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This chapter has been allocated 60 template pages. It currently counts 76 pages (excluding this page and the bibliography), so it is 16 pages over target. Reviewers are kindly asked to indicate where the chapter could be shortened.

Chapter 15: National and Sub-national Policies and Institutions

Contents

Executive Summary

There has 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 [robust evidence, high agreement].Mitigation of climate change is increasingly occurring in the context of multiple-objective policy-making which includes development planning in developing countries. [Section 2]. There is limited evidence to assess the plans' effectiveness, but preliminary indications suggest that they can offer opportunities for innovative climate and development policies [medium agreement]. [Section 2]The institutional and governance arrangements of a country are an important factor in the implementation and success of a policy [high agreement, medium evidence].

The stringency or size of emissions mitigation policies has a larger effect on emissions than the type of policy [high agreement, medium evidence] [Section 5.3 and 5.4]. Among the most frequently used instruments are regulations and information measures for energy efficiency [high agreement, robust evidence] [Section 5.2]. There is robust evidence and medium agreement that standards and labelling for energy efficiency have brought about significant energy savings at negative costs to society. There is medium evidence that energy management systems and energy audits have resulted in significant energy saving at negative costs to the society. Theoretically there may be governmental failure in setting appropriate regulations and information measures, but there is limited empirical evidence that supports this argument. [Section 5.5]

Countries that have put in place stringent carbon or fuel taxes have usually done so gradually and often as part of a general overhaul of the tax and fiscal system [Section 5.3]

There is robust evidence and moderate to high agreement that carbon taxation is effective in reducing emissions cost-effectively, and this applies to fuel taxes as well, which are much more common. There is robust evidence that in most countries (and this applies particularly to poor and middle income countries), these 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 and people have come to realize that they are not necessarily damaging to the economy, the fee level has often been increased [medium evidence, medium agreement] [Section 5.3]. Hypothecated instruments such as refunded emission payments make a higher fee level possible and thus may make possible more environmental improvement [medium evidence] [Section 5.3].

Economic theory suggests that emission trading systems are a cost-effective policy instrument because they induce consumers and firms to reduce emissions in the least costly way, (a feature that they share with emissions taxes) [high agreement, medium evidence]. They are so far relatively rare and have not been stringent [robust evidence, high agreement]. When policy coordination between jurisdictions is imperfect, they may cancel the effects of other policies or become redundant [high agreement, robust evidence]. 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]. [Section 5.4]

There is medium evidence that the voluntary agreements have been environmentally effective given a proper institutional framework, consisting of capable industrial associations, and governmental will, capacity, and involvement in the review process. The strengths of voluntary agreements are speed and flexibility in phasing in measures, and facilitation of information exchange among stakeholders [medium agreement, medium evidence]. Voluntary agreements had no significant environmental impact in some jurisdictions due to their limited scope or the lack of a suitable institutional framework [high agreement, medium evidence]. [Section 5.5]

There is medium agreement and medium evidence that climate technology policy is needed over and above general emission reduction policy and general technology policy if new technologies that lower emissions are to be developed and deployed to their full potential. Technology policy is more than R&D – it includes assistance for commercialization and technology transfer. [Section 6]

Climate relevant actions at the sub-national level are increasing, often in the context of local development choices [high agreement, robust evidence]. When there is synergy between these actions and development goals, these actions can result in effective outcomes. However, care needs to be taken to avoid scope for carbon leakage and collective action problems [high agreement, medium evidence]. [Section 2, Section 8]

The links between mitigation and adaptation policies are not obvious. Policies to adapt to climate change may be in conflict with policies to mitigate it [medium agreement, medium evidence]. In certain domains such as landuse planning, the potential for policies that combine both mitigation and adaptation may be high [medium evidence]. [Section 10]

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 diversity of institutional and governance structures that have been created across the world for mitigating climate change and formulating and implementing related policies. It seeks to draw lessons from the variety of experiences in this regard. The next section lays out the criteria that have been used in the literature to assess policy instruments and packages, and goes on to classify the major types of policies: regulations and standards, taxes and subsidies, tradeable permits, voluntary agreements, information policies, and others. The methods that have been used in the literature to assess the performance of policies are discussed as well as the issues that arise in assessing the strength of the evidence for whether policies have had particular effects or not. In assessing the impact of a policy, it is necessary to be clear about what would have happened in the absence of the policy and this is perhaps the most crucial component of any evaluation.

Section 15.5 begins the assessment of the different types of policies that have been used. Among the most widely used policies have been labelling, regulations, and standards for appliances and buildings to promote energy efficiency. These are found to have been effective in reducing energy consumption and associated greenhouse gas emissions. Moreover, these policies have sometimes had negative costs. They have, accordingly, been highly cost-effective.

A second set of widely used policies, taxes and charges on fossil fuels, are found to have had a significant impact on emissions in the long run. The distributional impacts of such taxes are mildly regressive or neutral in developed countries and generally progressive in developing countries.

Tradeable permits have been less widely implemented to date but are increasing in frequency. Their main advantage is their cost-effectiveness.

The key benefits of voluntary agreements between regulators and industry are flexibility and political feasibility. Voluntary agreements have be environmentally effective and cost effective given a proper institutional framework. A conducive institutional arrangement includes, in particular, governmental review or consultation process during implementation, as well as accompanying measures such as subsidies for energy audits and equipment. However, voluntary agreements have frequently failed to be environmentally effective. Their key attraction to polluters is to pre-empt regulation. The catch is that without the threat of regulation, there is little incentive to assume environmentally strict targets.

The impacts of various policies on innovation and technological advance are examined in Section 15.5. It is seen that policies that address emission reduction in the present cannot generally be expected to also be sufficient to induce the necessary innovations in technology that will allow for further emission reduction in the future. Direct government support for research and development is also typically required.

Policy instruments are not usually used in isolation and the impact of particular instruments depend on the entire package of policies and the institutional environment in which they are introduced and implemented. Interactions between different policy instruments may be of importance. Policies are, therefore, best designed and implemented as packages and not in isolation. The interactions between policies at different levels of government, national and subnational, is assessed. On occasion certain policies may cancel the effectiveness of other instruments. Tradeable permit programs are particularly problematic when policy coordination is imperfect.

Sub-national, or local governmental policies, have been proliferating across the world, backed by theoretical social science literature that demonstrated the rationale for sub-national initiatives. These different types of theoretic arguments tend to share that smaller-scaled, community-based, bottom-up efforts are important to come up with more effective and legitimate mitigation policies. Subnational experimentation has often paved the way for national policy-making. However, local governments naturally tend to choose policies that are not intrusive to the local economy since leakage to other jurisdictions is perceived as a very serious issue. Moreover, tight local emission regulations can be offset by increased emissions in other jurisdictions. At the local governmental level, leakage becomes a more formidable barrier than at the national level.

The links between mitigation and adaptation policies are not obvious. Policies to adapt to climate change may be in conflict with policies to mitigate it. In certain domains such as landuse planning, the potential for policies that combine both mitigation and adaptation may be high.

The financing for national policies is a particularly acute issue for developing countries. A number of instruments to channel international support for mitigation actions in developing countries are assessed.

15.2 Institutions and Governance

15.2.1 Why institutions and governance matter

Institutions and the processes of governance that underpin them are central to understanding national and sub-national responses to climate change. Using North's widely cited conception, institutions are the rules of the game or more formally, the "...humanly devised constraints that shape human interaction"(D. North 1990, p.4). These constraints can be formal, such as laws and policies, or informal, such as norms or conventions. In this framework, organizations -- such as parliaments, regulatory agencies, private firms, and community bodies -- develop and act in response to institutional frameworks and the incentives they frame. Institutions can constrain and shape interaction (human or business) through direct control, through incentives, and through processes of socialization.

Governance is less clearly defined, but broadly constitutes the process of constructing collective decision making and the resultant rules (Chhotray & Stoker 2009). In this sense, governance is about the process of institutional change(Kjaer 2004). While there are many perspectives on governance from different disciplines, there is increasingly a broad agreement that the process of making decisions involves multiple actors, governmental and non-governmental. In the broadest sense, governance encompasses who makes decisions, how these decisions are made, and whether and how decision-makers are held accountable for their decisions.

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). It colours the way in which problems are perceived; it can influence decisions about appropriate policy goals or objectives, and also which instruments are considered to be most acceptable in attaining those goals (Hall 1993, pp.278–9). More recently it has been argued that policy paradigms and their institutions can serve to limit the entry of new ideas (Radaelli & Schmidt 2004; Mitchell 2010) in that the way in which institutions are constituted can set the parameters of what people talk about, as well as who talks to whom in the process of policy making (Radaelli & Schmidt 2004, p.197). In this way, 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; Unruh 2002; Walker 2000).

Thus, existing institutions, governance and policy regimes are an important aspect of the lock-in to hydrocarbons within the energy system (Hay 2002, p.215). Conversely, responding to the challenge of climate change requires deliberate shifts in institutional constraints and governance structures to steer economies and societies toward lower carbon trajectories. To do so requires explicit and deliberate decisions that bring about a change in institutions, or rules of the game, at national and subnational levels. This section explores various mechanisms through which this shift is being brought about and can be brought about in order to effectively respond to climate change.

15.2.2 Governance of climate mitigation: Legislation, plans, and the policy framework

Since AR4, many countries have articulated a wide range of measures and actions to address climate change. These efforts span both developed and developing countries --those listed under Annex 1 and those not under Annex 1 of the UNFCCC. There are notable differences, however, in the objectives and institutions set up to address climate change mitigation in developed and developing countries. Among developing countries, governance of climate change tends to be initiated and articulated mostly at the national level, with sub-national measures deriving from national policies. In many (though not all) high-per-capita-emission developed countries, provincial and local governments have been active in autonomously developing the policy framework for climate mitigation.As might be expected, among developing countries, low-income countries with very low per-capita emissions have not been active in mitigation policy. These measures defy easy categorization and have taken a wide array of forms that render comparison difficult. This section looks both at broad comparisons across several countries and at brief case studies.

15.2.2.1 Cataloguing national legislation and plans

A notable trend since AR4 is the proliferation of national legislation, policies and plans that explicitly and, in many cases, primarily address climate mitigation. There is no centralized system of tracking these various national actions. To provide some summary information on the breadth of measures, and the diversity of forms (Legislation and policy), and objectives, Table 15.1 provides a summary of measures taken by selected countries as of June 2012. Since it is not possible to include all countries, for reasons of tractability, the list below focuses on the countries that comprise the G-20 grouping, which includes both Annex 1 and non-Annex 1 countries. The European Union is also included, since EU Directives provide the basis for national actions in several European countries. The table does not seek to comment on the adequacy or effectiveness of these actions.

There has been a trend toward nation-wide climate legislation and policies since AR4. Table 15.1 reveals that of the seventeen countries for which data is available, eight have passed climate-focused legislation of which seven were passed since 2007. The rest all have national policies in place of varying degrees of comprehensiveness, in some cases supplementing climate legislation. (THREE COUNTRIES TO BE CLARIFIED Turkey, Saudi Arabia and Argentina). In many cases, national legislations and plans explicitly refer to countries' voluntary pledges committed at the Copenhagen COP. There is, however, wide variation along three axes: the degree of specificity; the explicit focus on greenhouse gases versus other objectives; and the approach to governing.

(1) National approaches vary in how specific they are about the measures being put in place. In some cases, the policy or legislation spells out a concrete approach, as with the UK Climate

Change Act, while in other cases, the policy or legislation puts in place a process to develop more concrete measures.

(2) They also vary in the degree of explicit attention to greenhouse gases. In general, Annex 1 countries tend to articulate their objective more directly around limitation of greenhouse gases, while many non-Annex 1 countries emphasize that approaches to climate change must be consistent with sustainable development, economic growth, and co-benefits.

(3) Finally, national styles and traditions of governance also shape divergence across approaches. For example, China has a National Climate Change Programme, but climate change objectives are also embedded within the country's 12th Five Year Plan. The United States has national regulations in place based on an "Endangerment Finding" under the Clean Air Act that enables environmental regulation focused on greenhouse gases. The United Kingdom has adopted a carbon budget approach in its Climate Change Act, 2008, followed up by a Low Carbon Transition Plan (2009) that spell out how the Act is to be implemented.

Table 15.1 Legislation and Policy

Country	Type	Year	Legislation/ Plan Name	Categorization	Objective(s)
Argentina	NAI				
Australia	AI	2011	Clean Energy Act 2011 (Central act of clean energy legislative package and related legislation)	Legislation	The objects of this Act are as follows: 1. to give effect to Australia's obligations under: (a) the Climate Change Convention; and (b) the Kyoto Protocol; 2. to support the development of an effective global response to climate change, consistent with Australia's national interest in ensuring that average global temperatures increase by not more than 2 degrees Celsius above pre-industrial levels; 3. to: (a) take action directed towards meeting Australia's long-term target of reducing Australia's net greenhouse gas emissions to 80% below 2000 levels by 2050; and (b) take that action in a flexible and cost-effective way; 4. to put a price on greenhouse gas emissions in a way that: (a) encourages investment in clean energy; and (b) supports jobs and competitiveness in the economy; and (c) supports Australia's economic

					growth while reducing pollution.
Brazil	NAI	2010	National Policy on Climate Change-PNMC (Política Nacional sobre Mudança do Clima) -- Law No. 12187/ 2009, Decree No. 7390/ 2010	Legislation	The objectives of the National Policy on Climate Change shall be consonant with sustainable development with the purpose of seeking economic growth, eradication of poverty and reduction of social inequalities.
		2008	National Plan on Climate Change	Policy	1. Stimulate efficiency increase in a constant search for better practices in the economic sectors; 2. Keep the high share of renewable energy in the electric matrix, preserving the important position Brazil has always held in the international scenario; 3. Encourage the sustainable increase in the share of biofuels in the national transport matrix and also work towards the structuring of an international market of sustainable biofuels; 4. Seek for sustained reduction deforestation rates, in all Brazilian biomas, in order to reach zero illegal deforestation; 5. Eliminate the net loss of forest coverage in Brazil by 2015; 6. Strengthen inter-sector actions concerned with the reduction of the vulnerabilities of populations; and, 7. Identification of environmental impacts resulting from climate change and stimulates scientific research that can trace out a strategy that can minimize the socio-economic costs of the country's adaptation.
Canada	AI	2007	Kyoto Protocol Implement ation Act	Legislation	The purpose of this Act is to ensure that Canada takes effective and timely action to meet its obligations under the Kyoto Protocol and help address the problem of global climate change.
China	NAI	2011	The 12th Five-Year Plan for the	Policy	Reduce emission intensity by 17% from 2011 to 2015; Increase the share of renewables in the

			Development of National Economy and Society (2011-2015)		primary energy consumption mix from 8.3% in 2010 to 11.4% in 2015; Decrease energy intensity by 16% from 2011 level in 2015; Forest coverage rate to rise to 21.66 percent and forest stock to increase by 600 million cubic meters.
		2007	National Climate Change Programme	Policy	1. To control greenhouse gas emissions; 2. To enhance capacity of adaptation to climate change; 3. To enhance R&D; and, 4. To raise public awareness and improve management.
European Union	AI	2008	Climate-Energy Legislative Package (CARE): Improve and extend the greenhouse gas emission allowance trading scheme (Directive 2009/29/EC) (amending Directive 2003/87/) -- CARE 1; An 'Effort Sharing Decision' (Decision No 406/2009/EC) – CARE 2; Promotion of the use of energy from renewable sources (Directive 2009/28/EC) - CARE 3;	Legislation	1. Quickly and sharply reduce emissions of GHGs and 2. More secure energy sources. Response of Question 1 in (http://ec.europa.eu/climateaction/docs/climate-energy_summary_en.pdf). 2. 20-20-20 target: 20% emission reduction; 20% EU Energy consumption from renewable energies; and 20% reduction in primary energy use compared to projected level through energy efficiency improvement by 2020.

			Geological storage of carbon dioxide – CARE 4 (Directive 2009/31/EC)		
France	AI	2010	Grenelle II	Legislation	This Law implements France's "Grenelle de l'Environnement" which requires companies to report on carbon dioxide emissions, lays a legal framework for carbon capture and storage, and addresses transportation, renewable energy, and energy efficiency of buildings. Also known as "Grenelle 2," the provisions incorporate six main themes: urban planning, transportation, energy, biodiversity, risks to health, and governance. The "Grenelle 2" supersedes "Grenelle 1" law which was passed in 2009.
Germany	AI	2007 (2008 updated)	Integrated Climate and Energy Programme	Policy	Security of supply, economic efficiency and environment protection. Package of 14 legislative proposals covering energy efficiency, renewable energies in the electricity and heat sectors, biofuels, transport and Non-CO2 greenhouse gas emissions.
India	NAI	2008	National Action Plan on Climate Change	Policy	The National Action Plan on Climate Change identifies measures that promotes our development objectives while also yielding co-benefits for addressing climate change effectively. Eight national level missions: 1. National Solar Mission; 2. National Mission for Enhanced Energy Efficiency; 3. National Mission on Sustainable Habitat; 4. National Mission for a Green India; 5. National Mission on Strategic Knowledge of Climate Change; 6. National Water Mission; 7. National Mission for Sustaining the Himalayan Ecosystem; and, 8. National Mission for Sustainable Agriculture.
Indonesia	NAI	2007	National Action Plan addressing Climate Change	Policy	The objective in formulating a National Action Plan to address climate change is for it to be used as guidance to various institutions in carrying out a coordinated and integrated effort to tackle climate change. Addressing the impact of

					climate change should not be conducted by a few sectors only. Good coordination between sectors is essential to ensure the success of climate change mitigation and adaptation efforts in Indonesia. Climate change and its impacts are complex and dynamic problems. The National Action Plan must therefore be continuously evaluated and improved periodically by various stakeholders.
Italy	AI	2007	Climate Change Action Plan	Policy	
Japan	AI	1998 (2005 enforced)	Law concerning the promotion of measures to cope with global warming	Legislation	All the clauses of the Act amended in 2003. The main points of the amendments are as follows: Establishment of the Council of Ministers for Global Environmental Conservation by law; Development of the Kyoto Achievement Plan; and Stipulation of the establishment and implementation of countermeasures by local governments.
		2008	Action Plan for Achieving a Low-carbon Society	Policy	Japan has proposed to share globally the long-term goal of “halving total global greenhouse gas emissions by 2050 from its current level of emissions”.
Korea Korea	NAI	2012	National Emission Trading Program	Legislation	Introduce national level emission trading in 2015.
		2010	Framework Act on Low carbon Green Growth	Legislation	The purpose of this Act is to promote the development of the national economy by laying down the foundation necessary for low carbon, green growth and by utilizing green technology and green industries as new engines for growth, so as to pursue the harmonized development of the economy and environment and to contribute to the improvement of the quality of life of every citizen and the take-off to a mature, top-class, advanced country that shall fulfill its responsibility in international society through the realization of a low-carbon society.
Mexico	NAI	2012	General Law on Climate Change	Legislation	1. 30% reduction in emission growth measured against a "business as usual" pathway by 2020, and 50% by 2050; 2. 35% of energy to come from renewable

					sources by 2024; 3. Obligation for government agencies to use renewables; and, 4. Establishment of a national mechanism for reporting on emissions in various sectors.
		2009	Special Climate Change Program	Policy	Reducing GHG emissions by 50% by 2050 compared to their 2000 level.
Russia	AI	2009	Climate Doctrine of the Russian Federation	Policy	The strategic goal of climate policy is to achieve secure and sustainable development of the Russian Federation. Three areas for climate policy going forward: improving research to better understand the climate system and assess future impacts and risks; developing and implementing short- and long-term measures for mitigation and adaption; and engagement with the international community.
Saudi Arabia	NAI				
South Africa	NAI	2011	National Climate Change Response - White Paper	Policy	• Effectively manage inevitable climate change impacts through interventions that build and sustain South Africa's social, economic and environmental resilience and emergency response capacity. • Make a fair contribution to the global effort to stabilise greenhouse gas (GHG) concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner.
South Africa	NAI	2008	Vision, strategic Direction and Framework for Climate Policy	Policy	Proposes action in the following areas: (1) GHG emission reductions; (2) Intensification of current initiatives; (3) 'Business Unusual' call for action; (4) Preparing for the future; (5) Vulnerability and adaptation; (6) Alignment, coordination and cooperation among stakeholders.
Turkey	AI				

United Kingdom	AI	2009	The UK Low Carbon Transition Plan	Policy	This White Paper sets out the UK's first ever comprehensive low carbon transition plan to 2020. This plan will deliver emission cuts of 18% on 2008 levels by 2020 (and over a one third reduction on 1990 levels).
		2008	Climate Change Act	Legislation	Two key aims of the act are: 1. Improve carbon management, helping the transition towards a low-carbon economy in the UK; and, 2. Demonstrate UK leadership internationally, signalling we are committed to taking our share of responsibility for reducing global emissions in the context of developing negotiations on a post-2012 global agreement at Copenhagen in December 2009.
United States of America	AI	2009	Endangerment Findings for Greenhouse Gases under the Clean Air Act	Regulation	Finds greenhouse gas threatens public health, and that contributions by motor vehicles contribute to greenhouse gas pollution. These findings provide a basis for regulating emissions from motor vehicles

15.2.2.2 Case studies of national approaches and sub-national implementation

[Author Note: This section to be shortened and organized thematically rather than country-wise in the SOD so that material from the case studies will be used, but not presented as such.]

Given the wide diversity in approaches taken by different governments to climate actions, brief case studies help shed light on how countries approach the institutionalization of their domestic climate programmes. The countries represented here were selected because they represent a diversity of approaches, and without any judgement on the effectiveness or lack thereof of their climate programmes.

China

The impetus for domestic action on climate change in China is widely attributed to shifts at the national government level leading to changed incentives at provincial, city and enterprise levels. The most direct manifestation of greater political weight given to the issue was creation of a 'National Leading Group on Climate Change' In June 2007, which was significantly housed in the apex National Development and Reform Commission and chaired by the premier(Tsang & Kolk 2010). This high political profile and authority marked a departure from earlier national coordination groups of climate change.

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 & Hobbs Forthcoming; Teng & Gu 2007; Qi et al. 2008; Tsang & 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).

In a clear example of a co-benefits based approach to climate mitigation, the literature emphasises strongly that provincial implementation of targets is enabled by linking action to local motivations, notably energy efficiency (Kosktka & Hobbs Forthcoming; Teng & Gu 2007; Qi et al. 2008; Richerzhagen & Scholz 2008; Tsang & Kolk 2010). Tsang and Kolk (2010) go so far as to say that Chinese leaders essentially equate climate change with energy conservation. They note that members of the State Council on Energy Conservation and the Emissions Reduction Leading Group are identical. Kosktka and Hobbs (Forthcoming)identify three ways in which this alignment of global and local objectives happens: interest bundling, through which objectives of political institutions are tied to local economic interests; policy bundling, to link climate change with issues of local political concern; and framing in ways that play to local constituencies. While the initial emphasis has been strongly on energy efficiency for which there are strong co-benefits justifications, future efforts, such as targets on renewable energy and creation of provincial carbon markets (Han et al. 2012) will require different forms of justification and possibly access to finance.

