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INTERGOVERNMENTAL PANEL ON climate change

Chapter 11

Policy, Financing and Implementation

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Chapter 11 has been allocated a total of 85 pages in the SRREN. The actual chapter length (excluding references & cover page) is 113 pages: a total of 28 pages over target. Government and expert reviewers are kindly asked to indicate where the chapter could be shortened in terms of text and/or figures and tables.

Financing and Implementation

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EXECUTIVE SUMMARY

Government policies are required for the substantial increase in deployment of RE required to help mitigate climate change. Market signals, through the current structure of energy markets, even when incorporating carbon pricing, have not been sufficient to trigger significant RE growth.

Multiple success stories from around the world demonstrate that policies can have a substantial impact on RE development and deployment. Where renewable deployment has been successful, specific policies in support of RE have been put in place. Only rarely has deployment occurred without specific policies in support of renewables, for example geothermal in Iceland; solar thermal in China. At the same time, not all RE policies have proven effective and efficient.

To be effective and efficient, policies must be specifically targeted to RE in order to address and overcome the numerous challenges that currently limit uptake and investment in RE capacity, in research and development of RE technologies, and in the infrastructure necessary for integrating RE into the existing energy system. After more than 30 years of policy experience, there is now a clear understanding of what works and what does not. This understanding is particularly clear with policies to promote power generation; while a wide variety of approaches exist in the transport and heating sectors, thus far none stand out.

Instrument design is key for policies to be effective and efficient. Policy instruments are most effective if tailored to the requirements of individual RE technologies and to local political, economic, social and cultural needs and conditions. Due to an energy system's long-term nature, the necessary investments in RE plants, in manufacturing facilities, in infrastructure for integration and R&D rely on stable and predictable policies and frameworks deliberately conceived and covering the energy sector more generally. Clear, long-term, consistent signals and well-designed policies are crucial to reduce the risk of investment sufficiently to enable high rates of deployment, the evolution of low-cost applications, and an environment conducive to innovation and change. Successful policy ultimately will be successful only if efforts on R&D and new technology development are finally deployed in the marketplace and become part of the energy system, thereby exploiting the cost reduction potential through learning by doing and economies of scale.

Well-designed policies are more likely to emerge in an enabling environment, and they will be more effective in rapidly scaling up RE. An enabling environment combines technological, social, institutional and financial dimensions. It is characterised by the readiness of society and stakeholders, including decision-makers to create an environment in which RE development and deployment can prosper. This readiness is motivated by a wide range of drivers, including the low climate and environmental impacts associated with most RE resources and technologies, and RE's potential to enhance energy security, to provide energy access for the world's poorest people, and to create new job opportunities.

The intertwined requirements to achieve the needed rate of deployment involve a systemic and evolutionary process. Thus, coordination is essential among policies—both RE policies and those in other related sectors such as agriculture, transportation, construction—and among the sub-components of the enabling environment, whether economics, technology, law, institutional, social and cultural.

The global dimension of climate change and the need for sustainable economic development call for a global partnership on deploying RE that recognizes diversity of countries, regions and business models. Deployment of RE provides opportunities for international cooperation, while wide-scale integration of RE will demand it. New finance mechanisms and creative policies on all levels are needed to stimulate technology transfer, investment and deployment of RE. For a problem as vast as climate change, an enabling environment is effective only if the private sector in its broadest form—meaning from small to large enterprises—is supported and is a partner in the process.

Policies to promote RE can begin in a simple manner to provide initial incentives for investing in RE. To achieve higher shares of RE, more comprehensive policies are required that address specifically the various barriers hindering RE deployment. For the efficient integration of RE into the energy system, the interaction among all energy carriers and energy efficiency options must be optimised (See Chapter 8). Today’s energy system was designed primarily for fossil and/or nuclear energy carriers, and a transformation is required to reflect the characteristics of RE technologies. In the longer term, a structural shift is needed for low-carbon dioxide emitting RE to meet the energy service needs of people in developed and developing countries. This implies important changes in societal activities, practices, institutions and social norms, and government policy has a critical role to play in driving this transformation. Political will and effective policies to promote RE deployment in concert with decreasing energy intensity are integral to this transition.

The now-required energy transition differs from previous ones in two ways: the available time span is restricted to a few decades, while in much of the world RE must develop and integrate into a system—including in some cases policies and regulations—that was constructed to suit fossil fuels and nuclear power. As such, combinations of strategic and directed policies to meet interim and long-term targets and advance infrastructure will be critical, alongside long-standing political commitment and the flexibility to learn from experience and adapt as situations change.

11.1 Introduction

This report explores the potential for low-carbon dioxide (CO_2) emitting renewable energy (RE) technologies to meet the energy service needs of people in both developed and developing countries. Capturing the potential of the globe's RE resources depends on a wide spectrum of factors. In order to achieve a transition of the scale required and the speed in which it must occur to avoid catastrophic climate change, it will be important to systematically implement policies on a wide-scale to overcome the barriers to RE discussed earlier in this report.

The previous chapters have explained the state of technological understanding, barriers and policy issues specific to individual technologies, and have described the required issues of integration. Chapter 10 has reviewed over a hundred scenarios and undertaken detailed studies of the potential from different rates of technological learning. It shows that there are large uncertainties in the future development of RE since it depends on external factors, such as economic growth, as well as the degree to which well-designed RE policies are put in place to overcome barriers and feed into a virtuous cycle of lowering costs and further increasing deployment.

This chapter sets out the issues surrounding the policies, financing and implementation of RE to enable this virtuous cycle to develop. It lays out the general RE policy options, including financing, that are available for rapidly increasing the uptake of RE, examines which policies have been most effective and efficient to date and why, and it looks at both RE specific policies and policies that create an "enabling environment" for RE. Issues concerning individual RE resources and/or technologies are examined in the appropriate technology chapter.

The key findings of this chapter are the following (for more details, see Box 11.1):

- Targeted RE policies accelerate RE development and deployment;
- Multiple success stories exist and it's important to learn from them;
- Economic, social, and environmental benefits are motivating Governments and individuals to adopt RE;
- Multiple barriers exist and impede the development of RE policies to support development and deployment;
- 'Technology push' coupled with 'market pull' creates virtuous cycles of technology development and market deployment;
- Successful policies are well-designed and -implemented, conveying clear and consistent signals;
- Policies that are well-designed and predictable can minimize key risks, encouraging greater levels of private investment and reducing costs;
- Well-designed policies are more likely to emerge and to function most-effectively in an enabling environment;
- The global dimension of climate change and the need for sustainable development call for new international public and private partnerships and cooperative arrangements to deploy RE;

- Structural shifts characterize the transition to economies in which low CO_2 emitting renewable technologies meets the energy service needs of people in both developed and developing countries;
- Better coordinated and deliberate actions accelerate the necessary energy transition for effectively mitigating climate change.

As previous chapters have described, RE capacity and production of electricity, heat and fuels have increased rapidly in recent years, although most technologies are growing from a small base. Large-scale hydropower, which accounts for a significant portion of global electricity generation and represents a major share of total energy production in several countries, is clearly an exception. The number of countries with RE policies in place has also risen significantly, particularly since the early to mid-2000s, as discussed in Section 11.2.

This trend toward more RE policies in a growing number of countries has played an important role in advancing RE and increasing investment in the RE sector; this has been particularly true for non-hydro renewables. RE policies have a critical role to play in the transition to an energy future based on low-CO_2 RE. Although there are limited examples of countries that have come to rely primarily on RE without supportive policies (such as Iceland with geothermal and hydropower; as well as Brazil, which generates more than 80 percent of its electricity with hydropower (IEA, 2009c)), in most cases targeted policies are required to advance RE technology development and use.

11.1.1 The Importance of Tailored Policies and an Enabling Environment

To date, in almost every country that has experienced significant installation of RE capacity, production, and investment in manufacturing and capacity, there have been policies to promote RE. There is now clear evidence of success, on the local, regional and national levels, demonstrating that the right policies have a substantial impact on the uptake of RE and enhanced access to clean energy. A limited number of communities and regions have made quite rapid transitions to or toward 100 percent RE; some countries are also experiencing rapid growth in RE, with some seeing a rapid increase in the share of total energy demand met by RE.

At the same time, the IEA (IEA, 2008b) has found that only a limited number of countries have implemented policies that have effectively accelerated the diffusion of RE technologies in recent years (Lipp, 2007). Simply enacting support mechanisms for RE is not enough.

Tailored policies are required to overcome the numerous barriers to RE that currently limit uptake in investment, in private R&D funding, and in infrastructure investments. Accelerating the take-up of RE requires a combination of policies but also a long-term commitment to renewable advancement, policy design suited to a country’s characteristics and needs, and other enabling factors.

The issue of finance can be examined in ways, including (i) an assessment of the current trends in renewable energy finance, (ii) an analysis of the linkage between policy effectiveness and finance mobilisation, and (iii) a review of public finance instruments as a policy option available to governments.

Policies are most effective if targeted to reflect the state of the technology and available RE resources, and to respond to local political, economic, social and cultural needs and conditions.

Moreover, policies that are clear, long-term, stable and well-designed, and that provide consistent signals generally result in high rates of innovation, policy compliance, and the evolution of efficient solutions. When these factors are brought together, a policy can be said to be well-designed and -tailored.

Well-designed policies are more likely to emerge, and to lead to successful implementation, in an enabling environment. An "enabling environment" is defined as:

"A network of institutions, social norms, infrastructure, education, technical capacities, financial and market conditions, laws, regulations and development practices that in concert provide the necessary conditions to create a rapid and sustainable increase in the role of renewables in local, national and global systems" (i.e., that enable targeted RE policies to be effective and efficient).

An enabling environment combines legal, economic, technological, social and cultural, institutional and financial dimensions, including both the public and private sectors and well as civil society. It is not a critical prerequisite for RE policies. Countries can start small, with simple incentives, and build up. However, the importance is to avoid situations in which lack of attention to the enable environment produces bottlenecks in the sectors—such as lack of a skilled workforce, or inability to obtain affordable financing or permitting. Coordination with policies related to other key and inter-linked sectors—including agriculture, transportation, construction, technological development, and infrastructure—is also important.

Policy and regulation, and their design, play a crucial role in improving the economics of RE, and as such can be central to attracting private capital to RE technologies and projects, and influencing longer-term investment flows.

Finally, achieving a sustainable energy system, one in which low-CO_2 RE meets the energy service needs of people around the world, will require a structural shift to a more integrated energy service approach that takes advantage of synergies between RE and energy efficiency. The RE growth seen to date must be accelerated on a global scale for RE to play a major role in mitigating climate change. This is true not only for those RE technologies which have already seen successes related to manufacture and implementation, but also for other RE resources such as renewable heat, which thus far has experienced limited growth and limited policy support despite its enormous potential (IEA, 2007a; Seyboth, Beurskens *et al.*, 2008).

To enable this shift, a combination of well-designed policies, financing mechanisms, and stakeholder involvement is required which address the broad spectrum of issues barriers ranging from technological through to social concerns. It implies important changes in societal activities, practices, institutions and social norms.

The encouragement of 'innovation' is a central component for realization of successful RE policies and an enabling environment. Although innovation is often understood as the development and implementation of new technologies, it can also be viewed as the development of new practices such as new business models, institutional and social activities. The concept of innovation and its relationship to policies is discussed further in section 11.6.

11.1.2 Roadmap for Chapter

This chapter begins in Section 11.2 by highlighting recent trends in RE policies to promote deployment, as well as trends in financing and research and development funding. Section 11.3 examines the various drivers of RE policies, and 11.4 briefly reviews the many market failures and barriers that impede the development of RE policies. Section 11.5 presents the various policy options available to advance RE development and deployment, and discusses which have been most effective and efficient to date, and why. In Section 11.6, an enabling environment is defined and explained. The chapter concludes with Section 11.7, which focuses on broader considerations and requirements for a structural shift to a sustainable, low-carbon energy economy.

Throughout the chapter, a number of case studies in boxes highlight key messages of the chapter and provide insights into policy experiences that offer lessons for other regions or countries. See, for example, Box 11.2 which examines how Germany has achieved a rapid increase in deployment of many RE technologies across end-use sectors through a combination of well-designed and well-implemented RE support measures that have been predictable and long-term, and that have been adjusted as situations change over time, and that have been enacted alongside policies to create an enabling environment.

Given the tremendous range of conditions, needs, technologies, capacities and other circumstances around the world, the focus of this chapter is very broad. This chapter endeavours to examine policies relevant to RE in many different ways—scale of projects, penetration levels, application, technological maturity, economic state of the country or community where RE technologies are deployed, level of access to modern energy services, and so forth. Figure 11.1 shows just a few of the factors that play a role in decisions and policy making. Clearly, it is not possible to cover everything in a single chapter. For aspects that go beyond what is included here—for example, related to energy access or integration—refer to the relevant chapters elsewhere in this report.

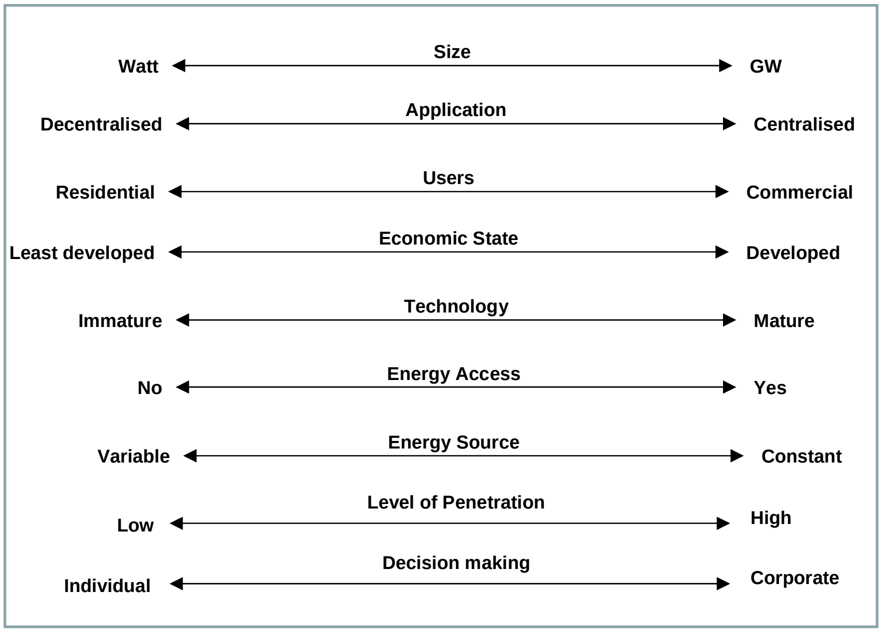

Figure 11.1 Breadth of policy making discussed in Chapter 11

Finance is also covered throughout the chapter as it is a critical and interrelated to every aspect of policies and policy making. The issue of finance can be examined in several ways, including (i) an assessment of the current trends in renewable energy finance, (ii) an analysis of the linkage between policy effectiveness and finance mobilisation, and (iii) a review of public finance instruments as a policy option available to governments. As mentioned above, financing and investment trends are covered in Section 11.2, followed by a box discussing how financiers think and elements necessary to minimize risk and encourage investments. Section 11.4 includes the barriers to financing; 11.5 explains the links between policies and financing, and how best to maximize public funds and encourage private investment.

Box 11.1 Key Messages Related to Policy, Financing and Implementation

1**. <u>Targeted RE policies accelerate RE development and deployment</u>**. Targeted policies should address barriers to RE, including market failures, and appropriate market signals are crucial to trigger significant RE growth, but are not sufficient.

2.**<u> Multiple RE success stories exist around the world and it is important to learn from them</u>**. They demonstrate that the right policies have an impact on emissions reductions and the enhanced access to clean energy. They also demonstrate the importance of learning by doing, including learning from mistakes, to achieving success.

3. **<u>Economic, social, and environmental benefits are motivating Governments and individuals to adopt RE.</u>** In addition to mitigation of climate change, benefits include economic development and job creation, increased security of energy supply, greater stability and predictability of energy prices, access to energy, and reduced indoor air pollution. In general, climate change mitigation is a primary driver for developed countries whereas developing countries focus more on energy access and energy security through RE. In low-lying developing

countries, RE's potential for climate change mitigation becomes an issue of economic and physical survival.

4. **Multiple barriers exist and impede the development of RE policies to support development and deployment.** These primarily relate to the degree of awareness, and acceptance, of climate change policies; a lack of knowledge of how RE can mitigate the problem and a lack of sufficient public governance capacity to elaborate and make RE policies operational; the momentum of the existing energy system, including policies that were enacted to advance or support the existing fossil-based system and that now undermine RE policy; and a lack of understanding on the part of policy-makers of the needs of financiers and investors.

5. **'Technology push' coupled with 'market pull' creates virtuous cycles of technology development and market deployment**. Public RD&D combined with promotion policies have been shown to drive down the cost of technology and sustain its deployment. Steadily increasing deployment allows for learning, drives down costs through economies of scale, and attracts further private investment in R&D.

6. **Successful policies are well-designed and -implemented, conveying clear and consistent signals.** Successful policies take into account available RE resources, the state and changes of the technology, as well as financing needs and availability. They respond to local, political, economic, social, financial, ecological and cultural needs and conditions. RE deployment policies can immediately start in every country with simple incentives, evolving toward stable and predictable frameworks and combinations of policies to address the long-term nature of developing and integrating RE into existing energy systems.

7. **Policies that are well-designed and predictable help to minimize key risks, encouraging greater levels of private investment**. Reducing risk helps to lower the cost of capital, improving access to financing of RE technologies and projects, and reducing their costs as well as the end cost of delivered energy. As a result, they can reduce the amount of public funds required to achieve the same levels of RE development and deployment.

8. **Well-designed policies are more likely to emerge and to function most-effectively in an enabling environment**. An enabling environment integrates technological, social, cultural, institutional, legal, economic and financial dimensions, and recognizes that technological change and deployment come through systemic and evolutionary (rather than linear) processes. Also important is coordination across policies, the dimensions of the enabling environment and, where relevant, different sectors of the economy including broader energy policy, transportation and agriculture.

9. **The global dimension of climate change and the need for sustainable development call for new international public and private partnerships and cooperative arrangements to deploy RE**. RE deployment is a part, and a driver, of sustainable development. New suitable finance mechanisms on national and international levels, involving cooperation between the public and private sectors, work to stimulate technology transfer and worldwide RE investment as well as advancing the necessary infrastructure for RE integration. New partnerships would recognize the diversity of countries, regions and business models.

10. **Structural shifts characterize the transition to economies in which low CO_2 emitting renewable technologies meet the energy service needs of people in both developed and developing countries.** When RE is treated as the norm, as fossil fuels are today, a structural shift

will have occurred. Political will and effective policies to promote RE deployment, in concert with decreasing energy intensity, are an integral part of the needed energy transition. Further, transitions require important changes in societal activities and practices, business conditions and institutions.

11. **Better coordinated and deliberate actions can accelerate the necessary energy transition for effectively mitigating climate change.** The now required transition differs from previous ones in two primary ways. First, the available time span is restricted to a few decades. Second, RE has to develop within the existing energy system (including policies, regulations and infrastructure) that generally were built to suit fossil fuels and nuclear power. Thus it is important to align attitudes and political actions with the known requirements for effectively mitigating climate change. Critical are combinations of strategic and directed policies established to meet interim and long-term RE targets and advance the required infrastructure. Long-standing commitment is essential alongside the flexibility to adapt policies as situations change.

Box 11.2 Case Study Germany: From a single instrument to a comprehensive approach

Since the oil crises in the 1970s, Germany has devoted significant resources to RE technology development and market deployment. As a result of German R&D efforts, by the mid-1980s many different technologies were ready for market deployment even though not yet cost competitive (IEA, 2004a) But in the 1980s and beyond, RE in Germany faced a political–economic structure that was largely hostile. Declining oil prices and surplus electric capacity in the late 1980s made it difficult for RE to compete economically. Further, the electricity supply system was dominated by large utilities that relied on coal and nuclear generation and opposed all small and decentralised forms of generation, which they deemed uneconomic and foreign to the system (Jacobsson and Lauber, 2006).

In 1989, the government established a subsidy (€ 0.031/kWh, USD_{2005} 0.053/kWh) for the first 100 MW of wind power installed in Germany. Beneficiaries were obliged to report on performance so that a common knowledge base was established. In 1990, Germany’s first feed-in law (FIT) was enacted, obliging utilities to connect RE power plants to the grid, to purchase the generated power, and to buy the electricity at a specified percentage of the retail rate: for wind and solar energy, this amounted to 90 percent of the average tariff for final customers. (Lauber and Mez, 2004).

The FIT was revamped in 2000, and broadened into the Renewable Energy Sources Act (Erneuerbare Energien Gesetz - EEG). Geothermal and large biomass power plants were added under the scheme, and cost-based tariffs were introduced. The level of the remuneration is calculated on the basis of a technology’s generation costs, and specified tariffs are guaranteed to all RE generators for at least 20 years (Lipp, 2007).

