate change in other policy areas can enhance the effectiveness of mitigation policies. Policy areas that can be aligned with mitigation policies may include energy security, local air pollution, job and employment, traffic congestion and safety, trade and finance (UN 2012) (Kok and De Coninck, 2007).

Challenges also apply to the linking of climate policy with energy-security policy. Security of energy supply is an important concern for those countries depending on energy imports. The principle goal of energy security policies is to ensure energy supply in a reliable and affordable manner. The main inter linkage between energy security and climate change is the GHG emissions resulting from combustion of fossil fuel in our energy system. While reducing dependence on imported fossil fuel is a major objective of many energy importing countries, there is a clear inter linkage between energy security and mitigation (Lecuyer and Bibas, 2011; Toichi, 2012).

In the past, the policies on air quality and on GHG mitigation have been separate. However, the two are intimately related, especially in transportation sector (Ribeiro and De Abreu, 2008). These policies can work synergistically. Policies that reduce GHG emissions by reducing fossil fuel use will also reduce emissions of other pollutants. Measures that result in improved energy efficiency are always win-win solutions for both air quality pollutants and GHG mitigation. Subject to cost and availability of technology, fuel-switching measures are also beneficial for both (ApSimon et al., 2009).

Mitigation is not always synergistic with energy security and air quality goals. Sometimes, the various objectives imply a trade-off. For example, Carbon capture and storage may raise concerns about energy security and also air quality due to its estimated higher NOx emissions (Tzimas et al., 2007). Through improving inter linkage between different institutional, these trade-offs can be dealt with better.

Trade and financial policies also offer opportunities for mainstreaming mitigation. Sustainable production and sustainable consumption policies will affect trade flows through a more sustainable manner. Green investment initiatives will incorporate mitigation concerns through making investment more sustainable. Energy subsidy reform is also crucial to address climate change mitigation.

To the implementation of mainstreaming mitigation, mainstreaming should be a key component of any international, national or sectoral development framework. First, mitigation needs to be mainstreamed in appropriate national and sector planning processes to widen specific national and sectoral development goals. For developing countries, such integration of mitigation into development planning is of greater importance. There is an issue of lack of cooperation, coordination and joint decision-making at different level (Tyler, 2010).

To achieve goal of mainstreaming, the requirement of government capacity, leadership and influence are deterministic. Mitigation plan should be institutionalized and contextualized within the national plan to align economic and social development with mitigation actions. The institutions embedded for mainstreaming climate change mitigation may differ for related issues.

Capacity in developing countries presents the most significant barrier to mainstreaming of mitigation policies, including lack of training and expertise in climate change issues and weak enforcement and oversight. Therefore, a key prerequisite for developing countries to successfully mainstream and implement policies is to build training and awareness, enhance coordination between ministries and provide adequate finance to enable enforcement (Lemma et al., 2009).

Mainstreaming can make an important contribution to mitigation through aligning with other policy goals. Without serious political will and follow-up implementation of these policies and measures, it may be more difficult to achieve the goal of climate change mitigation.

15.7.3 Interactions when policies are conducted at different jurisdictional levels

Climate policy has been conducted at various jurisdictional levels: international, national, regional (state or provincial), and local (municipal). Important interactions can occur across jurisdictional levels. Some interactions are beneficial, reinforcing the intended effects. Others are problematic, interfering with the planned objectives. Sound policy making requires attention to these interactions.

15.7.3.1 Beneficial interactions

Policies introduced by a local jurisdiction sometimes reinforce the goals of efforts undertaken at a higher jurisdictional level. In particular, a sub-national policy can enhance cost-effectiveness if it addresses market failures that are not confronted by a national climate policy. Thus, for example, an RPS or R&D subsidy could usefully complement a national emissions pricing policy if there are no policies at the national level addressing the innovation market failure.

The connections between instruments that deal with climate change and those that deal with congestion or local pollution also present an opportunity to policy makers, but they are very different since the latter vary depending on the socioeconomic context, technology, fuel and vehicle use (Parry et al., 2007; Oikonomou and Jepma, 2008; Vanderschuren et al., 2010; Parry, 2013)the case of S Africa). For example, urban planning implemented jointly with fuel or carbon taxes can help fast growing developing countries minimize resource waste by avoiding urban sprawl. Policies incentivizing more dense urban architecture combined with the appropriate infrastructure for modern public transport can be an important complement to energy taxation. Such policies can be supported (and possibly financed) by fuel taxes if the policy maker wants to discourage citizens from making private decisions that are incompatible with this broader vision; policy combinations for this sector are discussed in greater detail in chapter 8. Conversely, subsidising fuels and taking a hands-off urban planning approach can result in urban sprawl and a growth in private automobile use along with growth in resulting emissions.

Local-level action can also be a good source of information by allowing experimentation. In the United States, environmental policies by the federal government have a history of evolving out of successful policy "experiments" undertaken by states (Goulder and Stavins, 2011; Shobe and Burtraw, 2012). Thus, an appealing feature of local-level actions are their ability to try out policy options not currently in place at the higher jurisdictional level; the higher jurisdiction may have more confidence in introducing a policy subsequently if it already has a successful track record at the more local level.

Finally, local policies can produce beneficial strategic interactions. If national policy is insufficiently stringent, a stringent state/province or even municipal policy may create pressure on the national government to increase its own policy's stringency. (Goulder and Stavins, 2011) cite the example of California, which repeatedly increased the stringency of its local air pollution standards and was repeatedly followed by the Federal government increasing Clean Air Act regulations' stringency. Similarly, (Lucon and Goldemberg, 2010) note the importance of Sao Paulo's GHG-reducing policies in influencing other local and even regional governments in Brazil.

15.7.3.2 Problematic interactions

Policies introduced at different levels sometimes interact in ways that compromise or weaken the intended environmental or economic impacts.

On particular difficulty that may arise is the problem of emissions leakage. This can occur, for example, when a climate change policy introduced at a lower jurisdictional level is "nested" within a cap-and-trade program implemented at a higher jurisdictional level. Consider the case where a cap-and-trade program exists at the national level, and where a subnational authority introduces a new policy intended to reduce its own (subnational) emissions beyond what would result from the national program alone. The subnational jurisdiction's efforts might indeed yield reductions within that jurisdiction, but facilities within that jurisdiction will now have excess allowances from the national program. They will sell these excess allowances to facilities in other sub-national jurisdictions, and these other facilities' emissions will now be higher than they would have been otherwise. Since overall emissions at the higher level are determined by the given national-level cap, the effort by the sub-national jurisdiction does not succeed in reducing nationwide: it just causes emissions leakage – offsetting increases in emissions elsewhere in the nation. The national cap effectively prevents sub-national jurisdictions from achieving further emissions reductions. (Goulder and Stavins, 2011; Shobe and Burtraw, 2012).

The issue applies to the United Kingdom's efforts to reduce emissions through a tax on CO2 emissions by electric power generators in the country. For each unit of emissions, these generators would need to pay this tax in addition to the price that they paid for EU ETS emissions allowances. Although the tax will likely cause greater abatement by generators within the UK, the impact on overall emissions in the EU is not clear, since overall European emissions are largely determined by the Europe-wide cap under the EU ETS. On this, see (Böhringer et al., 2008; Sartor and Berghmans, 2011).

This leakage program can be avoided when the lower-level jurisdiction's program is nested within a carbon tax program, rather than emissions cap, at the higher level. In this case, the subnational policies generally are not environmentally irrelevant. The reduced emissions in the subnational jurisdiction do not lead to a fall in the emissions price (the carbon tax) at the national level; hence there are no offsetting increases in emissions in jurisdictions outside the jurisdiction introducing the more stringent policy (De Jonghe et al., 2009; Fankhauser et al., 2010; Goulder and Stavins, 2011). This can be an important advantage of a carbon tax over a cap-and-trade system.

15.7.4 Interactions between policies conducted at the same jurisdictional level

Interactions also can arise when different policy instruments are introduced at the same jurisdictional level. These interactions can be beneficial or problematic in terms of the cost-effectiveness of reducing greenhouse gas emissions.

15.7.4.1 Beneficial interactions

The potential for cost-reducing interactions is greatest when the different instruments address different market failures. A fundamental principle of public policy is that the most cost-effective outcome results when there are as many policy instruments as the number of market failures involved, with each instrument focusing mainly on a different market failure (Tinbergen, 1970).

Climate policy often focuses on addressing one market failure in particular – the climate-change-related externalities associated with GHGs. However, another important market failure applies in the market for innovation: because new knowledge can spill over to third parties, innovators often cannot capture all of the social benefits from the new knowledge they create. Introducing two policy instruments to address the two market failures can lower the costs of achieving given emissions reductions.

Consider, for example, the case where emissions pricing (through a carbon tax or cap and trade) is introduced to address the emissions externality, while a subsidy to R&D is engaged to address the innovation market failure. In addition to helping reduce emissions by encouraging fuel-switching and a reduction in demand, emissions pricing can help spur innovation. Likewise, the R&D subsidy can promote invention of low-carbon technologies, thereby helping to curb emissions. Hence the interactions of the two policies are beneficial. Although each of the two policies might to some degree affect both of the market failures, emissions pricing is particularly well-focused on the first, while the R&D policy sharply addresses the second. Using two instruments helps achieve emissions reductions at the lowest cost. In this connection, (Fischer and Newell, 2004) and (Oikonomou et al., 2010) find that a policy combination including a price on GHG emissions and renewable energy subsidies achieves emissions reductions at significantly lower cost than either of these policies alone. (Schneider and Goulder, 1997) obtain a similar result for the combination of carbon tax and R&D subsidy.