However, it would be incorrect to assume that once national targets are allocated to provincial levels, compliance with targets at the provincial level is automatic or straightforward. Various devices are used to induce, persuade and occasionally force action. These include use of “responsibility contracts” signed between political officials and state-owned enterprise managers, to align their incentives, and the ability to raise prices for electricity and water or even terminate supply in the case of non-compliance. Pragmatism also plays a role, as in the use of “sleeping management” techniques through which enterprises are asked to close temporarily in rotation, so as to manage compliance while avoiding labour disruption.

There are some indications that implementation is hampered by a lack of dedicated financing(Teng & Gu 2007). So far, implementation has been facilitated by framing climate mitigation in terms of local objectives, using a diverse variety of techniques. In one example, Shanxi province has established a sustainable development fund through a tax on provincial coal, based on a perception that it is in the province’s interests to shift away from dependence on coal (Kosktka & Hobbs Forthcoming).

China represents a case of strong signalling from the national government to sub-national authorities about the necessity of climate action. This is translated into action through creation of parallel institutional forms at the provinces, and implementation is facilitated through use of a co-benefits framing of climate change, facilitated by a wide array of locally specific coordination mechanisms, incentives and disincentives.

Brazil

Brazil’s climate actions are governed by climate legislation – the National Policy on Climate Change – which was approved in early 2010. This legislation enshrines in national law its voluntary Copenhagen pledge to reduce greenhouse gas emissions by between 36.1% and 38.9% of projected emission levels in 2020 and, critically, sets in place an approach and mechanism to do so. The Brazilian approach rests on devising national sector-specific plans to reduce emissions by stipulated absolute amounts so as to add up to the overall planned reduction(da Motta 2011; E. L. La Rovere 2011).

Institutionally, implementation of the overall approach is coordinated by an Inter-Ministerial Commission on Climate Change, with an additional role being played by a multi-stakeholder Brazilian Climate Change Forum to solicit views and build agreement around the Brazilian approach, particularly in the lead up to the Copenhagen COP(da Motta 2011). Responsibility for designing sector-specific approaches rests with individual ministries. A substantial component of mitigation action is focused on forest protection, with the dominant instrument being enhanced implementation of Brazil's Forest Code. A second sector is agriculture, where instruments such as access to credit from government banks and provision of soft loans are to be used to incentive low carbon approaches. The energy sector is the third significant sector with efforts to promote biofuels and increase energy efficiency and renewable energy the key objectives. By mid-2012, these sector specific policies were in progress, and it is preliminary to assess either design or outcomes.

Politically, passage of Brazil's climate legislation and the creation of a political coalition around it appear to have been influenced by at least two trends in the years preceding 2009(Hochstetler & Viola forthcoming). First, a robust national debate around and passage of a Forest Code has helped build a credible institutional framework to limit deforestation in the Amazon, making feasible considerably diminished emissions from the forest sector. Second, new coalitions, comprising both those who expected to find opportunities to gain from CDM and REDD+ mechanisms, as well as industry who sought to avoid potential international sanctions related to climate change.

An interesting trend is the presence of independent sub-national planning and actions on climate change in politically important states and cities, such as Sao Paulo and Rio de Janeiro(Setzer 2009; D' Avignon et al. 2010; Lucon & Goldemberg 2010a). In late 2009, a new Sao Paulo law commits the state to undertake mandatory economy-wide GHG emission reduction targets of 20% by 2020 from 2005 levels. According to Lucon and Goldemberg(2010a) this represents a rare case of a sub-national entity going beyond national policy, particularly in the developing world, and could have contributed to building a political climate favouring national action(Lucon & Goldemberg 2010a). In addition, Brazil has been actively promoting local, primarily urban, GHG inventories as a way of promoting climate and air quality co-benefits (D' Avignon et al. 2010).

Brazil represents a case of a non-Annex 1 country passing national legislation, and then going beyond the plan at the regional level. Its approach is based on sectoral absolute GHG targets, adding to a reduction below the expected trajectory of emissions. Passage of this legislation has been facilitated by domestic political shifts particularly around the forest sector and opportunities for CDM credits.

United States

The United States represents a case where the centre of gravity on climate change is at the sub-national level. Indeed, sub-national jurisdictions have operated in a manner that appears to compensate for the lack of political momentum at the national level(Selin & Van Deever 2009).

At the national level, an economy wide "American Clean Energy and Security Act" that would have established a cap and trade system narrowly failed passage in the American legislative system (Barry G. Rabe 2010a). Subsequently, federal efforts at climate regulation have focused on a regulatory finding under the US Clean Air Act that greenhouse gases are an air pollutant that are harmful to human health, opening the path to limited federal regulation of emissions from vehicles and power plants (Barry G. Rabe 2010a).

Although progress at the federal level has been slow and halting, the United States has witnessed multiple efforts at sub-national scales, through unilateral and coordinated action by states, judicial intervention, and municipal-scale action (Carlarne 2008; Barry G. Rabe 2009; Barry G. Rabe 2010b; Posner 2010). The list of actions suggests wide-scale uptake of state-specific measures by 2009: over half the US states had enacted legislation or passed an executive order requiring reduction in GHG emissions; forty seven states had completed GHG inventories; twenty two states had formulated action plans; six states had statewide reduction commitments and associated policies; twenty-eight states had enacted renewable portfolio standards; fifteen states had established carbon dioxide standards for vehicles; and twenty-three states had some form of cap and trade system for carbon dioxide emissions from major industrial sources (Barry G. Rabe 2009, sec.Introduction, page 72–73).

Climate policy in the state of California is particularly worth noting both because of the size of its economy and because California has a history as a pioneer of environmental innovation (Mazmanian et al. 2008; Farrell & Hanemann 2009). The California Global Warming Solutions Act, 2006 place a cap on all GHG emissions and reduce them to their 1990 levels by 2020 (Farrell & Hanemann 2009). The law is sectorally focused and includes regulations on power plant emissions, energy efficiency standards, vehicle emissions policies and introduces a cap and trade system for large point sources. California. California's leadership within the US may be attributed to a self perception of the state as a leader in environmental protection, the existence of strong research and policy institutions, an unusual advantage conferred on California under the Clean Air Act that allows it to request a federal waiver in favour of more stringent standards, as a result of its past efforts, and the political and regulatory climate around energy in the wake of energy de-regulation in the US, and specifically the California energy crisis(Farrell & Hanemann 2009).

In a noteworthy development, instead of a competitive "race to the bottom" of regulatory standards across states, there is evidence of upward leveraging through regional initiatives diffusion across states(Posner 2010). For example, there is a multi-state cap and trade system in the Northeastern region of the United States, the Regional Greenhouse Gas Initiative (RGGI), with similar efforts in the Western and Midwestern Regions (Barry G. Rabe 2010a). In addition, there have been efforts to construct regional climate action plans, notably in the Northeast, in collaboration with neighbouring Canadian provinces (Carlarne 2008). Moreover, a coalition of state attorney generals from twelve states filed suit in federal court over the definition of carbon dioxide as a pollutant under the Clean Air Act (Barry G. Rabe 2010a). The successful challenge paved the way to the subsequent "Endangerment Finding" that has enabled federal regulation of GHGs.

In another example that works against the logic of collective action, there has also been an expansion of municipal scale action(Gore & Robinson 2009). This disperse local action to address a global problem appears driven by network-based communication and motivation, citizen initiative, reputational incentives for local government, and the scope for co-benefits from climate mitigation measures. On the last point, however, (Barry G. Rabe 2009) notes that while co-benefits may have been an important driver of earlier actions such as renewable portfolio standards, there is a growing shift away from such "stealth" measures that wrap climate actions in other justifications, and toward more explicit attention to climate change as a primary objective of policies.

The United States represents a case of experimental, bottom up climate governance, led by states and municipalities. Given the collective action nature of climate change, and the scope of leakage, the success of this effort depends on the extent to which the trend to aggregate upward can be strengthened and accelerated, and whether robust safeguards can be put in place against back-sliding.

South Africa

{New intro text to be added linking to broader South African plan}

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). Integrated planning in accordance with international best practice was to start from demand for energy services, balancing and integrating those considerations with planning of supply (Borchers 2000; Gonah & Graeber 2000; Marquard 2006) The National Energy Regulator published the country's first two national IRP (Tyler 2010). Subsequent to the second plan (NER 2004), the Department of Minerals and Energy reverted to supply-side focused electricity and liquid fuels masterplans, before a swing back to integrated planning. IRP2010 was undertaken by the Department of Energy (separated in 2009 from minerals) and was published in 2011 (DoE 2011).

IRP 2010 was different in important respects. A single parameter, least-cost, had been the objective of optimization models informing earlier plans, subject to constraints. Analysis had been undertaken by planners in Eskom and / or academic researchers. IRP2010 considered multiple criteria much more fully, and carbon was prominent among these. Several scenarios explicitly considered a constraint of 275 Mt CO_2–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(RSA 2011), IRP2010 mainstreamed carbon into electricity planning to a significant extent.

IRP2010 also represented a change of process, with more extensive consultations through an inter-departmental task team convened by the DoE. This built on experience with stakeholder involvement in long-term mitigation scenarios (SBT 2007).

While IRP2010 has taken an important step towards alignment of electricity planning and climate policy, broader issues of alignment remain – within the broader energy sector and across sectors. The literature continues to point to the need for alignment across policy domains (Tyler 2010; Trollip & Tyler 2011).

India

India has adopted a sectoral approach to its national climate policy based on pursuit of 'co-benefits' – measures that 'promote … development objectives while also yielding co-benefits for addressing climate change effectively' (National Action Plan on Climate Change). India's National Action Plan on Climate Change (NAPCC) is, therefore, strongly shaped by co-benefits driven concerns, with climate mitigation understood to be the secondary benefit emerging from development policies. The co-benefits approach has been central in winning broader political support for action on climate mitigation (Dubash 2011b, sec.Introduction).

Adopted in 2008, the Indian National Action Plan on Climate Change (NAPCC)(Prime Minister's Council on Climate Change 2008) 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. Some of these missions had specific focus and targets, such as a Solar Mission aimed at enabling 20,000 MW of solar power by 2022 (Solar Mission). Others, such as a National Water Mission, have broader and more diffuse objectives including water conservation, creation of a database, and promotion of basin level integrated water management (National Water Mission). Other missions focus on energy efficiency, agriculture, Himalayan ecosystems, sustainable agriculture, sustainable habitat, a 'Green India' mission focused on the forest sector, and a strategic knowledge mission. The emphasis is on using policy levers available at the central government level to change policy frameworks in specific sectors so as to induce co-benefits based actions.

The Missions have led to changes in institutional arrangements. The National Mission on Enhanced Energy Efficiency has considerably strengthened the Bureau of Energy Efficiency, while the solar mission has requires complex interaction between a range of governance levels, spanning central government agencies providing a subsidy, to state regulators setting and enforcing renewable purchase obligations.

The performance across missions is uneven. The two energy related missions, on solar and energy efficiency were based on specific policy and implementation mechanisms that were rapidly operationalized. For example, the Solar Mission is built around the use of a reverse-auction method that allows companies to bid for the minimum subsidy they would accept to provide solar power. The energy-related missions may also have been implemented rapidly because they served to address India's growing concerns over energy security (Dubash 2011a; Atteridge et al. 2012).

In addition to federal policies, the Government of India has directed states to develop State Action Plans on Climate Change. These plans were initiated between 2009 to 2011, and, initial indications suggest that they are predominantly focused on implementing national level directives. However, in some cases, 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 et al. 2012).

Denmark

Denmark is an interesting case study of public private ownership and local involvement. Denmark acted towards the end of the 1970's to improve energy security. A Danish Energy Agency was established in 1976, as an agency under the Ministry of Climate, Energy and Buildings(ENS 2012a)to support renewable energy and energy efficiency programmes. Since then Denmark has built an important wind manufacturing industry with about 20% of the 2011 global wind market(REN21 2011). It did this in the early years by requiring that information about the reliability of wind turbines was easily available; by creating an accessible support programme to establish a domestic market; by guaranteeing loans from local banks, thereby 'normalising' the process; and by including rules which enabled local co-operative investment thereby creating a large group of individuals supportive of Danish energy policy (Garud & Karnøe 2003; Karnoe & Buchhorn 2008). Denmark have established a holistic set of inter-related institutions and governance which maintain that early pragmatism with policy. In March 2008, The ENS appointed a Commission on Climate Change (ENS 2012b), which consisted of ten scientist, each possessing special knowledge in the fields of climate, agriculture, transportation and economics. This led to the Danish Energy Plan, 2012, where total energy use in Denmark's energy and transport system is to be reduced by 25% and 100% of energy supply is to come from renewable energy by 2050.

The Danish State owns the transmission network(Energinet.dk 2012) which is responsible for security of supply; ensuring the well-running electricity and gas markets; and infrastructure development, including developing the cooperation for an IT system and smart grid roll out via the Distribution Network Operators – thereby again ensuring all information is available and brought together in one place with the intention that 3rd parties – such as private energy service companies – can then participate . The Danish State is also the majority owner of Dong Energy (Dong Energy 2012) an energy company which is developing, amongst other things, offshore wind farms and electric vehicle co-operation within Denmark. The intention is to complement Engerinet's infrastructure role with further electricity market integration by linking the electricity cables from the offshore wind farms to another country (i.e. with Germany), as well as potentially develop electric vehicles as system balancers. The energy supply function also includes public not-for-profit organisations, often city municipalities. The Danish Energy Regulatory Authority(DERA 2012) which regulates the Danish markets for electricity, natural gas and district heating. The Minister of Climate and Energy formally appoints the members of the board, but the Minister has no powers of instruction in relation to the board members. DERA also sets the allowed price for electricity companies with an obligation to supply (i.e. the companies that supply customers who have not chosen their own supplier in the free market). In the natural gas market, the regulation also focuses on the network companies. Natural gas can be stored in underground storages, and DERA also controls the prices and access conditions of the two Danish storage facilities. Finally, DERA sets the price for natural gas supplied by the natural gas companies with an obligation to supply. In the district heating market, both production and network companies are monopolies and regulated as non-profit undertakings. The board of DERA consists of a chairman, six ordinary members, and two alternates. Energy planning is the responsibility of the Danish Energy Agency, which works with the Danish Ministry of Environment, which has the responsibility for Planning (Danish Ministry of the Environment(MIM 2012). Planning for renewable energy has been devolved down to municipality level(Sperling et al. 2010).

United Kingdom

The British example of institution and governance is one of a country deeply attached to market principles as the basis for climate policy, which has also implemented an independent institutional and governance system designed to deliver substantial carbon emission reductions by 2050 (80% from 1990 levels). Kern *et al.*(2012)explain how the Department of Energy was disbanded in the UK in 1992, following privatizations of most of the energy monopolies in Britain. Energy became a division within the Department of Trade and Industry while independent Regulators (Offer and Ofgas, finally combined to become Ofgem in 2000) were introduced to oversee the non-competitive aspects of the energy industry. Climate Change was the responsibility of the Department of Environment, as was energy efficiency measures.

However, as climate change and energy security became more important there was an institutional break when the Department of Energy and Climate Change was created in 2008 via the Climate Change Act. A key driver was to bring together energy demand and supply, as well as increase the visibility of the importance of Climate Change to the British Government. This Act also set legally binding carbon dioxide reduction targets of 80% by 2050 from 1990 levels. The Committee on Climate Change (CCC) was created as an independent advisor to the Government to set carbon budgets (ie the total amount of carbon which can be produced during different timeframes) to enable the 80% cut by 2050; to analyse and advise on how to meet those budgets; and to monitor progress. The CCC is a unique model in that it is a statutory body with authority to track, monitor, and stimulate compliance with sectoral carbon budgets by interacting with all government departments that are relevant to sectors that emit GHGs. While it cannot enforce outcomes, the CCC relies on an information and dialogue model to induce compliance.

Great Britain is made up of 3 devolved administrations, N. Ireland, Scotland and Wales. Devolved responsibilities do not include energy policy but do include renewable energy and energy efficiency. For example, Scotland, through the Scotland Climate Change Act, 2009, has higher targets for carbon emission reduction and renewable energy deployment by 2020. Thus, whilst Scottish based companies or people can take advantage of British support, they can also take advantage of Scottish policies implemented by the Scottish Government.

Other institutions include Ofgem, the independent energy regulator, which is responsible for energy regulation of networks and markets. The Energy Act, 2008 put in place powers to enable funding of the appropriate development of infrastructure via network charges. Further institutional creation has occurred with the Office for Renewable Deployment (ORED) [and Energy Efficiency Deployment Office (EEDO)] within DECC, which brings together the framework requirements for renewable energy deployment, including financing and unlocking barriers, such as planning.

England and Wales has created a two-tier policy structure for planning under the Planning Act, 2008. The independent Infrastructure Planning Commission Energy is able to make decisions on infrastructure projects of national importance, providing it takes notice of National Policy Statements and other legislation which impacts on the same area(DECC 2011). With respect to energy, this is any onshore project over 50MW and offshore over 100MW, as well as other infrastructure. While it has been implemented to speed up the planning process for infrastructure of national importance, it is not clear yet that this will be the case(Allmendinger & Haughton 2012).

Within the UK, there is currently no requirement for local authorities to take action on climate change. This coupled with limited funding means that local authorities may not develop and implement sufficiently ambitious low-carbon plans to fit with national policies(CCC 2012).

[Author note: Germany to be added]

15.2.2.3 Conclusions: National Legislation and Plans

Evidence of national legislation and plans reveals a strong trend toward concerted national actions, often enshrined in legislation, and, in case of plans, often backed by budgetary allocations and well-defined programs. This trend is markedly amplified from AR4, and particularly so for measures taken by developing countries. At the same time, many countries have only recently embarked on their legislative or planning processes, and in most cases, it is too early to assess outcomes.

For the most part, legislation and policies are directed at enabling change at a sectoral or a sub-sectoral level, rather than through direct enforcement mechanisms. However, in some cases, there are strong mechanisms driving implementation, such as China's enforcement of targets, or the UK's information and analysis based approach built around a Climate Change Committee.

The cases show a mix of policies that are articulated in terms of climate objectives and those that are articulated around achievement of co-benefits as a driver of action. Emerging economies, such as China, India, Brazil and South Africa show a strong tendency toward co-benefits based actions. The UK provides the most direct case of carbon based budgeting as an overarching policy framework.

Finally, there is some evidence of bottom up climate policy "experimenting" driven by sub-national actions(Hoffman 2011). The clearest case of this is the US, but there are other examples, such as in Brazil and India.

15.2.3 Nationally Appropriate Mitigation Actions (NAMAs)

In addition to national legislation and plans, several countries have also formulated mitigation actions of various forms, which are often referred to under the umbrella term "nationally appropriate mitigation actions" (NAMAs). As a label to describe national actions, NAMAs emerges from the international negotiation process and specifically the Bali Action Plan (BAP) (UNFCCC 2007, para.1.b.1 and 1.b.2). The BAP calls on developed countries to undertake "nationally appropriate mitigation commitments or actions" and includes within this "quantified emission limitation and reduction objectives." Developing countries are called on to take "nationally appropriate mitigation actions" (NAMAs) supported and enabled by technology and finance. Relevant for this chapter is a discussion of the ways in which countries have sought to develop and implement NAMAs.

There is no broad agreement on the scope and definition of NAMAs. NAMAs could, for example, be articulated in terms of national emissions intensity or trajectories, sectoral emissions, or specific actions at sectoral or sub-sectoral levels(Sterk 2010a). Consequently, NAMAs may constitute the sub-components that would collectively comprise climate plans.

A precursor of NAMAs is the concept of "sustainable development policies and measures" (SD-PAMs) – government actions that have both development and GHG benefits -- which were actively discussed in the literature as a way of linking national actions to the global regime (K. A. Baumert & Harald Winkler 2005). SD-PAMs were intended as a way of recognizing and providing support to actions that squarely fall within national development priorities, but that also result in climate-related gains. (H Winkler et al. 2008).

It is important to note the distinction between NAMAs and Clean Development Mechanism (CDM) projects. While CDM is a project based mechanism, NAMAs can operate at a variety of scales. Also, while only some NAMAs may be supported by carbon credits, the financing mechanism for CDM is necessarily carbon credits. Most significantly, while CDM projects are GHG mitigating projects that are intended to also have sustainable development benefits, NAMAs are intended to be actions prioritized by national development concerns that also bring climate gains. This reversal of prioritization suggests that NAMAs are more likely to arise from bottom up national processes.

15.2.3.1 Case studies of NAMAs

It may be most appropriate to shed light on definitional and conceptual challenges around NAMAs by inductively building from case studies. A study of South African mitigation actions suggests that although the term 'NAMA' is not widely used, there are a range of ongoing actions that could be defined as such. These range as broadly as a bus rapid transit system for Cape Town, a sectoral initiative to scale up renewable energy through a feed in tariff, a carbon tax, and a financing facility for solar water heaters and household thermal efficiency improvements(Tyler et al. 2011) . From this discussion emerges important conceptual issues, such as whether NAMAs should reflect the entire chain of policy actions required to implement a policy (e.g. policy paper, research, particular policies such as feed in tariffs) or only specific elements of this chain that directly lead to mitigation outcomes. Further, is it useful to categorize NAMAs based on whether they have direct effects or indirectly, for example, through introducing a price signal? *[Note: this case is drawn from an ongoing multi-country project. Subsequent revisions will include reference to more cases.]*

Comparing possible NAMAs across countries further reveals the breadth of possible options and the extent to which definitional questions remain(Jung et al. 2010). Since NAMAs can be a specific project, such as a bus system, or embedded within a larger transport plan, or even more ambitious, part of a larger sector strategy. This ambiguity on scope introduces challenges of attribution, as NAMAs within a sector may have interactive effects. NAMAs may also have effect at different time scales, and may operate directly or have indirect effect depending on implementation of other, complementary policies.

These complexities highlight the governance challenge inherent in designing and implementing NAMAs, which may operate at a variety of scales – local, national and global – and require complex coordination across government departments at these scales. While this coordination is often thought of as a hindrance, an emergent view suggests that such forms of "polycentric" governance require effective sharing of power, productive competition across jurisdictions, and space for experimentation(Sovacool 2011). From this perspective, the messiness of creating and implementing NAMAs is a strength rather than a weakness.

15.2.3.2 Linking NAMAs to international support

Much of the writing on NAMAs is focused on the challenges of linking national actions to the international climate framework. Conceptual difficulties include the legal nature of NAMAs(van Asselt et al. 2010), financing of NAMAs and associated concerns of avoiding double counting (Cheng 2010; Jung et al. 2010; van Asselt et al. 2010; Sovacool 2011) and measurement, reporting and verification of NAMAs (Jung et al. 2010; Sterk 2010a; van Asselt et al. 2010).

Whether or not NAMAs are eligible for carbon credits may depend on the ease with which a counter-factual test – what would have happened in the absence of the NAMA – may be applied (Okubo et al. 2011). In addition, the MRV of NAMAs is confounded by the range of possible types of NAMAs, the variation in the scale at which they may be implemented, interactivity across NAMAs, and the time scale over which they would have impact (Jung et al. 2010; Sterk 2010a). Interactive effects across NAMAs are particularly problematic from an MRV perspective. For example, if a country has a renewable energy feed in tariff, then renewable energy based carbon credits should only be allowed for projects that are unprofitable after the tariff, and that are further supported by international action (Sterk 2010b).