Reflecting the new structure of electricity markets, the EEG obligated grid operators and electricity suppliers to purchase RE electricity. Under the EEG, the generator delivers RE electricity to the grid operator, who then passes it to electricity suppliers (Langniß, Diekmann *et al.*, 2009). The Act has been amended twice, reflecting progress in technology development and stringent requirements on the integration of RE (Büsgen and Dürrschmidt, 2009). Lately, the extra burden from financing the EEG has been discussed more widely (Frondel, Ritter *et al.*, 2010).The additional costs amounted to 4.3 billion € in 2007 (5.12 billion USD_{2005}) (Büsgen and Dürrschmidt, 2009).

Several other policies have been used to promote deployment of RE electricity, to support further R&D, and to level the playing field (Laird and Stefes, 2009). Federal banks have awarded soft loans with low interest rates and favourable payment conditions, easing access to capital. Changes to German building codes granted RE the same legal status as other power generation technologies. Moreover, municipalities were obliged to allocate potential sites for wind power facilities in their land development plans. The requirements on such sites were legally defined (IEA, 2004b)

Due to a combination of support measures, Germany has seen rapid growth of electricity generation from RE. Germany's share of electricity from RE rose from 3.1 percent in 1991to 7.8 percent in 2002, and more than doubled by the end of 2009 to 16.9 percent (Wüstenhagen and Bilharz, 2006; German Federal Ministry for the Environment, 2009). Wind energy has experienced the greatest increase, but bioenergy and solar PV have grown substantially under this policy as well. (See Figure 11.2). The EEG sets a target for 30 percent of Germany's power to come from RE by 2020 (Büsgen and Dürrschmidt, 2009).

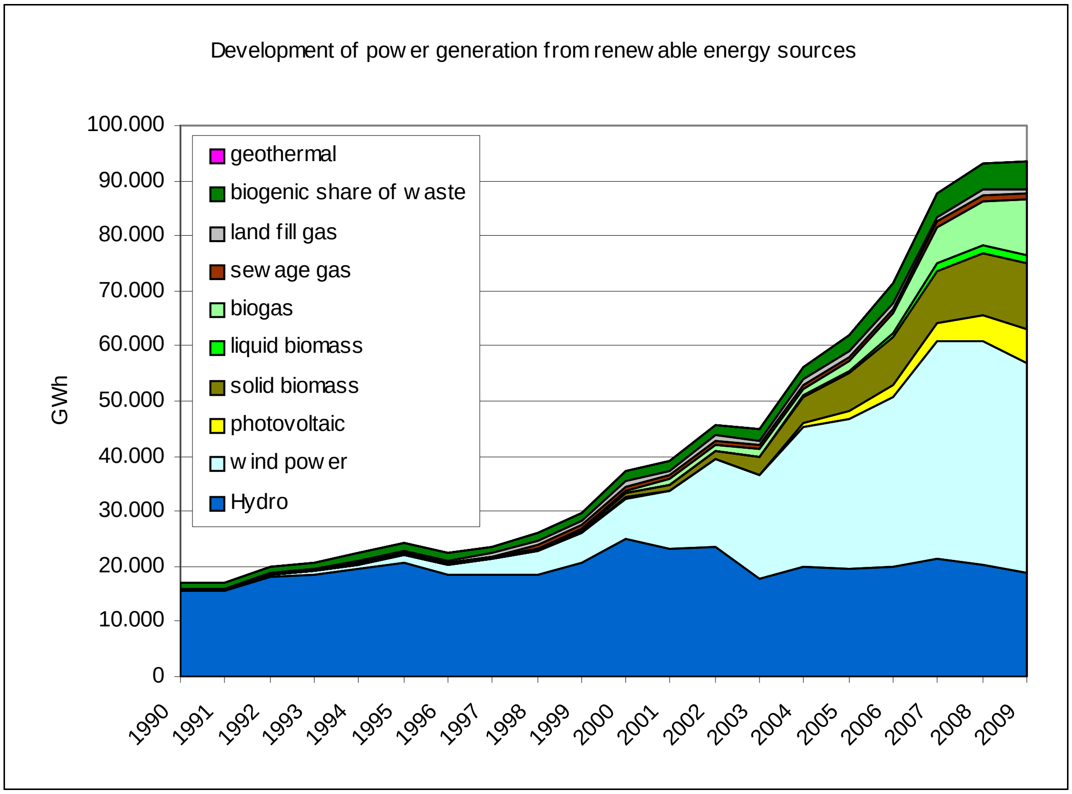

Figure 11.2 Development of Electricity Generation from RE in Germany, 1990-2008 (German Federal Ministry for the Environment, 2009).

Since 2000, the focus of Germany's RE promotion policies has broadened to include heat and transport fuel markets. A comprehensive "market acceleration programme" was introduced to award investment grants and soft loans for RE heat systems. In 2009, this was supplemented with a mandate requiring a minimum share of RE for heating and cooling in new buildings.

Initially promoted by tax exemptions (Bomb, McCormick *et al.*, 2007), RE transport fuels are now mandated through a blending quota on fuel suppliers.

The government's overarching frame for RE development has been creation of ambitious targets for the use of RE in individual sectors and for the economy as a whole. The share of RE in total primary energy supply increased steadily from 1.3 percent in 1990 to 8.9 percent in 2009 (BMU, 2010).

The German example shows how rapidly RE can advance when policies are well-designed and -implemented, conveying clear and consistent signals, and adapting to changes with technologies and in the marketplace. RE deployment policies can start with simple incentives, evolving toward stable and predictable policies and frameworks to address the long-term nature of developing and integrating RE into existing energy systems.

11.2 Current trends: Policies, financing and investment

Policy mechanisms to promote RE are varied and include regulations such as mandated quotas for RE electric capacity, feed-in tariffs, biofuels blending mandates, and building codes requiring passive or active use of solar and other RE resources for heat, light or power; fiscal policies include tax incentives and rebates; and financing mechanisms. Table 11.1 lists and defines a range of mechanisms currently used specifically to promote RE, and notes which types of policies have been applied to RE in each of the three end-use sectors of electricity, heating and cooling, and transportation. Each of these options for promoting RE deployment is discussed further in Section 11.5. Policies that create additional enabling conditions to advance RE are not included here, but are discussed in detail in Section 11.6.

The number of RE policies—specific RE policy mechanisms enacted and implemented by governments—and the number of countries with RE policies, is increasing rapidly around the globe. The focus of RE policies is shifting from a concentration almost entirely on electricity to include the heating/cooling and transportation sectors as well. These trends are matched by increasing success in the development of a range of RE technologies and their manufacture and implementation (See Chapters 2-7), as well as by a rapid increase in annual investment in RE and a diversification of financing institutions. This section describes recent and current trends in RE policies and in public and private finance and investment.

11.2.1 Trends in RE Policies

While several factors are driving rapid growth in RE markets, government policies have played a crucial role in accelerating the deployment of RE technologies to date (Sawin, 2001; Meyer, 2003; Sawin, 2004b; Rickerson, Sawin *et al.*, 2007; REN21, 2009b)(IEA, 2010).

Until the early 1990s, few countries had enacted policies to promote RE. Since then, and particularly since the early- to mid-2000s, policies have begun to emerge in an increasing number of countries at the national, provincial/state, regional, and municipal levels (REN21, 2005; REN21, 2009b). Initially, most policies adopted were in developed countries, but an increasing number of developing countries have enacted policy frameworks to promote RE since the late 1990s and early 2000s (Wiser and Pickle, 2000; Martinot, Chaurey *et al.*, 2002).

1 **Table 11.1** Existing RE Policy Mechanisms, Definitions and Use by Sector

		End-use Sector		
Policy	**Definition**	**Electricity**	**Heating/ Cooling**	**Transport**
REGULATORY				
Access Related				
Net metering	Allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation. The meter flows backwards when power is fed into the grid.	X		
Priority Access to network	Provides RE supplies with unhindered access to established energy networks.	X	X	
Priority Dispatch	Ensures that RE supplies are integrated into energy systems before supplies from other sources.	X	X	
Quota Driven				
Renewable Portfolio Standard/ Renewable Obligations or Mandates	Obligates designated parties (generators, suppliers, consumers) to meet minimum RE targets, generally expressed as percentages of total supplies or as an amount of RE capacity. Includes mandates for blending biofuels into total transportation fuel in percent or specific quantity. Also RE heating purchase mandates and/or building codes requiring installation of RE heat or power technologies.	X	X	X
Tendering/ Bidding	Public authorities organize tenders for given quota of RE supplies or supply capacities, and remunerate winning bids at prices mostly above standard market levels.	X		

Tradable Certificates	Provide a tool for trading and meeting RE obligations among consumers and/or producers. Mandated RE supplies quota are expressed in numbers of tradable certificates which allow parties to meet RE obligations in a flexible way (buying shortfalls or selling surplus).	X	X	
Price Driven				
Feed-in tariff (FIT)	Guarantees RE supplies with priority access and dispatch, and sets a fixed price per unit delivered during a specified number of years.	X	X	X
Premium payment	Guarantees RE supplies an additional payment on top of their energy market price or end-use value.	X	X	
Quality Driven				
Green energy purchasing	Regulates the option of voluntary RE purchases by consumers, beyond existing RE obligations.	X	X	
Green labeling	Government-sponsored labeling (there are also some private sector labels) that guarantees that energy products meet certain sustainability criteria to facilitate voluntary green energy purchasing. Some governments require labeling on consumer bills, with full disclosure of the energy mix (or share of RE).	X	X	X
Guarantee of origin (GO)	A (electronic) document providing proof that a given quantity of energy was produced from renewable sources. Important for RE trade across jurisdictions and for green labeling of energy sold to end-users.	X	X	
FISCAL				
Accelerated depreciation	Allows for reduction in income tax burden in first years of operation of renewable energy equipment. Generally applies to commercial entities.	X	X	X

Investment grants, subsidies or rebates	One-time direct payments from the government to a private party to cover a percentage of the capital cost of an investment in exchange for implementing a practice the government wishes to encourage.	X	X	X
Energy production payments	Direct payment from the government per unit of renewable energy produced.	X	X	
Production/ investment tax credits	Provides the investor or owner of qualifying property with an annual income tax credit based on the amount of money invested in that facility or the amount of electricity that it generates during the relevant year. Allows investments in RE to be fully or partially deducted from tax obligations or income.	X	X	X
Reductions in sales, VAT, energy or other taxes	Reduction in taxes applicable to the purchase (or production) of renewable energy or technologies.	X	X	X
PUBLIC FINANCE				
Grants	Grants and rebates that help reduce system capital costs associated with preparation, purchase or construction of renewable energy equipment or related infrastructure. In some cases grants are used to create concessional financing instruments (e.g., allowing banks to offer low interest loans for RE systems).	X	X	X
Equity investments	Financing provided in return for an ownership interest in an RE company or project. Usually delivered as a government managed fund that directly invests equity in projects and companies, or as a funder of privately managed funds (*fund of funds*).	X	X	X
Loans	Financing provided to an RE company or project in return for a debt (i.e., repayment) obligation. Provided by development banks or investment authorities usually on concessional terms (eg lower interest rates or with lower security requirements).	X	X	X

Guarantees	Risk sharing mechanism aimed at mobilizing domestic lending from commercial banks for RE companies and projects that have high perceived credit (i.e., repayment) risk. Typically guarantees are partial, that is they cover a portion of the outstanding loan principal with 50%-80% being common.	X	X	X
OTHER				
Public Procurement	Public entities preferentially purchase renewable energy and RE equipment.	X	X	X

According to the Renewable Energy Network for the 21st Century (REN21)[1], the only source that currently tracks RE policies annually on a global basis, the number of countries with some kind of national RE target and/or RE deployment policy in place almost doubled from an estimated [55] in early 2005 to more than [100] in early 2010 (REN21, 2010). At least [80] countries had adopted policy targets for RE by early 2010, up from 45 (43 at the national level and two additional countries with state/provincial level policies) in mid-2005 (REN21, 2006). (See Figure 11.3) Many of these countries aimed to generate a specific share of their electricity from RE sources by a specific date (with most target years between 2010 and 2020), while many (with some overlap) had targets for share of primary or final energy from RE. There were also a large number of countries with specific RE capacity targets by early 2010 (REN21, 2010). In addition, many existing policies and targets have been strengthened over time and several countries have more than one RE-specific policy in place (REN21, 2010).

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[1] REN21 is a global policy network that is open to a range of stakeholders and connects governments, international institutions, non-governmental organisations, industry associations, and other partnerships and initiatives. Its goal is to advance policy development for the rapid expansion of RE in developed and developing and economies.

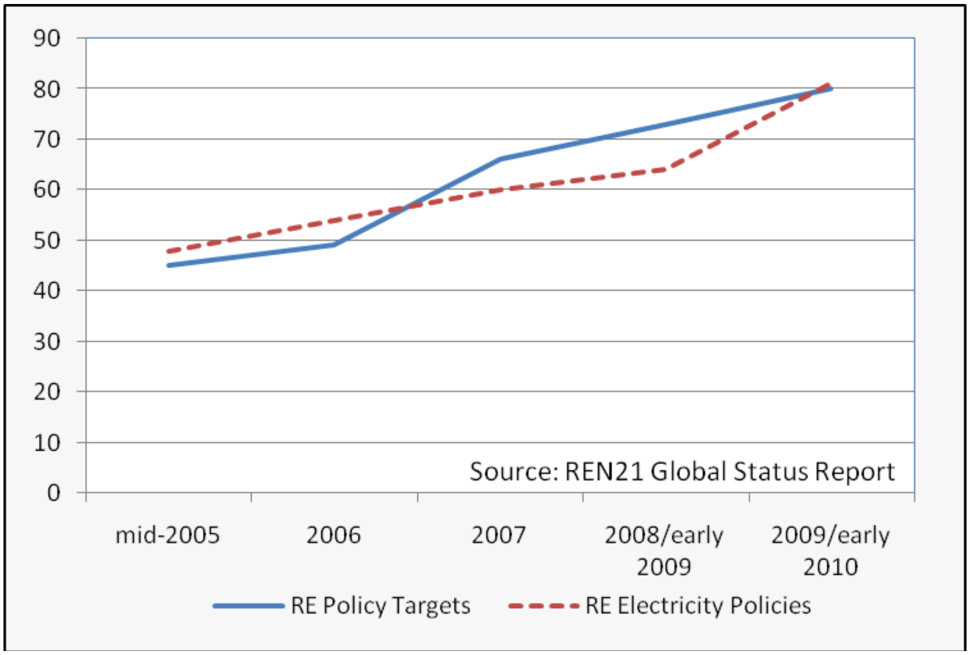

Figure 11.3 Number of Countries with RE Targets or Electricity Policies, 2005-early 2010
Sources: (REN21, 2005; REN21, 2006; REN21, 2007; REN21, 2009b; REN21, 2010). [Authors: To be updated][2]

RE policies are directed to all end-use sectors – electricity, heating and cooling, transportation. However, most RE deployment policies enacted by date of publication had focused on the electricity sector. At least 81 countries had adopted some sort of policy to promote RE power generation by early 2010 (IEA, 2010; REN21, 2010), up from an estimated 64 in early 2009 (REN21, 2009b), and at least 48 in mid-2005 (REN21, 2006). (See Figure 11.3) These included regulations such as feed-in tariffs (FITs), quotas, net metering, and building standards; fiscal policies including investment subsidies and tax credits; and government financing such as low-interest loans. Of those countries with RE electricity policies, approximately half were developing countries from every region of the world (REN21, 2010).

By early 2010, feed-in tariffs had been enacted in at least 50 countries at the national level (including much of Europe), and in 23 states, provinces or territories (Mendonça, 2007; Rickerson, Sawin *et al.*, 2007; Rickerson, Bennhold *et al.*, 2008; REN21, 2009b). Renewable Portfolio Standards (RPS) or quotas are also widely used and, by early 2009, had been enacted by an estimated 10 countries at the national level, and by at least 52 states or provinces (REN21, 2009b).

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[2] Data derived from REN21 Renewable Energy Policy Network (2005): Renewables 2005 Global Status Report, Worldwatch Institute, Washington, D.C., pp. 19-26; GSR 2006 Update, pp. 8-11; GSR 2007, pp. 21-28; GSR 2009 Update, pp. 17-20; and GSR 2010 draft. Note that all numbers are minimum estimates. Not all national renewable energy targets are legally binding. Overall RE targets and electricity promotion policies are national policies or targets, with the exception of the United States and Canada, which cover state and provincial targets but not national. 2006 statistic for number of countries with RE promotion policies is not available, so figure shows the average of 2005 and 2007 data from REN21.

Many additional forms of policy support are used to promote renewable electricity, including direct investment subsidies or rebates, tax incentives and credits, net metering, production payments or tax credits, or sales tax and VAT exemptions. By mid-2005, some type of direct capital investment subsidy, rebate or grant was offered in at least 30 countries (REN21, 2005); this number had risen to at least 45 countries by early 2010 (REN21, 2010).

In addition, an increasing number of governments are adopting incentives and mandates to advance renewable transport fuels and renewable heating technologies (International Energy Agency (IEA), 2007; REN21, 2009b; Rickerson, Halfpenny *et al.*, 2009). For example, in the 12 countries analysed for the International Energy Agency (IEA), the number of policies introduced to support renewable heating either directly or indirectly increased from five in 1990 to more than 55 by May 2007 (IEA, 2007b).

By early 2010, at least 28 countries at the national level and at least 36 provinces or states had adopted mandates for blending biofuels with gasoline or diesel fuel, while others had set production or use targets (REN21, 2009b). Most mandates require blending relatively small (e.g., up to 10) percentages of bio-ethanol or biodiesel with petroleum-based fuels for transportation; Brazil has been an exception, with blending shares in the 20-25 percent range (Goldemberg, 2009). Production subsidies and tax exemptions have also increased in use, in developed and developing countries (REN21, 2010). Another policy trend seen particularly with bioenergy, and biofuels especially, is the adoption of environmental and other sustainability standards, including regulations on associated lifecycle CO_2 emissions, such as the U.S. Renewable Fuel Standard and mandatory sustainability standards under the EU Renewable Energy Directive (European Commission (EC Roadmap), 2009; USEPA, 2010).

Beyond national policies, the number of regional policies and partnerships is increasing. The EU Renewables Directive entered into force in June 2009, setting a binding target to source 20 percent of EU final energy consumption from RE by 2020; all member states have been assigned targets for 2020 which are driving RE policies at the national level (REN21, 2009c)(EC, Directive 2009/28/EC, 2009). Another example is the Mediterranean Solar Plan, an agreement among countries in the region for research and deployment of 20 GW of RE by 2020 (Resources and Logistics (RAL), 2010).

Several hundred city and local governments around the world have also established goals or enacted renewable promotion policies and other mechanisms to spur local RE development (Droege, 2009; REN21, 2009b). Innovative policies such as Property-Assessed Clean Energy (PACE) have begun to emerge on this level. Under PACE programs, local governments issue bonds to raise money and offer low-interest loans for RE investments that are paid back over time through property taxes (Fuller et al, 2009). Indeed, some of the most rapid transformations from fossil fuels to RE based systems have taken place at the local level, with entire communities and cities—such as Samsø in Denmark, Güssing in Austria, and Rizhao in China—devising innovative means to finance RE and transitioning to 100% sustainable energy systems (Droege, 2009; Sawin and Moomaw, 2009).

Despite the increasing number of countries, states and municipalities with RE policies, the vast majority of capacity or generation for most non-hydropower RE technologies is still in a relatively small number of countries. By early 2010, five countries—the United States, Germany, Spain, China and India—accounted for more than 85% of global wind energy capacity. Three countries—Germany, Spain and Japan—represented approximately 82% of the world's solar photovoltaic (PV) capacity, while a handful of countries led in the production and use of biofuels (REN21, 2009b).

11.2.2 Trends in RE Finance

11.2.2.1 Trends Along the Financing Continuum

In response to the increasingly supportive policy environment, the overall RE sector globally has seen a significant rise in the level of investment since 2004-2005. These global figures are aggregated for all types of finance, with the possible exception of public R&D. Figure 11.4 shows that $117 billion [TSU: will need to be converted to USD_{2005}] of new financial investment went into the RE sector in 2008, up from 15.5 billion USD_{2005} in 2004[3].