Other market failures besides the innovation market failure can potentially justify (on cost-effectiveness grounds) multiple policies at the same jurisdictional level. Some studies suggest a market failure associated with reliance on crude oil, claiming that reliance on oil produces an "economic vulnerability externality," given the possibility of supply disruptions on the world oil market (Jones et al., 2003). Under these circumstances, the combination of emissions pricing (to address the climate change externality) and a tax on oil consumption (to address the vulnerability externality) can be a cost-effective way of dealing with both climate change and economic vulnerability. Several authors (e.g., (Nordhaus, 2009)) emphasize that the vulnerability to world oil price changes is largely a function of the share of overall oil consumption in GDP, rather than the share of consumed oil that comes from imports. This suggests that the vulnerability externality is best addressed through a tax on oil consumption rather than a tax on imported oil.

Several studies (Greene, 1998; Goulder and Parry, 2008; Gillingham et al., 2009) argue that there is a market failure associated with consumer purchases of durable energy-using equipment (automobiles, refrigerators, etc.), according to which consumers systematically underestimate their own future gains from purchasing more energy efficient durables. To the extent that this market failure is significant, the combination of emissions pricing and a second instrument (for example, an energy-efficiency standard for appliances) to address this additional market failure could lead to beneficial interactions and promote cost-effectiveness.

15.7.4.2 Problematic interactions

Multiple policies at the same jurisdictional level also can yield problematic interactions. This can happen when multiple policies only address the same market failure. Consider the situation where a given jurisdiction attempts to reduce greenhouse gases through both emissions pricing and another policy such as a performance standard (a limit on the ratio of emissions per unit of production). Economic theory claims that emissions pricing tends to promote a highly cost-effective outcome by promoting equality in the marginal costs of emissions-abatement across all the facilities that face the given price of emissions (the carbon tax or the price of emissions allowances). If, in addition, facilities face a performance standard, then this added policy approach either is redundant or it compromises cost-effectiveness.

It is redundant if meeting the performance standard would involve marginal abatement costs lower than the emissions price. In this event, cost-minimizing firms would be induced to meet or exceed this standard by the emissions price alone: there is no need for the standard. On the other hand, if the performance standard entails a cost per unit of abatement that is significantly higher than the emissions price, then this requirement sacrifices cost-effectiveness. Relying on emissions pricing alone would have promoted emissions reductions by the facilities that can achieve those reductions at the least cost. Thus it would likely have led to a situation where the more expensive technology approach was not employed. Hence in this case the combination of emissions pricing and the performance standard does not promote cost-effectiveness.

Emissions price policies interact with other policies differently, depending on whether the emissions price policy involves a quantity limit (as is the case under cap and trade) or a stipulated emissions price (as is the case under an emissions tax). In the presence of a cap-and-trade program, introducing an additional instrument such as a performance standard might yield no further reductions in overall emissions (Burtraw and Shobe, 2009; Fankhauser et al., 2010). The reason is that overall emissions are determined by the overall cap or number of allowances in circulation. The problem is formally very similar to the difficulty described in subsection 15.7.3 above, where in the presence of a national cap-and-trade program an effort by a sub-national jurisdiction to achieve further emissions reductions is likely to have difficulty achieving that goal. In contrast, introducing a performance standard in the presence of an emissions tax can in fact lead to a reduction in overall emissions. The price of emissions – the emissions tax – does not change when the performance standard causes a reduction in emissions. For this reason the reduction caused by the performance standard does not lead to a compensating increase in emissions elsewhere. Overall emissions fall.

For similar reasons, the same difficulty arises when a carbon tax is introduced in the presence of a cap-and-trade program at the same jurisdictional level (Fischer and Preonas, 2010).

Nevertheless, as suggested above, the combination of emissions pricing and some other policy could be justified in terms of cost-effectiveness to the extent that the latter policy directly addresses a second market failure that emissions pricing does not directly confront.

It is important to recognize that the notion of a "market failure" pertains only to the criterion of economic efficiency. Another important public policy consideration is distributional equity. Concerns about distributional equity can justify supplementing a given a given policy instrument with another in order to bring about a more equitable outcome. This may be desirable even if the multiplicity of instruments reduces cost-effectiveness.

15.8 National, State and Local Linkages

15.8.1 Linking policies: potential and challenges

Linking or harmonizing initially separate climate policies can reduce costs. By linking hitherto separate cap-and-trade policies can lower costs by helping promote further gains from trade. In the absence of linkage, the two cap-and-trade systems are likely to yield differing market prices for allowances, implying differences in marginal costs of abatement across the two systems. Overall costs could be reduced if less abatement were carried out by the system with high abatement costs, and more by the system with lower abatement costs. Linking the systems accomplishes this. The market price will settle somewhere between the initial prices, consistent with this change in the geographical distribution of abatement effort.

The analogue to linking two cap-and-trade systems is harmonizing initially separate carbon tax systems. Such harmonization also can yield cost savings. Suppose that the EU initially had a carbon tax of $15 per ton, and that the U.S. originally instituted a carbon tax of $25 per ton. In this situation, the marginal abatement costs of facilities facing the tax will likely be higher in the U.S. than in the EU since facilities will keep costs to a minimum by pursuing abatement until the cost of abatement reaches the value of the avoided tax. The same overall abatement over the two regions could be achieved at lower cost with a carbon tax that is between $15 and $25. After harmonizing the two tax rates, facilities in the US will undertake less abatement, while facilities in the EU will undertake more. The added abatement costs in the EU will fall short of the avoided abatement costs in the US, however, since the starting point involves higher costs in the US than in the EU.

Achieving policy linkage or harmonization involves several challenges. One is that it can substantially alter the distribution of wealth among the national or subnational entities involved. When two cap-and-trade systems are linked, for example, the entity that initially faced higher allowance prices will benefit from the now-lower prices, while the entity with initially lower allowance prices will suffer higher allowance prices. In order to make linkage attractive to both parties, it might be necessary for the gaining party to offer some form of compensation to the losing party. In principle, linkage can lower the overall costs to each of the entities involved once a side-payment has been provided. But negotiating the side-payment can be very challenging.

A second consideration is the magnitude of international revenue flows and associated macroeconomic impacts. A potential difficulty associated with internationally linked cap-and-trade programs is the potential for very large revenue flows from the nations' purchasing allowances to the nations selling them. In contrast, an internationally harmonized carbon tax does not directly produce any international revenue flows. The potential for large international revenue flows under cap and trade raises concerns about exchange rate and other macroeconomic effects. However, experience to date with the European Union's Emissions Trading Scheme yields no evidence of adverse exchange rate or macroeconomic consequences from trade-induced revenue flows.

At the same time, arriving at a uniform international carbon tax raises practical difficulties. Various nations may claim that they already tax carbon through existing taxes on individual fossil fuels or on refined fuels (gasoline, home heating oil, etc.). Arriving at a uniform international tax on carbon would in theory require knowledge of the incidence of a wide range of existing energy taxes – in practice this can only be approximated. Individual nations might well manipulate the calculations so as to suggest they are already paying significant taxes on carbon and thereby avoid much of an increase as part of an international effort to obtain a uniform international tax rate.

Thus there are significant challenges involved in linking systems internationally, no matter whether the systems involved involve cap and trade or carbon taxes.

15.8.2 Federalism

In the last few years an increasing number of sub-national administrations across the world have been active in the design and application of climate change policies. Subsection 15.2 has reported some of these experiences, whereas subsection 15.8 has dealt with some of the interactions that may arise with the simultaneous use of climate policy instruments by several jurisdictions. This subsection goes a little back and is basically interested in the allocation of climate policy responsibilities across the different levels of government that usually exist in most countries (central, regional and local administrations). Although such allocation involves the use the policy types described in subsection 15.4, the emphasis here will not be on instrument use in itself as this was already covered in the previous parts of the chapter (policy description, interactions and synergies, evaluation of experiences, etc.). The objective of this subsection would be to examine the theoretical backing for such practical applications and to extract lessons that may be useful for future sub-national applications and even for the design and implementation of national and supra-national mitigation policies.

When dealing with the reasons for and guidelines for the 'vertical' allocation of responsibilities among jurisdictions that co-exist in a country, the theory of fiscal federalism (economic federalism) offers valuable insights. In short, that the responsibility for public decision-making over a particular issue (e.g. allocation of public goods, economic stabilization, or distribution) should be given to the jurisdictional level that could better manage it. In this sense, fiscal federalism contends that the central government should have the basic responsibility for functions whose national extension would render ineffective and inefficient a sub-national approximation, including 'national' public goods (Oates, 1999).

Given the global and public good nature of climate change, its jurisdictional allocation should actually be at the highest possible level. A sub-global allocation, as observed in Chapter 13, would lead other jurisdictions that are not active in climate change mitigation to benefit without paying the costs, i.e. in a free-riding fashion (Kousky and Schneider, 2003). The costs for a sub-national administration may be actually beyond those of pure mitigation, as climate policies implemented by a jurisdiction might bring about leakage, a 'horizontal' movement of economic activities to other jurisdictions without mandatory requirements (Kruger, 2007; Engel, 2009). Moreover, the 'reshuffling' that may be associated to sub-national policies may reduce their environmental effectiveness (Bushnell et al., 2008). As a consequence, climate change mitigation would be provided in a sub-optimal level with sub-national allocation of responsibilities.