However, designing NAMAs around transaction costs might run counter to designing them for targeted focus on national development priorities. For example, large scale sectoral NAMAs provide the least scope for interactive effects and leakage and the lowest measurement costs but offer the least prospect for locally tailored sustainable development gains(Jung et al. 2010). Exploring the extent of this trade-off and managing it carefully will be an important part of implementing NAMAs.

15.2.4 The role of stakeholders including NGOs

[TSU note: This section to be completed for SOD]

15.2.5 Conclusion

The evidence on institutional change and governance arrangements on climate change is scattered and diverse. However a few trends emerge clearly. First, there is a considerable increase in formal government led institutionalization of climate action through both legislation and policy since 2007. Second, these actions take multiple forms, ranging from facilitation of bottom up experimentation to close monitoring of top-down carbon budgets. National context is central to understanding the particular forms that national actions take. Third, in general, implementation mechanisms are under-developed and the emphasis is on inducing and stimulating action. Fourth, there is a profusion of activity at sub-national levels, notably in urban areas often driven by networks of non-governmental actors, but also in sub-national jurisdictions – states and provinces. Fifth, in many countries, climate change is articulated in ways that emphasize the co-benefits from climate mitigation policies, with energy efficiency a particular focus. This articulation helps win political support for climate mitigation action. Sixth, since implementation is in its early stages, it is difficult to assess the extent of leakage across jurisdictions, but there are few signs of a "race to the bottom." Finally, there is insufficient evidence to assess whether some forms of national climate action are superior to other forms. The approach taken by various countries is driven by local institutional and political context, and legislative and policy measures are tailored to operating within the constraints of national political and institutional systems.

15.3 Characteristics and classification of policy instruments and packages

15.3.1 Criteria for assessment of policy instruments

Several criteria have been usually employed to assess the effects of climate change policies and these have been laid out in Section 3.10. The criteria that have been used in this chapter are environmental effectiveness, cost effectiveness, distributional considerations, institutional feasibility, and effects on objectives other than GHG emission reduction.

15.3.2 Climate policies and other energy policy objectives

As discussed in the preceding section, policies against climate change may have additional objectives in the minds of policy makers. In this context (Knudson 2009) differentiates between policy goals (broad statements on desirable outcomes such as the reduction of greenhouse emissions), policy targets (a measurable reflection of the preceding goals) and policy instruments (the tools that are used to meet the policy targets). The paper indicates that the Tinbergen rule is clear on the need to have at least a policy instruments for each policy target as, otherwise, some targets will not be achieved. Indeed, a good measure for assessing the policy instrument would be its impact on the matching target. This setting also explains the growing complexity of climate change policies, as many simultaneous climate policy instruments may interact negatively and a climate policy instrument may complicate the achievement of other related targets (Knudson 2009; Sorrell & Sijm 2003).

15.3.3 Regulations and Standards

Regulations and standards(assessed in detail in Section 15.5.2) were the core of the first environmental policies and are still very important in environmental and climate policies all around the world (OECD 2008). They are conventional regulatory approaches that establish a rule and/or objective that must be fulfilled by the polluters who would face a penalty in case of non-compliance with the norm. There are three categories of standards that are applicable to climate change policies:

- *Emission standards* are the maximum allowable discharges of pollutants into the environment, and can also be termed as performance standards (Stavins 2003)
- *Technology standards* that mandate specific pollution abatement technologies or production methods (IPCC 2007)
- *Product standards* that define the characteristics of potentially polluting products (Gabel 2000). These include standards for energy efficiency of appliances, buildings, etc.

15.3.4 Taxes and charges including border adjustments and subsidy reductions

Taxes and charges (assessed in detail in Section 15.5.3) 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 emissions or on the consumption of a product that is highly linked to greenhouse emissions, such as fuel, and, given the global and uniform characteristics of the taxed emissions, tax rates should ideally not be geographically variable (OECD 2001). Product taxes with single tax rates facilitate tax compliance and administration. In the last few years many taxes on greenhouse gas emissions have been introduced within green tax reform schemes, with the total or partial use of revenues to reduce other distortionary taxes (Gago & Labandeira 2000). Environmental taxes do not provide certainty on the environmental outcome, but are likely to be cost-effective because marginal abatement costs are equal to the tax rate for all polluters (IPCC 2007). They also provide continuous incentives to the introduction of clean technologies, as polluters are willing to pay less taxes in the future. Major attention was given to the distributional impacts of these taxes as they affect many necessary goods (Grainger & Kolstad 2010). Overall, taxes on greenhouse gases are a preferred instrument for economists (Newell & Pizer 2008).

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

Finally, subsidies are often described as equivalent to taxes. They have been proposed to promote carbon sequestration in forests (see Section 15.5. 6). Subsidies affecting the prices of fossil fuels or road transport are common, bringing about a higher use of energy and an increase greenhouse emissions. Therefore, a policy to reduce or to remove such subsidies would reduce GHG emissions(OECD 2008).

15.3.5 Tradable permits

In 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 that, as in environmental taxation, leads to cost-effectiveness and a continuous encouragement of cleaner technologies (Stavins 2003). The allocation of emission permits can be done through free distribution (grandfathering) or through auctioning, which could allow the use of revenues in a green tax reform fashion. Tradable permits have become an important option for climate change policies as they share the benefits of economic instruments and show a high institutional feasibility (Ellerman et al. 2010). Indeed, they provide certainty on the environmental outcome and, given the characteristics of greenhouse gas emissions, prices unrelated to the geographical location of the emitter would lead to lower administration and compliance costs.

15.3.6 Voluntary agreements

Voluntary agreements (assessed in Section 15.5.5) represent an evolution from traditional mandatory approaches based on conventional or economic regulations and intend to provide further flexibility to polluters. They are based on the idea that, under certain conditions, polluters can decide to commit themselves to go beyond regulation due to self-interests. Voluntary agreements can be developed in different ways: in most cases the voluntary commitment is assumed as a consequence of an explicit negotiation process between the regulator and the pollutant. In other cases a spontaneous commitment may be viewed as a way to avoid future mandatory alternatives from the regulator (which is also the basis for the preceding alternative). Finally, there are cases where the regulator promotes standard environmental agreements on the basis of estimation of costs and benefits to firms (Croci 2005).Some authors have stressed the positive properties of these approaches as their bigger flexibility in may encourage more innovation and cost-effective solutions (Golub 1998).

15.3.7 Information Policies

A typical market failure in the environmental domain is the lack of relevant information among firms and consumers. 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, such as the carbon footprint (Wiedmann et al. 2006), collection of data on greenhouse data emissions by major polluters and disclosing it and education and training (OECD 2008).The beneficial environmental impacts of these instruments will tend to be reduced when there are relatively few private benefits involved and their environmental effectiveness will depend on the availability of choices for target groups (OECD 2008). These policies, assessed in Section 15.5.1, are often relatively light in terms of public expenditure and thus with a high institutional feasibility (Hatch 2005).

15.3.8 Land and infrastructure planning

Land and infrastructure planning (see Chapter 12) are traditional public policies, i.e. usually without explicit climate-change rationale, but with a huge influence on greenhouse gas emissions (Doremus & Hanemann 2008). Land and infrastructure planning has especial interest in metropolitan areas, where a large share of population and economic activity is concentrated as urban planning decisions have important effects on mobility and emissions. Urbanisation is becoming particularly important in developing countries, and therefore, the benefits of a proper land and infrastructure planning are also higher (OECD 2009).

15.4 Approaches and tools used to evaluate policies and institutions

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 or implementation method, one wishes to assess qualitatively or measure quantitatively 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. If, hypothetically, a policy is implemented to encourage diffusion of windmills, and subsequently power from windmills increases by x%, one cannot assume that this increase is due to the policy. Quite likely, windmill usage would have increased in the absence of the policy, so the impact of the policy is appropriately assessed as the *increase* in diffusion brought about by the policy. To know this amount, one need to subtract the counterfactual or but-for level of diffusion from x. The identification of this counterfactual or “but-for” world is the greatest challenge in policy evaluation.

Statistical methods can be used to attempt to “control for” the evolution of the world in the absence of the policy, but the power of these methods is usually weak. The most reliable basis for estimating counterfactual developments is to build program evaluation into the design of programs from their inception (Jaffe 1998). If the planning of such evaluation is undertaken at the very 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. For example, if grants are made to firms or other entities on the basis of proposals of some kind, and those proposals are scored or ranked by the granting agencies, then these scores or rankings can be retained and combined with collection of data on the performance of both those entities that receive grants and those that don’t. This allows a rigorous statistical measure of the effect of the grants by comparing the performance of the entities that received grants to those that did not, using the ex-ante scores to control for underlying differences (Jaffe 2002).

These ex-post data analyses would be useful if data is available (also see chapter 3 for detail). However, sometime data is not available and several simulation analyses can be utilized. 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. CGE models are empirical versions of a general equilibrium system that combine a mathematical description of the economic relationships between sectors and institutions with the use of national accounting data (Bergman 2005). 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 (absence of policy) (see, e.g. Weyant & Hill 1999; 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, also called experimental economics approach conducted in the laboratory settings, is one of the useful method to help understand how markets function as they are expected and evaluate the effectiveness of, for example, emissions trading. Laboratory experiment is the application of experimental economics methods to study economic questions related to emissions trading scheme and other public bads (Kotani, Tanaka, and Managi 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. Then data provided from the experiment are applied to check the validity of economic theories. Laboratory experiments enable control of factors that influence the performance of policy instruments like emissions trading. Thus, this method can help to understand how each exogenous factor affects the performance of an emissions trading scheme.

In reality, we need to keep in mind that there are often different objectives exist. Therefore, analyses of multiple criteria considering comparative assessments of competing policy alternatives are important. It is designed to integrate disparate opinions, measurements, perspectives, preferences and priorities in a single comprehensive framework, which is used for policy recommendation or operational advice.

When conducting a prospective evaluation of different policies, there may be substantial uncertainty regarding baseline setting, i.e., how GHG emissions will grow in the absence of policy intervention (a without-policy scenario). For national baselines, assumptions on political decisions, economic incentives and social behaviours are important but difficult to predict in modelling exercises(Strachan 2011). Key assumptions may greatly influence modelling results include the growth rate of the economy, resource prices and production, technology development and short-term supply disruption events (EIA 2010).

Many policies often take place simultaneously. Example includes air pollution and CO2 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 2010). 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.

15.5 Assessment of the performance of Policies and Measures

15.5.1 Introduction

Chapter 3.8 provides an overview of criteria for assessment of climate change policies. Previous Assessment Reports have applied these criteria to the evaluation of policy instruments and implementation approaches, mostly at a theoretical level. There are fewer ex-post evaluations that provide empirical evidence on the effectiveness of such policies in practice. Although such ex-post analyses are data-demanding, labour-intensive, and methodologically challenging, an increasing number of studies are available, and are reviewed below.

This section does not review all polices, confining attention to key policy instruments with wide applicability. For policies specific to individual sectors, refer to the policy sections of Chapters 5 through 12.

15.5.2 Regulation and Information measures

Energy prices in all nations are affected by taxes, subsidies, environmental and safety regulations, emission trading systems, and so forth. To keep the resulting energy price at the appropriate level would make the economic systems less greenhouse gas intensive in the long term.

However, this 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 (IPCC 2007 AR4).However, these potentials are often hampered by barriers that slow their penetration (IPCC 2000 TAR). For example, consumers often lack information as to which appliance is cheapest in terms of lifecycle costs at retail shops. Furthermore, even if they have the information, many consumers behave myopically and buy cheap appliances even if they know that this results in high operating costs later.

This phenomenon has been widely perceived in terms of behaviourial economics since the AR4. Firms and individuals often behave irrationally in energy saving and greenhouse gas reduction activities, as they do in many other economic activities as well. As such, price adjustment alone is not enough as mitigation policy. 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 and information measures, as the key elements of such an architecture, have been widely used by governments in attempts to overcome energy efficiency barriers.

Often policymakers and researchers alike misunderstand the nature of energy efficiency regulations. Regulations for energy efficiency are generally not designed to restrict the behaviour of firms and individuals at their expense. Instead, most regulations are meant to remove barriers, thereby saving the money of firms and individuals and reducing the costs to the society, as demonstrated by much literature in what follows in this section. As such well-designed regulations can be complementary to energy pricing policies. On the other hand, theoretically, there are situations in which regulations can substitute for energy pricing policies, since the former may be politically more feasible than energy price increases in some situations. But such cases are rarely reported in empirical literature.

Ex-ante estimates of the impact of such regulation and information measures are sometimes exaggerated, by simply assuming that the policies will bring about realization of the full technical potential. More appropriate estimate of the policy impacts have to depend on ex-post analyses, as the policies often deviates from the pure original idea and there are many elements that may undermine the effectiveness of policies in the real policy process. For this reason, this section puts much focus on ex-post evaluations.

In what follows regulation and information measures are reported in a combined manner, as 'standard and labelling' because they are often implemented in a package, where minimum energy efficiency standards are set to remove the worst performing products from the market, and information labels are implemented to encourage consumers to buy more efficient appliances from the remaining ones. In combination these two are supposed to transform the market towards more energy efficiency. For this reason, it is appropriate to assess the impacts by the regulation and information measure as a package, not individually.

15.5.2.1 Standards and Labelling

Many countries have implemented standards and labelling for appliances and automobiles in building, industry, and transportation sectors. For a list of policies implemented in different countries, see [TSU note: to be completed].

Appliance standards can help address a number of market failures (Kenneth 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. The results showed that, controlling for household income and other household characteristics, renters were significantly less likely to have energy efficiency refrigerators, clothes washers and dishwashers.

In order to overcome such barriers, Minimum Efficiency Performance Standards (MEPS) and mandatory labels have been used by several countries since the 1980s on a range of residential equipment including refrigerators and freezers, clothes washer and driers, and air conditioners. 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. These gains have been made without sacrificing levels of service, since in all but one case the size or capacity of the equipment monitored has either remained the same or increased. With regard to the cost effectiveness,(K. Gillingham et al., 2006)reported that the value of net benefits from appliance standards were 10.6USD/GJ of energy saved.

On the impacts of building codes for insulations of households, (Jaffe and Stavins 1995) found that building codes across states in the U.S. made no observable difference to observed building practices in the decade 1979-1988. Later on, however, (Jacobsen and Kotchen2011) evaluated the effect of a change in the energy code applied to building using residential billing data on electricity and natural gas, combined with data on observable characteristics of each residence. The study was based on comparisons between residences constructed just before and after an increase in the stringency of Florida’s energy code in 2002. They found that the code change was associated with a decrease in the consumption of electricity by 4% and natural gas by 6%. They estimated average social and private payback periods that range between 3.5 and 6.4 years.

(Aroonruengsawat et al 2011) studied the impacts of state-level residential building codes on per capita residential electricity consumption. Using panel data for 48 US states from 1970-2006 and controlling for the effect of prices, income , and weather, they showed that 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. Estimates were larger in states where codes were more stringent and more strictly enforced.

A strand of the literature criticizes energy efficiency standards by arguing that much of the gains may be erased by rebound effects (Khazzoom 1980; 1987; Brookes 1992; Inhaber 1997). (Geller 2005) reviewed the empirical evidence of rebound effects. He noted energy efficiency analysts who suggested that the rebound effect erodes some of the energy savings due to technical efficiency improvements did make a valid point, based on the empirical evidence. Some consumers and businesses would increase their demand for energy services as the cost of the service declines. But he argued that the empirical evidence suggested that the size of the rebound effect was very small to moderate (10 to 30 percent typically) with the exact magnitude dependent on the location, sector of the economy, and end-use. As such those suggesting that the direct rebound effect would lead to a net increase in energy use appeared to be grossly exaggerating the magnitude of the phenomenon.

15.5.2.2 Energy Management Systems and Energy Audits

Global, country-specific, and industry-specific analyses continue to show that significant energy efficiency improvement opportunities exist in the industrial and building sector, many of which are cost-effective. However, industrial facilities are not always aware of their overall energy efficiency improvement potential or specific technologies and measures that can be implemented (Price and Lu 2011).

Energy Management Systems (EMS) are a loose collection of business processes, carried out atplants 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. Among the typical elements are: strategic plans; maintenance checklists; manuals documenting projects; energy purchase, use and disposal procedures; measurement processes; performance indicators and benchmarks; progress reporting; energy coordinators; and demonstration projects (McKane et al 2007).

Historically EMS started as business practice of energy intensive industries such as steel and power (Kajiki 2010). As such they have been widely recognized as a cost effective instrument to these industries. 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).

While EMS and energy audits are widely used by practitioners at operational level of industrial facilities and buildings, policy makers and academic researchers are often ignorant of the existence. Both EMS and energy audits have origin in energy intensive private firms, and the government has been playing the role to disseminate the knowledge to much broader range of economic entities.

The legal status and coverage of EMS systems vary 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, Galitsky and Kramer, 2008). In Japan EM systems are mandated by law. (Tanaka 2007).

(Santo and Labanca 2003) analyzed mandatory energy manager program in Italy and reported that number of companies and public authorities were not in compliance with the obligation on appointing an energy managers. Also they pointed out that the appointment of managers did not necessarily resulted in energy saving actions due to institutional barriers.

(Kimura 2009) undertook case studies of thirteen factories in Japan and reported that the response by firms to mandatory EM systems was mixed. Some companies actually used EM to improve their energy efficiency, but others implemented EM only superficially on paper and it did not deliver energy efficiency improvement.

Conducting an energy audit or assessment is a key step for identifying the energy efficiency improvement potential, but many plants do not have the capacity to conduct an effective evaluation(Price and Lu 2011; Vreuls 2005; ECCJ 2007). Against this backdrop 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).

A key policy issue is the extent to which implemented audits result in implementation of efficiency improvements. (Anderson and Newell 2004) analyzed technology adoption decisions of manufacturing plants in response to government-sponsored energy audits. Overall, plants adopted about half of the recommended energy-efficiency projects.

The U.S. Department of Energy ("DOE") Industrial Assessment Centers, located at 26 universities throughout the U.S., performed in-depth assessments of industrial facilities. The results were then presented to the plant in a confidential report with findings and recommendations. In 2001, the IACs performed 590 facility assessments that identified 3350 energy efficiency recommendations with an average estimated simple payback period of 0.9 years. The facilities implemented 46% of these recommendations; the implemented recommendations had an average simple payback period of 0.5 years(Lynn, Galitsky and Kramer 2008).In 2006, the U.S. DOE Save Energy Now program completed 200 assessments at large energy consuming manufacturing plants and found that the typical large plant could reduce its energy bill on average by over USD 2.5 million per plant. Six month follow up surveys indicated that about 7% of the recommendations had been implemented, saving an estimated USD 30 million annually and more than 70% of the recommendations had been implemented, were in progress, or were planned for implementation(Lynn, Galitsky and Kramer 2008).

(Gruber and Fleiter 2011) studied the program offering partial subsidies for energy audits launched by the German Ministry of Economics in 2008. The purpose of the audits was to identify energy saving potentials in Small and Medium-size Enterprises (SMEs) by qualified independent consultants. The consultants found substantial energy efficiency potentials in all the companies. On average, each company implemented 2.8 out of 5.3 recommended measures as a direct result of the energy audit. The program costs to the government amounted to 0.14-0.19USD/GJ energy saved, which was equivalent to 1.6-2.1 USD/tCO2.

On the cost effectiveness, (Khan 2006) analyzed the energy audit programme in Finland.Net impact was a cumulative energy saving of 29PJ. Cost efficiency, as a ratio between costs and energy savings, is for government 0.09-0.18 USD/GJ. For end users the result of the energy audit programme is a net annual return and the ratio between net return and energy savings was in the range of 0.9-1.1 USD/GJ.

(Kimura 2009) conducted a case study on the energy audit program by Energy Conservation Center of Japan(ECCJ), which provided on-site energy diagnosis service to 2409 small to medium facilities in 2004-2007. The costs for the government was 12USD/GJ, that was equivalent to USD260/t-CO2. The benefits for society, as the net benefit to private firms minus the costs to government, were 2.9USD/GJ, that was equivalent to USD61/t-CO2. He also analyzed the energy audit program by New Energy Development Organization(NEDO) of Japan, which provided on-site energy diagnosis service to 502 large scale facilities in 1999-2007. The costs for the government were 0.68USD/GJ, that was equivalent to USD15/t-CO2. The benefits for society, as the net benefit to private firms minus the costs to government, were USD1.7/GJ, that was equivalent to USD38/t-CO2.

(Kimura 2010) conducted a case study on Tokyo Metropolitan Government (TMG)'s policy that mandated firms to implement EM systems, with intensive energy audits were conducted by the government. He reported that the net benefits to firms were 68USD/tCO2, that was equivalent to USD3.1/GJ and net costs to the society (government plus firms) were 91USD/tCO2, that was equivalent to USD4.2/GJ . The latter costs were rather high because the firms implemented costly options such as photovoltaic in addition to low cost energy efficiency ones and the total costs were reported.

Comparing the three programs, the costs to the government is higher for ECCJ and TMG program than NEDO program since the target facilities were smaller in the former than the latter. As such economy of scale is at place for energy auditing program.

15.5.2.3 Crosscutting Evaluation of Energy Efficiency Programs by the Government

(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). Cases include: Netherlands appliance labelling, German KFW soft loans, British Energy

Efficiency Commitments(AID-EE), New York ENERGY STAR market support program, New York Empower program, Thai Thin tube CFL program, Danish kitchen appliance, California multi-family rebate program. The analysis found that the average cost-effectiveness across all programs, taking into account all costs and all benefits, was USD0.6/GJ. In other words, on average, the programmes delivered USD 0.6 of net benefits for every GJ of energy saved. The eight programmes clearly delivered significant energy savings, and most were extremely cost effective.

(Gillingham, Newell and Palmer 2006) reviewed several types of energy efficiency policies: appliance standards, financial incentive programs, information and voluntary programs, and management of use. They identified up to four EJ of energy savings annually from these programs, at least half of which was attributable to appliance standards and utility-based demand side management programs. The cost-effectiveness were estimated as 10.6USD/GJ and 9.4USD/GJ respectively. [Author note: Authors are considering putting together a table summarizing the results from this section, particularly if we could put the cost-effectiveness calculations on a comparable basis, e.g. USD/tCO2 or USD/GJ.]

15.5.2.4 Conclusion

There is robust evidence that standards and labelling for energy efficiency have brought about significant energy savings at negative costs to the society. There is medium evidence that energy management systems and energy audit have resulted in significant energy saving at negative costs to the society. The caveat is that the analyses of energy management systems and energy audits above may be biased to the extent that researchers chose to focus on successful cases. Theoretically there may be governmental failure in setting appropriate regulations and information measures, but there is limited empirical evidence that supports this argument.

15.5.3 Taxes, charges, subsidies, subsidy removal and leakage issues

15.5.3.1 Introduction

Carbon taxes are a theoretically attractive instrument precisely because they are broad as well as technology and fuel neutral. To cut administrative costs the tax can be levied "upstream" (ie at the points of production or entry into the country). Recently two major coal producers, Australia and India introduced carbon taxes. Although the taxes are low, these countries are thereby joining the small but growing group with any carbon tax. Those that have sizeable carbon taxes are fewer still – mainly a few Northern European countries. Even then, taxes typically have some exemptions motivated by the fact that other (competing) countries have no taxes: often heavy industries, subject to international competition, are exempted making evaluations more difficult. In the broader picture we note that well-designed economic instruments for environmental protection are still not nearly as prevalent as they should be. One reason may be that economists have not yet meaningfully accounted for the importance of political feasibility, which often hinges on risks to competitiveness and employment, or on the distribution of costs rather than on considerations of pure efficiency alone. (Sterner and Coria 2012).