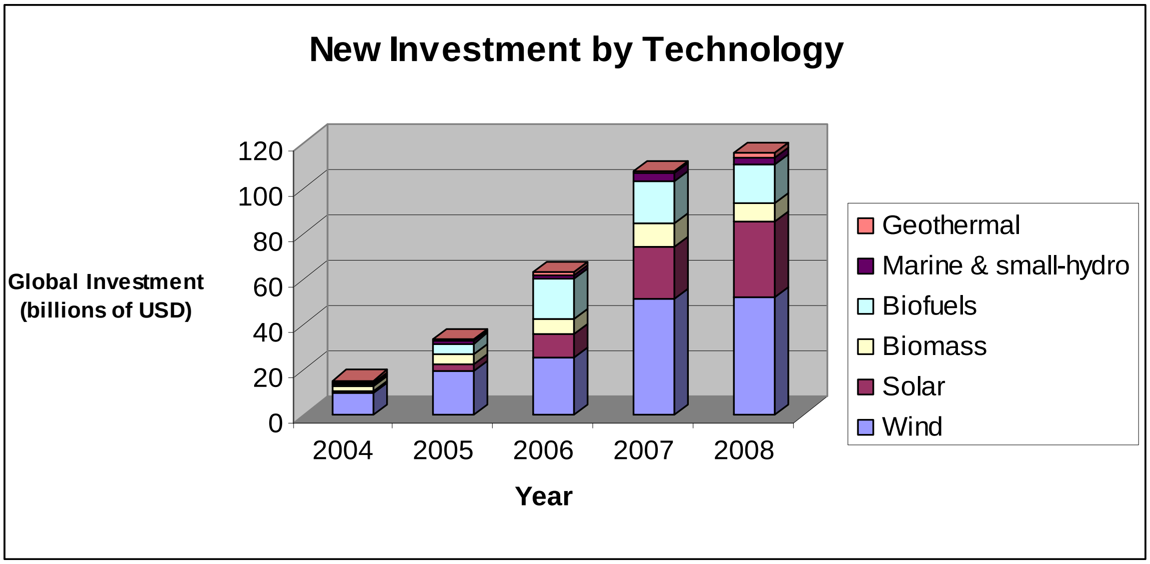

Figure 11.4 Global Investment in RE, 2004 – 2008 (UNEP and NEF, 2009). [TSU: figure will need to be converted to USD_{2005}]

Financing has been increasing along the continuum into the five areas of i) R&D; ii) technology development and commercialization; iii) equipment manufacture and sales; iv) project construction; and v) the refinancing and sale of companies, largely through mergers and acquisitions. The trends in financing along the continuum represent successive steps in the innovation process and provide indicators of the RE sector's current and expected growth, as follows:

- Trends in R&D funding and technology investment (i, ii) are indicators of the long to mid-term expectations for the sector – investments are being made that will only begin to pay off several years down the road.

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[3] Derived by stripping out the energy efficiency investment figures from United Nations Environment Programme and New Energy Finance (2009): Global Trends in Sustainable Energy Investment 2009: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency, Paris. (Will update with 2009 data.)

- Trends in manufacturing investment (iii) are an indicator of near term expectations for the sector – essentially, that the growth in market demand will continue.
- Trends in new generating capacity investment (iv) are an indicator of current sector activity.
- Trends in industry mergers and acquisitions (v) are an indicator of the overall maturity of the sector, and increasing refinancing activity over time indicates that larger more conventional investors are entering the sector, buying up successful early investments from first movers.

Each of these trends is discussed in the following sub-sections. Table 11.2 provides information about the variety of financing types, arranged by phase of technology development. Although the concept of a continuum infers a smooth transition between the different types of financing involved, the reality is that financiers each have their own risk and return expectations and have different external drivers that make the different segments less or more attractive for commercial investment.

11.2.2.2 Financing Technology R&D

Figures collected by the International Energy Agency (IEA, 2008b) are a good guide to public RE R&D spending in OECD countries up till the middle of this decade. (IEA, 2008b) provides supplementary information on spending by large non-OECD economies, while data for spending on some forms of RE technology in non-IEA European countries is provided in (Wiesenthal, Leduc et al., 2009). The IEA data suggest the heyday of public funding in RE R&D occurred three decades ago. Spending on renewables peaked at 2.03 billion USD_{2005} in 1981. As oil prices dropped, spending fell by over two thirds, hitting a low in 1989. It has crept up since then, to about 727 M USD_{2005} a year in 2006.

The relationship between spending on RE R&D and movements in the oil price illustrate the significant role that the ‘security of supply’ consideration has on government decisions to fund research into alternative sources of energy. By this logic, governments would choose to focus their attention on technologies that have greatest potential to harness natural resources that are present on their territories. Indeed, this is argued by (International Energy Agency (IEA), 2008), noting that New Zealand and Turkey have spent 55 percent and 38 percent, respectively, of their RE R&D budgets on developing geothermal energy. Non-IEA countries also justify focusing on a particular energy resource by pointing to its relative local abundance, like solar energy in India (JNNSM, 2009) and Singapore (SERIS, 2009). But there are important exceptions to the rule. Germany, for instance, spends more on photovoltaic R&D than any other country in Europe (European Commission, 2009) but does so with a view to growing a competitive export industry (IEA, 2008b).

Photovoltaics and bioenergy are each now the beneficiaries of a third of all government R&D on RE. The proportion spent on wind has remained stable since 1974 and declined for geothermal, concentrating solar and solar for heating and cooling applications. Ocean energy and other RE technologies have also received support but at a much lower level. An overview of the kind of research being funded around the world in these areas can be found in (European Commission, 2006).

It is perhaps most instructive to look at R&D spending patterns in recent years when policy support for renewables has been growing quickly. Spending on wind, bioenergy, PV and concentrating solar thermal power averaged 536 M USD annually in the EU Member States over the 2002-2006 period, compared to 226 M USD$_{2005}$ in the United States and 95.7 M USD$_{2005}$ in Japan during the same years (European Commission, 2009). The International Energy Agency (IEA, 2008b) notes that averaging figures over this period hides some steep increases in spending, which have occurred in UK, France, Hungary and China. By 2006 Chinese spending on solar and wind R&D was up in the 37 and 42 M USD$_{2005}$ range, roughly equivalent to that of Spain.

The European Commission (European Commission, 2009) provides a snapshot of how nuclear energy, fossil energy and RE spending compared against each other in 2007 (35%, 8% and 22% of total spending, respectively, with the balance going chiefly to energy efficiency). Time-series data for the shifts in spending among different categories of energy technology for OECD countries are available in (IEA, 2008b). The dominance of nuclear energy spending is still apparent, although much lower than in the 1980s.

With regard to private sector support for R&D, data is often collected by public bodies on the share of company turnover that the private sector ploughs back into R&D on its products. A company re-investing a high share of its earnings is taken to recognize that its future profitability depends on its ability to acquire new knowledge. Encouraging companies to behave in this way has long been a strategic priority of EU countries (Lisbon European Council, 2000).

There are marked differences between the R&D re-investment rates of companies headquartered in Europe and active in the energy business. The European Commission (Wiesenthal, Leduc et al., 2009) identifies the wind, PV and biofuel sectors as having rates in the region of 2.2-4.5 percent, consistent with the rates found in the sectors producing electrical components and equipment (3.4 percent) and industrial machinery. Electricity supply companies or oil majors have total (i.e., not just RE) rates of 0.6 percent and 0.3 percent, respectively, which the Commission rationalizes by saying these industries are “supplier dominated”.

11.2.2.3 Financing technology development and commercialization

While governments fund most of the basic R&D and large corporations fund applied or ‘lab-bench’ R&D, venture capitalists begin to play a role once technologies are ready to move from the lab-bench to the early market deployment phase. According to Moore and Wüstenhagen, venture capitalists have initially been slow to pick up on the emerging opportunities in the energy technology sector (Moore and Wustenhagen, 2004), with Renewable Energies accounting for only 1-3 percent of venture capital investment in most countries in the early 2000s. However since 2002 venture capital investment in RE technology firms has increased markedly. Venture capital into RE companies grew from $188 million USD$_{2005}$ to $3.81 billion USD$_{2005}$[4], representing a compound annual growth rate of 60 percent . This growth trend in technology investment now appears to be a leading indicator that the finance community expects continued

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[4] Derived by stripping out energy efficiency investment from venture capital figures in United Nations Environment Programme and New Energy Finance (2009): Global Trends in Sustainable Energy Investment 2009: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency, Paris.

significant growth in the RE sector. Downturns such as that experienced in 2008/2009 may slow or reverse the trend in the short term, but in the longer term an increasing engagement of financial investors is foreseen in RE technology development (UNEP and NEF, 2009).

Table 11.2 Table of Financing Types Arranged by Phase of Technology Development

Table of Financing Types arranged by Phase of Technology Development	
R&D	Public and corporate support for technology R&D is provided through a range of funding instruments.
Technology Commercialisation	**Venture Capital** is a type of private equity capital typically provided for early-stage, high-potential, technology companies in the interest of generating a return on investment through a trade sale of the company or an eventual listing on a public stock exchange.
Manufacturing and Sales	**Private Equity** investment is capital provided by investors and funds directly into private companies often for setting up a manufacturing operation or other business activity. (can also apply to Project Construction) Public Equity investment is capital provided by investors into publicly listed companies most commonly for expanding manufacturing operations or other business activities, or to construct projects. (can also apply to Project Construction, below)
Project Construction	Asset Finance is a consolidated term that describes all money invested in generation projects, whether from internal company balance sheets, from debt finance or from equity finance. Project Finance, debt obligations (i.e., loans) provided by banks to distinct, single-purpose companies, whose energy sales are usually guaranteed by power off-take agreements. Often known as off-balance sheet or non-recourse finance, since the financiers rely mostly on the certainty of project cash flows to pay back the loan. Corporate Finance, debt obligations provided by banks to companies using ‘on-balance sheet’ assets as collateral. Most mature companies have access to corporate finance, but have constraints on their debt ratio and, therefore, must rationalise each additional loan with other capital needs. Bonds are debt obligations issued by corporations directly to the capital markets to raise financing for expanding a business or to finance one or several projects.
Small Scale Technology Deployment	Consumer loans, micro-finance and leasing are some of the instruments that banks offer to households and other end-users to finance the purchase of small scale technologies. Different forms of SME finance is also generally needed to help companies set up the required sales and service infrastructure.

Carbon	Carbon finance in the form of loans or investment can now be accessed from some banks or investors in return for future carbon (e.g. CDM) revenue streams.
Sale of Companies	Mergers & Acquisitions involve the sale and refinancing of existing companies and projects by new corporate buyers.

11.2.2.4 Financing manufacturing facilities

Once a technology has passed the demonstration phase, the capital needed to set up manufacturing facilities will usually come initially from private equity investors (i.e., investors in un-listed companies) and subsequently from public equity investors buying shares of companies listed on the public stock markets. These forms of capital are also used to finance some of the working capital requirements of companies, with the rest coming from bank loans. Private and public equity investment in RE has grown from \$0.168 billion in 2002 (\$0.155 billion USD_{2005}) to \$18.07 billion (\$19.92 billion USD_{2005}) in 2008, representing a compound annual growth rate of 118 percent (UNEP and NEF, 2009). Even with this very fast growth in manufacturing investments several technologies had supply bottlenecks through early 2008 that delayed sector growth and pushed up prices. For example the solar sector suffered from global silicon feedstock material shortages while the wind sector experienced an undersupply of key components such as gearboxes and shaft bearings. This pressure eased in late 2008, when the economic downturn slowed order books and led to a major supply glut in the RE industry.

In 2008 stock markets in general dropped sharply, but RE shares fared worse due to the energy price collapse, and the fact that investors shunned stocks with any sort of technology or execution risk, and particularly those with high capital requirements (UNEP and NEF, 2009).

11.2.2.5 Financing Large-Scale RE Projects

Financing RE generating facilities involves a mix of equity investment from the owners and loans from the banks (‘private debt’) or capital markets (‘public debt’ raised through bond offerings). The share of equity and debt in a project typically ranges from 20/80 to 50/50, depending on the project context and the overall market conditions. Both types of finance are combined into the term ‘asset finance’, which represents all forms of financing secured for RE projects.

Asset financing to the RE sector has grown from \$6 billion in 2002 (\$5.52 billion USD_{2005}) to \$97 billion (\$106.9 billion USD_{2005}) in 2008, representing a compound annual growth rate of 59 percent (UNEP and NEF, 2009). This rate of growth outstrips actual growth in generating capacity since external investment was not the dominant financing approach early in the millennium when the sector was still being developed and financed in-house by various first mover industry actors.

In recent years capital flows available to RE projects have become more mainstream and have broadened, meaning that the industry has access to a far wider range of financial sources and products than it did around 2004/2005 (UNEP and NEF, 2008). For instance the largest component of total renewable energy capital flows today is through project finance investment (DBCCA, “Investing in Climate Change 2010: A Strategic Asset Allocation Perspective”), an approach that mobilises large flows of private sector investment in infrastructure.

11.2.2.6 Financing Small Scale Technologies

Consumer loans, micro-finance and leasing are some of the instruments that banks offer to households and other end-users to finance the purchase of small scale technologies. However most investment in such systems comes from the end-user themselves, usually through purchases made on a cash basis. Global investment in small and residential RE projects was $20 billion in 2008 (UNEP and NEF, 2008) [TSU: will need to be converted to USD_{2005}], about 17% of total investment in RE projects.

11.2.2.7 Financing Carbon

The mechanisms created through the UNFCCC include a range of instruments used to monetise the GHG offset value of climate mitigation projects. Here they are described as financing carbon, although other GHGs are also involved in this generalisation. Carbon markets include a range of instruments used to monetize the CO_2 offset value of climate mitigation projects. According to the World Bank (World Bank, 2009b), the primary carbon markets associated with actual emission reductions (i.e. the CDM, JI and voluntary transactions) decreased to US$7.2 billion in 2008, down from US$8.2 billion a year earlier. Meanwhile the overall carbon market continued to grow, reaching a total value transacted in 2008 of about US$126 billion, double the 2007 value [TSU: will need to be converted to USD_{2005}].

According to the Risø CDM Pipeline analysis, RE projects now account for the majority of CDM projects, with 60% of all validated and registered CDM projects, 35% of expected Certified Emissions Reductions (CER) by 2012 and 13% of CERs issued to date. The low share of CERs issued is mostly due to the very large industrial gases projects that have been small in number but quick to build, accounting for 75% of CERs issued to date.

The Risoe CDM Pipeline Analysis has also calculated the total underlying investment associated with building the proposed 4,968 carbon mitigation projects that have reached at least the CDM validation stage. Of the $60 billion of total projected investment, $39 billion or 65% is for renewable energy projects [TSU: will need to be converted to USD_{2005}].

11.2.2.8 Refinancing and the Sale of Companies

In 2008, $64 billion ($70.55 billion USD_{2005}) worth of mergers and acquisitions (M&A) took place involving the refinancing and sale of RE companies and projects, up from $6 billion ($5.53 billion USD_{2005}) in 2002 or 48% compound annual growth (UNEP and NEF, 2009). M&A transactions usually involve the sale of generating assets or project pipelines, or of companies that develop or manufacture technologies and services. Increasing M&A activity in the short term is a sign of industry consolidation, as larger companies buy-out smaller less well capitalised competitors. In the longer term, increasing M&A activity provides an indication of the increasing mainstreaming of the sector, as larger entrants prefer to buy their way in rather than developing RE businesses from the ground up.

11.3 Key drivers, opportunities and benefits

There are multiple factors that shape the development of energy policy, including renewable energy. This section sets out some of those other factors, as well as the mitigation potential of RE. Deployment of RE has been driven in great part by government policies, and policies for the deployment of RE are, in turn, driven by several environmental, economic, social and security goals. Drivers are factors that are pushing for the deployment of RE (for example climate change and the need to reduce fossil fuel emissions from the energy sector). Drivers can also take the form of opportunities which, for example, lead a country to invest in RE with the explicit goal of developing a new domestic or export industry. Certain benefits of RE, like for instance reduced emissions, improved health and more jobs may also drive promotion policies. The distinctions among these factors are necessarily close and overlapping. In this section we use the term “driver” to describe drivers in its narrower sense as well as opportunities and benefits. Examples from selected countries are included hear for illustrative reasons.[5]

The relative importance of the drivers, opportunities or benefits varies from country to country and may vary over time, as changing circumstances affect economies, attitudes and public perceptions. RE technologies offer governments the potential to realize multiple policy goals, sometimes simultaneously, that cannot be obtained to the same extent or quality through the development and use of conventional energies (Goldemberg, 2004b).

Key drivers for policies to advance RE are:

- Mitigating climate change
- Enhancing access to energy
- Improving security of energy supply and use
- Decreasing environmental impacts of energy supply
- Decreasing health impacts associated with energy production and use and, a key issue which is both a driver and an opportunity: fostering economic development and job creation.

In general, economic opportunities drive policies in most developing countries, where RE are often the only affordable means for providing energy access. So in terms of share on global population concerned, this driver has been most important. In most developed countries, a driver for the promotion of RE is to reduce environmental impacts of energy supplies and to decrease dependence on energy imports. In terms of RE capacity added globally in the last twenty years, the driver has been most important. In addition, the possibility of developing a new industry with related jobs is seen as an opportunity in some countries. Such motivations are of increasing importance in many emerging and developing economies as well.

11.3.1 Climate change mitigation

RE is a major component for climate change mitigation, its potential being the focus of this report. The degree to which RE mitigates climate change depends on many factors. Policy

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[5] For a comprehensive review of features of RE compared to other energy carriers refer to Chapter 9.

makers have also acknowledged that the use of RE may also increase greenhouse gas emissions in particular cases (see Chapter 10).

As a result, RE is an integral aspect of government strategies for reducing carbon dioxide (and other) emissions in many countries (Burton and Hubacek, 2007; Lipp, 2007), including all member states of the European Union (e.g. (BMU, 2006; European Parliament and of the Council, 2009). Several U.S. states, including California (California Energy Commission and California Public Utilities Commission, 2008) and Washington (CTED, 2009), and numerous U.S. cities, from Chicago (Parzen, 2009) to Miami (City of Miami, 2008), have adopted RE targets and policies to advance their strategies for addressing climate change. Over 1,300 European municipalities have joined the Covenant of Mayors by March 2010 committing them to reduce carbon dioxide emissions beyond the EU objective of 20 % by 2020 with the help of among others the deployment of RE (European Commission, 2010).

Developing countries are also enacting RE policies in order to address climate change, among other goals. The 2009 meeting of Leaders of Pacific Island Countries observed that in addition to RE offering the promise of cost-effective, reliable energy services to rural households it will also provide a contribution to global greenhouse gas mitigation efforts (Pacific Islands Forum, 2009).

11.3.2 Access to energy

This section explores the goal of universal access to energy as a driver of RE technologies. Broader ‘access’ issues for RE technologies, such as access to networks or resources is discussed in Sections 11.4 and 11.6.

Renewable energies have the ability to effectively and quickly provide access to affordable modern energy services, including lighting, communication, and refrigeration, and therefore RE plays an important role in achieving the millennium development goals (Flavin and Aeck, 2005). Distributed RE can avoid the need for costly transport and distribution networks, which can make energy more costly for people in poor, remote communities than it is for urban populations (Flavin and Aeck, 2005). Access to modern, cleaner energy may also reduce indoor air pollution, improving infant and maternal health; it advances education, agriculture and communications; it improves income generation; and it supports hunger eradication (Asian Development Bank, 2007; Asian Development Bank, 2009).

One of the benefits of RE technologies is that the size of the plant can be adapted in response to the energy resource or demand at hand. Moreover the capacity addition of some RE technologies, such as wind energy or photovoltaics, can be in modular form, making it adaptable to increasing demand. Also because of their modularity and flexible size, RE technologies have received increased attention from governments looking to electrify rural and remote areas [Authors: Reference missing]. Another significant benefit of RE is that it often provides the lowest-cost option for remote and off-grid areas (Mahapatra et al. 2009; Pereira et al. 2006)

Programmes to increase the rate of access to energy and based on RE have occurred in many countries. For example, in 1996, the Government of Nepal established the Alternative Energy Promotion Centre for RE technologies in non-electrified areas to improve the well-being of the country’s impoverished rural population [Authors: Reference missing]. Likewise in Nigeria, where two-thirds of the population lives in rural areas, the government’s Renewable Energy Master Plan calls for RE deployment to improve energy services to the poor and thereby advance rural economic development (Energy Commission of Nigeria and United Nations Development Programme, 2005). Other developing countries—including Bolivia (REN21, 2009b), Bangladesh (Urmee, Harries *et al.*, 2009), Brazil (Pereira 2009) China (The Peoples Republic of China, 2005) India (Hiremath, Kumar *et al.*, 2009), Mozambique (Fundo de Energia 2007); Nepal (MEST, 2006), Pakistan (Government of Pakistan, 2006), Tonga, South Africa (Department of Minerals and Energy, 2003), and Zambia (Haanyika, 2008)—have adopted RE policies for providing energy access to rural areas.

Energy access is not just a developing country issue (European Commission, 2006). Low income households in developed countries generally spend substantially higher shares of their income on energy than do higher income households. Policy makers have identified RE as one potential means to ensure affordable energy services to low income households;(Walker, 2008a). Examples of these programmes include the Weatherization Assistance Program in the United States [Authors: Reference missing] and the linking of Carbon Emission Reduction Target to fuel poverty in the UK (DECC, 2009).