Yet as observed later on, even if the central government has a major responsibility in this area, this does not preclude the allocation of mitigation responsibilities within a federation. But even within the theory of fiscal federalism there are other reasons that may justify sub-national action in this field. First, as noted by (Edenhofer et al., 2013), the exploitation of heterogeneous sub-national preferences for mitigation would lead to efficiency gains. This is actually one of the reasons for the decentralization theorem, a centrepiece of fiscal federalism, which in fact justifies sub-national allocation of certain public goods. If this is coupled with mobility of agents across jurisdictions (Tiebout sorting), preferences on climate mitigation would be better revealed and 'horizontal' fiscal interactions would be now efficiency-enhancing. However, the global nature of climate change may limit migration, as there might not exist a compelling reason for migration due to reduced GHG emissions (Shobe and Burtraw, 2012).

Moreover, decentralization can contribute to policy innovation by providing an opportunity to experiment with different approximations. Indeed, there might be potential gains from learning by doing in policy terms without imposing large costs on an entire country or the world with untried options (Oates, 2002). On such a context, sub-national governments could also choose to be leaders in the development of climate policies to obtain potential economic gains that are associated to "first movers" (Jänicke and Jacob, 2004) and may provide guide and incentives to other jurisdictions to follow them. Besides, as they tend to be smaller, sub-national governments may be able to adapt to new situations in a swifter manner and therefore may have a greater flexibility to modify existing climate change policies or to define new ones (Puppim de Oliveira, 2009; Galarraga et al., 2011).

Other general approaches to federalism, such as cooperative and democratic federalism, may also provide reasons for sub-national involvement in this area (Inman and Rubinfeld, 1997). On the one hand, cooperative federalism argues for allocating pure public goods to the local level, counting on the power of inter-jurisdictional bargaining to improve allocations. On the other hand, democratic federalism incorporates sub-national powerful representation in central decision-making on public goods. In any case, federal structures may be crucial for the transmission of mitigation policies because most sub-national governments are now responsible for matters that have huge effects on GHG emissions: land use planning, building codes, waste management, traffic infrastructure and management, public transport, etc. (Collier and Löfstedt, 1997; Bulkeley and Betsill, 2005; Doremus and Hanemann, 2008). But sub-national governments also have direct policies aimed at GHG mitigation: energy efficiency programs, educational efforts, green procurement standards, partnership agreements with local businesses, or tree planting (Schreurs, 2008).

Yet another reason for a sub-national role in climate policies is beyond the standard collective action approach followed so far. By indicating that externality-correcting regulations and global agreements are not the only pace to tackling climate change problems, (Ostrom, 2010) suggested a polycentric approach in which mitigation activities are undertaken by multiple (public and private) units at diverse scales. The prevalence of sub-national actions in the field, contentious to other approaches, may be actually a proof of polycentrism in the area (Sovacool, 2011) In a way, the polycentric approach could be seen as a reinterpretation of the findings of the federalism literature, as actions should involve many different agents in a reinforcing manner.

Finally, further issues may explain sub-national allocation. Local authorities, for instance, may be more effective in reducing GHG emissions from some sources such as waste and transport, as this may provide significant co-benefits to local citizens (Kousky and Schneider, 2003). Moreover, sub-central administrations are usually closer to the places and citizens impacted by climate change. Even though climate change is a global phenomenon, the nature of its impacts and severity varies (sometimes significantly) across locations so some sub-national governments have reasons to be more protective than national or supranational administrations (Andreen, 2008). This is also the case of adaptation, where sub-national authorities can better manage challenges such as flood risk, water stress, or "climate proofing" of urban infrastructure (Corfee-Morlot et al., 2009). In all the preceding situations, sub-national governments may tailor actions and policies to people's needs, with an easier identification of priorities and difficulties as they are closer to citizens than more centralized administrations (Lindseth, 2004; Galarraga et al., 2011).

In sum, as in other environmental areas (Dalmazzone, 2006), there is theoretical backing for the allocation of climate-related policies to sub-national levels of government, although there are several limiting factors to a widespread reliance on these administrations. A federal structure that provides coordination and enables an easier transmission of climate policies throughout the agents of the economy is likely to increase the effectiveness of actions against climate change. Moreover, the lessons learnt in the design and application of climate policies at different jurisdictional levels could be used in a global setting.

15.8.3 Summary concerning policies for abatement and new technology including linkages and interactions between policies (15.5 – 15.8)

Section 15.5 reviewed a range of instruments. Simplified economics analyses suggest that one instrument, a price on carbon would suffice – not only would additional instruments be redundant but they would probably threaten efficiency as well. A couple of points are worth making. First of all, real world politics tend to produce a package of instruments, partly because politicians at different jurisdictional levels are involved and partly for other reasons. We have discussed a number of factors implying that this may be a good thing. In addition to a carbon price, there are strong separate arguments for a technology policy to correct for the externality implied by insufficient protection of property rights. Support for research, development, deployment, and where applicable, transfer of low-emission technologies in conjunction with carbon pricing is called for.

Next, we have seen in 15.5.4 that there are cognitive and institutional factors that imply barriers to market response to rising carbon prices. Therefore, well-designed regulatory approaches, information programs, voluntary agreements and government provision, can and do serve as a complement to price policy as a way to remove barriers, thereby saving the money of firms and individuals and reducing social costs. There are many examples in the literature of energy efficiency regulations achieving emission reductions at low and negative cost. While rebound effects would reduce some of these measured gains there is little evidence it would eliminate them. Direct rebound effects are mostly in the range of 10-30% or less while economy-wide effects are likely to be larger, but difficult to quantify. Rebound effects would further be virtually eliminated if regulations were combined with instruments that provide a higher carbon price.

In several sectors such as transport, urban planning and buildings, energy, and forestry, government planning and provision of infrastructure is important, even crucial, for achieving emission reductions in a cost-effective manner. Absent the appropriate infrastructure, the costs of achieving significant emission reduction might be prohibitive (15.5.6).

There remains the issue of which economic instrument, a tax or an ETS, is best for setting a carbon price that is sufficiently high to actually start decreasing emissions at the rate policy makers desire. One of the attractions of emission trading schemes appears to have been that it is possible to appease industry lobbies by giving them permits for free. A second argument that has been made in favour of an ETS is it may be easier to link permit schemes across borders than to agree on common taxes. (Harmonization is advantageous, since it reduces costs.) There is however no general agreement on this. Some analysts believe the opposite, that it will be easier to link taxation systems within an international agreement, (Helm, 2003; Nordhaus, 2007; Jaffe et al., 2009; Metcalf and Weisbach, 2011) and 15.8.1.

There are on the other hand, arguments in favour of taxes, -- low set-up costs and an absence of price volatility. Most importantly, as we saw in this section, a cap-and-trade scheme negates the environmental effects of other policies implemented by jurisdictions at lower jurisdictional levels than the jurisdiction imposing the cap. This is a serious problem precisely because all ETS's so far, unlike taxes, have been insufficiently ambitious relative to the requirements needed to achieve a 1.5 degree, 2 degree or even a 3 degree. Indeed, this may be one reason why sub-jurisdictions feel compelled to adopt policies of their own, see further 15.8 for a discussion of federalism. Fortunately, ETS's can deal with this issue by tightening the cap when it ceases to bind or if the permit price falls too low. Price floors may be used to avoid this problem and together with price ceilings, may be used to reduce volatility as well. But then, we are back to a tax-like instrument, albeit via a rather complicated route.

As a final point, it is worth repeating that the important choice, if policy makers want to reduce emissions substantially, is to make sure that the level at which policies are is applied is sufficiently stringent: viz either a high tax, a low cap, coupled with powerful incentives for new technology, and the rest of the policy package. From this perspective, the choice of policies would seem to depend mainly on which instrument is politically most promising for achieving stringency. A related design issue is that it is important to have mechanisms to tighten the stringency if new preferences or new science imply that the policy maker wants to tighten standards after an initial lax period.

FAQ 15.2 What is the best climate change mitigation policy?

There is no best policy. Different policies play different roles as seen in Table 15.1. A combination of policies that meets all three roles will be most effective. It should be designed and adjusted so as to complement rather than substitute for other policies in the same and other jurisdictions (See 15.7.3). Appropriate designs depend on national and local circumstances and institutional capacity.

Table 15.1: Three Roles of Climate Policy Instruments

	Providing a price signal	**Removing barriers**	**Promoting long-term investments**
Examples of policy instruments	*Economic Instruments* - Fuel, energy, or carbon tax - Emission trading system	*Regulatory Approaches* - Appliance standards - Energy management systems and energy audits *Information Programs* - Appliance labelling *Voluntary Actions* - Voluntary agreements	*Technology Policy* - Government grants for R&D - Feed-in Tariff for renewable power *Governmental Provision* - Government provision of low-emission urban and transport infrastructure
Suitable Context	The entire economy	Behavioural (cognitive and computational) constraints, asymmetric information, non-competitive markets	Technology development for emission reduction

15.9 The role of stakeholders including NGOs

This section considers the role of stakeholders and civil society, rather than politicians and policy makers, in developing and delivering concrete climate mitigation action. The extent and complexity of climate change means that everyone has a stake in the climate debate, whether on the impacts or the mitigation side.

This clearly has practical implications for policy makers. Devising policy which attempts to be more inclusive by explicitly involving all stakeholders in both the design and implementation processes would be lengthy and politically challenging, as well as placing significant demands on stakeholders in terms of their knowledge of the drivers and impacts of policy action (Irvin and Stansbury, 2004).