Concerning the few countries (mainly in Europe) that have some substantive experience, much has been written and claimed in the grey literature: Representatives of Swedish authorities for instance seriously claim that since the carbon tax was introduced, large parts of the heating sector have transitioned from fossil fuels to renewables and that the carbon tax has contributed strongly to the decoupling of carbon emissions and growth in Sweden: "During the 1990 – 2007 period, the CO2 equivalent emissions were reduced by 9 % while at the same time our country experienced an economic growth of + 51 %", Hammar and Åkerfeldt (2011). Similarly just for the period 1990-95, The Swedish Ministry of the Environment estimated that CO2 emissions fell about 15% because of the tax (Johansson 2000). The various Nordic countries have different levels and different design of the carbon taxes. The Danish government provides approximately 25% reduction of the tax if a company signs an energy savings agreement with the Ministry of Transportation and Energy. Per capita emissions in Denmark were reduced by 15% from 1990 to 2005. Industrial emissions were also estimated to decrease by 23% during the 1990s, after adjusting for growth and market-induced industry restructuring (Enevoldsen 2005). See also Sumner et al (2011) for a detailed overview (table 6 for instance has 9 different country or state examples).

There is however less rigorous published work that is empirical (as opposed to theory or simulation studies) on the effect of these taxes according to the criteria usually established of efficacy, efficiency, fairness and instrument cost. This is no doubt because it is hard: there are no clear counterfactuals or "experimentally" clean comparisons. Instead multiple instruments and many other factors coevolve in each country to produce policy mixes with different outcomes in terms of energy intensity and emissions but it is hard to tease out from this the clear conclusions we want on efficiency and fairness. In the case mentioned of Sweden, one would really need to separate out possible supply, technology and other effects in the biomass supply chain and the effects of other policies, from the pure effect of the carbon tax.

There are however rigorous studies and they point in the same direction as the grey literature mentioned – although, as expected, with greater caution concerning causality, significance and size of effects. (Bruvoll & B. M. Larsen 2004 and 2006) found a significant but modest reduction in emissions per unit of GDP in Norway as a response to carbon taxes. The modest effect may be partly explained by the fact that there were generous exemptions. Similarly small results (of one or two percent) were found for the UK (Cambridge Econometrics 2005). Bruvoll and Larsen 2004 also find a significant effect of all policies from 1990 to 1999 on Norwegian emission intensity (a 12% reduction) but they are only able to attribute a fraction of this to the carbon tax the efficiency of which was heavily reduced by all the exemptions for carbon-intensive industries as well as the inelastic demand in those sectors.

Berkhout et al 2004concludes that the energy tax in Holland had a small but significant impact on household energy consumption, with an average yearly decrease of 8% for electricity demand and 4.4% for gas. The average price elasticity for gas was found to be lower since gas is used for heating and households appear not to factor in annualized future heating costs into investments in insulation and so on. Martin et al 2011 find strong impacts on energy intensity of the UK's Climate Change Levy (CCL), introduced in 2001, on manufacturing plants. The CCL is a fund type package including an energy tax (the CCL) which added an average of 15% to energy costs, with the possibility of getting a 80% discount on the tax rate by joining a Climate Change Agreement (CCA) obliging companies to adopt a specific target for energy consumption or carbon emissions. Lin (2011) uses a difference-in-difference method to estimate the mitigation effects of the carbon taxes of five European countries: Denmark, Finland, Sweden, Netherlands and Norway. The results show that the carbon taxes were effective in reducing CO2 emissions although the effect was not statistically significant in all countries. The paper again suggests that the mitigation effects are reduced due to tax exemption policies on energy intensive industries.

Also Aldy and Stavins (2012) set out to paint a broad picture of the experience with carbon taxes and point to the lack of really clean examples. However they point to the fact that the market often creates experiments which are analogous to the introduction of policies. Increased fuel prices 2008 for instance, led to a shift in the composition of vehicles sold increasing fuel-efficiency, while also reducing miles traveled (Ramey and Vine, 2010). Longer-term evaluations of the impacts of energy prices on markets have found that higher prices not only reduce demand but have induced more innovation – measured by frequency and importance of patents – and increased the commercial availability of more energy-efficient products, especially among energy-intensive goods such as air conditioners and water heaters (Newell, Jaffe, and Stavins, 1999; Popp, 2002). Another example of tax-promoted technology innovation would be from the carbon storage in the Norwegian Sleipner gas field, Sumner et al (2011).

Aldy and Stavins (2012) summarize the experience of carbon taxes in northern Europe by noting that they have yielded significant variations in the effective tax per unit CO2 across fuels and industries within each country, (contrary to the cost-effective prescription of a common price in all sectors). In addition, fiscal cushioning to carbon taxes – by adjustments to pre-existing energy taxes – and to the EU ETS – by adjustments to then pre-existing carbon taxes – are common, especially for those industries expressing concerns about their international competitiveness. Nonetheless, these nations have demonstrated that carbon taxes can deliver greenhouse gas emission reductions and raise revenues to finance government spending and lower income tax rates (OECD, 2001; Government of Denmark, 2009; Government of Finland, 2009; Government of Norway, 2009).

Yuan et al. 2009 evaluate three groups of energy policies implemented by the Chinese government since 1980. The first group of policies is those adopted in 1991 to promote energy-saving. The second group refers to those policies related to the Law of the People's Republic of China on Energy Conservation promulgated in 1998. The last group of policies are captured in the Medium and Long Term Specific Schema on Energy Saving and adopted in 2004. The results show that energy policies, and higher energy prices, have contributed to decrease energy intensity in China. The first group of policies had a higher impact on energy intensity than the other two. Fisher-Vanden et al. 2006 find that around 50% of the decline in energy intensity in Chinese industry 1997-9 can be explained by price effects. R&D accounts for 17% of the decline.

15.5.3.2 Other product taxes as proxy for carbon taxes

While pure and broad carbon taxes are rare, there are common and close substitutes such as taxes on gasoline or diesel fuel[1]. These can be interpreted as a carbon tax; in some countries this is clearly stated as an objective of fuel taxes, in others it is not. Whether intentional or not, fuel taxes function similarly to a carbon tax for the uses covered. One reason they are considered politically easier to implement in some countries is that transport as such is not subject to much international competition and hence direct leakage rates are low. An important share of all revenues from environmentally related taxes in fact come from taxes on motor fuels. Such taxes were introduced in various countries, primarily Europe and Japan a long time ago. One of the main purposes was to finance road building but irrespective of the motivation, the effect is to raise prices to the consumer and restrict demand and thus they have important environmental impacts.

The efficacy of fuel taxation is sometimes questioned since consumers are locked into patterns of use by habit, culture, vehicle characteristics and urban infrastructure and architecture. The short-run response to higher fuel prices is thus often small (price elasticities of the order of -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, see e.g., (Graham & Glaister 2002)). This means that in the long run, a ten percent higher fuel price will lead 7-8% reduction in fuel use and emissions. The fact that the benefits (to climate) come in the long run while the political "price" is paid within the short-run attention span of an electoral cycle at most, is clearly a problem. However the potential long-run effects are large; (Sterner 2007) shows that the whole OECD would have had 30% higher fuel use had not the EU and some other members had high fuel taxes (in other words if all the OECD countries had had as low tax and consumer price as the US has). Similarly the OECD could have more than 35% lower fuel use if all the countries (including notably the USA) would have had as high taxes and prices as the UK. The accumulated difference in emissions over the years is enough to be noticed at the level of a few ppm in CO2

[1]Other sectors could also be studies for instance electricity demand which naturally has elasticities that vary between sectors and countries. Complicated tariffs including fixed charges and charges for maximum power complicate the picture but (Jamil & Ahmad 2011) find that most sectors have fairly price elastic demand, suggesting that taxes can be an important environmental policy instrument.

concentration, reasonably making fuel taxes the empirically most important policy instrument actually tried.

Fuel taxes are thus clearly effective. Theory suggests very strongly that they are efficient compared to for instance fuel efficiency mandates, driving restrictions or subsidies to new technologies. The only possible argument against this would be if consumers who buy vehicles are unable to correctly internalize the long-run savings of more fuel efficient cars. To empirically verify how efficient taxes are compare to for instance CAFÉ standards is difficult for reasons already mentioned but using an empirically based simulation model, Austin and Dinan (2005) find as expected that the tax would be significantly more efficient.

A further criterion of considerable importance is that of equity or fairness in cost distribution and fuel taxes are often attacked with the argument that they are regressive. (Benjamin 2011) analyses the distributional effects of carbon taxes on car 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. (Sterner 2012) shows that fuel taxes may be neutral or even weakly regressive (before revenue recycling) in rich countries but that they are generally progressive in poor countries. In many large and important poor countries and regions such as India, Indonesia, China and many African countries, the progressivity of fuel taxes is in fact quite strong.

De Vita et al (2006) studies all forms of energy demand to estimate long-run elasticities for Namibia 1980 - 2002. Aggregate energy demand is found to have a price elasticity of -0.34 but variation is high, from -0.9 for gasoline to -0.3 for electricity and virtually 0 for diesel. The problem of diesel is often compounded by the fact that it is not only used for road transport but for industrial use, electricity generation, agriculture and many other uses. Fuel adulteration and illicit use of untaxed or subsidized fuels for instance from agriculture in road transport is not uncommon. Naturally the distributional effects of other fuels also vary significantly. Several chapters in Sterner (2012) find that particularly taxes on kerosene, do tend to be regressive since kerosene is used predominantly by the poor for lighting and heating. In some countries this may also apply to taxes on electricity or coal.

15.5.3.3 Subsidy reduction

Many countries have either failed to tax fossil energy or even subsidized it. This is for instance often the case in oil and coal producing countries. In 2008, fossil fuel subsidies exceeded $500 billion globally (IEA, 2011). In at least ten countries, fossil fuel subsidies exceeded 5 percent of GDP, and constituted substantial fractions of government budgets (IEA, 2010). Eliminating subsidies to fossil fuels completely would reduce global emissions by around two gigatons per year 2020. Adopting a somewhat convoluted language, “Subsidy Reduction” has become an instrument in its own right. The G20 and APEC blocks have both agreed in 2009 to phase out fossil fuel subsidies in order “to deal with the threat of climate change” (G20 Leaders, 2009). 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 some research shows they are costly for the economy. For instance (Lin & Jiang 2011)have shown that China's energy subsidies amounted in 2007, to 1.4% of GDP. Subsidies for oil products consumption are the largest, followed by subsidies for the electricity and coal sectors.

Many developing country governments motivate their hesitancy to remove subsidies because of fear of social unrest. Protests over reduced petrol subsidies are common, recently there has been much unrest in Iran over this issue and earlier in 2012, riots erupted in Nigeria when President Goodluck Jonathan tried to eliminate very costly petrol subsidies. Historically such riots also helped precipitate the downfall of President Suharto in Indonesia 1998. Some countries, (including Iran and Indonesia in more recent years) have recognized that fuel subsidies actually accrue to the relatively wealthy and have managed to successfully reduce fossil fuel subsidies without too much unrest, by making sure that revenues saved are spent fairly – for instance through general lump-sum cash transfers (Aldy and Stavins 2012, Coady et al., 2010,Sterner 2012).

There are many studies showing that subsidies might indeed have some positive impacts but the subsidies typically come at great costs financially and to environmental quality (for example groundwater extraction, greenhouse gas emissions). Subsidies also have a pervasive property of creating strong lobbies for status quo. The few who gain from subsidies have a strong interest in their preservation and will fight hard to preserve them, see for example Badiani et al. (2012) for a careful analysis of agricultural electricity subsidies in India.

15.5.3.4 Aviation and Maritime transport

Carbon emissions from aviation account for more than 2 percent of the global total and are growing fast. (Green 2009) states that, combining the available technological, design and operational measures could enable the emissions of the world fleet to be cut by 65–70% per passenger-km by 2050 relative to the year 2000. However matters are complicated by the interaction of and trade-offs between carbon emissions, nitrogen emissions and contrail formation. Thus more complicated measures than simple fuel taxation will be needed. Furthermore fuel taxation may be less effective for air transport than for road transport since elasticities are likely to be very low (Pels et al. 2009) find fare elasticity to be around -0.2. Deregulation of this oligopoly industry could potentially lower the fares much more than they would be raised by any realistic carbon price. Countries currently regulating GHG emissions from domestic aviation include New Zealand, Australia (included in their emissions trading schemes). Germany charges an eco-tax on passengers flying domestic routes as well as those departing from the country and Sweden also had a similar tax for some time. EU will include the aviation sector in the EU ETS.

Keen et al (2012) show that the international aviation and maritime sectors today are not taxed nor are these fuel uses subject to any global measures to reduce emissions, although they represent at least 5 percent of the global emissions. A carbon tax of $25 per tonne would raise about $12 and $26 billion from aviation and shipping respectively by 2020. The study estimates this could lead to reductions of at least 5-10 percent.

15.5.3.5 Fees and other charges that are not really taxes: Road tolls

There are a large number of other areas which do not directly apply carbon pricing but which are relevant either because of ancilliary effects or because of analogy. Congestion pricing on roads or in cities is an obvious case in point and London provides the iconic example. The congestions fee in London is stiff and led to reductions in incoming private cars by 34%. The reduction in trucks and vans was smaller and there was an increase in taxis and busses but overall congestion is estimated to have been reduced by 30% which also entails some reduction in carbon emissions, see Leape (2006).Johansson et al (2009) study the effect of the congestion pricing in Stockholm where a low fee of 2 € resulted in a 15% reduction in total road use.

15.5.3.6 Combinations of Tax and Subsidy or Refunded Emission Payments.

In many applications there are numerous reasons why taxes cannot be used or cannot be set sufficiently high to match the Pigouvian level (i.e. to correspond to marginal damages). In real-world policy applications, taxes or fees often have exceptions or are combined with subsidies. Fees are in many cases collected in environmental funds that are subsequently used in ways that benefit the polluters. This is done for pragmatic reasons –to appease business, prevent firm closure, job loss, "carbon leakage". There may also be pure rent seeking and considerations of political feasibility in the face of powerful lobbies. Both theory and empirical evidence, for instance from NOx emissions in Sweden show that combinations of tax and refund or tax and subsidy can be politically more acceptable and thus environmentally more effective than simply a tax (e.g., see for instance (T. Sterner & Hoglund Isaksson 2006) or (Fullerton & Wolverton 1999)) or Sterner and Turnheim 2006 for effects on technology diffusion and Fredriksson and Sterner 2005 on effects of the fee on industrial lobbying. Norway has recently inaugurated a system whereby refunding of emission taxes goes to subsidising abatement expenditures and they are thinking of promoting similar solutions for carbon emissions.

15.5.3.7 Subsidies, Feed-in tariffs, Certificates

An interesting debate surrounds the use of subsidies to promote new technology RD&D. Feed-in tariffs (FIT) guarantee a fixed price to the seller of for example solar or wind energy while tradable green certificate (TGC) schemes provide an equivalent support that is however priced on the market. If markets were perfectly competitive and there were no risk, then FIT and TGC would be equivalent. However, in the presence of risk, it seems FIT are preferred since they eliminate the risk to producers (Alishahi et al 2011). When markets are imperfect, as in an oligopoly Tamas et al 2010 show that the tariff deviates more from the cost difference than the certificate price and FIT will encourage more supply of electricity (from both black and green producers) than TGC. Using data from the UK, the authors find that social welfare under TGC is consistently higher than FIT for a wide range of values of the parameters.

Tradable certificates are also used to create markets for energy efficiency so-called 'Tradable White Certificates' (TWC) schemes, combine mandatory energy saving obligations for energy companies with some flexibility including the option to trade energy saving certificates (see e.g. Bertoldi & Rezessy 2008; Bertoldi et al. 2010; Langniss & Praetorius 2006; Mundaca 2007, 2008; Vine & Hamrin 2008). From the economic-efficiency point of view, Giraudet et al. (2011) and Mundaca and Neij (2009) find that TWC schemes implemented in France and Great Britain maximise net social benefits. Cost-benefit ratios are estimated in the range of three (Great Britain) and two (France) approximately. The volume of certificates traded has been taken as a sign of cost-effectiveness (Mundaca et al. 2008; Pavan 2008). Similarly, competitive bidding processes associated with eligible technologies (e.g. cavity wall insulation in Great Britain) have been taken as another indication of the equalisation of costs among obliged parties. Various studies show that TWC schemes can achieve energy saving at lowest possible costs.

Transaction costs associated with customer persuasion seem to be largely driven by the lack of awareness of households regarding energy efficiency (Mundaca 2007). Financial efforts dedicated to persuade costumers are estimated to be around 10% and 30% of total investment costs for lighting and insulation technologies respectively but these numbers are very case specific. It is also clear that TWC schemes have supported the commercialisation of mature technologies (Giraudet et al. 2011; Mundaca & Neij 2009; Bertoldi et al. 2010; Pavan 2008; Mundaca et al. 2008). Given high cost-effective energy efficiency potentials, 'low-hanging fruits' have however dominated the sources of energy savings. For instance, more than 75% of savings came from wall insulation and compact fluorescent lamps in Great Britain (2002-2005). However new and more innovative technologies could be stimulated, if ambitious energy saving targets and a rigorous and enforceable definition of additionality are considered.

Also, many developing countries have significant programmes to promote the development of renewable energy. Important examples include China and India where planning and incentives imply heavy promotion of several different technologies but also countries such as Brazil that have pioneered biofuels such as gasohol from sugar cane.

15.5.3.8 Carbon Leakage, International competitiveness and Border tax adjustments:

Aichele and Felbermayr (2011) find that sectoral carbon imports for a committed 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.
It is generally hard to find decisive empirical results of environmental taxation on carbon leakage and reduced competitiveness but this is 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 for instance shown by (Elliott et al. 2010) who find that increased carbon emissions in developing countries could undo a fifth of the reductions achieved by industrialized countries imposing a carbon tax of $105 per tonne C. They also show that adding full border tax adjustments would eliminate this leakage

15.5.4 New approaches to emissions trading: Australia, California, South Korea and New Zealand

Since the start of the EU emissions trading scheme (Chapter 14), several countries andsubnational jurisdictions have put in place emissions pricing policies (Perdan and Azapagic 2011) (Citation). These schemes have a range of innovative design features, because of specific circumstances or as a result of the evolution of instruments of mitigation policy, and these may serve to inform the design of market-based mitigation policy in countries that take action in the future. Key aspects are hybrid designs combining price-based and quantity-based emissions control to price volatility; permit schemes that work equivalently to an emissions tax; recycling revenue from emissions pricing to reduce other taxes and achieve distributional objectives; and covering a large share of total emissions by way of upstream coverage of small sources and inclusion of forestry and agriculture.

15.5.4.1 Australia

Australia started a national scheme carbon pricing scheme in 2012, covering around 500 emitters and approximately 60 percent of Australia's greenhouse gas emissions. Electricity generation, industrial processes, 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 greenhouse gases 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), (Keenan 2012).

The Australian scheme started with a government-determined emissions price. During the first three years, the scheme acts like a carbon tax, but uses the legislative and institutional infrastructure of a permit system. The government issues permits at a predetermined price, and liable entities can buy an unlimited amount of permits at this price. Permits cannot be banked, and international emissions units are not eligible. The fixed price scheme offered advantages in the specific political circumstances (Jotzo 2012). A parliamentary majority could not agree on a national emissions target and a scheme cap, but could agree on a price. The effect on emissions levels is uncertain (Pearce 2012), but this was of minor concern in the short term.

In 2015, the scheme is slated to switch to emissions trading, with a fixed amount of permits issued at auction, and banking and international trading allowed. For three more years, the permit price will be kept within a rangedefined by a price floor and a price ceiling. The floor price is meant to provide greater confidence for low-carbon investments, in the context of open access to international emissions markets in which Australia is expected to be a buyer (Jotzo and Hatfield-Dodds 2011). The price ceiling addresses concerns about the risk of overly high emissions prices, though it will make it more difficult to link with other countries' schemes (Jotzo and Betz 2009).

Financial assistance is provided to households at a large scale. About half the initial value of permits was used to reduce effective income tax rates in lower income brackets and to increase welfare payments. This tax switch has been estimated to leave the large majority of low-income earners financially better off, place most of the net cost incidence on higher-income households, and is thought to ameliorate adverse effects on incentives to participate in the workforce (Freebairn 2011).

Financial assistance is also paid to carbon intensive industries. Emissions-intensive trade-exposed industries receive payments linked to the emissions price and to their output of specific products. The aim is to compensate these companies for loss in international competitiveness, while retaining incentives to reduce emissions per unit of output. Payments are also made to the most emissions intensive power stations. It has been found that the case for payments to trade exposed industries is limited in practice (Clarke and Waschik 2012), and that the influence of industry lobby groups was a strong factor in policy design (Garnaut 2008; Pezzey, Mazouz, and Jotzo 2010). The Australian emissions pricing scheme lacks bipartisan support and has been contested politically (Macintosh, Wilkinson, and Dennis 2010).

15.5.4.2 California

California passed regulations in 2011 to start a state-wide cap-and-trade scheme in 2013, in implementation of its climate change legislation that requires emissions to be reduced back to 1990 levels by 2020 (Hanemann 2008). All major industrial sources and powerutilities will be covered from the start, and from 2015 the distributors of fossil fuels will also be in the scheme. Around 360 companies with 600 installations are to be covered by the permit scheme, accounting for approximately 85 percent of California's greenhouse gas emissions. Allowances to industrial emitters and power producers and power producers will initially be given out for free. Offset projects are foreseen in forestry management, urban forestry, dairy methane digesters, and the destruction of ozone-depleting substances.

15.5.4.3 South Korea

South Korea has legislated for an emissions trading scheme to start in 2015, covering around 450 companies that have carbon dioxide emitting operations, accounting for around 60 percent of the countries' greenhouse gas emissions *Pointcarbon. It is expected that most of the permits will be given for free to industry in the first phases of the scheme. The emissions trading policy is seen as part of Korea's 'green growth' industrial strategy (Kim 2011).

15.5.4.4 New Zealand

New Zealand established an emissions trading scheme in 2008. Coverage expanded in stages from the forestry sector to fossil fuels and industrial emissions, 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).

The New Zealand system does not have an overall cap on emissions permits. International emissions units can be used, and the permit price is determined in international markets. Domestic permits are allocated for free to emissions intensive industries (and in the future to agriculture) based on their output (Lennox and van Nieuwkoop 2010), and as fixed amounts for other emitters. New Zealand's system includes a price ceiling; covered sources have the option of paying a fixed fee of NZ$25 per ton of emissions (Aldy and Stavins 2011). New Zealand's government hopes to link its system with Australia's in 2015, when the Australian program is slated to switch to emissions trading (Aldy and Stavins 2011), but the two governments would need to work out how to co-manage what would become a shared price ceiling.