Policy makers have also regarded RE, many of which can be used for decentralized systems, as a means to provide independence from central energy supply structures, thus allowing customers more freedom, control and governance on how energy is sourced and systems are managed Examples can be drawn from more than few hundreds micro hydro power plants that are managed, operated by local communities (Chhetri, Pokharel et al., 2009). In this respect, renewable energy technologies empower communities and allow more democratic decisions as opposed to centralised decisions of companies not controlled by public will.

11.3.3 Energy security

The addition of RE technologies to the broad energy mix alters concerns of energy security in different ways. The addition of RE to networks, gas or electricity, introduce new issues to its operation, and this is dealt with in Chapter 8. However, RE power plants may make a power grid more robust against grid failures and break-downs (Sawin and Hughes, 2007) thereby increasing the energy security of that system. Decentralizing energy systems, via RE or other options, can also reduce vulnerability to energy disruptions that might result from damage to infrastructure resulting from natural disaster or attack (Sawin, 2006). Some U.S. states rely on solar power, wind and other distributed generators for public safety and emergency preparedness purposes (Sawin, 2006).

RE can diversify energy supply portfolios. Thereby RE represents a portfolio in itself with different sources tapped. Diversity has a number of energy system benefits (Stirling, 1994) but the use of RE may also displace the need for other fuels. This is particularly valuable for countries that import large amounts of energy, or are particularly dependent on one fuel source or supplier (Lipp, 2007; Chien and Hu, 2008; Katinas, Markevicius *et al.*, 2008; Lee, Mogi *et al.*, 2009) (Hedanus, Azar et al, 2010). For example, China established its 2005 Renewable Energy Law, among others, to diversify energy supplies and safeguard energy security (Standing Committee of the National People's Congress, 2005). Brazil has promoted ethanol from sugarcane as an alternative to fossil transport fuels for thirty years to decrease dependency on imported fuels (Pousa, Santos *et al.*, 2007). The Jamaican Government aims to diversify its energy portfolio by incorporating RE into the mix, reducing reliance on oil (Government of Jamaica, 2006). RE sources are not necessarily domestic as for instance international trade with solid biomass (Ericsson and Nilsson, 2003), with ethanol (Walter, Rosillo-Calle *et al.*, 2008), and prospectively with power from solar energy (Battaglini, Lilliestam *et al.*, 2009) indicates. Thus REs do not necessarily decrease dependency on energy imports in general but they are a means to diversify energy supply in any case.

Even countries that are rich in fossil fuel reserves are recognizing that their fuel production could peak and begin to decline in coming years (Reiche, 2010). As a result, meeting demand for domestic use and/or for export could become increasingly challenging. One of the drivers for Nigeria's Renewable Energy Master Plan is the recognition that its petroleum age will likely end in a few decades. While increased exploitation of gas provides a bridge to a low carbon energy future, renewables loom large in the long-term energy vision for the country (Energy Commission of Nigeria and United Nations Development Programme, 2005).

Fossil fuel imports, which result in large budget and trade deficits for many developing country nations, have undermined their ability to meet the needs for basic services such as education, health care, and clean water (Flavin and Aeck, 2005). In contrast, many governments have regarded RE (particularly biofuels) as a means to enhance national balance of trade by substituting domestic renewable fuels for imported fuels (The National Greenhouse Strategy, 1998; Department of Minerals and Energy, 2003; DTI, 2007; Smitherman, 2009).

Finally, a 2005 study by the U.S. Department of Defense found that RE can provide reliable, flexible and secure electricity supplies for many installations and for perimeter security devices at remote installations, thereby enhancing the military's mission (U.S. Department of Defense, 2005).

11.3.4 Fostering Economic Development and Job Creation

A report by Goldemberg (2004) that compiled the results of several studies found that RE technologies have far greater job creation potential than do fossil fuel or nuclear-based energy systems.[6] The European Union underlines the potential of job creation - especially in rural and isolated areas - in the reasoning for the Directive on the promotion of the use of energy from renewable sources (European Parliament and of the Council, 2009). Manufacturing and operation of RE have led to a total of 157,000 jobs in Germany in 2004, and this number has grown to 280,000 in 2008 (Lehr, Nitsch *et al.*, 2008). Spain has more than 1,000 enterprises in the RE industry, employing 89,000 workers directly and an estimated 99,000 indirectly (Sainz, 2008). An EU modeling exercise found that, conservatively and under existing policies, the RE industries would have about 950,000 direct and indirect full-time jobs by 2010 and 1.4 million by 2020 in the EU-15. These are net numbers that account for projected losses elsewhere in the economy (UNEP, 2008). Developing domestic markets for RE are also seen as a means to attract new industries which may supply international markets in a second step thereby gaining competitive advantages. (Lewis, 2007; Lund, 2008). Policies to promote energy crops have been established to create new income streams for farmers allowing the adaptation of traditional policies to support the agricultural sector.

Similarly, RE development activities are providing significant employment in developing countries, e.g. the Nepalese biogas programme that has installed more than 200,000 individual

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[6] Chapter 9 discusses employment effects in more detail

household biogas plants employs more than11,000 people [Authors: Reference missing]. The South African government recognizes that, since the White Paper on Energy Policy was published in 1998, great strides have been made in empowering historically disadvantaged South Africans by redressing historical racial and gender imbalances in employment through RE [Authors: Reference missing]. And the Energy Research Institute and Chinese Renewable Energy Industries Association estimate that China's RE sector employed nearly one million people in 2007, with most of these in the solar thermal industry (UNEP, 2008).

Deployment and development of RE industries offer significant potential for economic development and job creation. However, the weight of such an assertion is weakened by the absence of an agreed method for calculation of economic development from RE, including the number of jobs created and the number of jobs omitted in other sectors (e.g. (Sastresa, Usón *et al.*, 2009).

Rural development is often tied with the deployment of RE in developing countries. The biogas program, operated by the Nepalese Alternative Energy Promotion Center together with the Dutch development organisation SNV, links the deployment of RE with its socio-economic development program. Digestate, a co-product in the generation of biogas, is widely promoted to boost cash crops and agriculture production. Micro-hydro technology is being used to run transport systems . In much of the world, the development and availability of information and communication devices have prompted companies and communities to develop electricity supply, and the easiest way is often through RE [Authors: Reference is missing]. Biogas systems in Shanxi Province, China, financed by local government subsidies and a local environmental association, have saved households money on fuel wood or coal, electricity, and fertilizer costs. The residue fertilizer has also increased food production, enabling household incomes to rise by as much as 293 USD annually ($302.45 USD$_{2005}$) (Ashden Awards for Sustainable Energy, 2006) referenced in (Droege, 2009)

In the developed and developing world, RE is seen as a means for increasing eco-development or tourism, and for driving economic (re)vitalisation. For example, the Austrian town of Güssing saw up to 400 tourists weekly by the late 2000s, coming to learn from the town's shift to RE. A new hotel, heated and powered by RE, was built to accommodate the influx of tourists (Droege, 2009). The Navarre region in north-eastern Spain has witnessed creation of thousands of jobs and revitalization of many old villages since it began installing wind turbines in the early 1990s. Populations of Iratxeta and Leoz, for example, doubled after the installation of local wind farms (Droege, 2009).

11.3.5 Non-Climate Change Environmental Benefits

The benefits of sustainable RE may include improvements in air and water quality, and reduced impacts of fuel extraction, and energy production and use on biodiversity. For example, recognition of the risks to health, particularly to women and children (Syed, 2008), brought about by poor air quality indoors and out, has led governments to establish a range of initiatives, including policies to advance RE. For example, avoiding negative environmental impacts is a major driver to promote clean energy technologies in China (Standing Committee of the National People's Congress, 2005; Gan and Yu, 2008) ; the government of Pakistan intends to develop RE in order to avoid local environmental and health impacts of unsustainable and inefficient traditional biomass fuels and fossil fuel-powered electricity generation (Government of Pakistan, 2006). The South African government, recognizes that inadequate living conditions and the lack of infrastructure in much of the country means that millions of people are routinely exposed to noxious gases and particulates from fossil fuel burning; thus, the need to improve air quality is a motivating factor in plans to deploy renewable energy technologies(Department of Minerals and Energy, 2003).

There is a growing recognition among scientists and policy makers that the exploitation of energy resources, if not properly controlled and managed, will have harmful impacts on biodiversity of plant and animal species (IPCC, 2002). Growing awareness of this potential of RE technologies has led governments to establish targets, or adopt other policies, to increase RE deployment. For example, the Commonwealth of the Bahamas pays special attention to RE technology as a means to sustain vulnerable ecosystem services (National Energy Policy Committee, 2008). In Nepalese villages, RE systems have been deployed to mitigate negative impacts on biodiversity resulting from the unsustainable use of biomass (Zahnd and Kimber, 2009).

However, policy makers have also recognized that not all RE are necessarily environmental sound and may even have negative impacts on the climate. For this reason, the German government has issued an ordinance on requirements pertaining to sustainable production of bioliquids for electricity production (German Federal Ministry for the Environment, 2009).

11.4 Barriers to RE policy-making and financing

This section focuses on the barriers to putting RE policies in place and barriers to RE financing to enable those policies being implemented. Chapter 1 offers an overview of barriers to RE development and implementation It categorises the barriers as: information and awareness; socio-cultural; technical and structural; economic and institutional and this section follows the same categories. The technical Chapters (2 to 7) cover the technology specific barriers, with Chapter 8 addressing energy system lock-in and RE integration. Barriers to the deployment of sustainable development potentials are discussed in Chapter 9. This final Chapter provides no overview or synthesis of the barriers covered in the preceding chapters.

This section 11.4 describes the barriers to policy-making; Section 11.5 sets out the policies which in large part are designed to overcome various barriers to RE as set out in Chapter 1, not only those related to policy-making. Section11.6 is also written in such a way that the key barriers to RE are matched by a dimension of the enabling environment to further overcome.

11.4.1 Barriers to RE Policy

As highlighted in Chapter 1, the categories of barriers to RE are not entirely unambiguous, and some can be argued to be in more than one category. Bearing this in mind, the central barriers to implementing RE policy are:

11.4.1.1 A Lack of Information and Awareness

- There is limited consensus on how the transitions of the various energy systems in the world would best proceed. Low-carbon energy portfolios may be composed of varying degrees of improved energy efficiency, increased RE supplies, fast-track development of carbon capture and storage at large fossil fuel conversion installations, or a new boost for nuclear power. Assessments of the different portfolios on transparent sets of sustainability criteria are generally lacking (IEA, 2006; IEA, 2008a).

- Many policy-makers lack the required knowledge to, and experience of, pro-actively integrating RE supplies with other low-carbon options (like energy efficiency), with other policy goals (such as poverty alleviation; spatial planning), and across different sectors such as agriculture, housing, education, health, telecommunication, tourism, transportation and industry [Authors: Reference is missing].
- RE technological development is uncertain, dynamic, systemic, and cumulative (Grubler, 1998; Fri, 2003; Foxon and Pearson, 2008). RE sources are local and circumstantial; their inventory and development requires multi-disciplinary expertise (Twiddell and Weir, 2006). Staying informed about the best technical options for local conditions requires time and links to the practitioner and scientific communities.
- Experience of how to enable a comprehensive transition to a sustainable energy system is not available, although there is some understanding of how energy transitions have occurred over the past centuries (Fouquet, 2008). While it is argued by some that a transformation to a low carbon energy system can only emerge from interactions between multiple interest groups covering specific stakeholders, such as individuals and businesses, and also wider institutional and social constituencies (Smith, Stirling *et al.*, 2005; Verbong and Geels, 2007), this is still an absence of evidence of how to do it.

11.4.1.2 Socio-Cultural

Changing energy behaviour is not a simple, nor a mechanical process. While prices, information, education and technological availabilities contribute to changing people’s ways of producing and consuming energy, energy behaviours are not dictated by context variables in a mechanical way. This is especially the case for what is called “active” behaviour – the fact of actually changing “ways of doing” with energy, such as adopting a distributed RE technology or switching to a RE electricity supply – as opposed to “passive” behaviours – the fact of subscribing to a campaigning NGO, or supporting a policy to increase the share of RE in the supply mix. This translates into a slow build-up of support for RE, followed by pressure to have RE policies; and then a complex active-passive interaction with the outcomes of those policies.

- Behaviour relates in a complex way to individual values (Stern, Dietz, Abel, Guagnano & Kalof 1999), attitudes (Ajzen 1991), personal norms (Oskamp 2000), social norms (Cialdini 1990) and current ways of living (Sovacool 2009 ; Shove, 2003, 2004). This makes it sometimes difficult to find ways of sustaining a shift from “passive” to “active” behaviours.
- There often remains a gulf between the high levels of “passive” support for RE found in opinion polls [reviewed in Devine-Wright 2005] and the lesser extent of active support for distributed generation and renewable energy (Sauter & Watson 2007; McGowan & Sauter 2005; Bell et al 2005).

11.4.1.3 Technical and Structural

Energy use and supply is a complex, global technical-socio-economic activity (Williamson, 1985; IEA, 2009c). Most energy systems worldwide are still fossil fuel based (IEA, 2009c). Economic regulation of markets and networks with their rules, standards and licenses which maintain the character of those fossil fuel based energy systems occupy a central place. The existing energy system exerts a strong momentum for its own continuation (Hughes, 1987), which Locks-in and locks-out new technologies and ways of doing things (Unruh, 2000) and this leads to the following barriers to policy making:

- the encumbants of a system includes specialised and skilled staff, organizational strength, influential networks, and lobbying power (Hughes, 1986; Hall, 2003).
- Technical, administrative and political codes, procedures and laws constrain the scope, applicable instruments, and time horizon of change via public regulation (Mitchell, 200).
- Regulatory and administrative frameworks set up for non-renewable energy sources do not need to address market failures for RE. For example, split – incentives relate to the lack of incentive for a tenant to improve their rented home or land; or between owners of water rights to install a hydro plant that might benefit a riverside village, despite benefits which the latter may accrue; or between a lack of understanding on the part of policy-makers or officials living in urban areas of the benefits RE may bring rural populations (Beck and Martinot, 2004).
- The current educational and skill base unduly supports incumbent technologies and firms as distinct from potential ones, thereby failing to react quickly enough to the emergence of new generic technologies. This then leads to inadequate workforce skills due to an absence of, or insufficient capacity, for training. This constrains the rate at which RE installations can be constructed, repaired and maintained. It constrains the knowledge on emerging options; it aggravates a low awareness and acceptance by authorities, companies and the public.
- The socio-political aspect of momentum also ensures change is constrained. Apart from an asymmetry of information, regulators, policy-makers and politicians may lack commitment, have their own hidden agendas, or be captured by interest groups and as a result may not optimize ‘social welfare’ (Laffont and Tirole, 1998)

11.4.1.4 Economic

- Discourse and action in the energy world is still based on the concept of “cheap fossil fuels” and “affordable nuclear risks” (IEA, 2006; IEA, 2008b). The external costs and risks of non-sustainable options continue to be insufficiently recognized, identified , quantified and incorporated (Beck and Martinot, 2004, Renewable Energy Technology Development (RETD), 2006). This means that energy markets continue to favour fossil fuels and nuclear power more than they should. While it is widely accepted that the social costs of energy use should be incorporated into the price of energy (Stern, 2006), it is difficult to measure those social costs (Stirling, 1994). Even accounting for the difficulties of appropriate measurement, public energy policies are only modestly moving in the direction of full social cost pricing (Stewart, Kingsbury et al., 2009).
- Well-intended regulations can turn perverse when not carefully designed and operated. Willis et al. (2009) document several barriers for RE under the CDM, for example. RE projects are at a comparative disadvantage in the CDM compared to projects which reduce other types of greenhouse gases (e.g. landfill methane flaring, HFC23 destruction)

because of insufficient regulatory certainty, difficulty in attracting project finance and high transaction costs (Stewart et al, 2009).

11.4.1.5 Institutional

- The building blocks, or enabling environment, of a successful RE policy may not be in place, and it may not be clear to policy-makers of all levels, whether international through to local, what institutions are required to get a policy going; and support to understand their best practice possibilities may be absent (Renewable Energy Technology Development (RETD), 2006) Clear goal setting implies boosting sustainable innovation regimes and operational dialogues with stakeholders (van den Bergh and Bruinsma, 2008); but a planning framework or inter-agency coordination may not exist or be rudimentary (ECLAC, 2009)
- RE project developers face a number of administrative barriers. There can be many authorities involved in deploying RE and a lack of co-ordination between them. A different acceptance of RE benefits between national and local authorities or disagreements on spatial planning rules for accommodating RE installations may lead to a long process for obtaining the necessary permits (OPTRES, 2007).

11.4.2 RE Financing barriers

As we have seen, there are many barriers to RE deployment and policy and market failures to overcoming them. This section focuses on their effect on the availability of financing.

Renewable energies represent a major step-change innovation as compared with existing energy-supply options. In terms of scale, capacity, energy resource characteristics, points of sale for output, status of technology, and a number of other factors, RE technologies are usually markedly different from conventional energy systems. The differences are not lost on financiers, as financing a RE plant is different from financing conventional fossil-fuelled power plants and requires new thinking, new risk-management approaches, and new forms of capital.

To become more effective at placing capital in RE markets, financiers must travel up a learning or experience curve. Market failures impede this learning process and create barriers to entry into the market. To operate effectively, markets rely on timely, appropriate, and truthful information. In perfect markets this information is assumed to be available, but the reality is that energy markets are far from perfect, particularly those like the RE market in technological and structural transition. As a result of insufficient information, underlying project risk tends to be overrated and transaction costs can increase (Sonntag-O'Brien and Usher, 2004).

Compounding this lack of information are the issues of financial structure and scale. RE projects typically have higher capital costs and lower operational costs than conventional fossil-fuel technologies. The external financing requirement is therefore high and must be amortised over the life of the project. This makes exposure to risk a long-term challenge. Support mechanisms like the CDM fail to directly address this barrier “until recently CER purchasers, even where those purchasers are financial institutions, have largely tended to limit their involvement in the project to being an off-taker of CERs, with payment to be made upon delivery, rather than providing project finance or becoming equity participants in the project” (Willis, Wilder *et al.*, 2009).

Since RE projects are typically smaller, the transaction costs are disproportionately high compared with those of conventional infrastructure projects. Any investment requires initial feasibility and due-diligence work and the costs for this work do not vary significantly with project size. As a result, pre-investment costs, including legal and engineering fees, consultants, and permitting costs have a proportionately higher impact on the transaction costs of RE projects. These costs apply as well to the CDM where, according to Willis and Wilder, the transaction costs of developing smaller scale RE projects as CDM projects may be prohibitively high compared to the volume of CERs expected to be generated (Willis, Wilder *et al.*, 2009). Furthermore, the generally smaller nature of RE projects results in lower gross returns, even though the rate of return may be well within market standards of what is considered an attractive investment.

Developers of RE projects are often under-financed and have limited track records. Financiers therefore perceive them as being high risk and are reluctant to provide non- recourse project finance. Lenders wish to see experienced construction contractors, suppliers with proven equipment, and experienced operators. Additional development costs imposed by financiers on under-capitalised developers during due diligence can significantly jeopardise a project.

11.5 Experience with and Assessment of Policy Options

Key Messages of Section 5

Most knowledge about policy mechanisms is to do with Feed-in-Tariffs and Quotas for renewable electricity. Because of this, there is a good understanding of their benefits and difficulties, their costs and their success. Although there are many other options for supporting RE, as set out in Table 11.1, often these options have only been tried in a few places and for a short period of time so there is less clarity about their value, difficulties, success, cost and so forth.

To date only a handful of countries have implemented effective support policies that have accelerated the diffusion of renewable technologies. (IEA, 2008a).

There are many ways to judge the success of renewable energy policy mechanisms. The most usual is via efficiency and effectiveness. Fairly clear and accepted methodologies of how to do this have been developed. There are other ways to assess renewable energy mechanisms, for example increased access to energy; improved health and so on, but there is not necessarily good evidence or information to do this very well.

The diversity of contexts for RE requires a policy designed for a particular place and use, and where possible having learnt from experiences in other contexts. It is therefore not possible to make a general statement such as: a FIT is better than a Quota mechanism, or vice versa. However, it is possible to make more specific statements, for example, that a FIT is better than a Quota mechanism if an energy policy goal is new renewable energy entrants; or a Quota mechanism is better than a FIT if a goal of the policy designers is to know the maximum annual cost of it.

The cost of moving to a sustainable energy system has been quantified in the hundreds of billion of dollars (Chapter 8), including maintenance and upgrades. This is so large that both public and private investment and involvement is required. Well designed policies reduce the risk of investment. These help both the flow of private finance, but also reduce the cost of capital, thereby initiating a virtuous cycle for investment.