It is argued that adopting an inclusive approach to climate stakeholders can bring advantages, notably through increasing the legitimacy of policy design, its durability and implementation (Lazo et al., 2000; Beierle, 2002; Dombrowski, 2010). However, the quality of the policy or political output resulting from a participatory approach is heavily dependent on the quality of the process which produces it (Reed, 2008).

Businesses and the Business Sector

It is clear that business itself as a sector is a stakeholder in the broader debate on climate change. There is a long history of business involvement in the formulation of climate policy and implementation at both the international and national levels. Businesses that would be negatively impacted by emission reduction policies responded to the emergence of climate change as a policy issue by opposing action to mitigate emissions (Newell and Paterson, 1998). Evidence also indicates that oil companies like Exxon Mobil have gone further and have promoted climate scepticism by providing financial resources to like-minded think-tanks and politicians (Antilla, 2005; Boykoff and

Boykoff 2007); However, divergences in the attitudes of oil companies towards climate change is explained in part by domestic institutional contexts and management structures (Rowlands, 2000; Levy and Kolk, 2002).

Following the agreement of the Kyoto Protocol, however, (Kolk and Pinkse, 2007) argue that some multinational companies' strategies have shifted towards influencing the shape of future policy action of national governments, and particularly towards market based policy responses such as emissions trading and voluntary agreements. More recently, business lobbies have emerged which see that they can benefit from regulatory measures to reduce emissions through the promotion of 'green' technologies' such as renewables, and have adopted a more stringent pro-regulation agenda (Vormedal, 2008). Nevertheless, the size of the fossil energy sector in many countries ensures that business opposition to emission reduction remains a strong force.

Civil society and NGOs

In addition to business, other stakeholders could be defined as members of civil society: "the wide array of non-governmental and not-for-profit organizations that have a presence in public life, expressing the interests and values of their members or others, based on ethical, cultural, political, scientific, religious or philanthropic considerations" (World Bank, no date). Civil Society Organisations therefore include community groups, non-governmental organisations (NGOs), unions, indigenous groups, charitable and faith-based organisations, professional associations, and foundations working towards a common purpose or goal through interactions with government (Cohen and Arato, 1992).

The most prominent members of civil society engaged in environmental governance are Non-Governmental Organisations (NGOs), which operate independently of government and rely on explicit support from parts of society in order to operate and work towards achieving their ends. The term NGO includes organisations representing business or industry interests, science-based groups, environmental or social organisations or community based groups operating at some or all levels of society, from the very local to the global (Betsill and Corell, 2008). Some organisations, such as 350.org, combine both grassroots approaches in terms of local activism with a global scope in their reach.

The role of NGOs is also diverse, and can include some or all of the following activities: raising public awareness, lobbying politicians and influencing business investment decisions, organising direct action or other activities such as consumer boycotts, representation of other stakeholders, the provision of scientific advice or other expertise, participation in negotiations, and the monitoring and implementation of agreements, (Gulbrandsen and Andresen; Guay et al., 2004; Betsill and Corell, 2008; Newell, 2008; Dombrowski, 2010).

(Newell, 2008) discusses an array of activities employed by NGOs, either individually or in loose coalitions, to hold governments and international institutions to account for the decisions they have made. The activities include legal actions to enforce governmental policy decisions, stakeholder activism to influence investment plans, and campaigns focused on multilateral development banks. While Newell is cautious about the desirability of substituting civil society activism for public democratic oversight, he concludes that the effect of their contribution to global governance is to plug the many gaps that exist in the contemporary architecture of global environmental governance" (p 117), and that civil society engagement in activism is likely to increase in the fact of a lack of firm action from governments.

While environmental non-governmental organisations (ENGOs) and Business and Industry NGOs (BINGOs) are the most high profile, other constituency groups also participate as observers at UNFCCC negotiations. In total there are nine civil society groupings mirroring the UN's Major Groups classification. These nine grouping are not perfect: as (Biermann and Gupta, 2011) point out, they are by no means a comprehensive representation of civil society – so, for instance, while women and youth are represented, men and old people are not. They have, however, been identified as a way of improving the legitimacy and accountability of governance processes by opening up decision making processes to participants from civil society (Dombrowski, 2010).

Global NGOs such as the World Wide Fund for Nature tend to have the majority of their membership and advocacy activities based in developed countries, but also have well-established projects working with communities in developing countries. This includes their Forest and Climate Initiative, intended to help counties develop national and local approaches which both protect forests and bring benefits to local communities (WWF 2011).

An analysis by the International Institute of Environment and Development of climate action in developing countries found extensive activity from civil society at all levels of the climate policy debate. The report highlights numerous case studies of 'bottom up' community and local level initiatives aimed at climate adaptation or mitigation which have been developed independently of overarching government policy, and which could be scaled up if they prove successful (Reid et al.).

These bottom up approaches are evident in developed countries such as the US and UK too, where groups of engaged but non-aligned individuals have come together to take practical action to reduce carbon emissions (Paterson and Stripple, 2010). Climate Reduction Action Groups (CRAGs) set targets for emissions reductions and meet to discuss progress, share tips and provide support to other group members. By doing so, individuals are taking responsibility for emissions reduction, and providing concrete action in a context where top down approaches may have been ineffective.

(Hoffman, 2011) identifies many of these exercises as 'experiments' in climate governance motivated by a frustration with 'conventional' top down policy responses and involving new actors, whether cities, businesses, environmental NGOs or a myriad of other stakeholders. While many of these experiments are as yet immature, they demonstrate the ability of civil society to fill a void in international governances responses to the problems posed by climate change.

15.10 Capacity Building

Because sustainable development involves a complex interplay between economic, environmental and socio-cultural considerations, it follows that for a country to achieve sustainable development it must consider all these issues in making short and long-term development plans. However, environmental considerations cannot be appreciated if there is lack of up-to-date information, knowledge, tools and skills to address the various issues. Therefore, if the needs of the present generation are to be satisfied without compromising the ability of future generations to meet their own needs, capacity building should be central to the sustainable development agenda (UNEP, 2002). This priority is strongly reflected in the Johannesburg Plan of Implementation, where capacity building, especially for developing countries and countries with economies in transition, features prominently throughout. It is also in the UNFCCC's capacity building framework for developing countries. The purpose of capacity building under this framework is to strengthen the capacities of Parties other than developed country Parties and other developed Parties not included in Annex II, particularly developing country Parties, to promote the widespread dissemination, application and development of environmentally sound technologies and know-how, to enable them to implement the provisions of the Convention.

15.10.1 Leadership capacity

Climate change appears to hurt the very ability for growth among vulnerable, poor countries. It limits their potential for expanding supply chains into value-adding industrial activities. As climate change starts affecting population dynamics causing pressures on resources, it may also cause destitution, migration, and, possibly, conflict, which in turn will also affect crucial variables such as political stability and the governance structures that are so crucial for development and investments (Sterner et al., 2012).

Against the backdrop of current global negotiations and initiatives to combat climate change, it is clear that low-income countries, like the Pacific Island Countries, need to develop appropriate political frameworks to negotiate a just and fair global deal on climate, including claims for compensation for adaptation-related costs, which is likely to be highest among the poorest and most vulnerable nations. Climate change is a severe and major problem that has the potential to seriously derail poverty alleviation in a number of African countries. Simply to defend their own interests in climate negotiations each country is going to need serious capacity to analyse the implications of climate change and to formulate country positions.

15.10.2 Capacity to formulate, implement an evaluate policies

According to the United Nations Conference on Environment and Development, building a country's capacity encompasses the country's human, scientific, technological, organizational, institutional, and resource capabilities. A fundamental goal of capacity-building is to enhance the ability to evaluate and address the crucial questions related to policy choices and modes of implementation among development options, based on an understanding of environmental potentials and limits and of needs as perceived by the people of the country concerned.[11]

Underlying the ability to formulate policies to enable countries to combat climate change and transition to a sustainable future is a foundation of solid research and education. The IPCC obliges parties to collaborate in research and promote capacity building especially in developing countries. Even with the necessary political framework in place, engaging effectively in global negotiations or opportunities presented by climate initiatives, these countries need solid domestic capacity in terms of skills and knowledge base to analyse and administer such programs.

15.10.3 Capacity in the public offices vs. private sector capacity

Climate change and the global policies to combat it also imply many opportunities for developing countries—opportunities such as CDM (Clean Development Mechanism) in the Kyoto Protocol and maybe NAMAs (Nationally Appropriate Mitigation Agencies) and REDD+ (Reducing Emissions From Deforestation and Forest Degradation) in the future—as well as commercial opportunities in new industries based on renewable energy.

In order to maximize the benefits of capacity building to both the public and private sectors, the conference of the parties to the UNFCCC decision (FCCC/SBI/2011/L.37) stated that further implementation of the capacity-building framework in developing countries should be improved by:

- Ensuring consultations with stakeholders throughout the entire process of activities;
- Enhancing integration of climate change issues and capacity-building needs into national development strategies, plans and budgets;
- Increasing country-driven coordination of capacity-building activities; and
- Strengthening networking and information sharing among developing countries, especially through South-South and triangular cooperation.