15.5.4.5 Northeast and Mid-Atlantic U.S.

The "Regional Greenhouse Gas Initiative (RGGI) is a cap-and-trade program that covers nine Northeast and Mid-Antlantic states in the U.S. (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont). RGGI came into effect in 2009. The initial cap is stipulated to remain constant until 2014. After that, it is planned to decrease by 2.5 percent each year from 2015 to 2020. Economic growth has been slower than expected and natural gas prices lower than expected, resulting in less coal power use. The cap is no longer binding and is unlikely to become binding through 2020 (Aldy and Stavins 2011.) Firms are still paying the floor price for each ton of CO2 that they emit. As of March 2012, this floor price was $1.93 per allowance (Point Carbon 2012). States have auctioned almost all allowances and used the revenue to fund, among other things, energy efficiency improvement programs.

A problem associated with most carbon pricing systems, but one that is especially significant for RGGI, is that electricity generation and emissions may "leak" outside the cap(Burtraw, Kahn, and Palmer 2005). In particular, demand for electricity in New York may increase production by Pennsylvania power plants, which are outside the cap (Stavins 2012).

15.5.4.6 Ex-post analyses

Before governments began using cap and trade to reduce greenhouse gasesas part of climate change policy, the United States had employed tradable allowance programs to reduce other pollutants. Tradable allowance programs helped draw down the amount of lead in gasoline, reduce air pollutants in the Los Angeles Air Basin, and reduce SO2 emissions across the United States. (see Chan et al. 2012;see also Ellerman et al. 2003for discussion of other pollutants).

A general finding from the experience with these earlier programs is that emissions trading can bring about significant cost savings relative to a system of fixed caps or quotas on emissions. The cost savings stem from trading, which promotes equality of marginal abatement costs across firms and thereby leads to abatement efforts being undertaken where abatement can be accomplished most inexpensively . The cost savings can occur through trading across facilities at a given point in time. In addition, the cost-savings can be expanded through *intertemporal* trading, that is, by provisions allowing firms to bank allowances by over-complying in one year and saving those allowances for use in future years.

One of the main challenges from earlier programs is to prevent serious "hot spots" - especially high concentrations in an area within the overall covered region. Fortunately, this should not be a problem in GHG allowance trading systems because greenhouse gases generally disperse themselves globally.

15.5.4.7 EPA Emissions Trading Programs

In the mid-1970s, the EPA developed a set of Emissions Trading Programs to increase flexibility in complying with air emissions standards for various pollutants under the Clean Air Act. A major problem with these early trading programs was the requirement that credits be pre-certified before firms were allowed to trade them; this requirement increased transactions costs, and these early programs resulted in few trades and little savings.

15.5.4.8 Lead Trading Program

Tradable credits were later used to help refineries limit costs in drawing down the amount of lead in the gasoline they produced. In 1982, new rules allowed firms to use lead in its gasoline above the usual limit if it purchased the credits to do so from a refinery that had used less lead than the usual limit in their gasoline. This new compliance method created a *de facto* tradable allowance system, with the aggregate pre-1982 levels somewhat analogous toacap. From 1982 to 1985, over half of all refineries participated in the market for lead rights in a typical quarter, and up to 1/5 of the rights were traded.Regulators did not have to worry about disparities in the amount of lead in different regions' gasoline – and therefore did not need to limit trading by region – because refineries' gasoline had a wide geographic distribution. Also, regulators did not need to pre-certify credits on a case-by-case basis, as they had in the earlier EPA Emissions Trading programs, thus allowing for a much more vigorous and dynamic market. (Ellerman et al. 2003.)

In 1985, the EPA announced a new goal to reduce lead to less than 10 percent of then-current levels. As part of this goal, the EPA allowed firms to "bank" lead reductions – specifically, if they reduced lead levels during 1985, they could save those "excess rights" for their own use or to sell to other refineries in 1986 and 1987. (Ellerman et al. 2003.)

These rule changes brought even greater trading of credits between refineries. Banking was also widely utilized. The EPA had predicted that refiners would bank seven to nine thousand tons of lead, with associated savings of $226 million (in 1985 dollars), which would have amounted to 20 percent of the estimated cost of the drawdown between 1985 and 1987. In the end, refineries actually banked a total of 10.6 thousand tons, implying even larger savings than the EPA originally estimated. (Ellerman et al. 2003.)

15.5.4.9 RECLAIM (SO2 and NOx in Los Angeles Air Basin)

RECLAIM, beginning operation in January 1994, was developed as an alternative to command-and-control regulations. It set caps for two ambient air pollutants, NOx and SO2, above expected emissions, with the overall caps steadily decreasing until, by 2003, emissions from covered sources would be about 50 percent below early 1990s levels. The caps would remain constant from 2003 forward. Markets for the RECLAIM Trading Credits (RTCs) emerged quickly and represented a high volume of trades (Ellerman et al. 2003). (Harrison and Nichols 1992) and (Johnson and Pekelney 1996) estimate cost savings at about 40 percent compared to the counterfactual command-and-control approach that RECLAIM replaced.

RECLAIM encountered serious problems of price volatility. During the summer of 2000, demand for electricity in California greatly increased, while imports of electricity from out-of-state decreased. In response, utilities turned to old gas-fired power plants to meet the increased in-state demand and reduced out-of-state supply. This decision increased demand for NOx RTCs, thereby dramatically increasing those permits' prices, from an average of $4,284 per ton in 1999 to over $40,000 in 2000 (Ellerman et al. 2003). These high NOx RTC prices contributed to higher wholesale electricity prices in California during that summer, although supplier market power and related market imperfections also played significant roles increased electricity prices(Joskow and Kahn 2002). In response to the high prices for NOx RTCs, and the corresponding high electricity prices, regulators temporarily allowed electricity providers to pay a fee of $15,000 per ton of NOx when they exceeded their caps, with fee revenue recycled to pay for emissions reductions elsewhere.

(Ellerman et al. 2003) note that, while the increase in demand caused emissions to exceed the 2001 cap by 3000 tons, or 20 percent, the use of allowances from the 1999 and 2001 periods reduced the allowance shortfall to only 1,110 tons, or about six percent of the cap. The RECLAIM system did not allow borrowing or banking except from adjacent years. Perhaps if greater inter-year borrowing and banking had been allowed, the NOx RTC squeeze could have been avoided. In fact, a similar program in the Northeast of the U.S. that manages a reduction in NOx in 12 Northeastern states and the District of Columbia allows much greater banking (Ellerman et al. 2003).

15.5.4.10 SO2 (Acid Rain) Trading Program

In 1990, growing concern about the environmental costs of acid rain led the U.S. Congress to pass amendments to the Clean Air Act that mandated a reduction in SO_2 emissions from power plants. Power plants are the main source of SO_2 emissions, and SO_2 emissions are the main cause of acid rain. The amendments laid the groundwork for a tradable allowance system to reduce SO2 across the continental United States emissions by 50 percent. In so doing, they represented "the world's first large-scale pollutant cap-and-trade system" (Chan et al. 2012).

Ex-post analyses have found that the program achieved its environmental goals – and that it did so cost-effectively. The program achieved its original goal of reducing SO2 emissions by 50% (to 8.95 million tons) in 2007. The program's cost-effectiveness can be measured through a variety of methods. One important comparison is between costs (to the government, of administration, and to industry, of abatement) under the Cap and Trade program versus costs that the government and industry would have incurred if they had used a different system – such as mandating the use of specific SO2-reducing technology at specific plants – to achieve similar reductions in SO2 emissions. Since 1990, modellers have identified a range of 15-90% savings compared to various counterfactual policies(Chan et al. 2012 cite Carlson et al. 2000, Ellerman et al. 2003, and Keohane 2003). The program also performed well with respect ex-ante estimations of its costs. Where the government estimated a price tag of $6.1 billion (again representing costs to both government and industry), ex-post analyses showed costs to have been between $1.1 and $1.7 billion.

A touted attraction of cap and trade is its ability to reduce difference in marginal abatement costs across facilities. In Phase I of the SO2 program (1995-1999), about 33 percent of affected units obtained allowances from other units each year – presumably shifting abatement from high-abatement-cost plants to low-abatement-cost plants (Ellerman et al. 2003).

A second potential attraction of tradable allowance systems is that they give firms greater flexibility to innovate *new* cost-reduction methods. Policy that mandates specific emissions abatement methods potentially closes the door on the development of methods that regulators had not imagined (although there may still be development of cheaper ways of meeting the regulators' mandates). Regulatory mandates often give firms very little incentive to exceed the mandate, whereas, in tradable allowance systems, firms receive increased value for increased abatement no matter how much abatement they have already undertaken: increased abatement will allow the firm to sell more allowances, if it has more than it needs, or buy fewer allowances, if it has less than it needs.

Looking at the SO2 Cap and Trade system, there is evidence that innovation enabled emission reductions at much lower cost than would have occurred through technology mandates. In a conventional command-and-control system, regulators likely would have mandated that coal-fired power plants without scrubbers invest in expensive scrubber systems. Instead, innovations in mining, transportation, and power generation allowed for far greater use of low-sulfur coal than had been used before 1990, thus enabling some firms to reduce SO2 emissions without investing in scrubbers. (Chan et al. 2012.) Likewise, in the drawdown of lead in gasoline, evidence suggests that using a tradable permit system instead of the methods in place before 1982 provided incentives for more efficient technology adoption decisions (Kerr and Newell 2003).

In addition, there is evidence that the SO2 cap and trade program "succeeded in inducing innovation in scrubber technology," and "the costs of achieving a fixed level of scrubber performance have declined" (Chan et al. 2012). (Kumar & Managi 2010)analyze the effect on technological change of the SO_2 emissions trading scheme. They showtechnological progress due to emissions trading scheme exists althoughthe effect is smaller than other effects. However, (Fowlie 2010)find the SO_2 emissions trading schemedoes not have enough incentive to adopt more capital-intensive environmental compliance options for private electricity companies.

An additional potential cost of almost all Cap-and-Trade systems, separate from costs of administration and abatement, is uncertainty about and volatility of allowance prices. In the SO2 allowance trading program, prices were smoothed to an extent because firms were able to "over-comply" in one year and "bank" those allowances to use in later years (Ellerman et al. 2003). This motivation to save allowances for years when allowance prices would be higher led to an especially large reduction in SO2 emissions from 1994 to 1995. Emissions had been falling steadily throughout the 1980s, even before the implementation of the SO2 allowance trading program, and they continued to fall at about the same rate during the first half of the 1990s, but the reduction in emissions from 1994 to 1995 far exceeded the usual downward trend. (Ellerman et al. 2003) write, "The only precedent for such a rapid reduction in emissions of this magnitude in the history of the Clean Air Act is the lead phase-down program, which was also implemented by the use of emissions trading and banking." Because power plants banked SO2 allowances, they could use them when allowances were scarce, thereby softening price spikes.

A worry about the program that was related to concerns about the volatility of allowance prices was that there would be too few firms selling allowances at any one time to satisfy utilities' changing needs. In other words, some experts worried that the market would lack liquidity. To address this issue, the EPA auctioned 3% of allowances annually (with the auctions' profits being returned to participating firms). In addition to giving firms who needed allowances a sure-fire way to obtain those allowances, the auction also helped accomplish two other purposes. First, it enabled allowance price discovery (the price of allowances was not a matter of mystery, and, at any one time, all allowances sold for the same price). Second, it made it more difficult for firms to use market power in the allowance market to restrict new firms from entering the electricity market. (Chan et al. 2012.)

A variety of factors led to greater price volatility of allowances in the late 2000s, including natural disasters (primarily hurricanes such as Katrina and Rita), developments in other energy markets, and uncertainty about federal regulations (Chan et al. 2012). Later, when federal regulations that essentially mandated reductions in SO2 emissions *above and beyond* the cap in place, SO2 allowances prices settled near $0. In other words, traditional command-and-control regulation led to SO2 reductions that rendered the acid-rain-motivated Cap and Trade program superfluous.

One reason that the federal government created new regulations was that estimates of the social costs of SO2 had increased. Not only was SO2 linked to acid rain; experts realized that SO2 emissions themselves caused serious respiratory problems. Along the lines of this argument – that the cap was too high, given the new information –Chan et al. (2012) argue that the Cap-and-Trade program could have remained the primary SO2 reduction policy tool if the system had possessed more flexibility to tighten the cap, thus obviating the need for extra regulation that rendered the cap non-binding.

There were concerns before the implementation of the SO2 allowance trading program that some areas' coal plants would not reduce emissions very much (instead buying allowances from coal plants in other areas that did reduce emissions). These concerns turned out to be unfounded, as modelling analysis correctly predicted large emissions reductions in the Midwest, which was the area of most concern; the Midwest was upwind of the Northeastern U.S. and Southeastern Canadian areas that suffered the largest acid rain problems (Chan et al. 2012 cite Ellerman et al. 2000, 77–80 and Swift 2004, 7–8). Nevertheless, later regulations restricted trading to avoid geographic differences in emissions reduction; as discussed above, these restrictions effectively ended the Acid Rain SO2 trading program.

It is important to note that, from the perspective of fighting climate change, there is no compelling reason to restrict trading by region. In most cases, the source of a greenhouse gas has no bearing on its environmental impact. (Chan et al. 2012) write, "GHGs are evenly distributed throughout the global atmosphere, thus emissions from any given source have the same warming effect on the atmosphere as GHGs emitted anywhere else." However, to the extent that the processes leading to greenhouse gas emissions also tend to generate other, local, pollutants, trading has the potential to create hot spots of the local pollutants.

Laboratory Experiment

Using laboratory experiments, economists have studied the most efficient trading mechanisms (e.g., (Cason 2010)). More specially, the effects of imperfect competition ((R. Godby 2000);(Sturm 2008)) and uncertainty(R. W. Godby et al. 1997)have been examined. Sturm (2008) found emissions trading markets to be highly efficient even under imperfect competition. But it is not possible to restrict market power in general. This has to be taken into account in the design of the market institution. Godby et al. (1997) find uncertainty leads to significant price instability when banking is not allowed. Use of banking eliminates the instability, but reduces the efficiency of the market institution.

Recently experimental work has analysed implementation problems under emissions trading. For example, (Goeree et al. 2010)compare the effect of the initial allocation method (grandfathering or auction) for the emissions trade market and downstream products market. They found that the grandfathering rule resulted in dramatic increases in downstream product price.

(Stranlund et al.)test theoretical predictions concerning compliance behaviour in an experimental emissions trading scheme where banking is allowed. They show that the emissions trading scheme can achieve high rate reporting and permit compliance under low violation permit penalty and imperfectly monitored emissions. On the other hand, (Cason & Gangadharan 2006) found that a banking system lead to violations of correct emissions reportingwhen subjects(firm, plant and so on) face emissions uncertainty.

There are also experimental studies testing market performance of several different auction mechanisms. In general, the double auction mechanism is known to perform well under general settings and has been extensively applied in the marketable permits experiments (Cason 2010). However, (Kotani et al. 2011b) find that a uniform price auction is more efficient than a double auction.

15.5.5 Voluntary Agreements

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 with regulated obligations.

15.5.5.1 Government-Sponsored Voluntary Programs for Firms.

The government may provide programs that private companies can join voluntarily to reduce greenhouse gas emissions. US EPA provides a range of success stories on its webpage. For example, Performance Track program is claimed to have resulted in 370,000tCO2e reductions over 2000-2007.

There are also critiques. (Morgenstern, Pizer and Shin 2007), using a comparison group approach, reported that the observed shift in energy consumption from fossil fuel to renewable(?) electricity of companies that joined the US Climate Wise Program, a performance based emission reduction program, lasted only a year or two. (Brouhle, Griffiths and Wolverton, 2009), using a comparison group approach, evaluated the influence of a voluntary program in the U.S. metal-finishing industry and showed participation in the program yielded little, if any, additional reductions in emissions, while the regulatory threat was correlated with significant emission reductions by both participants and non-participants.

15.5.5.2 Voluntary agreements as a complement to mandatory regulations

Voluntary agreements are sometimes used as part of policies as a complement to mandatory emission regulations or tax. Through participation in the Climate Change Programs in the UK, energy intensive industrial sectors established energy efficiency improvement targets and companies that met their agreed upon target were given an 80% discount from the Climate Change Levy. Likewise, the Dutch government ensured industries participating in Long-Term Agreements 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 energyand reduce CO2,and implemented energy management systems(Price, Galistsky and Kramer2008).

(Bressers, Bruijn and Lulofs 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 of measures. They were, however, less positive on the transaction costs, due to the continuous consultation processes with the government.

(Ekins and Etheridge, 2006) analysed UK CCA and discussed that, while the targets in themselves were not stringent and were in the main met 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 which would have derived from the imposition of a flat-rate tax with no rebate and no CCAs, and in economic benefits for the sectors and companies with which CCAs were negotiated.

(Böhringer and Frondel, 2007) argued that they found little evidence that the commitment of the German cement industry was effective – that is, led to the reduction of specific energy consumption significantly below the business as usual level. They concluded the voluntary approach should require more monitoring.

15.5.5.3 Voluntary agreements as a major policy instrument in governmental mitigation plan

The Japanese Voluntary Action Plan (VAP) by Keidanren (Japan Business Federation) has played a central role in the national mitigation plan over years. By 1997 the Japanese government had already implemented an energy conservation law and its industries had achieved the highest energy efficiency performance in the world. In 1997, facing new political pressure to further reduce greenhouse gases, Keidanren established VAP. The action plan has been characterized by strong institutional framework. The plan is led by Keidanren and joined by 114 industrial associations. The plan covers about 80% of greenhouse gas emissions from industrial and energy transformation sectors of the country, and it covers about half of the national emissions. The plan is embedded in the regulatory culture in which government constantly exchange information and discuss a wide range of economic and environmental issues with the industrial associations. Against this backdrop the plan was well monitored and implemented under a constant pressure from the government. Formally the plan was reviewed annually in multiple governmental committees as one of major agenda, and independent third party committee was also established to monitor the implementation of the plan. Industries are required to be accountable with their environmental performance constantly. Typically they reported their activities, status of energy and CO2 reductions, and demonstrated that their performance in terms of energy and carbon intensity was ranking among the best of the world. There is no official sanction within this scheme, but the inaction or noncompliance meant public shame that might undermine their profit, as well as losing the favourable relationship with the government that has many other leverages with regard to the economic activities of the firms(Uchiyama et.al., 2012;Wakabayashi 2012; Tanikawa 2004).

(Wakabayashi 2012) reported, by two case studies, that the voluntary actions were environmentally effective. In cutting Perfluorocompounds (F-gas hereafter in this chapter . Note that this is different from Perfluorocarbons, orPFC. Perfluorocompounds includes PFC, SF_6, NF_6 and CHF_3. Although Perfluorocompounds are also abbreviated as PFC, we use the term F-gas to avoid confusion in this chapter), 19 semiconductor industrial associations launched voluntary action plans in 1998. The government assisted the firms by subsidies for F-gas deconstruction equipment, and by coordinating research and development programs for lower-emission processes. As the result, the F-gas emissions had been reduced by 58% during 1995-2009.

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. Technological solutions at moderate costs were roughly known at that time, but it was also recognized that there were many barriers such as lack of coordination among actors associated with the implementation of the 1W target (Meier, Huber and Rosen, 1998). Either regulations or voluntary actions were necessary to remove the barrier. Both government and industries were not confident if the entire range of appliances could really meet the targets in time. Nevertheless, the industry declared the 1W targets. It was possible for them to commit to the ambitious targets – ambitious in dual sense, in terms of wide coverage of appliances and early timing of goal, just because it was voluntary, not mandatory. In contrast, leading countries of mandatory regulations, Korea and Australia, implemented the regulations not sooner than 2010 and the coverage of appliances was not universal across the board. By 2003, almost all appliances met the target in time in Japan, with minor exception of plasma displays, an emerging technology at the moment. For this new technology the plan was rescheduled and the target was met a year later. Thus industries enjoyed the flexibility in phasing technical measures, which was also a characteristic of voluntary agreement. (Wakabayashi 2012).

For both cases of F-gas and 1W target, the benefit of voluntary action plan was quick establishment of plans and technical actions, which resulted in significant environmental improvement. Information exchange and sharing common expectation among industries contributed to remove barriers for such environmental actions. Governmental involvement to the process including annual review of implementation as well as governmental support for costly options played important role.

(Tanigawa 2004) argued, by interviews to 8 firms and questionnaire to 408 firms, that he identified the incentive mechanisms by which Japanese firms are driven toward pro-active environmental activities. The incentive mechanisms consist of the regulatory threat by the government, business risk management, improvement of productivity, and appeal to customers and investors by being a green firm.

(Uchiyama et. al. 2012) conducted an ex-post analysis for VAP. They concluded, by the decomposition analysis of 34 industrial and energy transformation sectors, the CO2 intensity defined as CO2 emissions per production activity dropped by 17.3% in the period from 1990 to 2010.However, this number includes the impacts of product mix change. (Sugino and Arimura 2011) examined whether voluntary actions by the manufacturing sector led to investment that reduced environmental impact by panel data econometric analysis at firm level. They confirmed that voluntary action plans had significant impacts in increasing investment related to energy efficiency.

15.5.5.4 Conclusion

There is medium evidence that the voluntary agreements have been environmentally effective given a proper institutional framework (Rezessy and Bertoldi, 2011; Wakabayashi 2012), consisting of capable industrial associations that serve as the arena for information exchange and development of common expectation among industries, governmental involvement including review process during implementation, as well as accompanying measures such as subsidies for energy audits and equipment and so forth. The key benefits of voluntary agreements are quick planning and actions when technological solutions are roughly known but still under uncertainties, flexibility in phasing the measures, and soft effects, that is to facilitate coordination and information exchange among key stakeholders toward proactive mitigation activities that are crucial to remove the barriers for energy efficiency and other environmental actions. On the contrary some voluntary agreements have not brought about significant environmental impacts due to their limited scope or lack of proper institutional framework such as governmental monitoring.

15.5.6 Policies to reduce tropical deforestation

15.5.6.1 REDD+ and Payment for Ecosystem Services (PES)

Global efforts to limit forestry emission in developing countries has focussed on REDD+ (reducing emissions from deforestation and forest degradation in developing countries [MAY INCLUDE OFFICIAL COP13 DEFINITION]) since the approach was fully included on the UNFCCC agenda as part of the Bali Action Plan of 2007 (UNFCCC 2007).

A central idea of REDD+ is to create a multi-level (global-national-local) system of Payment for Ecosystem Services (PES), where relevant stakeholders are incentivized and compensated for their efforts to sequester and store carbon in forests (Angelsen 2008). While REDD promises to offer significant, cheap and quick reductions of GHG emissions from forests (Stern 2006), a number of obstacles must be overcome to have a significant impact on the ground. This includes establishing a significant and predictable source of international funding. The delay in the creation of new post-2012 climate agreement that includes REDD+ implies that a potentially substantial source of funding has not emerged.

Several multilateral and bilateral initiatives have been established since 2007, including the Forest Carbon Partnership facility (FCPF) and the UN REDD Programme, both of which aim to assist countries in strengthening capacities, and prepare and implement national REDD+ strategies. Public funding from bilateral development aid budgets dominates the current international funding for REDD+. At the national level, about 50 developing countries are developing and starting to implement their national REDD+ strategies. Many countries seek to establish PES or PES-like systems which reward subnational units and local stakeholders based on performance, but the informational and institutional challenges for establishing an effective PES system remain high in most countries. National REDD+implementation is likely to rely heavily on non-PES policies, including those discussed below.