Carbon and RE interact in different ways. Carbon policy is not enough on its own to encourage sufficient deployment of RE.

The diversity of contexts requires adapted support policies and mechanisms that however can learn from experiences in other contexts.

RE policies are necessary to effectively and efficiently fulfil the various energy policy and technical integration issues asked of them and discussed in Chapters 1, 8, 9 and 10, including overcoming the large number and variety of economic, technical, social and other barriers as outlined in Chapter 1 and Section 11.4.

The Globe is faced with a different policy challenge with respect to climate change and the need to move to a low carbon energy system. While there have been very many past transitions, none before have been required to occur at a certain rate to meet a scientific outcome (Fouquet and Johansson, 2008). This means well-designed, strategically directed RE policy design is extremely important.

This section explains the available instruments, and their design, that policy makers can select to support RE technologies from their infant stages through to maturity and growth. Early on in a technology's development, R&D support is required. As a technology moves through its development cycle, different types of Government policies (for example, regulatory or fiscal) can be initiated (see Figures 11.5 and 11.6). These policies should, ideally, work together to create a virtuous cycle of support. (see Figure 11.5). Well designed policies should attract more private investment. This should lead to more deployment and cost reduction which in turn should attract more private investment (Hamilton, 2009), which also feeds into the virtuous cycle, whilst also leveraging public money as far as possible.

Section 11.5 provides analysis of policy design and what makes various policies most effective. It covers only those policies specifically targeting RE advancement; a full discussion of other policies required to create an enabling environment is provided in 11.6. Section 11.5.1 introduces the range of policy options available for developing and promoting RE, including government RD&D, and regulatory, fiscal and financial instruments as summarized in Tables 11.1 and 11.2. Section 11.5.2 gives an overview of policies for RE technology development and 11.5.3 discusses issues specific to developing countries. The next three sections examine policies to promote deployment of RE electricity (11.5.4), RE for heating and cooling (11.5.5), and for transportation (11.5.6), respectively. The section is summarised in 11.5.7. All of this occurs within an enabling environment, to a greater or lesser degree. This section has incorporated the policy issues related to financing through the relevant sub-sections of 11.5. 11.5.1 describes general policies for financing – specific policies for electricity, H&C, developing countries are in those sections.

11.5.1 Laying out the Policy Options

This section describes policy options in place around the world. It is possible to categorise and divide these policy in a number of ways (for example, those directly effecting RE price or those effecting RE demand). Our division is set out in Table 11.1 as regulatory, fiscal, public finance (including R&D) and other mechanisms, such as Government (or any other) procurement or green pricing.

Those policies can also be differentiated between those which provide technology push support, which tend to occur at the start of their development, and demand pull policies, which are implemented as the technology becomes nearer competitiveness. An appropriate balance between technology push and demand pull policies for any given technology can lead to a virtuous cycle of reducing costs, increasing investment and increasing demand and deployment (See Figure 11.5). Technology push policies can improve technologies and reduce their costs, attracting investment which can, along with demand pull policies, help introduce them to the market cycle and lead to greater deployment. The demand pull also helps to reduce their costs which in turns makes them more attractive in the market, which increases deployment which allows technology learning to occur, thereby improving the technology. In this virtuous cycle, investors have confidence in the technology, as a result of the earlier R&D, and capital becomes easier to access, leading new companies to enter the market and to increased competition for market shares through additional R&D investment for technological improvement. Designing a series of policies which together enables this virtuous cycle will lead to effective and efficient technology development and deployment. This section shows how this can be done. The general policy options available to policy makers, as set out in Table 11.1, are described. Greater detail about them occurs in the relevant renewable electricity, heating and cooling and transportation sections of 11.5.4, 11.5.5, and 11.5.6.

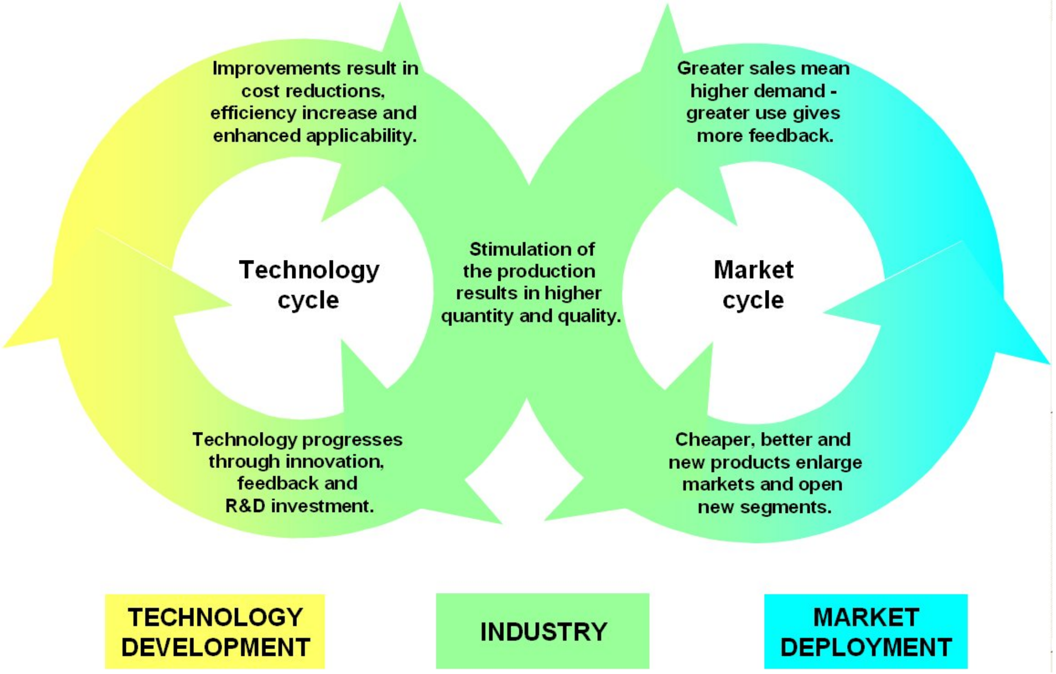

Figure 11.5 The mutually-reinforcing “virtuous cycle” of technology development and market deployment drives technology costs down (IEA, 2003).

11.5.1.1 Policies for Different Targets

RE policies can provide support from the R&D technology area through to payments for installed or available production capacity (heat or power), or generated electricity or produced heat (kWh). Both capacity and generation supplies can be qualified by RE source (type, location, flow or stock character, variability, density), by technology (type, vintage, maturity, scale of the projects), by ownership (households, co-operatives, independent companies, electric utilities), and other attributes that are in some way measurable which allows the amount of support to be made contingent upon it (Jacobsson and Lauber, 2006; Mendonça, 2007; Couture and Gagnon, 2009; Verbruggen and Lauber, 2009)). RE may be weighed by additional qualifiers such as time and reliability of delivery (availability) and other metrics related to RE's integration into networks (Klessmann, Nabe *et al.*, 2008; Langniß, Diekmann *et al.*, 2009).

11.5.1.2 Who enacts Policy?

Several levels of public authorities can be involved in implementing RE policies. International institutes may agree on goals and mechanisms (for example the International Energy Agency); some can enact Directives (for example, the European Commission; others mainly enhance understanding and awareness and distribute information (for example REN21 and IRENA). National Governments can vote laws, assign different policies and adapt, or create, regulations and other enabling environment dimensions (see 11.6). State, provincial or regional, and municipal or local initiatives may provide important support for local policies. In some countries, regulatory agencies and public utilities may be given responsibility for, or on their own initiative, design and implement support mechanisms.

11.5.1.3 Who benefits from Policy?

The direct beneficiaries of the policies are those across the technology development spectrum, although ultimately it is society. Beneficiaries range from scientists through to financing companies (banks, venture capitalists); incumbent energy supply companies owning, for example, grid assets, through to independent power producers such as local companies or public institutions; and industrial and commercial companies through to farmers, households, community-based co-operatives and other social innovations (Kok, Vermeulen *et al.*, 2002; Fouquet and Johansson, 2008).

11.5.1.4 Who pays for Policy?

Payment for technology push type-support tends to come from public budgets (multinational, national, local). Demand-pull mechanisms tend to place the cost on the end-users. For example, the cost of a renewable electricity policy is added to the electricity, although with exemptions or re-allocations for industrial or vulnerable customers where necessary or for equity or other reasons (Jacobsson, Bergek *et al.*, 2009) note that, if the goal is to transform the energy sector over the next several decades, then it is important to minimise costs over this entire period. However it is important to include all costs and benefits to society in that calculation. With this in mind, there is evidence that it may be cheaper to provide significant national investment over a period of perhaps 15 to 20 years – in order to bring renewables rapidly down their learning curves and reduce costs rapidly– rather than to introduce RE relatively slowly, with an associated slower reduction in costs (Fischedick, Nitsch *et al.*, 2002).

11.5.1.5 Description of Policy Options for Deployment and Infrastructure

Policy options available to policy makers can be divided primarily between regulatory, fiscal, public finance and other, as set out in Table 11.1.

- The regulatory policies are described as access based (meaning they are either related to payment for RE once it has accessed the distribution grid, beyond self-generation; or related to rules of connection access to a grid or rules for taking RE generation before other sorts of generation); Quota driven (such as obligations or mandates; Tendering/Bidding, Mandating, Tradable Green Certificates (TGC)); Price driven (Feed-in tariffs, premium or bonus payments); and Quality driven (such as green energy purchasing, green labeling and guarantees of origin).
- The Fiscal policies related to accelerated depreciation, investment grants, subsidies and rebates, energy production payments, production or investment tax credits; reductions in taxes (for example sales tax, VAT and so on)
- Public finance policies relate to grants; equity investments, loans and guarantees; and
- Other policies include public procurement.

The details of these are set out in the end-use sections.

11.5.1.6 The link between policy and finance

Policies, and their design, play an important role in improving the economics of renewable energy systems, and as such can be central to attracting private finance and influencing longer-term investment flows. Stern et al (2009) have proposed that governments have a role to play in reducing the cost of capital and improving access to capital by mitigating the key risks involved, particularly non-commercial risks that cannot be directly controlled by the private sector (Stern, 2009).

Private sector investment decisions are underpinned by an assessment of risk and return. Financiers want to make a return proportional to the risk they undertake, the more risk means a greater return will be expected [Finance Guide, 2009]. Expectations about the level of risk that will be taken, and the returns required varies with different financial institutions across the spectrum (see Figure 11.6). A policy framework to induce investment will need to be designed to reduce risks and enable attractive returns, and be stable over a timeframe relevant to the investment. To be fully effective, or 'investment grade', policy needs to cover all of the factors (see Box 11.3) relevant to a particular investment or project (Hamilton, 2009).

Box 11. 3 Investment Grade Policies

General features of investment grade policies include:

- Clearly set objectives: financiers may want to anticipate a policy review or change should progress not be on track. Policy design to achieve the objective may also differ: for example achieving a simple volume increase of renewable energy and seeking a diversity of renewable technologies within the energy mix are likely to require different incentive design.
- Stability across project-relevant time horizon: project finance may cover a 15 year period or greater. The legal or mandatory nature of goals and support mechanisms can foster greater confidence in policy and regulatory stability, together with a clear enforcement or penalty regime.

- Simplicity: complex market systems can increase risk and uncertainty, compared to more straightforward ones.

For a specific project, relevant policy areas include:

- Planning or licensing approval: clarity over average timeframe to move through the planning process and costs involved are directly relevant. Financiers will want to know if experience indicates a long planning period with a track record of objections, or multiple approvals from different agencies, that could delay project start-up (and revenue generation), this could prove unattractive
- Support mechanisms/incentives : a crucial part of making returns attractive; the design of mechanisms including feed-in tariffs will be important, with one international bank describing the design features as ‘transparency, longevity and certainty’ (Deutsche Bank, 2009) review provisions will also be closely scrutinised.
- Policy coherence across any relevant national or international supply chain, e.g. policies that might impact access to biomass feedstock; sustainability, water etc.
- Grid or infrastructure availability, access and costs: projects are unlikely to get financed if there is uncertainty over the availability of underlying infrastructure e.g. for offshore grid for offshore wind projects. The ability to sign a long-term power purchase agreement from a creditworthy off-taker may also be a key part of the financing equation. Infrastructure has implications for sequencing of planning and policy, as well as anticipating new regulatory needs.

A regional policy perspective, beyond national boundaries, may be increasingly relevant for larger scale penetration of renewable energy, with respect to anticipating medium-term rising levels of interconnection, particularly electricity, which could have implications for energy trading, energy pricing and so on. Source (Hamilton, 2009)

11.5.1.7 When public finance is needed

In addition to regulatory and fiscal policies, the provision of public finance can also be needed in some areas. For many renewable energy projects the availability of commercial financing is still severely limited, particularly in developing countries, where the elevated risks and weaker institutional capacities frequently inhibit private sector engagement. The gaps can often only be filled with financial products created through the help of public finance mechanisms (PFM). In addition, public financing can be required also for helping the commercial investment community gain experience with the new types of revenue streams that renewable energy projects provide, such as carbon and green certificate revenues delivered through new regulatory instruments. Without an understanding of these revenue streams, few investors will be willing to provide the up-front finance for these capital intensive projects. Having a public entity co-invest up-front capital in a project can provide the sort of comfort factor that private investors need to enter this space.

The fiscal policies include accelerated depreciation, reduction in sales VAT, energy production payments, production tax credits, capital and investment grants/subsidies and rebates. All of these are intended to make RE more competitive relative to other sources of energy.

Tax credits amount to tax-deductible sums that are calculated as pre-defined fixed amounts or a percentage of total investment in an installation. Investment tax credits focus on initial capital costs, whereas production tax credits address operating production costs. Credits can then be applied against other investments. Tax reductions and exemptions generally cover property, sales and value added tax and act directly on the total payable tax, thereby reducing its magnitude and thus the total cost associated with development (Connor, Bürger *et al.*, 2009b).

11.5.1.8 Other Options

Public procurement of RE and energy efficiency technologies is a frequently cited but not often utilized mechanism to reduce the long-term costs of purchased fossil fuel while stimulating the market for RE systems. The potential of this mechanism is significant: in many nations state and federal energy purchases are the largest components of public expenditures, and in many nations the state is the largest consumer of energy (IEA, 2009b).

11.5.2 Policies for Tech. Development

Key Section Messages

The costs of the transition to a low carbon economy are so large, that Governments are aiming to leverage their funding as far as possible with private collaboration and investment across the technology development spectrum

Policy measures in the RD&D sphere are becoming more collaborative and innovative as they seek new means of tapping into potential financiers, investors and innovators.

The amount of funding is not the only important factor – achieving an appropriate balance between R&D and deployment funding can accelerate 'learning' as can supporting efforts for 'bricolage' (or the steady progression of small scale learning which sum up to large scale innovation) rather than 'breakthrough' (i.e. focusing on large scale innovation)

Specific policies in support of renewable energy are required from the early stages of technology development through to when they become commercially mature. An important Government role is to fill in the 'gaps' in this continuum where support for technology development is lacking, while at the same time encouraging input (i.e. financial /in-kind support) from other sectors where possible. (Smith, Stirling *et al.*, 2005, IEA, 2008) (Stirling, 2009). A technology in the early and mid-stages of commercialization can enter a virtuous cycle of development, discussed above, as a result of the interaction of appropriate technology push and demand pull policies and enabling inputs, as set out in Figure 11.6 below.

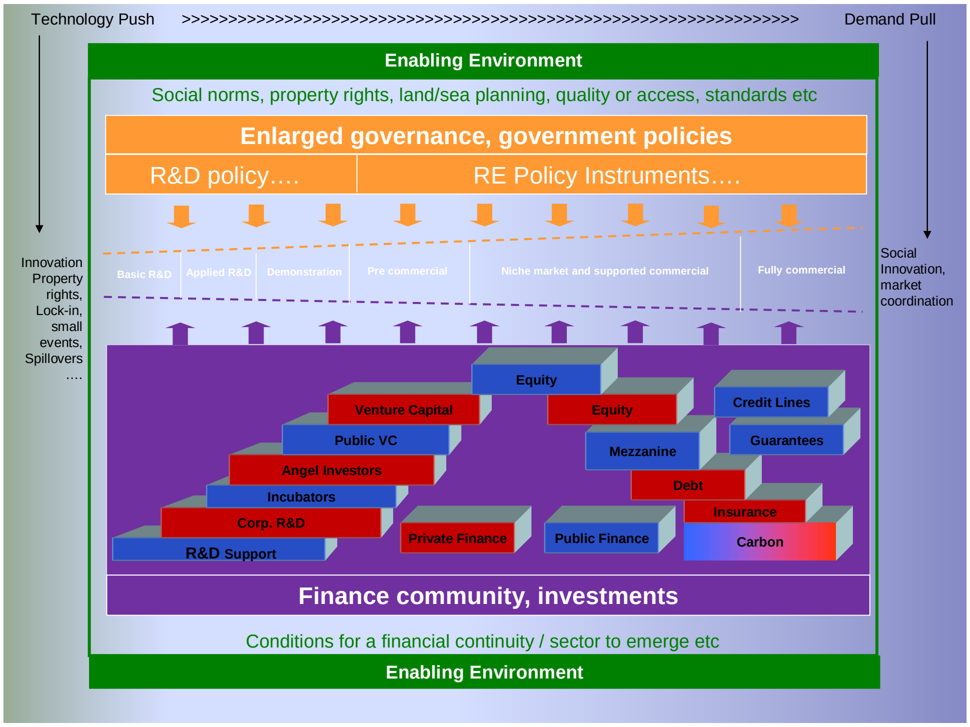

Figure 11.6 Enabling Inputs for Technology Development

Successful outcomes from R&D programmes are not necessarily related to the total amount of funding. Karnoe, 1990, compared the U.S. and Danish wind energy R&D programmes and found that, while the United States had invested 10 times as much in funding, they were less successful in turbine development because the United States had focused on scale and other factors rather than reliability (Sawin, 2001, Karnoe, 1990). In another paper, Garud and Karnoe 2003 (Garud and Karnøe, 2003) argue that 'bricolage not breakthrough' is the more successful approach to R&D policy. If a Government focuses on 'big' breakthroughs it tends to miss the small innovative additions to learning, which together gradually builds up to large scale innovation. Garud and Karnoe use the term bricolage 'to connote resourcefulness and improvisation on the part of the involved actors. Bricolage was characterised by co-shaping of the emerging technological paths as actors in Denmark sought modest yet steady gains. In contrast, actors in the US pursued a path Garud and Karnoe label as 'breakthrough' a term they use to evoke an image of actors attempting to generate dramatic outcomes. Successful technology development occuring via the bricolage, rather than the breakthrough, approach, is supported by detailed studies of RE technology development in Europe (Jacobsson and Johnson, 2000) but also the Japanese and Thai Case Studies (see boxes 11.4 and 11.8).

As Figure 11.6 above shows, technology development and deployment covers a broad range of policies, inputs and financing investments – both public and private. This spectrum of inputs should be available for RE technologies during their development. The timing of R&D policies, and their balance with other deployment policies, is also important (Langniß and Neij, 2004; Neij, 2008). R&D is best in the early phases of maturity, with deployment policies in the later phases. However, relatively early deployment policies in a technologies development accelerates learning, whether learning through R&D or learning through utilization (as a result of manufacture) and cost reduction. (Neij, 2008). Disentangling the contribution of public R&D

spending and economies of scale from cost reduction is difficult, especially since the commercialization of the technology stimulates private sector investment in R&D (Schaeffer, Alsema *et al.*, 2004).

Figure 11.6 above shows where investment – whether public or private – tends to be available in the technology development process. As with any new technology, RE technologies at some point area likely to traverse what has become known as the 'Valley of Death'. In this phase, development costs increase but the risk associated with the technology are not reduced enough to entice private investors to take on the financing burden (Murphy and Edwards, 2003). Continued support from governments is necessary in this phase (House of Commons - Innovation, 2008). In the United States and Europe, public-private partnerships for demonstration (where industry-led projects demonstrate new technologies with government co-funding) are increasingly viewed as one appropriate vehicle to vault this valley (Strategic Energy Technology Plan, 2007; House of Commons - Innovation, 2008; U.S. Department of Energy, 2009).

Governments should focus on 'smart subsidy' style policies that do not create dependence, i.e. a tendency to remain in a research slump that keeps technologies at the R&D and first demonstration stages rather than moving them on to deployment, Smart subsidies attempt to grow a new technology area, while minimizing long-term market distortions. They are meant to lead technology innovators toward commercialization and help attract early and later risk capital investment that otherwise would not be available because investors see high risk and protracted investment horizons. Grant-support models that are linked to performance can allow developers to build a track record, which developers who receive only traditional up-front grants cannot. It is also crucial that grant support remain as consistent as possible to avoid increased risk aversion in the event of public-funding cuts. At the same time, R&D subsidies remain "smart" when they have an 'exit-strategy' as the technology reaches pre-commercialization that will leave a functioning and sustainable sector in place upon their removal (ICCEPT, 2003).