15.10.4 Building capacity on both non-conventional and conventional energy sources

Many studies analyse the technological options for achieving deep reductions in greenhouse gas (GHG) emissions. For example, in a well-known Science article, (Pacala and Socolow, 2004) introduced a now-popular tool illustrating the ''wedges'' of potential reductions from available

[11] UN Department of Economic and Social Affairs Division for Sustainable Development, "National Mechanisms & International Cooperation for Capacity-Building in Developing Countries," in *Agenda21*, accessed November 18, 2010, chap/sec. 37.1.

technologies to bring the emissions path to a stabilization target. These kinds of studies are informative, but they focus on the capacity of technologies, rather than the cost-effectiveness of reduction options (that is, meeting the policy target at lowest cost for the society), the possibilities for innovation over time, or the role of policies in getting there. Economists who model climate policies, on the other hand, tend to focus on cost-effective solutions, but often with less technological detail. All models have difficulty incorporating realistic representations of technological change, uncertainties, barriers, and non-market based policies. It is important to remember that energy projections are difficult for proven technologies and even trickier for emerging ones. In one word, a key challenge for meeting emissions and technology goals is uncertainty. We are not sure what emissions reductions will ultimately be needed or what the corresponding prices will be. We do not necessarily have a good idea of the costs of large-scale deployment of existing technologies, when breakthrough technologies might arrive, or to what degree the costs and quality of existing technologies will be improved.

15.11 Links to Adaptation

15.11.1 Introduction

Despite international efforts, some climate change has to be anticipated. Governments started to plan policies aimed at tackling phenomena that are likely to take place or do take place already (Aaheim et al., 2009).

The policies are costly. Their annual expenditures for Europe in 2060, estimated in a number of peer-reviewed studies are summarized by (Osberghaus and Reif, 2010). Flood protection costs depend on the sea level rise and may vary between 0.3 and 4.0 billion euro. Additional annual irrigation expenditures in Western Europe alone may reach 6.2 billion euro. Water supply will claim 2.7 billion euro there. At the same time, health effects are expected to be positive in net terms: adverse higher temperature effects will be more than offset by decreased expenditures for cold-related diseases. Energy supply expenditures (mostly additional cooling installations in thermal power plants) are expected to be 0.6 billion Euro in Western Europe and 1.0 billion in EU-27 plus Norway and Switzerland. Energy demand is subject to a wide range of uncertainty. According to some studies net savings are expected as a result of lower heating needs, but others predict a reverse trend due to higher cooling needs. Transport infrastructure will claim from 3 to 6 billion Euro in EU-27 plus Norway and Switzerland. Consequently it can be expected that European annual expenditures on adaptation activities will exceed 10 billion euro. Moreover there are some important theoretical reasons to consider all estimates as very uncertain (Weitzman, 2009).

In food-insecure regions major adaptation needs are expected already in 2030 (Brown and Funk, 2008; Lobell et al., 2008; Seo and Mendelsohn, 2008). They are likely to result from the more general biodiversity changes triggered by climatic processes (Visser, 2008; Hoegh-Guldberg et al., 2008, p. -; Pörtner and Farrell, 2008; Heller and Zavaleta, 2009; Mawdsley et al., 2009). Adaptations necessary in wealthy regions are likely to be easier (Finger and Schmid, 2007), (Reidsma et al., 2010). In some regions – e.g. in Australia (Beebe et al., 2009) – both authorities and households are already involved in projects to improve water supply following lower and irregular rainfall. Such actions may have adverse side effects for human health. These secondary results add to adaptation costs, and their quantification is still a challenge. Even though adaptation activities will be costly, they have not been fully quantified so far.

Analysts emphasize that adaptation is not just a technical or scientific issue especially when there is a wide uncertainty as to future scenarios (Moss et al., 2010). It is a challenge for risk assessment capacity, changing human behaviour, and enhancing institutions (O'Brien, 16:07:34; Agrawal et al., 2008; van Aalst et al., 2008; Adger et al., 2008; Mertz et al., 2009; Costello et al., 2009; Vignola et al., 2009; Nath and Behera, 2010; ICLEI, 2011). Its total cost is likely to be much higher than expected (De Bruin et al., 2009).

15.11.2 Mitigative capacity and adaptation capacity link

There are tendencies to argue that mitigation and adaptation policies are related to each other (Smith and Olesen, 2010). This, however, is a controversial issue (Hamin and Gurran, 2009). First, effective climate change mitigation needs to be taken at the global level which makes the outcome largely independent of individual mitigation efforts. Moreover, well-known economic phenomena such as "carbon leakage" weaken the results of these efforts and may even make unilateral abatement detrimental unless a mechanism is adopted to prevent unwanted effects. Second, mitigative and adaptive capacities are fundamentally disjoint. Apart from carbon releases caused by land-use changes, the largest emission potential has been linked to economic growth in low and medium income economies. At the same time these economies are not so well prepared to address climate change challenges as the high income ones. For instance, threats to biodiversity anticipated in low-income tropical regions will not be coped with unless an adequate response in high-income economies is solicited. Nevertheless some links may be found and they need to be emphasized in order to reinforce climate protection policies.

15.11.3 Provision of local public goods by government as ways to mitigate and adapt simultaneously

Planting trees can be viewed both as a mitigation and adaptation activity (Canadell and Raupach, 2008). An example of a policy to mitigate and adapt at the same time is establishing green areas in urban centres (Report of the IPCC WG II 2012). Apart from this, however, local governments need to undertake mitigation and adaptation activities independently (Moser and Satterthwaite, 2008). Both types are necessary, but – because climate protection is a public good – governments may hesitate to be involved in the former while their constituencies will prompt them to address the latter. In some countries there have been drafted national adaptation strategies (Bizikova et al., 2008; Bedsworth and Hanak, 2010; Biesbroek et al., 2010).

15.11.4 Multi-objective analysis

The complexity of adaptation issue suggests multi-objective analysis for assessing policies. Its adequacy, however, seems to be limited. Multi-objective analysis is best suited for choosing a solution that reconciles conflicting and/or complementary objectives of a given individual or organization. In the case of climate change mitigation and adaptation problems, there is no such a single decision maker on whose behalf the analysis should be carried out. Those who undertake mitigation measures do not coincide with those who benefit from their results. They are apart both in terms of time and space. Thus there is little surprise that (if at all) multi-objective analyses are carried out with respect to adaptation questions only (Qin et al., 2008). However, analyses are carried out to identify 'no-regret' adaptation measures, i.e. measures that are sound under any reasonable scenario.

15.11.5 Mainstreaming mitigation and adaptation to development policies

Local and national governments, as well as international organizations pursue development policies. Their stated objective is meeting economic needs of populations affected. Nevertheless the diversity of criteria implies that these policies are often controversial: while meeting some needs, they work against some other ones at the same time. In particular, too little effort has been devoted to making sure that development policies and aid programmes take into account climate change concerns (UNDP, 2007; Figaj, 2010). At the same time funding for programmes needed is far from adequate (Ayers, 2009). Among other things, this results from wide ambiguities as to who should pay for adaptation costs (Dellink et al., 2009).

15.11.6 Land-use planning effects on mitigation and adaptation

Even though mitigation and adaptation policies are largely independent of each other, there is one area of human activity with profound effects on both of them. This is land use planning. Its potential for both mitigation (carbon sequestration) and adaptation (increasing resilience to climate change) is high (Pimentel et al., 2010). Urban sprawl and monoculture in farming are examples of poor land use planning processes with significant impacts both on climate change and adaptation capacity.

15.12 Investment and Finance

15.12.1 National and sub-national institutions and policies

The justification for investment and finance and the description of the various financial agreements and schemes have been elaborated in Chapter 13. An assessment of overall financial needs for mitigation, adaption and technology at different levels and the scale of financial gaps have been provided in Chapter 16. This section concentrates on how parties to the UNFCCC, particularly developing countries, are addressing climate change investment and finance.

Financing climate mitigation and adaptation in developing countries has been considered a key area of intervention to stabilise the climate at 1.5-2 degrees Celsius. (UNFCCC; 1/CP.15, 1/CP.17). These international developments have shaped domestic climate discourse and have also created incentives for sustainable development at national and local levels (Metz and Kok, 2008). Often times, national and sub-national efforts to finance climate change have had an explicit link to international processes or support.

Table 15.2 provides a snapshot view of the current landscape of national funds for climate change. This is not meant to be an exhaustive list but simply an attempt to illustrate the diversity of funding arrangements, focus areas (emissions sources or removals), and sources of finance. For a full treatment of climate finance, please refer to Chapter 16.

Table 15.2: Some sources of Climate Finance in selected Non-Annex 1 Countries

Fund (operational date)	Administration	Focus Area	Source
Green Energy Fund (2012)	Energy Commission, Government of Ghana	Mitigation	Domestic budget; International support
Green Economy Facility (2011)	Government of Ethiopia	Adaptation and Mitigation	Domestic budget, international support
Amazon Fund (2010)	Brazilian Development Bank	Adaptation, Mitigation, REDD	Primarily international contributions
China CDM Fund (2007)	Ministry of Finance, China	Mitigation	Certified Emissions Reductions tax, multilateral

Table 15.2 reveals that the funds have been reliant on both domestic as well as international sources of finance. The degree of institutionalization of these funds also varies from country to country- with the Green Economy Facility of Ethiopia possessing a broad mandate to set Ethiopia on a green economy track and the China CDM Fund more focused on project level funding. Some of

these institutions also have the responsibility of blending funding available from international, domestic and private sector sources (Flynn).

Such national funding entities also have the potential to help countries cope with the multiplicity of sources, agents and channels offering financial resources for mitigation activities (Glemarec, 2011; Smith et al., 2011). Increased fragmentation of international assistance has increased transaction costs for donors while the multiplicity and competitive nature of sources has challenged national and sub-national capacities (Knack and Rahman, 2007; Anderson, 2012). Limited absorptive capacity and human resource challenges are also present.