15.5.6.2 Agricultural technologies and intensification

Improved agricultural technologies and intensification are a two-edged sword for forest protection: higher yield enables farmers to get the same level of production on less agricultural land, but higher yield can raise farm profitability and provide a stimulus for forest conversion. Simplified policy prescription based on the logic of the global food exaction (Population x Food per capita ⍰ Food per unit agricultural land x Agricultural land) can therefore be highly misleading (Angelsen 2010). The net forest impact of improved technologies depends on a number of factors, e.g. localized technologies improvements in forested areas for products sold at national or global markets tend to stimulate deforestation (Angelsen and Kaimowitz 2001). Policies which stimulate agricultural production in non-forest areas are more likely to be forest conserving by keeping agricultural prices low and pulling labour out of forest frontiers.

A few empirical studies exist on the correlation between agricultural yield and cultivated areas, often referred to as the land-sparing argument. If "perfect land-sparing" yield change were occurring, the land-yield elasticity should be -1, but in reality behavioural and market responses can make this much lower. (Ewers et al. 2009), using country-level data for the period 1980-2000, find the elasticity to be -0.152 (t =-1.78) for developing countries and -0.089 (t=-0.57) for developed countries. Similarly, (Rudel et al. 2009) find no yield-area correlation across 10 crops and about 130 countries for the period 1970-2005.

15.5.6.3 Protected areas

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' (PAs being located in remote and inaccessible areas), and 'leakage' (more deforestation outside the PA). 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 PAs in Costa Rica. While a simple comparison suggests that PAs 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 PAs 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, PAs 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 PAs 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.

15.5.6.4 Community forest management (CFM) and tenure

CFM 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 CFM (Pagdee, Kim, and Daugherty 2006) find that 58 % were successful in meeting ecological sustainability criteria, e.g. “improved forest condition”. 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 (Chhatrea and Agrawal 2009). However, an analysis of central Himalaya in India 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, Prabhakar, and Mehta 2009).

Strengthening land rights is often put forward as a way to contain deforestation, but 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, Libecap, and Mueller 2000). But, land reforms which gives higher tenure security increases the value of land clearing and can therefore spur deforestation (Angelsen 1999; Araujoa et al. 2009).

15.5.6.5 Side-effects of development policies

Tropical deforestation is stimulated or constrained as a side-effect of policies which aim to enhance agricultural production and economic development. Economic development, in general, can discourage deforestation as higher off-farm wages and better employment opportunities that pull labour out of agriculture and forested areas (Rudel *et al.* 2005). But particular policies might have the opposite effects. Direct or indirect agricultural subsidies to promote agricultural production have stimulated deforestation, while their reversal has slowed done deforestation rates. The credit cutoffs to frontier landowners in the Brazilian Amazon is one factor behind the slowdown of deforestation since 2004 (Camara 2010) [Author note: another journal ref. to be found] Road building and infrastructure development provide farmers with better market access and higher incomes, but make new forest areas more accessible and more profitable for agricultural production. Particularly at early stages in the forest transition road building can be a strong trigger of massive deforestation (Weinhold and Reis 2008).

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.X, 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. It is therefore important to consider policies that are aimed specifically at the development and diffusion of new GHG reducing technologies, as a complement to the policies discussed in the previous section that target GHG reduction in general.

Most developed economies have policies in place designed at least in part to respond in a general way to technology market failures. These include the patent system and other forms of intellectual property, tax subsidies for firms engaging in Research and Development (“R&D”), and public funding of basic research. But most countries also utilize policies designed to foster the development and implementation of technology in particular sectors that are considered important from a social perspective, including defence, health and agriculture. The 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.

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. Figure 15.1 shows inflation-adjusted public expenditures for "Research, Development and Demonstration" ("RD&D") as reported to the International Energy Agency ("IEA") in its annual surveys.[2] In 2010, total inflation-adjusted public expenditures for "Research, Development and Demonstration" ("RD&D") as reported to the International Energy Agency ("IEA") in its annual surveys were just under $15 billion USD. The peak investment rate was in 1980, when world investment in energy RD&D was almost $20 billion. 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. Since 2000, world RD&D investment has begun to increase again, rising at an average rate of about 4.6% from 2000 to 2010. At this rate of increase, world RD&D relative to world GDP would not reach the 1980 level for many decades. If the growth rate of world energy RD&D could be increased 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).

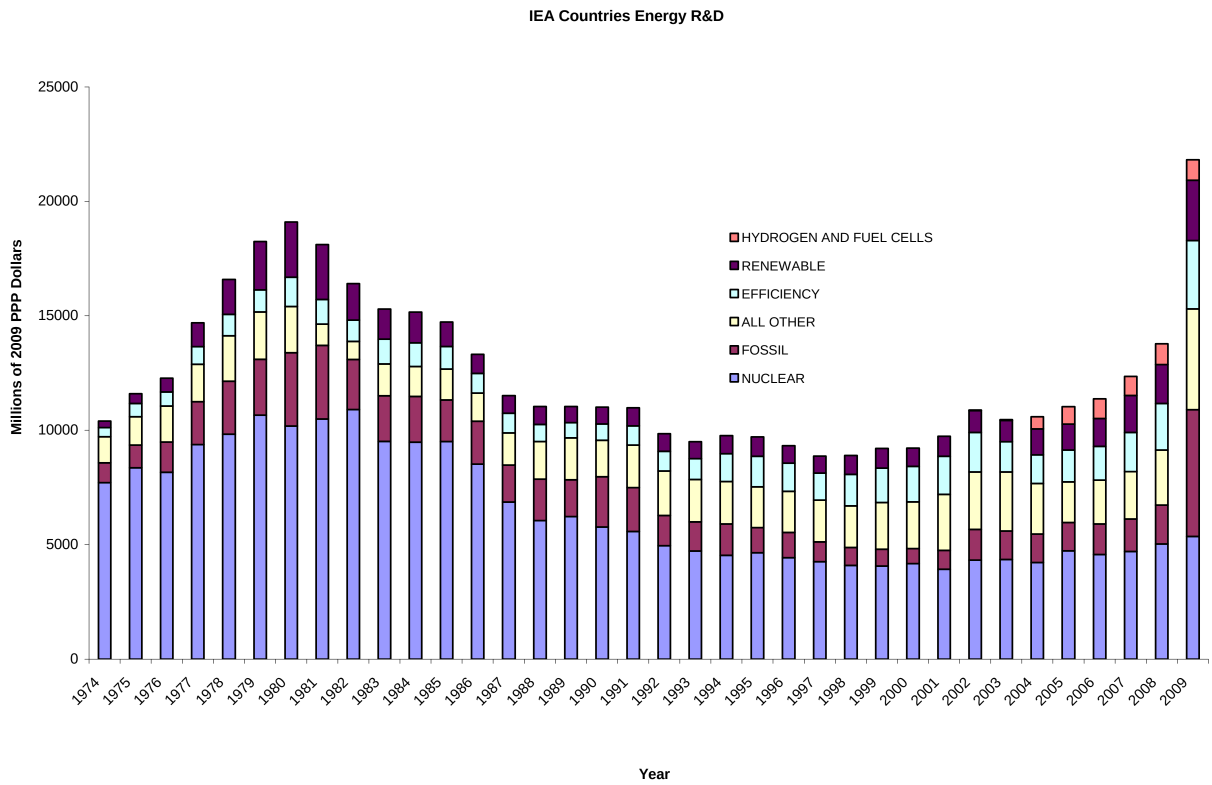

Figure 15.1 Inflation-adjusted public expenditures for Research, Development and Demonstration in IEA countries.

[2] 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."

Public investment in energy R&D is also small relative to public investments in technology in other sectors. In the U.S., for example, in 2009 (an anomalously high year for energy research funding), expenditures for R&D for the Department of Defence were more than six times the funding of R&D at the Department of Energy, and expenditures for R&D at the Department of Health and Human Services (primarily the National Institutes of Health) were more than three times as great as those at DOE (U.S. National Science Foundation 2011).[3]

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 & Zhang 2010).

There is relatively little empirical evidence as to the actual impact of public research investment on technological change. Overall (i.e. not focused on energy or environment), a survey of industrial R&D executives that included questions on the role played by publicly funded research in their own commercial innovation found that “the contribution of public research to industrial R&D is considerable and pervasive” (W. M. Cohen, Nelson, et al. 2002). A key question about public funding of research is the extent to which it “crowds out” private investment; if an increase in public investment causes a comparable decrease in similar private investment, then there will be no benefit. An analysis of the extent of crowding out using data from 17 OECD countries found that non-defence public research spending in public labs and universities did not result in crowding out, and public research support given directly to firms in the form of grants or tax incentives increases firm R&D spending (“crowding in” rather than crowding out) (Guellec & De La Potterie 2003).

With respect to energy technology, the U.S. National Research Council evaluated Federal Energy RD&D investments in energy efficiency and fossil energy for the period 1978-2000. As discussed further below, this assessment noted that evaluation of these programs is hampered by the agency’s failure to utilize a consistent methodology for estimating and evaluating the benefits of its RD&D programs. Nonetheless, 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, page 5). 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 (*ibid*, page 6).

A follow-up study (U.S. National Research Council 2007) developed a methodology for *prospective* evaluation of proposed RD&D programs, so that their potential economic, environmental and national security benefits can be estimated in advance and programs designed and selected to maximize these benefits. It does not appear that this prospective methodology has been utilized, and if it has there does not appear to have been any ex-post evaluation of the accuracy of the estimation methods.

There are both theoretical and empirical reasons why very rapid increase in public support for R&D in a particular sector is unlikely to be successful, and may even be counterproductive. The most important input to the R&D process is the specialized scientific and technical labor force. Such

[3] There is some research funding at other agencies that relates at least potentially to energy or climate change, but there is also health-related research at other agencies. These amounts do not change the qualitative relationships described above. For example, total basic research in all fields of science at the National Science Foundation is less than one-seventh the research funding of Health and Human Services.

specialized labor is inelastically supplied in the short run. That is, there are only so many people qualified to do energy R&D, and the number of such people can be increased only slowly. As a result, rapid increases in spending in a given area are likely to lead primarily to an increase in the wages of scientists and engineers rather than an increase in research activity, as increased efforts by entities seeking to undertake research bid up the wages of the limited supply of people qualified to do that research (Goolsbee 1988). The experience in the U.S. with the effort to double the budget of the National Institutes of Health over a decade also revealed that there are large adjustment costs associated with institutions scaling up rapidly to perform research in a given area (Cockburn et al. 2011). In this case, the rapid scale up was followed by a period of funding constriction (particularly after adjustment for inflation), which imposed large dislocation and wasted resources as institutions had to scale back their efforts shortly after gearing up and increasing them. This experience demonstrates the importance of increasing public support for energy technology at a rate that can be sustained and maintained over time.[4]

15.6.3 Public support for expansion of scientific and technical human capital

In the long run, it is possible to expand the supply of scientific and technical labor available to perform energy-related research. Despite the disruptions associated with the rapid increases in NIH funding in the late 1990s, over a longer period the NIH investment in health research has consciously and successfully expanded the relevant work force in the U.S. This occurred through two important mechanisms (Cockburn et al. 2011). First, the primary mode for NIH support of research is the provision of research grants to faculty at universities. Most of this money is spent on salaries, and a significant portion of it is used to hire graduate students who work, in effect, as apprentices with faculty, receiving extended scientific training in conjunction with their performance of the funded research. Second, NIH also has a parallel program of “training grants,” under which it provides money to universities on a competitive basis to be used for both tuition and student stipends. Over the last several decades, these mechanisms have made possible a dramatic increase in the number of trained health scientists in the U.S. If there are to be analogous efforts to increase greatly the energy research enterprise, analogous attention will have to be paid to developing the base of energy-related scientific and technical human capital.

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

As discussed in Chapter 3.X, in addition to the market failure associated with the public-good nature of research, there are also market failures related to public goods created by the production and diffusion of new technologies. The production of new technologies reduces their future cost through learning curve effects, and the use of new technologies by different parties contributes to their technological evolution through user-induced innovation. For this reason, there is a theoretical argument for public policy to support the purchase and diffusion of new GHG-reducing technologies, in addition to supporting related research.

Historical experience with other technologies also points to the need for public policy to support purchase and diffusion of new technologies. The technological transformation of the world economy necessary to achieve even modest mitigation targets is broad and deep. There are, indeed, not many historical examples in which change this profound has occurred over the span of a few decades. One example that is instructive is the transformation of the communications and computing sectors in the last fifty years or so. Both the end-use equipment and the infrastructure backbone of these systems consist today largely of technologies that did not exist and were in many cases not clearly visualized in 1960. Hence understanding the forces that facilitated the digital

[4] The temporary increase in IEA-reported RD&D in 2009 was driven by an increase in the U.S. that appears to have violated this principle. This increase was primarily driven by spending associated with the American Recovery and Reinvestment Act (“ARRA”, the so called stimulus bill), which included a number of temporary programs in the field rather than research per se.

revolution may be instructive in determining what policies would be needed to bring about profound technological change with respect to GHG emissions.

Publicly funded research certainly played a role in the digital revolution, but active government involvement as a purchaser was also crucial (Mowery 2011). In addition to supporting research in these areas through DARPA and other agencies, the government played a major role as a purchaser of components and systems, particularly in the early phases of technology development. 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). While it is impossible to say what these industries would look like today had there been no government procurement role, there is no doubt that their advance would have been considerably slower.

In the health sector, governments have played a somewhat different but equally important role as purchaser. In much of the world, health care is directly financed by the government, and in the U.S. public policy and private institutions have combined to create a third-party payment system for health care. Under either system, there is a known and reliable market for the purchase of new health care technology, and this assured market has played a key role in inducing private firms to make the complementary investments necessary to transform publicly-funded research results into medical treatments in use (Cockburn et al. 2011)

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.

Policies that increase the utilization of GHG-reducing technologies serve the dual purpose of reducing GHG emissions in the short-run, as well as fostering the long-run development and improvement of new technologies. The assessment of these policies as short-run GHG reduction tools was discussed in Section 15.5. In this subsection we consider additional aspects of these policies that relate to their efficacy in fostering long-run technological development.

FIT's, when set high enough, certainly encourage deployment of renewable technologies as the German case shows. The huge expansion in deployment appears to have fostered large cost reductions through learning-by-doing, economies of scale, and the increased incentive for R &D created by an expanding market, as the figures below suggest.

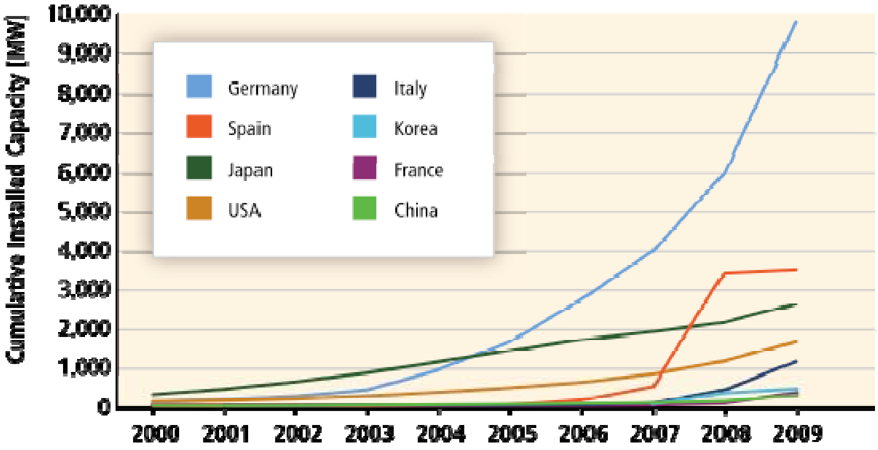

Figure 15.2 Installed PV capacity in eight markets (SRREN, 2011).

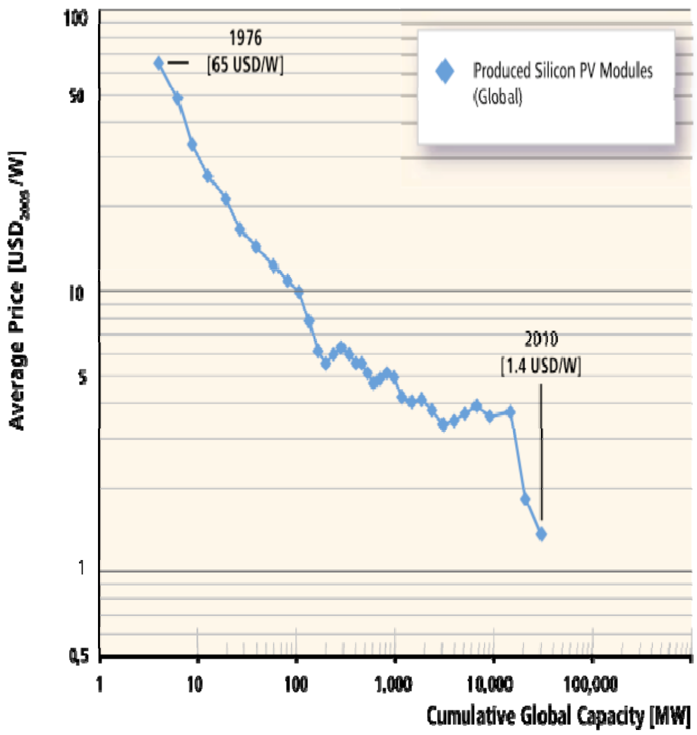

Figure 15.3 Solar price experience or learning curve for silicon PV modules. Data displayed follow the supply and demand functions SRREN (2011)

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 & Neuhoff 2008); (Mitchell et al. 2006), while others show RPS are relatively less expensive than FITs to archiving renewable energy target(see(K. Palmer & Burtraw 2005); (Böhringer & 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 & 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.

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 & 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.

An important example of technology deployment policy is the Brazilian bio-fuel experience (SREN Box 11.10; (de Freitas & Kaneko 2011). A combination of many policies, including initial subsidies, a flex-fuel mandate for auto manufacturers, and zoning and water-use regulation, have made Brazil a large producer and the world's largest exporter of ethanol. The theoretical case for subsidizing an emerging technology to achieve scale and learning curve benefits is supported, as Brazil now produces ethanol without subsidy (although an indirect subsidy in the form of reduced taxes for flex-fuel cars does remain in place). The economic costs of the policies over the years were more than outweighed by the economic benefits.

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 (L. Cohen & Noll 1991).

15.6.5 Intellectual Property

Patents, copyrights, trademarks 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 to exclude is to increase the economic return to knowledge, and thereby encourage investment in the creation and development of new knowledge.

It is important to recognize that the creation of this right to exclude is itself costly from a social perspective. Because the knowledge itself is inherently non-rival, the underlying social cost of additional parties using a bit of knowledge once it has been created is zero. This means that from a social perspective, once the knowledge has been created, it would be efficient to let everyone use it for free. The grant of exclusionary rights through intellectual property operates precisely by allowing knowledge creators to charge a price for the use of their creations, thereby eliminating some uses that would be socially desirable. Thus public policy towards intellectual property inherently involves a tradeoff 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. It is useful to consider fourrelated but distinct pathways in which this trade-off is manifest. First, a given country's IP policy affects the incentives and ability of firms and individuals *within* the country to *create and develop* new technologies. Second, it affects the incentives and ability of firms and individuals within the country to *adapt* technologies developed elsewhere to local contextual needs. Third, a given country's IP policy may affect the incentives of individuals and firms *in other countries* to create and develop new technologies, by affecting the perceived worldwide return to such investment. Finally, it affects the incentives for firms and individuals in other countries to *transfer* technologies they have developed abroad into the country whose IP policy we are considering, through mechanisms such as export, licensing, foreign direct investment or international collaboration. The first two of these mechanisms will be considered here; the third and fourth mechanisms are discussed in Chapter 16, Section 16.xx.

At a theoretical level, even within a given country, even focusing only on the rate of technological advance, the affect of IP policy is ambiguous, because the incentive for new creation and development is offset to some degree by the restriction on inventors' ability to build on previous inventions in developing their own. Despite the near-universal reliance on IP protection in the developed world, the empirical case for strong IP protection to encourage innovation is limited (A. B Jaffe 2000). This is due in part to the fact that IP regimes are endogenous, so that finding empirical tests that provide clear causal implications about IP policy and innovation is difficult(Hall 2007). (Park & Ginarte 1997) use aggregate data for 60 countries 1960-1990 and find that an index of the strength of IP protection is positively associated with R&D investment for countries above the median per capita income, but not for those below. Even for the high-income countries where strong IP appears to encourage R&D in these data, it is not clear to what extent strong IP encourages R&D, and to what extent countries with high R&D have a political environment that demands stronger IP protection. (Qian 2007) provides further perspective on these results. Using a careful matched sampling design with country fixed effects, she finds that national patent protection stimulates pharmaceutical development only at higher development levels, and that above a certain level of protection further strengthening actually seems to reduce innovation.

Taken as a whole, there is some evidence that stronger IP protection fosters innovation in developed countries, although the endogeneity of IP regimes makes it hard to know for sure.[5] There is virtually no evidence that stronger IP protection fosters indigenous innovation in developing countries (Branstetter 2004).[6]

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 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

[5]Evidence from surveys of firms suggests that any positive effect of IP protection on innovation is likely limited to particular sectors such as chemicals, pharmaceuticals and other materials-based industries (W. M. Cohen, Goto, et al. 2002) .

[6](Kanwar & Evenson 2003) find a relationship between strong IP protection and R&D intensity without distinguishing the effect for different levels of development. This paper does not deal with the issue of the endogeneity of IP regimes. In subsequent work (Kanwar & Evenson 2009) they use instrumental variable methods to deal with endogeneity and do not find a robust correlation between R&D intensity and IP strength.

adaptation of GHG-reducing technologies.[7] Whether or not strong IP protection in developing countries is likely to foster development of GHG-reducing technologies elsewhere, and/or the transfer of technologies developed elsewhere to developing countries, is discussed in Chapter 13.

15.6.6 The effect of environmental policy instruments on technology

There is some empirical literature assessing the impact of environmental policy instruments on technological change. For surveys, see (Newell 2010) and (David Popp, Newell, et al. 2010). Early work looked at the impact of policy instruments indirectly, by examining the correlation between pollution control expenditures (as a proxy for stringency of environmental regulation) and indicators of technological change. (A. Jaffe & Karen 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 & Mody 1996) did find that across the U.S. Germany and Japan, patenting rates were correlated at the industry level with pollution control expenditures.

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. (D. 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. 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.

The effect of different policy instruments on technology has been explored by examining the experience with the regulation of sulphur dioxide emissions in the U.S. Prior to the 1990 Clean Air Act Amendments ("1990 CAAA"), new coal-fired electricity generating plants were required to install flue-gas desulphurization or scrubbers that removed 90% of the sulphur from the exhaust stream. The 1990 CAAA replaces this new-plant technology standard with a system of tradable permits for sulphur dioxide emissions. This change created incentives for removal at greater than 90%, and for emission reduction at older plants not subject to the new-source standards. (D. Popp 2003) found that the rate of patenting on techniques for sulphur removal increased after the passage of the 1990 CAAA. (Lange & Bellas 2005) found that both capital and operating expenditures for scrubbers installed after the 1990 CAAA were lower than before that time, which they interpret as the result of technological change induced by the flexible incentives created by the new permit system. (Taylor et al. 2003) found similar results looking at both patenting and the contents of papers delivered at technical conferences.