Policy measures in the RD&D sphere are becoming more collaborative and innovative as they seek new means of tapping into potential financiers, investors and innovators. This encourages 'buy-in' from partners as early as possible in the technology development spectrum, and uses public money as efficiently and effectively as possible. This collaboration may be:

- **all public collaborations** (i.e. international centres of excellence);
- **or it may involve public private partnerships in research**, for example:
    - co-funded research has the benefit of creating direct research networking among different sectors (academy, industry), disciplines or locations. Research networks have the opportunity to draft joint action plans in order to meet short-, medium- and long-term goals for the performance and cost of their technology (IEA, 2008a). Governments can then scrutinize and adopt these plans. Road mapping is one example of collaborative R&D which has been outlined in Japan for photovoltaic technology, and in the European region (Strategic Energy Technology Plan, 2007; NEDO, 2009).
    - 'Open innovation' is a way for companies to acquire intellectual property by jointly contracting with one or more public R&D centres, while endorsing both the costs and benefits associated with the innovation. It is currently developed for silicon PV cells

in Belgium and the Indian government wants to explore a similar scheme (IMEC, 2009a; IMEC, 2009b; JNNSM, 2009).

- **or by Government or non-Government stimulation.** Prizes are sometimes used to foster technology development. For example, by late 2009, ten prizes of more than $1m ($1.1m USD$_{2005}$ [deflated using the 2008 factor] existed in the United States (Next Prize, 2009); In December 2008, the Scottish Government launched the 10 million Pound ($20.38 millionUSD$_{2005}$) 'Saltire' Prize for advances in wave and tidal energy (Scottish Government, 2008). Competing for a prize places the R&D risk on the shoulders of the competitors, but it gives them freedom in the way they approach innovation and is sometimes an easier process than applying for public grants (contracting, reporting, control) (Peretz and Acs, 2010).

Besides R&D support, public funding is also needed to help move technology innovations through the product development stages towards commercialization. This phase is often characterized by high-cost activities such as initial and secondary prototype development and testing, site development, supply chain formulation, construction, and grid interconnection. To convince investors, developers must prove that their technology will be able to perform in real-market conditions and be commercially viable (UNEP, 2005).

To lead technology innovation towards the market and to engage commercial investment in the RE sector, governments are starting to implement a range of new financing mechanisms capitalized by public sources. These include technology and business incubators, contingent grants, convertible loans and public-backed venture capital.

Technology incubators can assist developers in covering operating costs, provide advice on business development and raising capital, help to create and mentor management teams, and provide energy-related market research. An example is the UK Carbon Trust Incubator Programme, which furnishes an important stepping-stone to commercialization for new sustainable energy and "low carbon" technologies (UNEP, 2005).

Contingent grants are grants that are 'loaned' without interest or repayment requirements until technologies and intellectual property have been successfully exploited. They can serve to cover some of the costs during the highest-risk development stages and in some cases increase investor confidence and, in so doing, leverage highly needed risk capital.

Commercial bank loans are rarely accessible at the pre-commercial stage however some public agencies have been providing soft and convertible loans at this early phase of development. The Massachusetts Sustainable Energy Economic Development (SEED) Initiative, for example, provides loans from $50,000 to $500,000 for clean energy companies undergoing new product development [TSU: will need to be converted to USD$_{2005}$]. The state of Connecticut offers a range of financing instruments to promote and commercialize RE technologies through the Connecticut Clean Energy Fund (CCEF). One of their financing schemes combines grant support for demonstration projects with a soft loan that is repayable if the technology reaches commercialization.

Various government agencies have been experimenting with venture capital mechanisms as part of their overall industrial and economic development policy aimed at turning promising research into new products and services (SEF Alliance, 2008). Publicly driven venture capital funds have emerged in the United States, Australia and the UK. In most cases public sector VC is either invested independently or requires a matching commitment from commercial VC investors.

Box 11.4 Japan and PV: Coupling Technology Push with Market Pull

Japan first turned to RE in the 1970s, in search of energy security and stable supply after the first oil shock seriously weakened the nation's economy [ref: (Sugiyama, 2008)]. Starting in 1974, MITI (Japan's Ministry of International Trade and Industry) launched the "Sunshine Project", which aimed to achieve technological breakthrough with new energy technologies, and significant funds were directed to PV R&D (MEXT, 1978).

MITI worked to link this project to Japan's industrial development. Although the primary goal was development of solar energy technologies, especially PV, MITI expected that technological advances could have far reaching benefits beyond the energy field. In addition to providing electric power on a large scale, it was hoped that PV technologies would lead to new international markets for solar calculators and other appliances, taking the value created from the national investment in R&D beyond the objective to improve energy security through realization of a domestic supply of energy. [Authors: Reference is missing]

The investment paid off with the global increase in demand for electronic appliances and the expansion of a semiconductor market for computer "chips". By 1990, when MITI established an R&D consortium for PV development (Photovoltaic Power Generation Technology Research Association), electronic machinery companies like Sanyo and Sharp were the major players [ref: (Watanabe, 2000)].

By 1992, the "Sunshine Project" had demonstrated that PV could provide an alternative energy supply. In 1993, the purpose of RE advancement expanded to encompass sustainable development and environmental objectives including CO_2 reductions, and Japan transitioned to the "New Sunshine Project." Parallel to its R&D efforts, Japan established targets for PV deployment and initiated a gradually-declining subsidy for residential rooftop PV systems, in exchange for operational data, with the goal of driving down PV costs through economies of scale and commercial competition among manufacturers. To create market awareness, the government began promoting PV through a variety of avenues, including television and newspapers (IEA, 2003).

The result was a dramatic increase in installed capacity and accompanying reduction in PV costs. Japan rose from a minor player to become the world's largest PV producer in less than a decade. Over the 1994-2004 period, system costs declined by one third, from 2000 yen/kW ($18.0 USD_{2005}) in 1994 to 660yen/kW (6.0 USD_{2005}) in 2004 [Authors: Reference is missing]. (See Figure 11.7). Although market growth slowed when the subsidy program ended in 2005, the momentum of PV as viable power source had been proven.

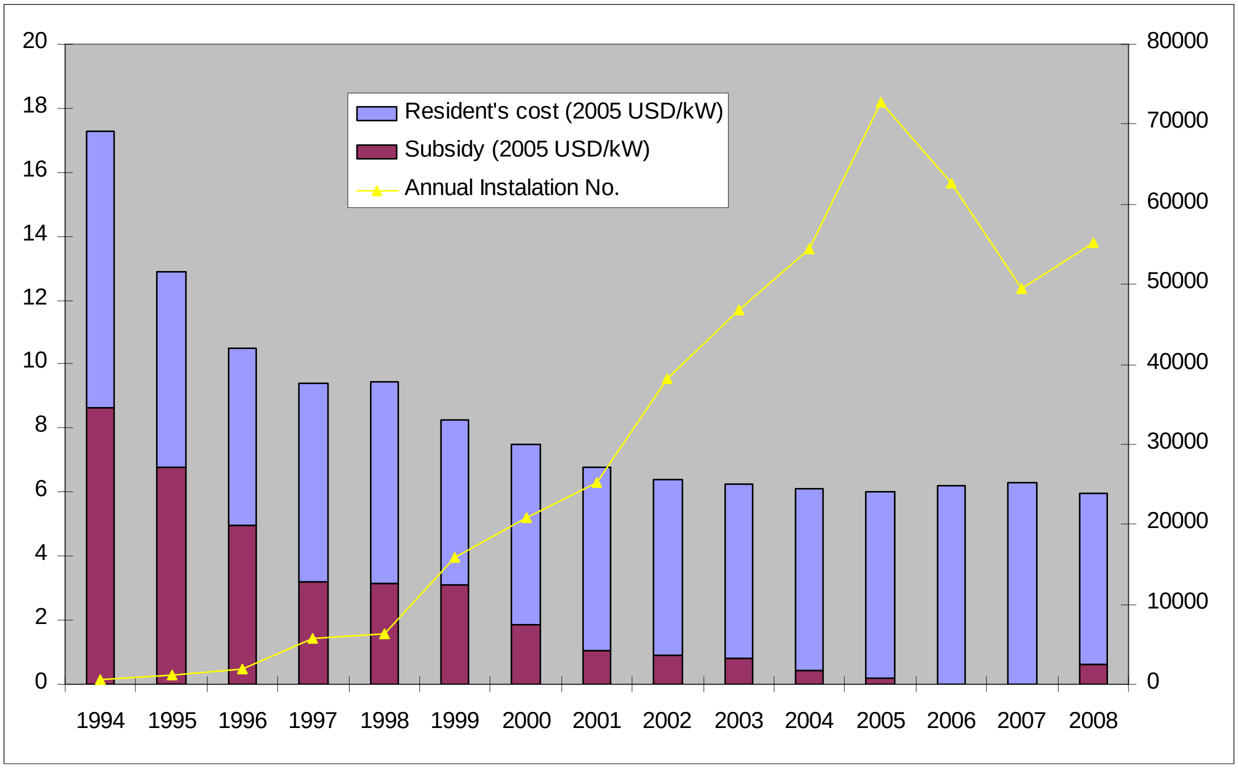

Figure 11.7 Annual costs, subsidies and numbers of rooftop PV in Japan (Ito, 2003; Kobayashi, 2003; NEPC, 2009)

In 2009, in the midst of a global recession, Japan's PV industry found further cause to support PV deployment—for the purpose of job creation and increased competitiveness in the international marketplace. The government introduced a buy back system for residential rooftop PV (residential producers can sell excess power to the utility company at the retail rate). The purpose is to further accelerate the introduction of PV and provide an incentive for customers to minimize their own use in order to sell as much as possible to their utility (METI, 2009).

For most of the past three decades, Japan enacted effective and consistent policies to promote PV and retained them even through major budget crises. It's experience demonstrates the importance of long-term targets and planning, the potential to link RE development to other applications and industries, as well as the virtuous cycle of declining costs, technology advances and increasing deployment that result from coupling technology push (R&D) with policies to create a market.

11.5.3 Developing Country Off-grid and Rural Issues

Many of the issues related to RE development are the same for developed and developing countries. There are several challenges for investors in RE in developing countries – just as there are in developed countries – and these are discussed in more detail in 11.5.4, 11.5.5 and 11.5.6. There have been several reviews of the importance of RE policies for developing countries, for example from the World Bank (World Bank, 2009a); their successes and difficulties (Parthan, Osterkorn *et al.*, 2010). These reviews reinforce the central role that national policy plays. There is no 'one size fits all' (Hamilton, 2009). The overall policy environment needs to provide enough confidence for investors.

There are a number of case studies relevant to developing countries: a case study on China, which is an example of a developing country which combines high tech manufacturing of RE; the largest deployer of RE in the globe of both large scale and small scale. It also provides an example of Kenya, and the very particular situation there which enabled RE success without policy support. Section 11.5.4 provides a case study of the FIT policies in Thailand; 11.5.6 provides a case study of Brazil; and biofuels section 11.6 provides a case study of capacity building in Box 11.15 Nepal. All these case studies illuminate the very diverse situation.

However, the rest of the section focuses on off-grid and rural issues – given the specific differences of requirements from developed countries.

11.5.3.1 Off-grid and rural RE policies in developing countries

About 1.5 billion people in developing countries lack access to electricity and about 3 billion people rely on solid fuels for cooking (UNDP and WHO, 2009). Indoor air pollution from biomass burning affects more than 2.4 billion people; 99 percent of the two million deaths annually due to in-door air pollution (primarily due to cooking with biomass) occur in developing countries (UNDP & WHO, 2009). Access to energy is of paramount importance as it increases living standards of rural populations, providing essential goods and services (Thiam, 2010). RE enhances access to reliable, affordable clean energy to meet basic needs, especially through small scale decentralized systems renewable, and it allows for industries, production and transport to leapfrog and avoid dependence on fossil fuels (Deutsche Bank, 2009).

This large population of people awaiting modern energy services cannot be served “unless new approaches are developed and put into action” (Zahnd and Kimber, 2009); New approaches include policies and implementation modalities to promote RE. Barriers include geographical disparity, which causes variation in transportation especially in remote hills and mountains; and lack of infrastructure which causes price variation in energy supply systems.

11.5.3.2 Successful examples

Smart subsidies such as those in Nepal (Renewable Energy Subsidy Policy 2009, Govt of Nepal) and in India have helped to overcome barriers to RE deployment. In Nepal, by 2009, more than 200,000 rural families were using domestic biogas technology for cooking (Pokharel, Mitchell *et al.*, 2010). By early 2009, in India, a cumulative total of 4250 villages and 1160 hamlets had been electrified using RE (REN21, 2009b). Contrary to that Nepal has managed to install more than 150, 000 domestic biogas plants from *ad-hoc* support mechanisms before a national rural (renewable) energy policy promulgated in 2006(Pokharel, Mitchell *et al.*, 2010). In Bangladesh to more than 100,000 solar home systems were promoted before a national level renewable energy policy was promulgated in 2008 (Pokharel, Munankami *et al.*, 2007).

Table 11.3 Financing of Small Scale RE sources in Various Developing Companies.

Country	**Investment Cost in US$ for 6 m3 biogas digester**	**Subsidy in US$**	**% of upfront investment contribution by users**	**% of GDP in 2009**
Bangladesh	346.17	142.21	58.9%	
Cambodia	551.23	165.37	70.0%	
Indonesia	661.48	220.49	66.7%	
Nepal	657.07	195.13	70.3%	
Pakistan	471.85	98.11	79.2%	
Vietnam	347.27	69.45	80.0%	

Source: compiled from SNV (2009) [figures deflated using 2008 factor]

As of 2000, Argentina's government offered concessions through which the winning company gained a monopoly in a given region, and the government provided grants to cover lifecycle costs, subsidizing rural household electricity consumption up to only a minimum level in order to keep costs down and target only those truly in need of assistance (Reiche, Covarrubias *et al.*, 2000). Benefits of this system included creation of a large market which provided a critical mass for commercially sustainable businesses and to reduce unit costs through economies of scale (for equipment, transactions, operation and maintenance). In addition, it has appealed to large companies that have their own sources of funding. This system has been duplicated in a number of other developing countries, including Benin, Cape Verde, South Africa and Togo (Reiche, Covarrubias *et al.*, 2000; Osafo and Martinot, 2003).

In both the Philippines and Bangladesh, there are networks of consumer-owned and -managed cooperatives that receive financial incentives in exchange for meeting annual performance targets and providing electricity to members and the local community. As of 2003, results in both countries were mixed (Osafo and Martinot, 2003).

11.5.3.3 Enabling Policies for Rural and Off-grid Electrification

For many low income developing countries, simply channelling a subsidy to rural areas is not enough. This is due to immature markets and a lack of capacity, and a weak and fragmented supply chain (see Box 11.15). Even demand for RE needs to be generated with awareness and sensitivity because illiterate people cannot realize the advantages of RE, lack information on technology and its accessibility as well as availability (see Box 11.15). It is also important for policies to encourage private sector investment. To account for this, the Rural Energy Policy 2006 of Nepal emphasises the need for public-private partnerships to promote RE in rural areas. Bangladesh, too, has adopted an RE policy that aims to mobilize internal as well as external resources for investment to achieve its RE. The *Bhutanese* Government has a comprehensive policy that promotes public-private partnerships in addition to long-term direction that aims to ensure energy security through diversification of supply mix and demand-side management.

While developing policy to enhance access to energy some issues like pro-poor orientation, regional balanced, and social inclusion are given due consideration (e.g. Sunsidy policy of Nepalese and Indian government). Increased emphasis for linkages with micro credit and other rural development activities are also focused policy in Bangladesh and Nepal. Although energy access through REs are subsidy driven, policies are formulated envisaging the assurance of enhanced commercialisation and sustainability of the sector.

Developing countries have multiple tasks of development, so more integrated renewable policies emphasising on energy access, rural and regional development, betterment of health and education sector and promoting better environment, employment and industrial sector development should be promulgated.

Box 11.5 Building the Solar Energy Market in Kenya through Product Quality

Kenya is home to one of the largest and most dynamic per capita solar PV markets among developing countries. Cumulative sales since the mid-1980s are estimated to be in excess of 300,000 systems, and annual sales growth has regularly topped 15% since 2000 (Acker and Kammen, 1996; Jacobson and Kammen, 2007). Household systems account for an estimated 75 percent of solar equipment sales in Kenya. This unsubsidized market arose to meet demand for reliable power in rural areas through relatively low-cost and dependable solar home systems. Solar is the largest source of new electrical connections in rural Kenya and, starting in about 2000 also began spreading to neighbouring countries (Jacobson and Kammen, 2007).

Despite this commercial success, product quality threatened to derail the market in the 1990s, when reports began to emerge about problems with low-quality amorphous silicon (a-Si) modules, which were indistinguishable from high-quality modules (Duke, Graham *et al.*, 2000; Hankins, 2000; Duke, Jacobson *et al.*, 2002). It was not clear initially if this performance gap related to inherent properties of the solar technology (Staebler and Wronski, 1977) or to issues in the manufacturing and/or field performance (Duke, Graham *et al.*, 2000; Hankins, 2000; Duke, Jacobson *et al.*, 2002; Faiman, Bukobza *et al.*, 2003). Advertisements in local newspapers sparked a heated debate about quality, consumer rights, and the ethics of negative advertising.

In 1999, a set of private studies on the performance of the solar modules for sale in Kenya indicated clearly which brands were performing well, and which were not (Jacobson, Duke *et al.*, 2000). This information – disseminated widely and publicly– had a major impact on the industry, inducing manufacturers to improve product quality. As a result, the market resumed rapid growth (Jacobson and Kammen, 2007).

Several years after the 1999 study, a new line of low performing a-Si modules began to enter the market in significant quantities. The approach to weeding out these panels was a close repeat of the earlier episode (Duke, Jacobson *et al.*, 2002). Re-emergence of quality problems in the Kenya market confirmed that the issue could not be solved decisively by one time testing efforts, or by focusing on the improvement of individual low performing brands. Rather, institutional solutions that persistently require high performance for all brands are needed to ensure quality.

As a result of these events, the Kenya Bureau of Standards (Kenya Bureau of Standards, 2003) collaborated with the Kenya Renewable Energy Association to draft performance standards for a range of solar products, including a-Si modules. The government drafted and adopted new standards, drawing heavily from codes established by the International Electrotechnical Commission (IEC, 2001).

However, because the KBS lacked access to the necessary equipment and technical capacity to carry out all specified tests, continued involvement of local solar groups and international academic teams was critical to communication, and at times enforcement, of the Kenyan national solar standards. Thus, while the move to adopt national performance standards represented a positive step towards an institutionalized approach to quality assurance, the adoption of un-enforced standards requires continued vigilance and partnerships among research and testing groups, the solar industry, and the government.

This Kenya solar story makes clear that an ‘enabling environment’ for a clean energy technology can evolve during or even after the market begins to expand. Further, there is often a need for continued assessment and analysis to build what initially can be fragile RE markets, and science and engineering inputs can be critical at many stages of the evolution of a RE system and market. At present the Kenyan solar market has, with some ups and downs, continued to expand; as of 2007 over 35,000 new systems were sold annually in Kenya (Jacobson and Kammen, 2007).

11.5.3.4 Financing for Off Grid and Rural RE in Developing Countries

Various policies exist to mobilize the different forms of financing required for RE deployment, and there are covered earlier in 11.5. In addition to policy mechanisms, the provision of public finance can also be required because financing for RE continues to be a challenge in most regions of the world. For many projects, the availability of commercial financing is limited, particularly in developing countries, where elevated risks (geopolitical, economic and regulatory) and weaker institutional capacities inhibit private sector engagement. Risk is a critical obstacle to the flow of future revenue streams for financing the deployment of new technologies (UKERC, 2007). In developed countries, governments can play a role in reducing the cost of capital and improving access to capital by mitigating the key risks, particularly non-commercial risks that cannot be directly controlled by the private sector (Stern, 2009). In the developing world, stronger intervention may be necessary to unlock private-sector investment in new technologies (UNEP Finance Initiative, 2009). As in the developed world, a stable national regulatory regime can reduce the risk of investments in new technologies. But given the budgetary constraints facing most developing country governments, additional funding—including direct public financing of projects—may be necessary to underwrite the costs of low-carbon policy frameworks.