However, more evidence is needed to ascertain how national funding entities cope with aid fragmentation and proliferation, particularly as some preliminary evidence shows that what is reported to the DAC as climate change related aid may diverge from the actual program goals (Michaelowa and Michaelowa, 2011).

In addition, ensuring coherence between national institutions dedicated to climate change and cabinet entities such as Ministry of Finance or the Office of the President may help to overcome coordination challenges. However, the evidence base is reliant on case studies and, currently, may not offer general conclusions (Thornton, 2010).

15.12.2 Policy change direction for finance and investments in developing countries

There has been a flurry of initiatives in recent years to develop new ways of channelling international finance. Three policy change directions are noticeable.

First, financing climate objectives by mainstreaming climate change into development planning has been gaining ground. However, the benefits and costs of integrating climate change considerations into development planning in general are not clear. (OECD, 2005) warns of “mainstreaming overload” as climate change competes with other sectors like governance and gender to be mainstreamed into core development planning. Barriers to integrate climate and development objectives have been identified as: lack of human and institutional capacity, lack of coordination among line ministries (Knack and Rahman, 2007; Kok et al., 2008)

Second, the concept of co-benefits or climate and development as “win-win” outcomes is also increasing traction even if the framing may not be explicitly in the form of co-benefits. There is evidence to indicate that some countries are trying to achieve climate change objectives by formulating policies on sectors like energy and agriculture (Thornton, 2010). Reducing emissions has also been seen as a by-product of reducing energy costs in the case of China (Richerzhagen and Scholz, 2008b). REDD+ is seen as another major opportunity to deliver both emissions reductions and livelihood benefits. However, (Campbell, 2009) and (Adams and Hulme, 2001) argue that the ability to define these win-win objectives is major factor for success.

Third, there is an expansion of actors involved in climate finance and investment. This development has the potential to address implementation gaps, generate greater participation from stakeholders, and encourage public-private partnerships that promote sustainable development (Pattberg, 2010).

Two areas of need emerge from the literature (Cameron; Zingel, 2011). Attracting carbon finance investments will require strengthening institutional and governance capacities at the national and sub-national levels in recipient countries. Specifically, the ability to assess and approve projects, demonstrate accountability and transparency to their own populations, as well as to the development partners to raise levels of investment confidence will be needed. In addition, robust mechanisms to ensure accountability are needed. This would involve greater transparency in both donor and recipient countries. The role of civil society organizations and the media could be strengthened for good governance and accountability.

15.13 Gaps in Knowledge and Data

We have ascertained with some certainty that there is a role for all three pillars that have been mentioned throughout this chapter: The creation of a sufficiently high Carbon price signal; The removal of barriers and finally Support for new technologies. We do however not know the exact levels of climate damage at different levels of atmospheric content, we do not know the costs of reduction to reach various levels, nor the exact levels of each of the possible tradeoffs between these pillars. Given that the ultimate goal is to curb the growth in emissions, there may conceivably be tradeoffs between the three pillars. A given reduction in emissions might conceivably be achieved either by just a very high price on carbon or a somewhat more moderate price of carbon combined with sizeable efforts on the removal of barriers so that the economy actually does swiftly adapt to the new carbon price signal. Similarly there an be a choice between spending resources on abatement today (generated by a carbon price and barrier removal) on the one hand and investments today in new technology that will make abatement (and high carbon price signals) easier to implement in the future. Possibly there are large variations by sector and country - The optimal combinations and tradeoffs between the three pillars are an area on which we may need more research. However we do know enough to make a start in the right direction.

While the distributional incidence of taxes has been studies quite extensively, much less is known about the distributional incidence of other policies.

The valuation of co-benefits from emission reduction has been studied comprehensively in the United States (Muller et al, AER 2011), but much less is known about other countries. This is important because taking these co-benefits into account could significantly lower the cost of emission reduction, and perhaps offer negative costs, in several sectors.

15.A Annex: Methodology and Sources for the Production of Figure 15.1

Categorization

A note on categorization:		**Short version for dropdown**
1. Formal, legally binding climate strategy: An act that has been passed by a national parliament, that is in force, and that intends to bring about limits or reductions in greenhouse gas emissions as a primary intent of the act, as indicated, for example, through declaration of this intent in the title or statement of objectives . This legislation may include a national climate goal, but this is not a necessary condition. • If a parliament does not exist, the equivalent government act necessary to pass legally enforceable measures should be used as the benchmark. • If there is no single overarching act, but multiple sectoral piecemeal acts in place, then a reasoned judgement must be made on whether these add up to a larger strategy. Normally, a single sectoral act only that includes as one of its objectives limiting ghgs would not be counted in the absence of evidence of a larger strategy. • An adaptation-focused act nor one that focuses on accounting for emissions alone would not be counted.	1	Formal, legally binding climate strategy

2. Political, non-binding climate strategy: One or more documents or statements passed by a national government to promote climate mitigation, but not passed by a national parliament or through any other formal lawmaking process, which includes: • Strategy, plan or framework for climate mitigation that states in its title and/or in its statement of objectives limiting or reduce GHG emissions. AND • A coordinating body charged with developing and implementing the strategy, plan or framework.	2	Political, non-binding climate strategy
3. None of the above (includes countries that were studied but where no information was found, even after a thorough search)	3	None of the above
4. Analysis incomplete (includes countries that were studied, but where categorisation was not possible, because e.g. information was not fully traceable, not public or in a language other than those available to the research team)	4	Not studied

S. No	Country	Category		Sources
		2007	2012	
1	Afghanistan	3	3	No information available
2	Albania	3	3	http://ec.europa.eu/enlargement/pdf/key_documents/2012/package/al_rapport_2012_en.pdf
3	Algeria	3	3	http://www.mem-algeria.org/construction/index.htm
4	Andorra	3	3	http://www.mediambient.ad/index.php?option=com_content&view=article&id=189&Itemid=171
5	Angola	3	3	Information untraceable.
6	Antigua and Barbuda	3	3	http://agricultureantiguabarbuda.com/ministry/
7	Argentina	2	2	http://www.enre.gov.ar/web/web.nsf/Files/PRONUREE_Decreto140.pdf/$FILE/PRONUREE_Decreto140.pdf; strategy: http://www.ambiente.gov.ar/archivos/web/UCC/file/estrategiaCC.pdf
8	Armenia	3	3	http://www.minenergy.am/
9	Australia	3	1	http://www.comlaw.gov.au/Details/C2011A00131
10	Austria	1	1	See EU
11	Azerbaijan	3	3	http://www.eco.gov.az/en/
12	Bahamas, The	3	3	http://www.best.bs/climate/coord/function.htm; http://www.best.bs/Documents/ClimateChangePolicy.pdf
13	Bahrain	3	3	http://www3.unog.ch/dohaclimatechange/sites/default/files/FCCCCP2012MISC2_0.pdf
14	Bangladesh	3	2	http://www.sdnbd.org/moef.pdf
15	Barbados	3	3	http://www.caribjournal.com/2012/04/25/barbados-approves-climate-change-policy/
16	Belarus	3	3	http://www.minpriroda.by/en
17	Belgium	1	1	See EU
18	Belize	3	3	http://www.doe.gov.bz/legislation.html
19	Benin	4	4	http://www.giswatch.org/es/node/280. Website in French
20	Bhutan	3	2	http://www.nec.gov.bt/nec1/?page_id=34
21	Bolivia	3	3	http://cambioclimatico-

				pnud.org.bo/foros/Estrategia_bosque_CC.pdf
22	Bosnia and Herzegovina	3	3	http://ec.europa.eu/enlargement/pdf/key_documents/2012/package/ba_rapport_2012_en.pdf
23	Botswana	3	3	1. http://www.mewt.gov.bw/ and 2. http://www.mewt.gov.bw/DEA/article.php?id_mnu=39
24	Brazil	3	1	http://www.preventionweb.net/files/12488_BrazilNationalpolicyEN.pdf
	Brunei	3	3	http://www.nec.gov.bt/nec1/?page_id=34
25	Bulgaria	1	1	See EU
26	Burkina Faso	3	3	No mitigation policy
27	Burma (Myanmar)	3	3	http://www.myanmar-unfccc-nc.net/index.php?option=com_content&view=article&id=11&Itemid=7
28	Burundi	3	3	http://www.undp-alm.org/projects/burundi-national-adaptation-programme-action-napa/reports-and-publications
29	Cambodia	3	3	http://www.camclimate.org.kh/index.php/nccc-new/33-a-strategic-plan-to-cope-with-climate-change.html
30	Cameroon	4	4	http://www.minep.gov.cm/
31	Canada	1	3	http://laws-lois.justice.gc.ca/eng/acts/K-9.5/page-1.html
32	Cape Verde	4	4	http://www.governo.cv/
33	Central African Republic	3	3	Information untraceable.
34	Chad	3	3	Information untraceable.
35	Chile	3	2	http://www.mma.gob.cl/1304/articles-49744_Plan_02.pdf
36	China	2	1	1. http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File188.pdf and 2. http://www.gov.cn/english/official/2011-11/22/content_2000272.htm
37	Colombia	3	3	https://www.dnp.gov.co/LinkClick.aspx?fileticket=tYD8BLf-2-g%3d&tabid=1238
38	Comoros	3	3	Information untraceable.
39	Congo, Democratic Republic of the	3	3	Information untraceable. http://www.minenv.itgo.com/
40	Congo, Republic of the	3	3	Information untraceable.
41	Costa Rica	3	2	http://cglobal.imn.ac.cr/documentos/estrategia-nacional-de-cambio-climatico; http://www.digeca.go.cr/documentos/legislacion/Acuerdo%2036-2012%20MINAET%20Oficializa%20Programa%20Pais%20Carbono%20Neutralidad.pdf
42	Cote d'Ivoire	4	4	http://www.environnement.gouv.ci/
43	Croatia	3	3	http://www.azo.hr/ClimateChange
44	Cuba	2	3	http://www.undp.org.cu/eventos/dialogo_gef/Estudios%20de%20Vulnerabilidad%20y%20Adaptaci%F3n%20y%20Proceso%20de%20la%20Segunda%20Comunicaci%F3n%20Nacional.pdf; http://www.edf.org/sites/default/files/9623_Cuba_Enviro_Strategy_2007-2010.pdf