There is other evidence that more flexible environmental regulations are more effective at inducing technological change than rules that specify a particular technology to achieve regulatory goals (e.g. the U.S. scrubber rule). (Kerr & Newell 2003) found that the tradeable permit system used for the gasoline lead phasedown in the U.S. encouraged efficient technology adoption decisions by U.S. refiners. (Lanoie & CIRANO 2007) studied seven OECD countries and found that spending on environmental R&D was higher where flexible performance standards (which specify a target level of performance, but do not specify the technology to be used in achieving that target) were used than where technology standards were used. (Johnstone & Haščič 2009), also looking at OECD countries, found that the "quality" of environmental innovations was higher where the more flexible regulations were used, with quality measured by the number of different countries in which a given

[7] 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)

environmental invention was patented. (Johnstone, Haščič & Kalamova 2010) find that stringency, predictability and flexibility of environmental regulations are all associated with a higher level of patenting related to environmental technologies across OECD countries over time.

More recently, a few studies have explored the effect of renewable energy policies on energy innovation. (Johnstone, Haščič & D. Popp 2010) found that policy had a significant impact on patent applications for renewable technologies, with different policy instruments being effective for different technologies. (D. 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.

15.6.7 Building program evaluation into government technology programs

As noted above, 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 (A.B. 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.

15.6.8 Conclusion

Based on theoretical and empirical research, we can draw the following conclusions about public policy to facilitate the development of GHG-reducing technologies:

1. The rate of return to R&D is high. There is no way to know the "optimal" level of R&D related to GHG specifically, but the current level seems low in proportion to the public importance of the issue. Discontinuous or unpredictable increases are likely to be counterproductive, but sustained increase would be appropriate.
2. It is crucial that research funding be structured in such a way as to increase the supply of specific human capital in parallel with the increase in research support. Training grants as an important component of the overall support would be one way to achieve this goal.
3. 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.
4. There is the potential for intellectual property enforcement to impede the diffusion of new GHG technologies, thereby inhibiting both GHG reduction and further improvement of the technologies.
5. Data collection for program evaluation should be built into technology policy programs.

15.7 Synergies and tradeoffs among policies

15.7.1 Mainstreaming mitigation into multi objective policies

Development interacts with climate change in a circular fashion. Social and economic development is a very driver to climate change, while climate change and its impact also can have a very negative influence on social and economic development. Climate change is also competing with development in terms of shifting financial resource away from promoting development. The complex relationship between development and climate change needs an integrated approach to integrate or mainstream climate change within framework of sustainable development. Such integration approach is even more important for developing countries. The sustainable development agenda of developing countries could be very wide policy 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 wider context for both mitigation and adaptation with respect to promoting integrated mitigation policies and measures (Wilbanks and Sathaye, 2007). Mainstreaming climate change in other policy areas can enhance the effectiveness of mitigation policies. Policy areas can be aligned with mitigation policies may include energy security, local air pollution, job and employment, traffic congestion and safety, trade and finance (Kok & de Coninck 2007).

15.7.2 Inter-linkage of non climate policy goals with mitigation, Measures to widen policy goals

Security of energy supply is an important concern for those countries depending on energy import. 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.

In the past, the policies on air quality and on GHG mitigation has been detached, however, the two are intimately related, especially in transportation sector (Ribeiro & de Abreu 2008). 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).

It should be noticed also that mitigation is not always synergetic with other policy goals. Sometimes, there is a clear trade-off can be identified. For example, Carbon capture and storage main 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. Green production and green 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.

The following table gives a summary on how synergies between mitigation and other policy goals can be achieved through measures to mainstreaming mitigation.

Table 15.2 Interlinkages and measures to mainstreaming mitigation policies and measures

Issues	Inter linkages	Measures to mainstreaming mitigation
Energy Security	Improvement of energy efficiency; Promotion of renewable energy and other clean energy;	Energy conservation in supply and demand Promotion of renewable energy Fuel switch to clean energy

Air quality	Improvement of energy efficiency; Fuel switching	Energy conservation in supply and demand Fuel switching
Trade and Investment	Green production Green consumption Green investment initiative	Energy subsidy reform

15.7.3 Options for mainstreaming

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. Such institution

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 (Ellis et al, 2009).

Mainstreaming can make an important contribution to mitigation through aligning with other policy goals, but without serious political will and follow-up implementation of these policies and measures, goal of mitigation can't be realized.

15.7.4 Interaction of technology policy and GHG reduction policies

The technology policies described in the previous section interact with other climate policies. New technologies will ultimately be developed and used widely only if there is a market demand for products or processes embodying them. With respect to technologies with zero or low GHG emissions, the market demand will be vitally dependent on the extent to which GHG policy imposes costs or restrictions on the emission of GHG. Using technology policy to "push" the development of low-GHG technologies without the "pull" of GHG reduction policies to make them economically attractive is unlikely to be successful. Further, because technology development is an investment process with long lead times, encouraging GHG-reducing technology development requires effective long-term policy commitment, so that parties investing today will believe that there will be a market demand for their low-GHG technologies many years in the future (Newell 2010).

Conversely, using only the "pull" of GHG reduction policies, without technology policy to "push" technology development, will likely lead to technology development that is slower than if both kinds of policies are used (Newell 2010). As discussed in the previous section, there are important market failures in the markets for technologies themselves that are distinct from the market failure connected to climate change itself. Further, other sectors in which we have observed the kind of major technological advances now desired with respect to GHG have all enjoyed the "push" of sector-specific technology policies, including communications (Greenstein 2011), semiconductors and computers (Mowery 2011) and pharmaceuticals/biotechnology (Cockburn, et al 2011).

15.7.5 Interactions of different polices at different national levels

When several different policy instruments are introduced by the same jurisdiction, the impact of this multiplicity of policies can be beneficial or problematic in terms of cost-effectiveness of reducing greenhouse gas emissions.

15.7.5.1 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 1952).

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 (see 15.6). Introducing two policy instruments to address the two market failures can be beneficial by lowering the costs of achieving 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. For this reason, using two instruments helps achieve emissions reductions at the lowest cost. In this connection, Fischer and Newell (2005) and V. Oikonomou, Flamos, and Grafakos (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. These studies claim that reliance on oil produces an "economic vulnerability externality," given the possibility of supply disruptions on the world oil market (Jones, Leiby, and Paik 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 the issues of 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 (Green 1998; Goulder and Parry 2008; Gillingham, Newell, and Palmer 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.

15.7.5.2 Problematic interactions

Policies at the same jurisdictional level also can yield problematic interactions. This can happen when multiple policies only address one 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). Burtraw and Shobe (2009) point out that, 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. The reason is that overall emissions are determined by the overall cap or number of allowances in circulation. To the extent that the performance standard yields reductions in emissions, the demand for emissions allowances falls. This causes the price of allowances to fall until all the allowances in circulation are again demanded.

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.

Two emissions pricing policies -- a cap-and-trade program and a carbon tax – also can interact in ways that are problematic. Fischer and Preonas (2010) argue that a carbon tax will have no emissions reduction effect on a system where a cap-and-trade program is already in place if the tax is set at a level that is less than or equal to the prevailing allowance price, as long as it is applied with the same scope as the emissions cap, since the allowance price will absorb it (the allowance price will fall to zero). On other hand, if the tax is higher than the prevailing allowance price, then the cap will be redundant. If the cap-and-trade system has a price floor, than the combined policies effectively lead to a carbon tax equal to the official carbon tax plus the minimum allowance price.

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 instrument is employed to address a second market failure such as the innovation market failure.

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 Theoretical Consideration: Roles and Motivations of Sub-nationals

Climate change mitigation issues entail global collective action problems. Conventional collective action theory predicts that no one will voluntarily change behaviour to reduce energy use and GHG emissions without externally imposed regulations at the global scale (Brennan, 2009).However, Ostrom (2010) claims that many mitigation activities can be undertaken by multiple units at diverse scales, and a polycentric approach can be an improvement to the analysis exclusively reliant on global solutions. In this regard, extensive empirical research (Poteete et al., 2010) shows that if certain conditions are met, free riders are deterred and costly and positive actions are frequently taken without an external authority imposing regulations. The crucial factor here is that a combination of structural features leads many of those affected to trust one another and to be willing to take an agreed-upon action that adds to their own short-term costs because they do see a long-term benefit for themselves and others and they believe that most others are complying (Ostrom 2010, p. 551). Discussions with neighbours in a community about actions that can be taken locally to reduce GHG emissions generate more concrete information about the unrecognized costs of individual, family, and business activities. Likewise, discussions held among mayors and other political leaders at the local level can enhance their knowledge of policies they can adopt and how linking with others increases the benefits and impacts of their actions more clearly (Ostrom 2010).

Regarding trust and reciprocity, normative theories that use such concepts as social capital, democratic deliberation, and citizen participation should also be noted. “Green political theorists” (Weiss, 2005; Bernstein, 2005) suggest that including citizens and local NGOs in the policy process can make the policy-making process more deliberative and participatory. This can enhance reciprocity and trust among private and public actors, enabling community-based civil societies’ efforts to implement measures more effectively and legitimately. As a result of well-informed, sound communication that can be achieved in less hierarchical and collaborative forms of governance, it is even expected that some actors adopt a sense of ethical responsibility for their own carbon footprint and are led to change their lifestyle from a current model of mass production/consumption that relies on exhaustible fossil fuels to a new model that is based on autonomous and self-sustainable communities.

In fact, multiple benefits are created by diverse actions at multiple scales and many municipalities and local businesses do often highlight the co-benefits of local climate mitigation action (e.g., energy saving and renewable expansion measures), such as cost savings and the creation of green jobs in their communities (Aoki 2010, Betsill and Rabe 2009).A growing number of prefectural/local officials and local NGOs now cite the vulnerability of their communities and moral imperatives to protect future generations, especially in the absence of serious action at the national level (Aoki 2010, Warden 2007). Policy diffusion via mutual learning can accelerate this course of action among sub-national jurisdictions.

Furthermore, effective implementation of mitigation policies requires innovation in low-carbon technologies. As to this aspect, there have been arguments that emphasize “transition management;” made by scholars who shed light on the dynamic interrelation between technological innovation and socio-economic change (Geel 2004; Kemp and Loorbach 2003;Rotmanset al. 2001). Recognizing that existing markets are often absent for emerging technologies, they argue that small-scale social experiments should be set up to probe various niche markets along with suggested transition paths, for examples, mobility, supply chains and energy supply. With multiple niches being maintained at the local level, “transition management” can avoid technological lock-in and minimize risks when the experiments turn out to fail. Once niche experiments succeed, on the other hand, the fruits of technological innovation can go on to affect existing markets, on-going business customs and practices, policy and administrative institutions, and governance forms which co-evolve and change, resulting in a more systemic transformation of our society into a low-carbonized one.

15.8.2 Proliferation of State and Local (Sub-national) Activities: Current Status

In high-income democracies (that have high per-capita emissions), the volume and variety of sub-national climate initiatives is large and growing (Betsill and Rabe 2009, p.205; Kahn 2010, p. 197). Some state and local initiatives have aimed to go well beyond nationwide policies and measures (Aoki, 2010).

15.8.2.1 Local and municipal level

Cities have become a critical site for the mobilisation of climate mitigation policy(Harriet Bulkeley 2010). There has been widespread adoption of GHG emissions reductions targets, many of which go beyond those agreed internationally and nationally, embedded within a policy approach which emphasises the need to measure GHG emissions, implement climate action plans, and monitor progress(Alber & K. Kern 2009). A wide variety of measures to realise these goals have been implemented across urban planning, built environment, transportation and infrastructure sectors, but have primarily focused on energy efficiency. There has historically been less focus on issues of energy supply, on other major infrastructure systems (transport, waste, water) or on the need to limit energy and resource consumption(Harriet Bulkeley & Kristine Kern 2006; Rutland & Aylett 2008; Schreurs 2008; Wheeler 2008).

Municipal authorities have led urban climate change policy responses within a context of multilevel governance(Harriet Bulkeley & Michele M. Betsill 2005; Gustavsson et al. 2009). Often in the absence of formal authority or specific competencies, municipalities have used their self-governing and enabling modes of governance to develop and implement climate policy(Harriet Bulkeley & Kristine Kern 2006). This has been promoted by the self-organisation of municipalities in transnational and national networks(Granberg & Ingemar Elander 2007; Holgate 2007; Romero Lankao 2007). These approaches, coupled with the nature of available funding and growing interest in the opportunities of addressing climate change in private and third sector organisations, have led to a new wave of strategic interest in governing climate change in the city and an important role for partnerships and project-based or 'experimental' forms of urban response (Hodson & Marvin 2010; While et al. 2010; Harriet Bulkeley & Heike Schroeder 2011; H. Bulkeley & Castán Broto 2012). In short, 'horizontal' forms of multi-level governance through networks and partnerships have been critical in producing urban climate change policy. 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(Michele M. Betsill & Harriet Bulkeley 2006; M. M. Betsill & B. G. Rabe 2009).

There is strong evidence that addressing climate change has become part of the policy landscape in many cities and that municipal authorities have been able to reduce their own GHG emissions Wheeler (Wheeler 2008; Pitt 2010; R. M. Krause 2011; Rachel M. Krause 2011). There is more limited evidence that urban climate change policy has achieved wider mitigation goals in terms of: reducing GHG emissions at the urban scale; creating new logics and practices for urban development that realise climate change objectives alongside other urban goals; achieving widespread 'transitions' to low carbon urban development(H. Bulkeley et al. 2009; Harriet Bulkeley 2010; Hodson & Marvin 2010; P. North 2010; Scott-Cato & Hillier 2010; Rosenzweig et al. 2011; H. Bulkeley & Castán Broto 2012). Lessons from urban case-studies show that a wide variety of approaches and measures (e.g. incentives, regulations, voluntary standards, behavioural change schemes) can achieve policy goals, but that a significant challenge remains in 'scaling up' and 'mainstreaming' these approaches.

Where success has been forthcoming, critical factors include: the competencies and mandate of municipalities; financial resources; individual champions; political opportunities; and the realisation of co-benefits(M. Betsill & Harriet Bulkeley 2007; H. Bulkeley et al. 2009). Likewise, three sets of factors can explain the challenges that have been encountered in realising policy ambitions: institutional; political economic; and infrastructural(H. Bulkeley Forthcoming, p.1; Harriet Bulkeley

2010). Importantly, this suggests that realising local policy goals is not only a matter of improving the quality of information used in decision-making or enhancing municipal capacity, but of recognising and addressing the ways in which the processes of urban development and infrastructural provision challenge the ambitions of realising climate change mitigation in the urban context.

As the urban climate agenda gathers pace, an important challenge remains in terms of addressing the different capacities and responsibilities of urban communities to mitigate climate change. There has been limited engagement with what 'common but differentiated' responsibilities for addressing climate change means at the urban scale, and with the implications for how urban goals for climate change should be differentiated between and within cities. There is an important role for the international community and national governments in showing leadership with cities in establishing appropriate goals and mandates for action across highly uneven urban landscapes.

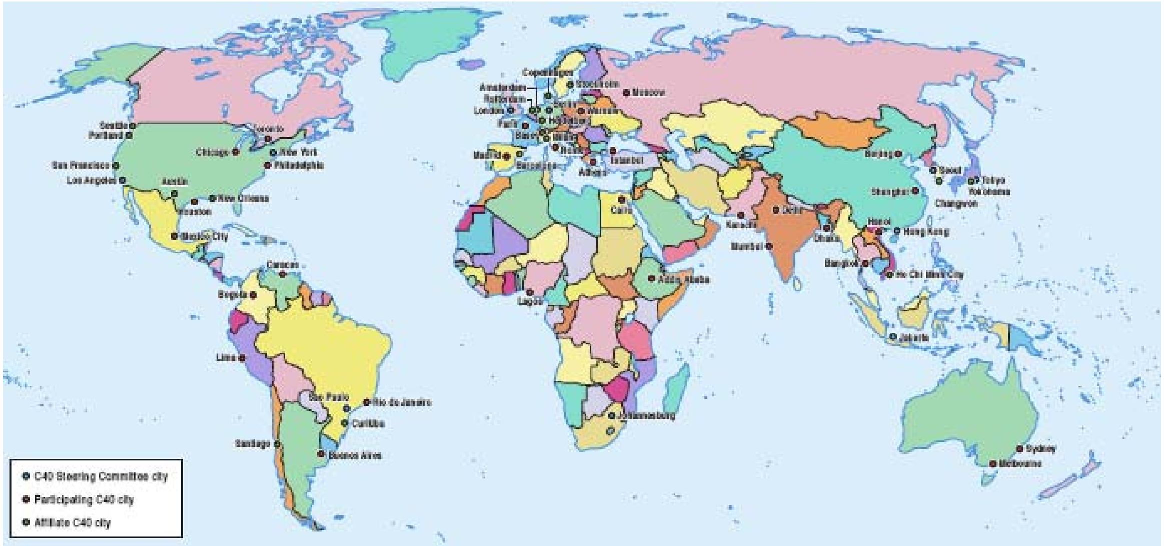

Figure 15.4 C40 Cities

15.8.2.2 State and prefectural level

California, the world's largest sub-national economy was one of the first U.S. states to pass major legislation—the ''Global Warming Solutions Act'' in 2006. The act requires drastic reductions from major industries including oil and gas refineries and utility plants (Global Warming Solutions Act of 2006, California Assembly Bill 32.) and calls for steady reductions over each of the next several decades, culminating in a level of state-wide emissions that are 50 percent below 1990 levels by 2050 (Betsill and Rabe 2009, p. 207).

Renewable energy has been a popular area of engagement at the U.S. state level. Twenty-eight states have enacted Renewable Portfolio Standards that mandate a formal increase in the amount of electricity distributed in a state that must be generated from renewable sources (Rabe and Mundo 2007). Also, fourteen states have formally agreed to follow California in seeking a federal government waiver to establish the world's first CO2 emissions standard for vehicles (Betsill and Rabe 2009, p. 205).

Efforts are also being made among some of the eastern U.S. states to develop carbon markets (Rabe, 2007). The Regional Greenhouse Gas Initiative (RGGI), joined by 10 states in the Northeast and Mid-Atlantic, plans to reduce CO2 emissions from the power sector by 10% by 2018 (http://www.Rggi.org (accessed July 4, 2010).). (See Section 15.5.4.5.)

In July 2007,Tokyo Metropolitan Government (TMG) introduced C&T to take effect in fiscal 2010, first one to be implemented in Japan and Asia. TMG aims to reduce total emissions among the capped sectors by 6% from the base-year emissions in the first compliance period (fiscal 2010 to fiscal 2014). In addition, the prospective cap in the second compliance period (fiscal 2015 to fiscal

2019) has been announced to be even stricter, aiming for a 17% reduction from the base-year emissions. The Tokyo C&T program differs from that of its EU-ETS and RGGI counterparts, since it also includes within its scope the large-scale office buildings that are concentrated in large cities.

TMG tries to diffuse its C&T program via inter-networking with 9 local governments within the Tokyo metropolitan area. California also built multistate network, attempting to emulate the RGGI experience through its sponsorship of the Western Climate Initiatives. This has resulted in signed cooperative agreements designed to produce a common C&T zone with Arizona, New Mexico, Oregon, and Washington.

15.8.3 Ex-post Analyses (Case Studies)

The literature does not yet provide definitive quantitative findings on the impact of subnational initiatives on emissions. But there are some qualitative studies that are worth mentioning.

15.8.3.1 Can initiatives be implemented in expectedly effective ways?

Backstrand*et al.* (2010) find that local mitigation policies do show some sign of effective implementation partly affected by networking functions. They conclude however that it is less clear to what extent measures have successfully contributed to a lasting reduction of the climate impact of the involved municipalities. While some emissions have been reduced due to specific measures, overall emissions often tend to increase due to political decisions that go against climate mitigation. In particular, Khan (2010) examined how municipalities (e.g., Vaxjo in Sweden, Kristiansand in Norway) have governed via enabling private actors to take on voluntary mitigation measures. By introducing rather informal, non-legalized policy instruments such as information campaigns, economic incentives and partnerships, political authorities are co-opted with corporations to implement long-term goal of carbon neutrality. Khan analyses that while participation in policy formation involves a wide array of stakeholders, implementation is manly made up of local officials, municipal companies and private enterprises. Business plays a key role while NGOs are less visible, as business actors are responsible for a large part of the local emissions. A deliberate strategy by municipalities is to focus on policy measures that give co-benefits to the local economy. In the CCP campaign, the opportunities for local economic gains were an important argument to motivate cities to engage in mitigation efforts (Lindseth, 2004; Bulkeley and Betsill, 2003). Thus municipal mitigation policies where stakeholders do take collaborative forms of governance tend to focus on technical solutions and on area where business opportunities exist. Measures with no clear win-win that do not offer benefits to the interest of powerful actors are much more difficult to carry through (Khan 2010, pp. 206-207). In the context of Japanese prefectural cases, Aoki (2010) also supports the above-mentioned findings.

15.8.3.2 Unintended consequences of networking functions

Furthermore, in the U.S. while the city-to-city networks do accelerate information sharing and policy learning among the sub-nationals, whether it facilitates a synergetic effect with policy innovation in one state or locality influencing other state or local jurisdictions remains uncertain (Bulkeley and Betsill 2009).

In Japan, a policy diffusion through which many active prefectural governments mimic conventional measures by the local governments that go along with the nationwide policy trend has been common (Aoki 2010). In fact, the measures that are perceived to have negative economic consequences to the local economy, such as TMG's C&T program, have not yet been introduced by other governments in Japan. Some of the factors that cause this consequence in Japan are as follows (Aoki 2010).

First and foremost, a mindset of the prefectural officials is against having such a measure. They tend to fear that implementation of such measures might make local private businesses vote with their feet, fleeing out of the local jurisdictions and this is something most disliked by the local legislatures. In addition, such intrusive measures as C&T and time regulation on 24-hour businesses have possibilities to undermine the principle of fairness and equity because they could impose disproportionate burdens on some industries when compared to the non-obliged others. These factors make public officials reluctant to promulgate these regulations. When prefectural governments are placed under these circumstances, mimicking the less intrusive measures that are already undertaken by the others and the national government enables, whether or not intentional, the public officials to appear as if they were fulfilling their accountability—networks formed between prefectural governments accelerate this process.

15.8.4 Interactions of policies between different levels of government

Climate policy has been conducted at various jurisdictional levels: international, national, regional (state or provincial), and local (municipal) (see the next section). Important interactions can occur across jurisdictional levels, both when the instruments employed at each level are the same and when they are different. Here again the interactions can be beneficial or problematic.

15.8.4.1 Beneficial interactions

As discussed in 15.7.3 above, cost-effectiveness can be enhanced when the two policies address two different market failures. A subnational policy can help enhance cost-effectiveness if it addresses market failures that are not confronted at the higher jurisdictional level. 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.

In addition, a smaller or more local jurisdiction might have better information about local conditions than the larger jurisdiction that encompasses it. One example concerns local electricity regulation. In the United States, for example, about half of electricity customers are served under cost-of-service regulation, while the other half of customers reside in regions with competitive electricity markets. In cost-of-service regulation, the value of emissions allowances would be included in the calculation of total cost and passed on to consumers indirectly, as part of the average cost of production. In competitive regions, the emissions price is transmitted through to the consumer price only when the polluting technology is the marginal technology. (Shobe and Burtraw 2012.) The transmission of the price signal is generally far stronger when prices reflect marginal costs, and the weaker signal in the cost-of-service region means that consumers may not respond as intensely to the emissions price. For this reason, the efficiency of the national emissions price policy would be improved if a complementary policy managed the weaker emissions price signal in cost-of-service regions. As local authorities have better information about the local regulatory environment in which they operate, they are well suited to playing a key role in drawing up this complementary regulation. (This issue can also be seen as two market failures requiring two policies, where the first market failure relates to GHG emissions and the second relates to market power of utilities in electricity markets.)