This lack of appropriate financing mechanisms available to end-users in developing countries is a barrier for financing (Derrick, 1998). Although several micro financing institutions are working in rural areas of developing countries (i.e. Bangladesh, Cambodia, Nepal), interest rates are high. Where such end-users financing is not available people are more likely go toward low quality cheaper RE products. Financing mechanism which enhance consumers’ ability to pay for renewable-generated services have been instrumental in many institutions in increasing the up-take of RE (Renewable 2004). There are some end users financing mechanisms in place in developing countries, for example: a revolving fund, credit cooperatives, renting schemes, utility schemes/leasing and hire purchase (Derrick, 1998)

According to Policy recommendation of Bonn Conference (Goldemberg, 2004a), financing strategies for renewable should address the financing needs of both suppliers/vendors and different categories of end-user consumers in a balanced manner. Any financing policies or mechanism targeting mainly rural areas of developing countries need to create renewable energy markets where individual households, small businesses and local communities can play a greater role in financing. Small scale and decentralized renewable energy systems in developing countries are normally financed with subsidies from the government, end-users contribution either in cash or kind (Pokharel, Mitchell *et al.*, 2010). Community or local villagers will invest their labor, time, and other social capitals in the renewable energy systems (Pokharel, Chhetri *et al.*, 2008). Micro-credits are also helping to mobilize the upfront investment from the users and based on technology users some time can also contribute own labour and local materials.

Box 11.6 Rural Electrification and Large-Scale RE in China

China has relied increasingly on RE to help meet rising energy demand, improve its energy structure, reduce environmental pollution, stimulate economic growth and create jobs (Zhang, Ruoshui *et al.*, 2009). During 2009, China installed more wind power capacity than any other country and, by the end of the year, ranked first globally for RE capacity and third for non-hydro RE (REN21, 2010). A strong domestic manufacturing industry for wind power, photovoltaics and solar thermal collectors has emerged, triggered in part by special promotion policies (Han, Mol *et al.*, 2010; Liu, Wanga *et al.*, 2010; Wang, 2010).

The Chinese government has devoted significant attention to RE development in recent decades. China began developing wind power in the early 1970s for the primary purpose of supplying power to remote areas (Changliang and Zhanfeng, 2009). Grid-connected wind power started in the 1980s with small-scale demonstration projects and evolved to a main source of power supply by 2003, when the Wind Farm Concession Program was established (Wang, 2010). Solar water heaters have been promoted since the 1970s (Han, Mol *et al.*, 2010), and biogas digesters since the 1980s (Peidong, Yanli *et al.*, 2009). Under the Township Electrification Programme, more than 1,000 townships in nine western provinces were electrified in just 20 months, bringing power to almost one million rural Chinese (National Renewable Energy Laboratory (NREL), 2004). Important to the success of China's rural electrification efforts have been education of local and national decision-makers, training and capacity building, technical and implementation standards, and community access to revolving credit (Wallace, Jingming *et al.*, 1998; National Renewable Energy Laboratory (NREL), 2004; Ku, Baring-Gould *et al.*, 2005).

In 2005, China issued the Renewable Energy Law, which institutionalized a number of support policies including mandatory grid connection standards, renewable energy planning, and promotion funding (Zhang, Ruoshui *et al.*, 2009). It was followed in 2006 and 2007 by specific regulations and measures supporting development of wind, solar, and biomass sources. The Medium and Long-term Renewable Energy Development Plan, released in 2007, set a national target for RE to meet 10 percent of total energy consumption by 2010 and 15 percent by 2020 (Wang, 2010). The 30 GW wind power target for 2020, as specified by The 11th Five Year Plan for Renewable Energy in 2008, was achieved a decade ahead of schedule (Wang 2010).

China continues to address challenges as they arise by developing and revising RE policies and measures, including: enhancing technical skills; establishing institutions to support R&D development and a national RE research institute; extending electricity transmission to ensure that new RE capacity can be effectively brought online; creating a domestic market to stimulate demand and avoid over-reliance on overseas markets; and establishing a national RE industry association to coordinate development and formally bridge the industry and policymaking processes (Martinot and Junfeng, 2007; REN21, 2009a).

11.5.4 Policies for Deployment - Electricity

To date, far more policies have been enacted to promote RE for electricity generation than for heating and cooling or transportation, and this is reflected in the vast literature available regarding RE electricity policy mechanisms. By the beginning of 2009, at least 64 countries had some sort of mechanism in place to promote renewable power generation (REN21, 2009b). As described in 11.5.1 above, we have divided RE policies into regulatory, fiscal, public finance and other. The two main regulatory mechanisms are the 'Feed-in tariffs' - which guarantee a price - and 'quotas' or RPS (Renewable Portfolio Standards) which ensure a quantity or market share through government-mandated targets, quotas or mandates. This section analyses and compares these 2 mechanisms before moving on to 'net metering, another less widely used regulatory policy, and then public financing mechanisms

11.5.4.1 Regulatory Policies

Feed-in Tariff (FIT)

The most prevalent national policy for promoting renewable electricity is the FIT (REN21, 2009b), also known as Feed Laws, Standard Offer Contracts, Minimum Price Payments, Renewable Energy Payments, and Advanced Renewable Tariffs (Couture and Gagnon, 2009), and is an over-arching term for price driven support. FITs can be divided between those where the Government sets a fixed price which is independent of electricity market prices and those that are linked to electricity market prices but paid a fixed premium price, also set by the Government. All FITs have different impacts on investor certainty and payment, ratepayer payments, the speed of deployment, and transparency and complexity of the system (Couture, 2009).

FITs have driven dramatic renewable electric capacity growth in several countries—most notably Germany and Spain—over the past 15 years (see Boxes 11.2 and 11.7) and have spread rapidly across Europe and around the world (see Box11.8) (REN21, 2006; Mendonça, 2007; Rickerson, Sawin et al., 2007; Girardet and Mendonca, 2009; REN21, 2009b). Although they have not succeeded in every country that has enacted them, those countries with the most significant market growth and the strongest domestic industries have had FIT policies in place (Sawin, 2004a; Mendonça, 2007). The IEA argues that the key for countries like Germany, Spain and Denmark has been high investment security coupled with low administrative and regulatory barriers (IEA, 2008b).

Box 11.7 Case study: Photovoltaics in Spain

Spain's experience with solar PV promotion is a clear case of learning by doing. To provide a predictable and transparent framework to attract private investments, the Spanish government enacted a feed-in tariff in 1998 and published indicative 2010 targets for installed capacity in the Plan to Promote Renewable Energies 2000-2010 (MIyE (Ministerio de industria y Energía), 1998; IDAE, 2009).

Due to the immaturity of the market, initially the FIT was not enough to develop the PV sector and, in 2001, a combination of investment subsidies and low-interest loans were established. They remained in place until 2005, and total direct subsidies to PVs during the period amounted to 64.6 USD_{2005} (IDAE, 2009).

The FIT was revised in April 2004 (ME (Ministerio de Economía), 2004) and again in May 2007 (MITyC (Ministerio de Industria Turismo y Comercio), 2007). In addition to raising the tariff for PV, both acts increased the maximum capacity of projects that could receive the high tariff (to 10 MW from May 2007). Combined with the economies of scale of these larger projects, the 2007 policy changes encouraged development of several new ground-mounted projects of 10 megawatts (MW). Newly installed capacity increased from 21 MW in 2005, to 107 MW in 2006, and 555 MW in 2007 (IDAE, 2008).

In September 2007, 85 percent of Spain's RE target had been achieved, setting off a one-year deadline for the government to publish new targets and tariffs, and for developers to complete projects under the existing scheme. This period was fine for most RE projects already under development, with relatively long lead times; but PV projects can be developed quite quickly. The one-year notice set off a mad rush to install PV systems before the existing system expired. As a result, 2,480 MW of PV were added in 2008, breaking all past records and making Spain the world leader for PV installations that year (IDAE, 2009).

Because the country's 2010 targets had been exceeded, in September 2008 the government established a new economic regime for future installations (MITyC (Ministerio de Industria Turismo y Comercio), 2008). For the first time, a differentiated tariff was established for building-integrated PV (BIPV) to encourage installations that don't require additional land and contribute to the social dissemination of RE. In addition, annual caps were set for new capacity, with separate caps set for ground-mounted (up to 10 MW) and rooftop (under 20 kW; and 20 kW to 2 MW) PV projects. If the caps are achieved in a given year, they can be increased by 10 percent the following year. At the same time, if the caps are reached, the succeeding year's tariffs for new installations decrease by a maximum of 10 percent.

The purpose of this new scheme was to: provide long-term predictability; better control the cost of the FIT; guarantee profits more-appropriate for a regulated market; encourage declining installation costs; increase competitiveness; and encourage distributed generation through BIPV.

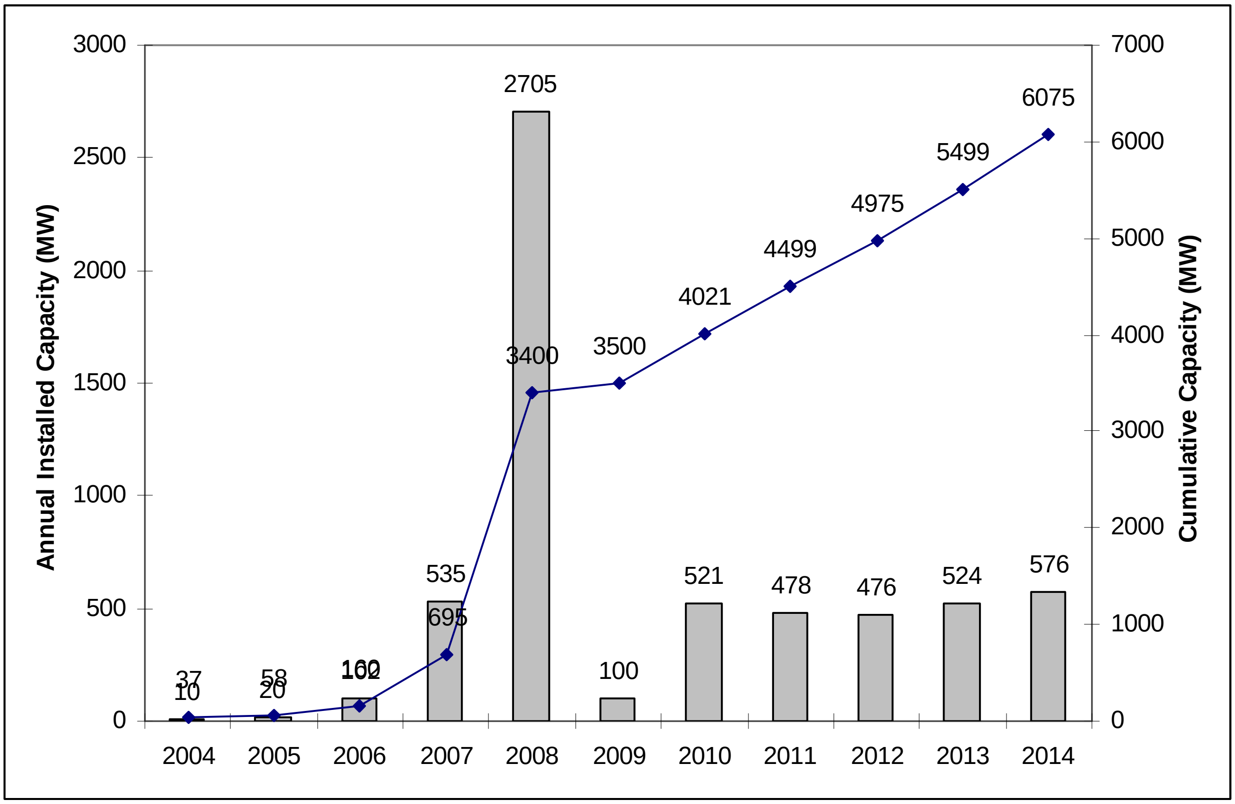

Figure 11.8 PV Installations in Spain, actual and projected (2004-2014).
Data are actual through to 2008; 2009 is an estimate and 2010-2014 data are projections. (IDAE, 2010)

The policy change resulted in a significant increase in distributed rooftop projects (IDAE, 2010). The tariff for ground-mounted projects continues to decrease over time. At the same time, uncertainty about the design of the new framework, to be adopted in late 2009, and the reduction in market size due to the cap on ground-mounted systems, led to job losses and company closures in 2008 (ASIF (Asociación de la industria Fotovoltaica), 2009). In 2009, the market collapsed and only [100] MW were added. (IDAE, 2010) Now that a firm policy is in place, the market is expected to pick up again and to remain constant. (MITyC (Ministerio de Industria Turismo y Comercio), 2008) (See Figure 11.8).

Overall, lessons from Spain's experience include: a combination of support schemes can be important for advancing RE technologies, particularly when the market is immature; ambitious long-term targets are critical as are predictable policies; and transitional incentives that decrease over time can foster technological innovation and control the total costs.

Box 11.8 Renewable energy in Thailand: policies and results

Decentralized, grid-connected RE has made a substantial and rapidly increasing contribution to Thailand's electricity supply. As of March 2010, 1364 MW of private sector RE was online with an additional 4104 MW in the pipeline (EPPO, 2010b; EPPO, 2010d). Strong market growth has been due to plentiful agricultural residues and a comprehensive set of policies including streamlined grid interconnection access, feed-in tariffs (FITs), tax breaks, and low-cost financing (Amranand, 2009; Fox, 2010).

Policies to accommodate grid interconnection of customer-owned RE started in 1992 with the Small Power Producer (SPP) program, which included standardized interconnection and power purchase agreements for generators up to 90 MW (Greacen and Greacen, 2004). By 2007 the program had saturated at 53 RE generators (mostly bagasse cogeneration) with combined nameplate capacity of 967 MW (EPPO, 2007b).

In 2002, Thailand adopted Very Small Power Producer (VSPP) regulations, modelled on U.S. net metering legislation, further streamlining utility interconnection requirements (Greacen, Greacen *et al.*, 2003). Initially attractive primarily to biogas projects in agricultural industries with substantial waste streams (Plevin and Donnelley, 2004), by February 2007 they brought on line 98 VSPP generators totaling 25 MW of capacity (EPPO, 2007b).

In 2006, the Thai government enacted a FIT that provides an adder paid on top of utility avoided costs, differentiated by technology type and generator size, and guaranteed for 7-10 years. Additional per-kWh subsidies are provided for projects that offset diesel use in remote areas, and utilities are provided further incentives to accommodate VSPPs. Incremental costs are passed through to consumers. (Amranand, 2008)

The government's decision was driven by concerns about increasing reliance on imported fossil fuels; difficulty siting new coal and natural gas plants; interest in reducing greenhouse gas emissions; encouragement from the Thai RE industry; and a national target of 8 percent RE by the 2011 (Prommin Lertsuriyadej, 2003; Thai Ministry of Energy, 2003; Amranand, 2008).

In response to the FIT, VSPP RE online capacity increased sharply, from 25 MW in February 2007 to 792 MW by March 2010; biomass and biogas account for most of this capacity"(EPPO, 2007a; EPPO, 2010c) .

Other important incentives for RE include an 8-year corporate tax holiday; reduction or exemption of import duties; technical assistance; and low-interest loans and government equity financing (Yoohoon, 2009).

Further, the government has worked to address challenges as they arise. For example, in response to companies that applied for power purchase agreements only to sell them to developers, the government began requiring a reimbursable bid bond for projects over 100 kW, and projects must produce power within one year of the scheduled date of commissioning to receive subsidies (Tongsopit, 2010). The variability of RE and small size of individual generators has been difficult to accommodate using traditional planning methods (Greacen, 2007). This has been acknowledged and partially addressed in the most recent 2010 revision of the Power Development Plan (EPPO, 2010a).

Thailand's experience demonstrates that well-designed and effectively implemented policies can lead to substantial deployment of RE in developing countries. The FIT adder has been instrumental in the increase, and in encouraging a diversity of RE sources. Explicit financial incentives for Thai utilities to purchase VSPP power helps overcome their reluctance to accommodate interconnection, grid operations, and billing challenges that can accompany distributed generation. The sequence of regulation, starting with interconnection policies and later adoption of FITs has allowed utilities to ‘learn by doing’ as they ramp up programs to accommodate distributed RE.

Counter-intuitively most FIT systems do not support the quantity of electricity *fed to* the grid, but the quantity of renewable power *generated*. FIT policies offer guaranteed, mostly nominal (without inflation correction) fixed prices for fixed periods of time, which are sufficient to cover the full costs of the project including a sufficient return on investment for every kWh RE produced by an identified and technically qualified plant. The FIT rates are fixed in a particular year depending on the state of development of RE technologies and then decrease over the years with technological progress.

FITs can be very simple – for example, available for one technology only, such as wind power. However, they are suited to incremental adjustments and can become more complex so that new technologies are added and prices are differentiated according to different attributes of the RE supplies, such as resource, location or time of day generated (Mendonça, 2007; Couture and Gagnon, 2009; BMU, 2010). The costs of the FITs or premium payments are covered by energy taxes or, more frequently, by an additional per-kilowatt hour charge spread across electricity consumers, sometimes with exemptions, for example the major users in Germany (BMU, 2010).

Like all mechanisms, their success comes down to details but the most successful FIT designs have included most or all of the following elements (Sawin, 2004b; Mendonça, 2007; Klein, Held *et al.*, 2008; Couture, 2009):

- Priority dispatch and access
- Establish tariffs based on cost of generation and differentiated by technology type and project size;
- Ensure regular adjustment of tariffs, with incremental adjustments built into law, to reflect changes in technologies and the marketplace
- Provide tariffs for all potential generators, including utilities
- Guarantee tariffs for long enough time period to ensure adequate rate of return
- Ensure that costs are integrated into the rate base and shared equally across country or region
- Provide clear connection standards and procedures to allocate costs for transmission and distribution
- Streamline administrative and application processes.

Quota Obligations

After FITs, the most common policy mechanism in use is a quota obligation, also known as Renewable Portfolio or Electricity Standards (RPS or RES) in the United States and India, Renewables Obligations (RO) in the United Kingdom, Mandatory Renewable Energy Target in Australia (Lewis and Wiser, 2005). By the end of 2008, quotas were in place in at least 9 countries at the national level and by at least 40 states or provinces, including more than half of U.S. states (REN21, 2009c).

Under quota systems, governments typically mandate a minimum share of capacity or generation to come from renewable sources. Any additional costs of RE are generally bourne by electricity consumers. With the most common form of quota system, generators comply with the quota by installing capacity which an actor purchases. In the case, of the UK this is the electricity supplier who is responsible for all contractual arrangments. Elsewhere, for example Texas, renewable electricity may by bought through a bidding process.

Quota's and FITs can be linked to tradable systems, although it is only quotas where this has happened in practice , for example "tradable green certificates" (TGCs) in Europe, or "renewable energy credits/certificates" (RECs) in the United States (Sawin, 2004b; Mitchell, Bauknecht et al., 2006; Ford, Vogstad et al., 2007; Fouquet and Johansson, 2008). Generally, certificates are awarded to producers for the renewable electricity they generate, and add flexibility by enabling those actors which have a quota laid on them, for example, utilities, and generators to trade, sell, or buy credits to meet obligations—provided there is sufficient liquidity in the marketplace (Sawin, 2004b). The electricity suppliers, or other agents in the power sector, are also able to 'prove' they have met their obligation by showing the regulator (or other executive body) the number of certificates equal to their obligation.

Most quotas have in-built costs for those actors which don't comply with the quota – either a direct penalty payment or a more indirect 'buying-out' of their obligation. The penalty on certificate shortfalls must sufficiently exceed the expected market price of TGC. The expenses incurred by the actors in fulfilling their quota's – whether as penalties or buy-outs - are passed on in the standard electricity prices paid by customers (Mitchell, 2008).

In the early stages of quota systems, countries experimenting with TGC systems strictly applied 1 TGC/1 MWh. Since then "banding" has occurred meaning that I MWh of RE is given a different number of TGCs per MWh depending on their technology or attributes. For example, 1 MWh of wave power in the UK receives 2 ROCs. This doubles the value of the RE to the generator.

As with FITs, there are significant variations from one scheme to the next, even among various U.S. state policies (Wiser, Namovicz et al., 2007). Research by the Lawrence Berkeley National Laboratory suggests that more than 50 percent of total U.S. wind power capacity additions between 2001 and 2006 were driven at least in part by State RPS laws (Wiser, Namovicz et al., 2007). Experience in the United States demonstrates that the effectiveness of quota schemes can be high and compliance levels achieved if RE certificates are delivered under well-designed policies with long-term contracts which mute (if not eliminate) price volatility and reduce risk (Lauber, 2004; van der Linden, Uyterlinde *et al.*, 2005; Agnolucci, 2007; Rickerson, Sawin *et al.*, 2007; Toke, 2007; Wiser, Namovicz *et al.*, 2007)

Nevertheless, in some U.S. States (Wiser, Namovicz et al., 2007), as well as the United Kingdom, Sweden and elsewhere (Jacobsson, Bergek et al., 2009), targets have not been achieved. For example, under the UK Renewables Obligation in 2005, 2006, 2007 and 2008, eligible sources rose from 4.0 to 5.4 percent of electricity generation rather than the obligated 5.5 to 9.1 percent . From 2005 and 2008, between 59 to 73 percent of each annual obligation was met, with an annual average of 65% (DUKES, 2009).