45	Cyprus	1	1	See EU
46	Czech Republic	1	1	See EU
47	Denmark	1	1	See EU
48	Djibouti	3	3	Information untraceable.
49	Dominica	3	3	http://www.deromilly.com/pdfFiles/DOMINICA%20Low%20Carbon%20Climate%20Resilient%20Strategy%20%20(Final).pdf; http://www.dominica.gov.dm/cms/files/environment_natural_resource_mgmt_bill.pdf
50	Dominican Republic	3	3	http://www.uncclearn.org/sites/www.uncclearn.org/files/images/estrategia__nacional__para__fortalecer_los_recursos_humanos_republica_dominicana_08_2012.pdf; http://www.hoy.com.do/el-pais/2011/12/6/404770/RDlanza-Plan-de-Desarrollo-Economico-compatible-con-
	East Timor	3	3	http://timor-leste.gov.tl/?lang=en
51	Ecuador	3	1	http://derechosybosques.com/documentos/DECRETO_1815.pdf
52	Egypt	3	3	http://www.eeaa.gov.eg/ecc/ClimateMain.htm
53	El Salvador	3	3	Information untraceable.
54	Equatorial Guinea	3	3	http://www.guineaecuatorialpress.com/noticia.php?id=1312&lang=en
55	Eritrea	3	3	Information untraceable. http://www.shabait.com/articles/nation-building/5368-ministry-of-land-water-and-environment-addressing-natural-resources-conservation-issues
56	Estonia	1	1	See EU
57	Ethiopia	3	2	http://ldcclimate.files.wordpress.com/2012/05/crge-strategy.pdf
58	Fiji	3	2	http://www.foreignaffairs.gov.fj/images/Fiji%20National%20Climate%20Change%20policy.pdf
59	Finland	1	1	See EU
60	France	1	1	See EU
61	Gabon	3	3	http://www.gabon-vert.com/ (In French)
62	Gambia, The	3	3	http://www.mofen.gov.gm/
63	Georgia	3	3	http://moe.gov.ge/index.php?lang_id=ENG&sec_id=55
64	Germany	1	1	See EU
65	Ghana	3	3	http://prod-http-80-800498448.us-east-1.elb.amazonaws.com/w/images/2/29/GhanaGreen.pdf
66	Greece	1	1	See EU
67	Grenada	3	3	Information untraceable.
68	Greenland	1	1	http://www.climategreenland.gl/files/pdf/Informa2tion%20note%20on%20Greenlands%20commitments%20for%202013-2020,%20signed%20Kuupik%20Kleist,%2017.%20februar%202010%20[DOK316761].PDF
69	Guatemala	3	2	http://www.segeplan.gob.gt/downloads/clearinghouse/politicas_publicas/Recursos%20Naturales/Politica%20Nacional%20de%20Cambio%20Climático%20Guatemala.pdf

70	Guinea	4	4	Information untraceable.
71	Guinea-Bissau	3	3	Information untraceable. Information may be in French.
72	Guyana	3	2	http://www.lcds.gov.gy/, http://unfccc.int/resource/docs/nap/guynap01.pdf
73	Haiti	3	3	Information untraceable. Information may be in French.; other sources: http://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/Haiti%20Mission%20Presentation%20French.pdf; http://www.ht.undp.org/content/dam/haiti/docs/mdg/MDE-PNUD%20%20colloque%20durabilite%20et%20equite.pdf
74	Honduras	3	2	http://cambioclimaticohn.org/uploaded/content/category/1317405493.pdf; http://cambioclimaticohn.org/?cat=5&title=sobre
75	Hungary	1	1	See EU
76	Iceland	1	1	http://www.eea.europa.eu/soer/countries/is/climate-change-mitigation-national-responses-iceland; http://eng.umhverfisraduneyti.is/media/PDF_skrar/Stefnumorkun_i_loftslagsmalum_enlokagerd.pdf
77	India	3	2	1. http://pmindia.gov.in/climate_change.php and 2. http://pmindia.gov.in/committeescouncils_details.php?nodeid=7
78	Indonesia	2	2	1. http://forestclimatecenter.org/files/2011-09-20%20Presidential%20Regulation%20No%2061%20on%20The%20National%20Action%20Plan%20for%20Greenhouse%20Gas%20Emission%20Reduction.pdf and 2. http://adaptasi.dnpi.go.id/index.php/main/contents/54
79	Iran	4	4	Information not in English; http://doe.ir/Portal/home/default.aspx
80	Iraq	3	3	Information untraceable.
81	Ireland	1	1	See EU
82	Israel	3	2	http://old.sviva.gov.il/Enviroment/Static/Binaries/index_pirsumim/p0618_1.pdf; http://old.sviva.gov.il/Enviroment/Static/Binaries/ModulKvatzim/Brochure-ClimateChangeMitigationInIsrael-Nov2012_2.pdf
83	Italy	1	1	See EU
84	Jamaica	3	3	http://www.mwh.gov.jm/
85	Japan	1	1	1. http://www.env.go.jp/en/laws/global/warming.html; 2. http://www.env.go.jp/en/earth/cc/bagwc/overview_bill.pdf
86	Jordan	3	3	Information untraceable.
87	Kazakhstan	3	3	1. http://www.climate.kz/eng/?m=html&cid=19 and 2. http://www.climate.kz/eng/?m=html&cid=4
88	Kenya	3	2	1. http://www.environment.go.ke/wp-content/documents/complete%20nccrs%20executive%20brief.pdf; 2. http://www.kccap.info/index.php?option=com_content&view=article&id=27 and 3. http://www.kccap.info/index.php?option=com_phocadown

				load&view=category&id=33&Itemid=70
89	Kiribati	3	3	Information untraceable.
90	Korea, North	4	4	Not studied
91	Korea, South	3	1	www.moleg.go.kr/FileDownload.mo?flSeq=38428;
92	Kuwait	3	3	Information untraceable.
93	Kyrgyzstan	3	3	Information untraceable.
94	Laos	4	4	Website not in English; http://www.undp.org/content/dam/laopdr/docs/Reports%20and%20publications/UNDP_LA_National_Strategy%20on%20Climate%20Change_Lao%20PDR_2010.pdf
95	Latvia	1	1	See EU
96	Lebanon	3	3	Information untraceable.
97	Lesotho	3	3	http://www.environment.gov.ls/home/default.php#.UQI6dzfxjOc
98	Liberia	3	3	Information untraceable. http://www.emansion.gov.lr/2content.php?sub=44&related=23&third=44&pg=sp
99	Libya	3	3	http://www.environment.org.ly/
100	Liechtenstein	2	2	http://www.eea.europa.eu/soer/countries/li/climate-change-mitigation-national-responses-liechtenstein
101	Lithuania	1	1	See EU
102	Luxembourg	1	1	See EU
103	Macedonia	3	3	Information untraceable.
104	Madagascar	4	4	http://www.meeft.gov.mg/
105	Malawi	3	3	1. http://www.nccpmw.org/ and 2. http://www.nccpmw.org/index.php?option=com_filecabinet&task=download&cid%5B0%5D=43&Itemid=2
106	Malaysia	3	2	http://www.nre.gov.my/Environment/Documents/NCCP_080710_for-web.pdf
107	Maldives	3	3	http://www.environment.gov.mv/v1/
108	Mali	4	4	http://www.environnement.gov.ml/
109	Malta	1	1	See EU
110	Marshall Islands	3	2	http://www.sprep.org/attachments/Climate_Change/RMI_NCCP.pdf; http://www.sprep.org/att/IRC/eCOPIES/Countries/Marshall_Islands/57.pdf
111	Mauritania	4	4	http://www.environnement.gov.mr/index.php
112	Mauritius	3	3	http://www.gov.mu/portal/site/menvsite/menuitem.d0b3f18692db3d2d62aee21d48a521ca/
113	Mexico	2	1	http://www.diputados.gob.mx/LeyesBiblio/pdf/LGCC.pdf; http://www.semarnat.gob.mx/programas/Documents/PECC_DOF.pdf
114	Micronesia, Federated States of	3	2	http://www.fsmpio.fm/Nationwide_Climate_Change_policy.pdf
115	Moldova	3	3	http://clima.md/index.php?l=en
116	Monaco	3	3	http://en.gouv.mc/Policy-Practice/The-Environment/The-Climate-and-Energy-Plan-in-the-town
117	Mongolia	2	2	1. http://unfccc.int/resource/docs/natc/mongnc2.pdf and 2. http://climatechange.gov.mn/en/