Another area where local governments must play a role in implementing complementary policy is in urban planning. Local governments influence whether buildings have cool roofs, affect whether landscaping is designed to buffer against seasonal winds, allow or disallow outdoor clotheslines to dry clothes without electricity, regulate whether asphalt surfaces are minimized to lessen heat gain, and design transportation systems that influence where people live in relation to their work. Shobe and Burtraw (2012) note: “The sum of these activities will determine the infrastructure of communities for the next century, and the influence on the global climate, in the aggregate, is profound.” However, despite this important effect of local authorities’ decisions, it is unclear how responsive these authorities will be to the price signal associated with emissions pricing policy. For this reason, there is wide scope for policies that encourage complementary interactions between local planning and national emissions pricing.

Local-level action can also be a good source of information by allowing experimentation. In the United States, for example, environmental policies by the federal government have a history of evolving out of successful policy "experiments" undertaken by states (Burtraw and Shobe, 2012; Goulder and Stavins, 2011). 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 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.

15.8.4.2 Problematic interactions: Inconsistent Policies and Leakage

While some forms of collaboration and interdependencies across multiple levels of government are observed, there have not so far been any formal institutional mechanisms that are sought to resolve possible inconsistent policies related to climate change. Betsill and Rabe (2009) note however that in the U.S., there may be possible forms of vertical interaction between state and local jurisdictions, suggesting a range of possibilities for synergetic coordination and engagement in the future (p. 218).

Closely related to the problem of inconsistent policies is the problem of leakage. In this regard, Goulder and Stavins(2011) point out that state and federal climate regulations can overlap in ways not to achieve emissions reduction beyond those implied by federal policy because of the leakage problem. In the context of federal automobile fuel-efficiency standards (Corporate Average Fuel Economy (CAFE) standards) and state limits on greenhouse gas emissions per mile of light-duty automobiles (so-called Pavley standards, to be adopted in 14 states), empirical estimates indicate that about 70 percent of the emissions reductions achieved in the new car market in the Pavley states would be offset by increased emissions in new car markets elsewhere (Goulder, Mark R.Jacobsen, and Arthur van Benthem 2009). That occurs because the state-level initiative effectively loosens the national standard and gives automakers scope to profitably increase sales of high-emissions automobiles in non-adopting states.In addition, although the state-level effort may well spur the invention of fuel and emissions-saving technologies, interactions with the federal CAFE standard limit the nationwide emissions reductions from such advances.In May 2009, the Obama administrationreached an agreement with the 14"Pavley states," according to which the United States would tighten the federal fuel economy requirements in such a way as to achieve effective reductions in GHGs per mile consistent with the Pavley initiative. In return, the 14 states agreed to abandon this first phase of the Pavley effort, which was no longer necessary, given the tightening of the federal standards. The Pavley states intend to introduce further tightening of the greenhouse-gas-per-mile standards after 2016. This would imply fuel economy standards more stringent than those applying at the federal level. Hence the leakage issue remains very much alive (Goulder and Stavins 2011, p. 255-256).These studies suggest that the coexistence of national and sub-national policies raises questions about their interactions. Problems can arise when national and sub-national policies overlap.

Interactions at different jurisdictional levels can be problematic when the instruments employed at the two levels are the same. In this case one may describe the policy at the sub-national level as "nested" within the national policy. For example, when a subnational cap-and-trade program is nested within a national cap-and-trade program, it generally adds costs and is environmentally ineffective. (If it is non-binding, it is ineffective but does not threaten cost-effectiveness.) Consider the case where a subnational authority implements an emissions cap that is more stringent than the national cap. The extra stringency of the subnational cap lowers nationwide emissions below the level that would otherwise apply by the national cap alone. As a result, the national cap no longer binds: nationwide emissions are below the level implied by the national cap. This causes the price of allowances for the national cap-and-trade system to fall, which leads to increase in emissions in areas outside of the subnational jurisdiction that introduced the more stringent cap. This continues until emissions at the national level again reach the level of the national cap. The more stringent subnational policy has had no effect on nationwide emissions (Goulder and Stavins 2011, Burtraw and Shobe 2012).

On the other hand, if the subnational authority implements an emissions cap that is less stringent than the national cap, the cap at the subnational level will be non-binding. If there is no price floor for the subnational cap-and-trade system, the prices of the subnational allowances will fall to zero, rendering the program environmentally irrelevant.

Similar phenomena arise when a different instrument at the subnational level is nested within a national cap-and-trade program. Again, the reductions in emissions caused by the subnational program leads to a reduction in the price of allowances for the national program, which causes emissions outside the subnational jurisdiction to increase until the national cap once again binds. Thus, for example, a stringent subnational carbon tax will fail to reduce nationwide emissions. On this point, Bohringer et al. (2008) (cited in Fischer and Preonas 2010) find that in the context of the EU ETS, unilateral national emissions taxes in capped sectors are "environmentally ineffective and increase overall compliance cost of the EU ETS."

Finally, when subnational policies are nested or overlap with a national carbon tax, 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; Goulder and Stavins 2011). This is a major advantage of a tax over a tradeable permit program in jurisdictions in which perfect co-ordination of policies between different national and subnational levels cannot be assured.

15.9 Capacity building

The Convention is an international legal instrument that has been committed to by governments who share the common objective of stabilizing the greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. These governments however have different physical, institutional, economic, technological and human capacity to contribute to the objective of the Convention.

The Convention recognizes the common but differentiated responsibilities of the parties as well as their different capacities. It is for this reason that Article 4 (7) of the Convention defines the broad role and responsibilities of developed country parties and developing country parties. Developed country parties are to strengthen the capacity of developing country parties through the provision of financial resources and transfer of technologies. Developing country parties are to utilize these resources and technologies to voluntarily cut down on their GHG emissions and improve on their resilience to the impacts of climate change

Decision 2/CP.7 taken at the 7th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change, Reaffirmed that capacity building for developing countries is essential to enable them to participatefully in, and to implement effectively their commitments under, the Convention, in particular, preparation for their effective participation in the Kyoto Protocol process. Ministers and other heads of delegation Adopted the framework for capacity building in developing countries and Stressed the importance of capacity-building, as well as of developing and disseminating innovative technologies in respect of key sectors of development, particularly energy, and of investment in this regard, including through private sector involvement, market oriented approaches, as well as supportive public policies and international cooperation.

15.9.1 Capacity to Mitigate

The capacity to mitigate, particularly in the energy sector of developing country parties, is constrained by barriers. In the Pacific Islands, these barriers include:

Table15.3 Barriers constraining capacity to mitigate

Type	Barriers
Fiscal & Financial	Absence of sustainable capital fund for RE development
	Local investors are not confident on RE application projects
	Biased fiscal policies
Institutional	Inadequate capacity to address the challenges of climate change, including the design and implementation of RE projects
	Ineffective coordination among stakeholders
Knowledge, awareness and information	PICs lack qualified nationals in the area of RE applications
	Inadequate national public awareness campaigns
	Inadequate dissemination of information on best practices and success stories
	Lack of knowledge about the RE resource potentials in the PICs
	People in rural areas (and in some cases, urban/peri-urban areas) in the PICs lack knowledge about climate change
Legislative, regulatory and policy	Climate Change and Energy Legislations and Policies are either not in place or ineffective.
Market	Lack of private sector involvement in RE service delivery
	High costs of delivering RE services
Technical	Lack of sustainable RE-based energy system installations on the ground
	Absence of guidelines on RE technical specifications suitable for the PICs

While barriers to capacity building can be seen to be similar among a group of developing country parties, addressing these barriers should recognize that there is no "one size fits all" formula for capacity building. It should also recognize that capacity building must be country-driven, addressing the specific needs and conditions of developing countries and reflecting their national sustainable development strategies, priorities and initiatives. It is primarily to be undertaken by and in developing countries in accordance with the provisions of the Convention.

15.9.2 Capacity to Formulate Policies

Policy is a commonly used term and has different meaning to different people. But generally, a policy is as a principle or rule to guide decisions and achieve rational outcome(s).

It is not therefore uncommon to find that for the national outcomes on Climate Change (or greenhouse gas mitigation), parties to the Convention have a number of different policies to guide their decisions. This is the case as Climate Change is not en environment issues and a sustainable development issue. Policies on GHG mitigation can therefore be found in the National Climate Change Policy and related policies can be found in the National Energy Security Policy, the National Rural Development Policy, the Disaster and Risk Management Policy, etc. It is therefore not uncommon that there are inconsistencies among the Policies and these can become a barrier to progress. For instance, while the National Climate Change Policy would promote widespread use of renewable energy policy, the National Energy Security Policy would promote increased investments in the petroleum sector.

Lack of progress on mitigation in developing country parties are always associated with a disconnect between the adopted policies and what is actually happening on the ground. This disconnect is due to the absence of the enabling policy instrument. For instance, a policy to promote the widespread utilization of feasible renewable energy technologies will not make a difference unless it is followed through with a tax incentive, a change in legislation to allow independent power producers, feed in tariffs, etc.

Building the capacity and expertise to formulate comprehensive and effective policies is crucial to the success of the objective of the Convention. Absence of data and information is always a constraint to formulating food policies. Parties need to fully understand where they came from and where they are now in order to effectively chart where they want to be in the future.

15.9.3 Capacity to Implement Policies

The private sector has been identified in most parties to the Convention as the key driver of economic growth as well as the key implementer of governments' policies, including those relating to GHG. Private sector participation is therefore a measure of the effectiveness of the policies in attracting private sector capital and investments.

The COP-adopted framework for capacity building in developing countries recognizes that the initial scope of needs and areas for capacity building include institutional capacity building and the enhancement and/or creation of enabling environments.

15.9.4 Capacity to Evaluate Policies

Having policies in place in developing countries is necessary but not sufficient for the understanding of the progress towards the objective of the Convention. Parties must be able to evaluate the effectiveness of their GHG policies. The evaluation are however hampered by the absence of the baselines data and information, the absence of clear outputs, outcomes and performance indicators to evaluate the progress against.

15.10 Links to adaptation

15.10.1 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 (Daniel Osberghaus & Christiane 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 (Lobell et al. 2008), (Brown & Funk 2008), (Seo & Mendelsohn 2008). They are likely to result from the more general biodiversity changes triggered by climatic processes (Mawdsley et al. 2009), (Heller & Zavaleta 2009), (Pörtner & Farrell 2008), (Visser 2008), (Hoegh-Guldberg et al. 2008). However, adaptations necessary in wealthy regions are likely to be easier (Finger & 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 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 (ICLEI 2011), (Mertz et al. 2009), (Agrawal 2008), (Costello et al. 2009), (Adger et al. 2009), (Vignola et al. 2009), (Nath & Behera 2010), (van Aalst et al. 2008), (O'Brien). Its total cost is likely to be much higher than expected (Kelly de Bruin et al. 2009).

15.10.2 Mitigative capacity and adaptation capacity link

There are tendencies to argue that mitigation and adaptation policies are related to each other (Smith & Olesen 2010). This, however, is a controversial issue (Hamin & Gurran 2009). First, climate is a global public good 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 as 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.

15.10.3 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 & Raupach 2008). An example of a policy to mitigate and adapt at the same time is establishing green areas in urban centers. Apart from this, however, local governments need to undertake mitigation and adaptation activities independently (Moser & 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 are drafted national adaptation strategies now (Biesbroek et al. 2010)(Bizikova & Neale 2008)(Bedsworth & Hanak 2010).

15.10.4 Multiobjective analysis

The complexity of adaptation issue suggests multiobjective analysis for assessing policies. Its adequacy, however, seems to be limited. Multiobjective 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) multiobjective 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.

15.10.5 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)(Monika 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).

15.10.6 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 on climate change and adaptation capacity.

15.11 Investment and Finance

15.11.1 National and sub national institutions policies

Financing climate mitigation and adaptation in developing countries is regarded by many as a key area of intervention in order to stabilise the climate at 1.5-2 degree Celsius for which significant reduction in emissions will be required (COP 15/CMP5, 2009).

Parties to the UNFCCC have set up national and sub-national policies and most have drawn up programmes to address climate change. Annex 1 countries and some non-Annex 1 countries, particularly the BASIC countries and some emerging economics have set up financing schemes in their own countries to support these national and sub-national programmes aimed at addressing climate change. Table 15.4 presents a summary of some of the national carbon finance facilities in selected Annex 1 and non-Annex parties (UNFCCC, 2012).

Table 15.4 Some sources of climate finance

Fund	Administration	Focus Area	Operational Date
Green Energy Fund	Energy Commission, Government of Ghana	Mitigation	2012
Green Economy Facility	Government of Ethiopia	Adaptation and Mitigation	2011
Amazon Fund	Brazilian Development Bank	Adaptation, Mitigation, REDD	2009
Environmental Transformation Fund (ETF)	Government of the United Kingdom *(thru accredited development banks)*	Adaptation, Mitigation	2008
Hatoyama Initiative *(follow-up of Cool Earth Initiative)*	Government of Japan *(with private sector)*	Adaptation, Mitigation	2008
International Climate Initiative (ICI)	Government of Germany	Adaptation, Mitigation, REDD	2008
International Forest Carbon Initiative (IFCI)	Government of Australia	REDD	2007
Renewable Energy and energy Efficiency Partnership (REEP)	REEP (initiated by U.K Government)	Mitigation	2002

For instance, Brazil has the Amazon Fund to support projects that help to address deforestation of the Amazon forest (Table 15.4). The Amazon Fund was set up with seed donation from the Norwegian government and is managed by the country's national bank; it is being extended to cover neighbouring countries in the Amazon region.

Most low-income developing countries which make the bulk of non-Annex parties have no such financing scheme but relying on the existing international and multilateral funds. Besides, the policies are also not comprehensive enough to mainstream climate change in their national development agenda, eventually leading to their weak integration into local budgets. Such somehow renders their national climate change policies ineffective and susceptible to external risks. Worth mentioning however are the very few including Bangladesh, Ethiopia and Ghana which have functional national funding arrangements to finance the implementation of their climate change policies. Ethiopia has set up Green Economy Facility to finance low-carbon development for the country. Ghana has had a Renewable Energy law since 2011 and has established a Green Energy Fund to provide financial resources for the promotion, development and utilization of clean energy technologies addressing climate change. For both Ethiopia and Ghana, the main funding source is the national budget but grants from international sources are also solicited. The idea of co-benefits has also been picked up in Africa, e.g; Zambia and Kenya (Cull,Vincent,Davis, and van Garderen, 2011). Zambia is developing a national REDD+ strategy with assistance of the UN-REDD Programme. a collective programme which aims to contribute to the development of capacity for implementing REDD+. The UN-REDD Programme Zambia quick-start initiatives goal is to prepare institutions and stakeholders for effective nationwide implementation of the REDD+ mechanism. The programme objectives are to build institutional and stakeholder capacity to implement REDD+, develop an enabling policy environment for REDD+, develop benefit-sharing models, and develop MRV systems (Traynor, 2011). In Kenya, The carbon market, while still under development, potentially provides an opportunity for communities to generate income to support their livelihoods and conservation efforts. In particular, communities that live in remote areas that are not tourism destinations lack the financial incentives to protect their land. The ability of these communities to access carbon markets provides a potential source of revenue for forest conservation (Fitzgerald, 2011).

15.11.2 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. Annex 1 countries in particular, have been very active experimenting with a number of novel approaches. Such however have increased the fragmentation of international assistance for climate change financing. At the global level the number of initiatives appears to be increasing and this has obvious cost implications at the point of delivery, where national and sub-national capacities are often limited and not well placed to cope with the multiple administrative demands of different funding sources.

The following observations have also been made in developing countries particularly in respect to public sector investments (Cameron, 2011; Zingel, 2011):

i. More immediate priorities such as access to water, food security and energy have been the main drivers for climate change agenda. However, skill leadership in managing or running such climate change and related programmes have been a major challenge. This is partly due to country's weak manpower capacity.

ii. National institutions dedicated to climate change are more successful if such institutions or agencies are coherent with cabinet entities such as the Ministry of Finance or the Office of the President of the countries.

iii. Finance from international donors are often time-bound, creating pressure to bypass local (recipient country's) established arrangements in order to meet donors' deadlines. A common occurrence is that recipient countries have had to conform to donor requirements.

Hence the following suggestions are therefore being made:

i. *Expand Donor – Recipient Coordination*

Donor co-ordination where financiers of climate change programmes sit with government on a regular basis to co-ordinate funding exist in some countries, but this needs to be **expanded or introduced** in more developing countries. Such meetings facilitate an updated, transparent mapping of finance which is a pre-requisite for effective harmonization. Such meetings also allow host governments to be aware of the external financing for climate change activities in their countries and to institute stop gaps where needed.

ii. *Ensure effective Accountability*

Accountability should be both ways, where the recipient country is made to account for all the funding received and the donor country does same. Civil society organizations and the media can be further strengthened to serve a watchdog for good governance in accountability.

iii. *Strengthen institutional and governance capacity*

Strengthening institutional and governance capacities at the national and sub-national levels in recipient countries is crucial to attracting carbon finance investment, 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. Such would help under-developed regions like Africa to continue to improve the enabling environment and encourage private sector investment in carbon finance activities.

15.12 Gaps in knowledge and data

[TSU note: Section to be completed fort he Second Order Draft.]

15.13 Frequently Asked Questions

[TSU note: FAQs will be presented in box format throughout the text in subsequent drafts.]

While there is no one-size-fits-all and details matter, there are three broad categories of policies for the government to mitigate climate change effectively. 1) Appropriate pricing of energy and greenhouse gas emitting activities, 2) Regulatory and information measures to induce rational behaviour by firms and individuals, 3) Facilitate the development of technologies.

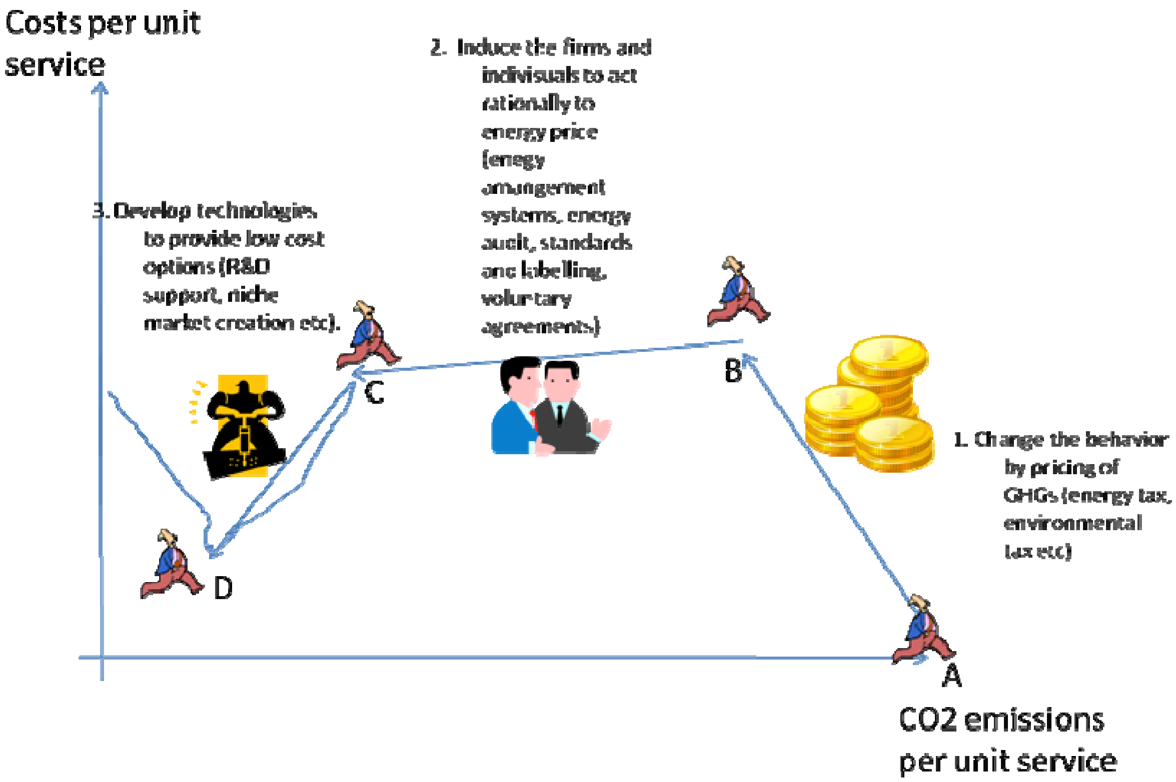

Figure 15.5 Role of policy instruments (conceptual).

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

Economic theories and numeric model calculations are useful to conceptualize and provide quantitative predictions of alternative mitigation policies. However, such evaluation often results in over- or under-estimates of the policy impacts due to oversimplification of the subject. As such, theories and numeric model calculations should be understood as describing many theoretical possibilities rather than predicting the policy impact in the real world.

This is why ex-post policy evaluations are always necessary to properly understand the effectiveness of policies. While ex-post analyses are data and labour intensive, they are used to find out whether the intended outcomes are obtained by the policy instruments that have been modified through the policy implementation process in the real world.

This IPCC report reviewed many estimates of costs and emission reductions by different policy instruments. The assessment of the literature brings us to the next FAQ.

15.13.2 What is the best climate change mitigation policy?

There is no one-size-fits-all. There is no single set of policy instruments that is the best across many nations. Appropriate designs depend on national circumstances such as policy practices and institutional capacity. Whichever policy instruments are chosen, details matter and they can either succeed or fail.

Still, our assessment points to the following three broad category of policy instruments as the choice of government for effective mitigation (Figure 15.5).

1. Appropriately price energy and other greenhouse gas emitting activities.

Energy prices in all nations are affected by taxes, subsidies, environmental and safety regulations, emission trading systems and so forth. To keep the resulting energy price at the appropriate levels will make the economic systems less greenhouse gas intensive.

However, it should be noted that it is often politically difficult to drastically change the price of energy since energy pricing is often recognized as a key part of income redistribution and industrial competitiveness policies.

2. Assist firms and individuals to take economically rational actions in given energy price systems.

Firms and individuals' behavior is often less than fully rational owing to costs of acquiring and processing information. This phenomenon has become widely known in terms of behaviourial economics since the AR4. This phenomenon applies to energy saving and greenhouse gas reduction activities as well. As such, price adjustment alone may not be enough as mitigation policy. The government can influence firms and individuals to behave more rationally by 1) enforcing compliance with technological standards such as energy efficiency standards , 2) providing know-how regarding energy savings by information measures such as appliance labelling, 3) assisting to establish Energy Management Systems, 4) assisting to receive Energy Audit service, and so forth. Such a governmental role can be further enhanced by industries through voluntary agreements.

3. Facilitate the development of GHG-reducing technologies:

Climate technology policy is needed over and above general emission reduction policy and general technology policy if new technologies that lower emissions are to be developed and deployed to their full potential. Technology policy is more than R&D – it includes assistance for commercialization and technology transfer.

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