118	Montenegro	3	3	http://www.mrt.gov.me/en/ministry?alphabet=lat
119	Morocco	3	3	http://www.minenv.gov.ma/index.php/fr/clima; http://www.ccmaroc.ma/maroc/default.html
120	Mozambique	3	3	http://www.convambientais.gov.mz/index.php?option=com_docman&task=doc_view&gid=67
121	Namibia	3	2	http://www.met.gov.na/News/Pages/LaunchoftheNationalPolicyforClimateChangeinNamibia.aspx; http://www.met.gov.na/AAP/TechnicalStudies/NationalClimateChangeCommittee/Pages/default.aspx
122	Nauru	3	3	No mitigation policy.
123	Nepal	3	2	http://moenv.gov.np/moenvnew/
124	Netherlands	1	1	See EU
125	New Zealand	1	1	http://www.climatechange.govt.nz/emissions-trading-scheme/; http://icapcarbonaction.com/index.php?option=com_wrapper&view=wrapper&Itemid=147; http://www.legislation.govt.nz/act/public/2002/0040/latest/DLM158584.html?search=ta_act_C_ac%40acur%40anif_an%40bn%40rn_25_a&p=4; http://www.dia.govt.nz/MSOS118/On-Line/NZGazette.nsf/6cee7698a9bbc7cfcc256d510059ed0b/3ccb2ba3743eb957cc25786400557b2d!OpenDocument&Highlight=0,2050)
126	Nicaragua	3	3	ploads/media/Estrategia_Nacional_Ambiental_y_de_Cambio_Climatico__2010.pdf
127	Niger	3	3	http://www.cnedd.ne/publications.htm
128	Nigeria	3	3	http://environment.gov.ng/issues/climate-change/
129	Norway	2	2	http://www.regjeringen.no/en/dep/md/documents-and-publications/government-propositions-and-reports-/reports-to-the-storting-white-papers-2.html?id=701; http://www.regjeringen.no/en/the-government/stoltenberg-ii/The-Big-Issues/binding-climate-policy/climate-friendly-policy.html?id=448280
130	Oman	3	3	http://www.oman.om/wps/portal/!ut/p/c1/04_SB8K8xLLM9MSSzPy8xBz9CP0os3hjA3cDA39LT18Tp0AXAyMvI2_TYEdjI4NgE_1wkA4kFd4hvo4GRsZhbl6WPmbGLi4mEHkDHMDRQN_PIz83Vb8gOzvN0VFREQDHWPLb/dl2/d1/L2dJQSEvUUt3QS9ZQnB3LzZfMzBHMDBPOUlNNEJRRDAySjJLNVNBMzIwUzQ!/?WCM_GLOBAL_CONTEXT=/wps/wcm/connect/en/site/home/gov/gov5/gov51/
131	Pakistan	3	3	http://www.mocc.gov.pk/
132	Palau	3	3	No mitigation policy.
	Palestine	3	3	Information untraceable.
133	Panama	3	3	Other: http://ec.europa.eu/europeaid/where/latin-america/regional-cooperation/documents/climate_change_in_latin_america_en.pdf
134	Papua New Guinea	3	2	1. http://www.occd.gov.pg/images/stories/documents/Publications_Vision2050.pdf and 2.

				http://www.occd.gov.pg/images/stories/documents/PNG_Interim_Action_Plan.pdf
135	Paraguay	3	3	http://www.minam.gob.pe/dmdocuments/ds-085-2003-pcm.pdf
136	Peru	1	1	http://www.sernanp.gob.pe/sernanp/archivos/imagenes/Estrategia%20Nacional%20de%20Cambio%20Climatico.pdf
137	Philippines	3	1	1. http://www.lawphil.net/statutes/repacts/ra2009/ra_9729_2009.html; 2. http://www.neda.gov.ph/references/Guidelines/DRR/nfscc_sgd.pdf; 3. http://climate.gov.ph/index.php/nccap-technical-document-nccap; and 4. http://pcw.gov.ph/law/republic-act-no-10174
138	Poland	1	1	See EU
139	Portugal	1	1	See EU
140	Qatar	3	3	http://www.gsdp.gov.qa/gsdp_vision/docs/NDS_EN.pdf
141	Romania	1	1	See EU
142	Russia	3	2	1. http://archive.kremlin.ru/eng/text/docs/2009/12/223509.shtml and 2. http://russia.1hnews.com/latest/the-administration-of-president-include-climate-control/
143	Rwanda	3	3	http://www.rema.gov.rw/rema_doc/RGG&CRS%202011/Rwanda%20Green%20Growth%20Strategy%20FINAL%20high%20res.pdf; http://www.rema.gov.rw/index.php?option=com_content&view=category&layout=blog&id=188&Itemid=161&lang=en
	Saint Kitts and Nevis	3	3	http://mosd.gov.kn/content1.asp?NID=51
144	Saint Lucia	3	3	http://www.climatechange.gov.lc/NCC_Policy-Adaptation_7April2003.pdf
145	Samoa	3	3	http://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/Samoa%20Strategic%20Program%20for%20Climate%20Resilence%20%28SPCR%29%20CRIP.pdf
146	San Marino	3	3	Information untraceable.
147	Saudi Arabia	3	3	Information untraceable.
148	Senegal	3	3	http://www.environnement.gouv.sn/article.php3?id_article=139 (this section last updated in 2004
149	Serbia	3	3	http://www.merz.gov.rs/en/node/916
150	Seychelles	3	3	http://www.emps.sc/index.php?option=com_content&view=article&id=127&Itemid=129
151	Sierra Leone	3	3	Information untraceable.
152	Singapore	3	2	http://app.nccs.gov.sg/page.aspx?pageid=114
153	Slovakia	1	1	See EU
154	Slovenia	1	1	See EU
155	Solomon Islands	3	2	http://www.sprep.org/attachments/Climate_Change/SI_Climate_Change_Policy.pdf
156	Somalia	3	3	Information untraceable.
157	South Africa	3	2	1.

				http://www.info.gov.za/speech/DynamicAction?pageid=461&sid=22503&tid=46501; 2. http://www.info.gov.za/view/DownloadFileAction?id=152834 and 3. http://www.southafrica.info/about/sustainable/climate-191011.htm#.UQJGmzfxjOc
	South Sudan	3	3	Information untraceable.
158	Spain	1	1	See EU
159	Sri Lanka	3	2	http://www.climatechange.lk/Documents/Climate_Change_Policy/Climate_Change_Policy_English.pdf
160	Sudan	3	3	Information untraceable
161	Suriname	3	3	http://www.gov.sr/sr/uitgelicht/we-zijn-het-bos-reddplus/wat-is-klimaatsverandering.aspx; http://www.climatecompatiblesuriname.com/en/
162	Swaziland	3	3	Information untraceable.
163	Sweden	1	1	See EU
164	Switzerland	1	1	http://www.bafu.admin.ch/klima/00493/00494/index.html?lang=de
165	Syria	3	3	Information untraceable.
166	Taiwan	4	4	
167	Tajikistan	3	3	http://unfccc.int/resource/docs/nap/tainap01e.pdf
168	Tanzania	3	3	http://www.vpo.go.tz/announcements/view_news_item.php?id=152&intVariationID=1
169	Thailand	3	2	http://www.onep.go.th/
170	Timor-Leste			
171	Togo	4	4	http://www.republicoftogo.com/Toutes-les-rubriques/In-English
172	Tonga	3	3	http://www.mecc.gov.to/images/stories/DOCs/FINAL_CLIMATE_CHANGE_POLICY.pdf
173	Trinidad and Tobago	3	3	Information untraceable.
174	Tunisia	3	3	http://www.changementsclimatiques.tn/
175	Turkey	3	2	http://iklim.cob.gov.tr/iklim/Files/IDEP/%C4%B0DEP_ENG.pdf
176	Turkmenistan	3	3	http://www.undptkm.org/files/news/2012/110712_Strategy_en.pdf
177	Tuvalu	3	3	http://www.pacificdisaster.net/pdnadmin/data/original/TUV_2012_NSAplan_CC_DRM_2012_16.pdf
178	Uganda	3	3	http://www.ccu.go.ug/
179	Ukraine	3	3	Information untraceable; other sources: http://www.elaw.org/node/3743
180	United Arab Emirates	3	3	Information untraceable.
181	United Kingdom	1	1	See EU
182	United States	3	3	http://www.epa.gov/nsr/ghgpermitting.html
183	Uruguay	2	1	http://www.reduambiental.edu.uy/wp-content/uploads/2010/08/Antecedentes-y-Agenda-taller.pdf; http://www.cambioclimatico.gub.uy/
184	Uzbekistan	4	4	http://unfccc.int/resource/docs/natc/uzbnc2e.pdf
185	Vanuatu	3	3	http://www.agriculture.gov.ck/index.php/downloads/moa-

				reports/86-vanuatu-meeting
186	Venezuela	3	3	Information untraceable.
187	Vietnam	3	2	http://www.dwf.org/sites/lauratest.drupalgardens.com/files/Vietnam%20Climate%20Change%20Strategy.en_.pdf.pdf
	Western Sahara	4	4	
188	Yemen	3	3	http://www.yemen.gov.ye/portal/Default.aspx?alias=www.yemen.gov.ye/portal/moew
189	Zambia	3	3	http://www.ccfu.org.zm/
190	Zimbabwe	3	3	http://www.met.gov.zw/
	EU (as one)	1	1	http://ec.europa.eu/clima/policies/package/index_en.htm

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