As with FITs, the success or failure of quota mechanisms comes down to the details. The most successful mechanisms have included most if not all of the following elements, particularly those that minimize risk (Sawin, 2004b):

- System should apply to large segment of the market
- Include specific purchase obligations and end-dates; and not allow time gaps between one quota and the next
- Establish adequate penalties for non-compliance, and provide adequate enforcement
- Provide long-term targets, of at least 10 years (van der Linden, Uyterlinde et al., 2005)
- Establish minimum certificate prices
- Liquid market to ensure that certificates are tradable
- Are accompanied by technology-specific investment subsidies (van der Linden, Uyterlinde *et al.*, 2005)

Comparison of Feed-in and Quota Systems

For several years, particularly in Europe and to a lesser extent in the United States, there has been debate regarding the efficiency and effectiveness of FITs versus quota systems (Rickerson, Sawin et al., 2007; Commission of the European Communities, 2008; Cory, Couture et al., 2009). Some 112 countries, states, provinces around the world have had experience with one or both of these mechanisms (REN21, 2009c). There are FITs that have been very successful and FITs that have not; quotas that have been effective, and some that have not (Sawin, 2004b). Because there are so many mechanisms in place and so many years of experience, it is possible to see from evidence the impacts of different design features.

An increasing number of studies, including those carried out by the International Energy Agency and the European Commission, have determined that well-designed and –implemented FITs are the most efficient (defined as the comparison of total support received and generation cost) and effective (defined as the ability to deliver increase of the share of renewable electricity consumed) support policies for promoting renewable electricity (Sawin, 2004b; European Commission, 2005; Stern, 2006; Mendonça, 2007; Ernst & Young, 2008; International Energy Agency (IEA), 2008; Klein, Pfluger *et al.*, 2008; Couture and Gagnon, 2009).

FITs have consistently delivered new supply, from a variety of technologies, more effectively and at lower cost than alternative mechanisms, including quotas, although they have not succeeded in every country that has enacted them, (Ragwitz, Held *et al.*, 2005; Stern, 2006; de Jager and Rathmann, 2008). The IPCC Fourth Assessment Report (2007) concluded that FITs have been more effective than quotas at deploying renewables and increasing production efficiency (IPCC, 2007a). According to Jacobsson et al (2009), tradable green certificate (TGC) systems in Sweden, the UK and Flanders are not meeting the criteria of effectiveness, efficiency and equity well (Jacobsson, Bergek et al., 2009). Although some U.S. states have successfully achieved their targets with RPS, others have not (Wiser, Namovicz et al., 2007).

However, quota systems have a number of characteristics, which may make them more attractive to policy-makers than FITs. Quota systems, particularly those with tradable certificate markets and without banding, do not regulate technology choice or price. Because of this some policy makers and analysts have considered them to be more market-oriented than FITs (Lipp, 2007). Moreover, quotas enable an annual maximum cost calculation, useful for those policy-makers which wish to know the total annual cost of the mechanism (Mitchell and Connor, 2004) , which is not the case for FITs, unless it is a 'capped' FIT. It is also relatively easy for a certain quota, of a certain technology, to be 'obligated' on an actor by a certain time – thereby providing short-term flexibility for the policy-maker.

Risk

An important key message of the chapter is that a policy's efficiency and effectiveness is very linked to its ability to reduce risk. The Stern Review on the Economics of Climate Change (Stern, 2006) concluded that "feed-in mechanisms achieve larger [RE] deployment at lower cost. Central to this is the assurance of long-term price guarantees [that come with FITs]…. Uncertainty discourages investment and increases the cost of capital as the risks associated with the uncertain rewards require greater rewards." (Stern, 2006) The IPCC (2007) notes that, in theory, if bidding prices and FIT payments are at the same level, the same capacity should be installed under either mechanism. However, "the discrepancy can be explained by the higher certainty of current feed-in tariff schemes and the stronger incentive effect of guaranteed prices." (IPCC, 2007b).

The degree of risk related to quotas will depend on the details of the mechanism. Risk may arise in a number of forms, including price risk (fluctuating power and certificate prices), volume risk (no purchase guarantee), and market risk; and all three risks increase the cost of capital (Mitchell, Bauknecht et al., 2006). While these risks exist within the British RO, they may not be experienced in other quota systems which set minimum prices, contract lengths and provide offtake contracts. However, while quota and tendering systems theoretically make optimum use of market forces, they may have a stop-and-go nature not conducive to stable conditions. Moreover, low-bid projects may not be implemented.

Technological and Geographic Diversity

Quota systems have been found to benefit the most mature, least-cost technologies (Espey, 2001; Sawin, 2004b; Jacobsson, Bergek et al., 2009). In the United Kingdom, Sweden and Flanders, TGC systems have advanced primarily biomass generation and some wind power, but have done little to advance other renewables (Jacobsson, Bergek et al., 2009). In the United States, between 1998 and 2007, 93 percent of non-hydropower additions under state RPS laws came from wind power, 4 percent from biomass, with only 2 percent from solar and 1 percent from geothermal (Wiser and Barbose, 2008b). It is of course possible for quotas to support specific technologies by giving them more tradable green certificates per MWh – as has recently happened in the UK in a direct attempt to increase diversity; or by mandating a technology quota under which utilities must purchase a certain number of RECs from a technology to meet their mandated quotas. For example, solar RPSs are becoming more common in the United States. FITs have encouraged both technological(Huber, Faber et al., 2004) and geographic diversity (Sawin, 2004b), and have been found to be more suitable for promoting projects of varying sizes (van Alphen, Kunz et al., 2008); Mitchell and Connor, 2004).

Participation and Social Equity

Jacobsson et al (2009) have noted that “equity is a crucial factor in creating social legitimacy for policies supporting an industrial revolution.”(Jacobsson, Bergek et al., 2009) Verbruggen and Lauber (2009) argue that the transition to sustainable power systems requires that independent power production is fully integrated in power systems (Verbruggen and Lauber, 2009). FITs tend to favour ease of entry and local ownership and control of RE systems (Sawin, 2004b; Lipp, 2007; Farrell, 2009), and thus can result in wider public support for renewables (Damborg and Krohn, 1998; Sawin, 2001; Sawin, 2004b; Hvelplund, 2006; Mendonça, Lacey et al., 2009).Mendonça et al (2009) have found that steady, sustainable growth of RE will require policies that ensure diverse ownership structures and broad support for renewables, and propose that local acceptance will become increasingly important as renewable technologies continue to grow in both size and number (Mendonça, Lacey et al., 2009). This is supported by studies in New Zealand and elsewhere (Barry and Chapman, 2009).

Many analysts argue that quota systems primarily benefit incumbent actors, which enables them to introduce RE at their own preferred pace (Girardet and Mendonca, 2009; Jacobsson, Bergek *et al.*, 2009; Verbruggen and Lauber, 2009). The transaction and administrative cost of a TGC system are higher than with FIT, making participation of small scale new entrants cumbersome, and therefore limited (Mitchell, Bauknecht *et al.*, 2006).

Support mechanisms shift economic wealth from some groups in society to others. Such shifts may simultaneously meet efficacy, efficiency, and equity concerns, or cause conflicts among them. Bringing RE electricity to deprived rural and urban populations increases equity. This is less clear if the cost of RE policy is spread across electricity consumers, but acquisition of the subsidy for domestic renewable energy technologies is by the wealthier (Jacobbson, 2010). The absence of excess profits makes it easier to balance the cost of support for the beneficiaries with payments made by non-beneficiaries (taxpayers or grid electricity customers). The few TGC systems that have functioned for a number of years and have been analyzed, show high or higher profits for the suppliers (Commission of the European Communities, 2008; Cory, Couture *et al.*, 2009; Jacobsson, Bergek *et al.*, 2009{Rickerson, 2007 #313)}.

Other regulatory RE policies

Other regulatory polices are related to access. Priority access and priority dispatch are generally important constituents of FITs. However, net metering, or net billing, enables small producers to “sell” into the grid, at the retail rate, any renewable electricity that they generate in excess of their total electricity demand over a specific billing period. Customers have either two unidirectional meters spinning in opposite directions, or one bi-directional meter that is effectively rolls forward and backwards, so that net metering customers pay only for their net electricity draw from the grid (Klein, Held *et al.*, 2008). Although net metering is most common in the United States, where it has been enacted in most states (Database of State Incentives for Renewables & Efficiency (DSIRE), 2009), the mechanism is also used in some countries in Europe and elsewhere around the world (Klein, Held *et al.*, 2008). The number of programs and participants has been increasing steadily (Energy Information Administration (EIA), 2008).

However, while the customer may see it as ‘fair’ that they are paid the same per kWh they inject into the electricity system as they pay for all incoming kWhs, electricity companies do not necessarily see it the same way arguing that they have to make, payments for distribution , transmission and network services and paying customers their retail price effectively costs them money (EGWG, 2001). Klein et al (2008) found that the remuneration is generally insufficient to stimulate significant growth of less competitive technologies like photovoltaics, since generation costs are significantly higher than retail prices (Klein, Held *et al.*, 2008). Based on impacts seen on small wind systems in the United States, Forsyth et al (2002) concluded that net metering alone provides only minimal incentives for consumers to invest in RE systems, particularly where people must deal with cumbersome zoning and interconnection issues. However, when combined with public education and/or other financial incentives, net metering might encourage greater participation (Forsyth, Pedden *et al.*, 2002). It is certainly easy to implement, in the sense that it requires only a meter which turns backwards.

11.5.4.2 Public Finance Mechanisms for Deployment

RE projects generally operate with the same financing structures applied to conventional fossil-fuelled energy projects. The main forms of capital involved include equity investment from the owners of the project, loans from banks, insurance to cover some of the risks, and possibly other forms of financing, depending on the specific project needs.

For many projects the availability of these needed forms of commercial financing is limited, particularly in developing countries, where the elevated risks and weaker institutional capacities inhibit private sector engagement. The gaps can often only be filled with financial products created through the help of public finance mechanisms.

There is a growing body of experience with the use of these instruments for promoting investments in RE deployment, mostly in the electricity sector. Their role is to help commercial financiers act within a national policy framework, filling gaps and sharing risks where the private sector is initially unwilling or unable to act on its own (UNEP, 2009).

Public finance mechanisms have a twofold objective: first, to directly mobilise or leverage commercial investment into RE projects and, secondly, to indirectly create scaled up and commercially sustainable markets for these technologies. To make the best use of public funding, it is essential that both these direct and indirect outcomes are sought when designing and implementing such mechanisms. Direct short-term benefits should not create market distortions that indirectly hinder the growth of sustainable long-term markets (UNEP, 2010).

The following provides an overview of the main public financing mechanisms being used today for promoting RE deployment and some of the experiences with their use.

In many countries there are significant gaps in the availability of equity financing for RE projects, particularly but not only in the developing world. Banks do not generally provide equity financing and the type of investment community that does so in the developed world is hardly present in developing countries. Equity-focused public financing mechanisms are therefore needed that are structured either as *funds* that take direct investments in companies and projects, or as “*funds of funds*” that invest in a number of commercial managed funds, each of which then invests in projects or companies (London School of Economics, 2009).

The bulk of the financing needed for RE projects is in the form of loans (concessional or otherwise), termed debt financing (London School of Economics, 2009). The challenges to mobilising this debt relate to access and risk. Many countries lack sufficiently developed financial sectors to provide the sort of long-term debt that clean energy and other infrastructure projects require. In these situations public finance mechanisms can be used to provide such financing, either directly to projects or as credit lines that deliver financing through locally-based commercial financial institutions. Credit lines are generally preferable, when possible, since they help build local capacity for RE financing (UNEP, 2009).

Credit lines can be an effective means of providing the needed liquidity for medium to long-term financing of clean energy projects. In markets where high interest rates are seen as a barrier, credit lines can be offered at concessional rates or structured on limited/non-recourse basis, or alternatively offered as subordinated debt to induce borrowing and direct credit to target sectors and projects: by taking on a higher risk position in the financial structure, this approach can leverage higher levels of commercial financing (London School of Economics, 2009). For example, credit lines from the World Bank, KfW and ADB helped the Indian Renewable Energy Development Agency become an important lender to, and key to the success of, the RE sector in India (see Box 11.9).

Box 11.9 Public Finance Case Study: India Renewable Energy Development Agency (IREDA)

IREDA is a Government-owned company incorporated in 1987 that provides debt financing to RE projects. IREDA invests mainly as a senior lender, lending up to 80 percent of a project's investment cost on terms up to 10 years with up to two year grace periods. Funded projects total over USD1 billion and have included wind, hydro, bio-mass cogeneration, industrial waste heat recovery power plants, industrial process efficiency. It has received international credit lines from the World Bank, ADB and KfW, amongst others, as well as grant support from the GEF. About one third of its capital is now raised domestically, both through bank borrowing and the issuance of tax free bonds. In India, State governments are now authorised to establish energy conservation funds; IREDA, as a national entity, has potential to replicate its capability by supporting development of such State funds (UNEP, 2009).

Mechanisms can also be targeted specifically at reducing the financing cost of credit provision, while the commercial finance institution provides the actual bulk of the financing. The spread between the interest rates collected from borrowers and the competitive returns paid back to the bank is essentially financed by public funds buying down the interest rate. This approach has been applied successfully in India for domestic solar thermal and solar PV systems, in Tunisia for solar thermal and in Germany for a range of RE technologies (UNEP, 2009).

In some countries guarantees can be a more effective instrument for helping local banks who are uncomfortable financing RE projects because of high perceived credit risk (i.e. repayment risk). The role of a guarantee is to mobilise domestic lending for such projects by sharing with recipient banks the credit risk of project loans they make with their own resources. Guarantees are most effective at addressing elevated perceptions of risk in that they help a bank gain experience in managing a portfolio of RE loans, which puts them in a better position to evaluate true project risks.

Fostering improved access to finance is necessary, but is not always sufficient to promote RE project deployment. Successful public finance mechanisms typically combine (i) access to finance with (ii) technical assistance programmes designed to help prepare projects for investment and build the capacity of the various actors involved (UNEP, 2009). Many examples exist of finance facilities that were created, but did not disburse because they failed to find and generate sufficient demand for the financing. Successful mechanisms actively reach back into the project development cycle to find and prepare projects for investment; that is, they work on both the supply and the demand side of the financing equation. Strategies to generate a flow of well-prepared projects for financing can involve partnerships with many market actors such as utilities, equipment suppliers and project developers, end user associations, and governmental authorities.

Box 11.10 Public Finance Case Study: Berkeley Sustainable Energy Financing District

The City of Berkeley, California established a Sustainable Energy Financing District (also called Property Assessed Clean Energy, PACE) in which it issued bonds and used the proceeds to provide loans to commercial and residential property owners for the installation of solar PV systems and energy efficiency improvements. Loans to property owners have 20-year terms, allowing loan payments to be matched with the energy savings. The City bears the credit risk of the loans but, in an important innovation, collects loan payments on the property tax bill. This tax assessment belongs to the property rather than the individual end-user, who effectively sells it with the property if he moves on. PACE investments effectively add to the property value. A number of additional U. S. cities (Boulder, CO, Palm Desert, CA, Babylon, NY, and others) have implemented versions of the PACE districts, and efforts are underway in Germany, Italy, and Portugal (Fuller, Portis *et al.*, 2009). This mechanism has the potential to 'flip' the financial equation such that the costs are not front-loaded but are paid for during the period of use. (Fuller, Portis *et al.*, 2009)

Box 11.11 Policy Experience with Wind Power in the United States

In the United States, installed wind energy capacity grew from 2.6 GW in 2000 to more than 35 GW in 2009. Federal tax incentives, state renewable portfolio standards (RPS), the improving economics of wind, and other RE incentives drove this development (Menz and Vachon, 2006; Wiser, Namovicz *et al.*, 2007; Adelaja, Y.Jailu *et al.*, 2010). The U.S. experience highlights the need for stable and consistent policies as well as multiple incentives to create a robust market that promotes steady growth in capacity and manufacturing facilities.

From 2001-2005, failure to consistently renew the federal production tax credit (PTC), which provides approximately 2 cents per kilowatt-hour for the production from wind facilities for the first 10 years of operation, created a boom and bust cycle for wind development (Bird, Bolinger *et al.*, 2005). Figure 11.9 shows the impact of allowing the PTC to expire in 2002 and 2004.

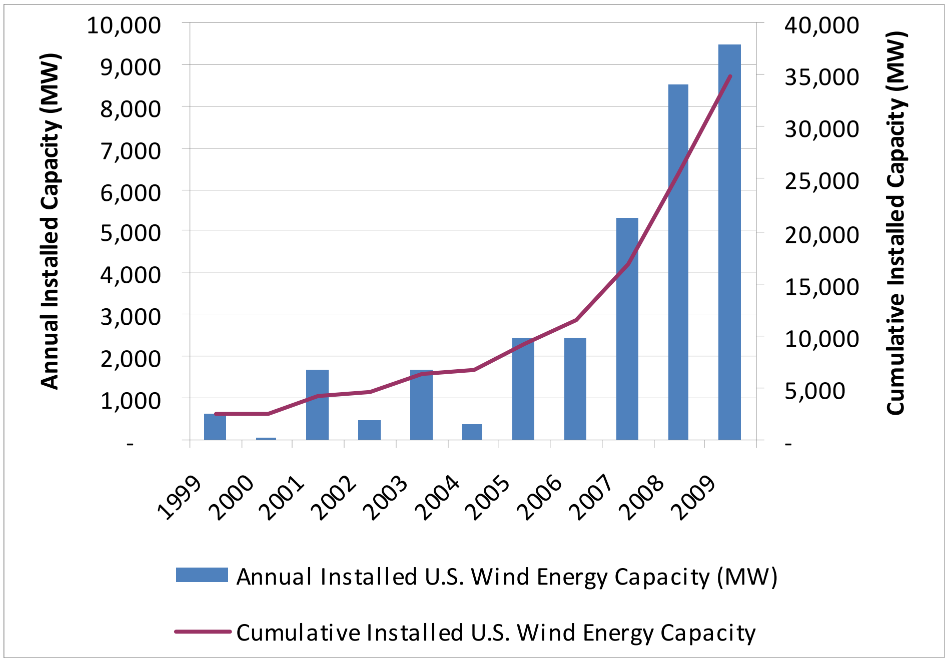

Figure 11.9 U.S. Wind Capacity, 2001-2009 [TSU: Source is missing]

Between 2005 and 2009, the rate of annual installations climbed steadily, as federal tax credits were re-authorized before expiring, more states adopted RPS laws, and many states strengthened preexisting RPS targets. As of May 2010, 29 states had adopted an RPS and another half dozen had established renewable energy goals. Many states require electricity providers to obtain 20 percent or more of the power needed to serve their loads from RE sources by 2020. Collectively, these state RPS policies call for more than 65 GW of new RE by 2020 (Wiser and Barbose, 2008a).

Some states have seen rapid growth through these policies, and Texas achieved its 2025 goal of 10 GW installed wind capacity by April 2010 (ERCOT, 2010). However, the socio-political context and siting barriers have impeded development in other states (Fischlein, Larson *et al.*, 2010), demonstrating the need to address barriers, such as siting and transmission, in addition to establishing targets and financial incentives.

Collectively, the combination of binding, long-term state RE targets and federal and state financial incentives, and efforts to address siting and financing barriers have created greater market certainty and reduced regulatory risk, which in turn have led to investments in manufacturing capacity and steadier industry growth in recent years (Wiser and Bolinger, 2009). Between 2004 and 2009, U.S. domestic manufacturing of wind turbines and their components increased 12-fold and, in 2009, 16 turbine manufacturers opened or announced plans for factories in the United States, up from only one turbine manufacturer in 2004 (AWEA, 2010).

Starting in 2008, the federal government provided RE support as part of its effort to help fuel economic recovery. In response to the inability of investors to utilize tax incentives during the recession, the government provided project developers with the option to receive cash grants in lieu of the federal tax credits and extended the tax credits for wind through 2012. This led to a record number of new wind power installations in 2009, which will likely extend through 2010 (Wiser and Bolinger, 2009).

11.5.5 Policies for Deployment - heating and cooling

Heating and cooling processes account for 40-50 percent of global energy demand (IEA, 2007a; Seyboth, Beurskens *et al.*, 2008) with consequent implications for emissions from fossil fuels. Historically, renewable energy policy has tended to have a greater focus on renewable electricity, with increasing activity in support of biofuels for transportation over the last decade. However, renewable energy sources of heat (RES-H) have gained support in recent years as awareness of their potential has been increasingly recognized. Many nations have some form of district heating. As well as heat delivery infrastructure this tends to imply some pricing and regulatory oversight. Waste heat from fossil fuel and nuclear generation is commonly used in systems across Eastern Europe, former soviet states and Scandinavia. (Ericsson and Svenningsson, 2009). RE for cooling (RES-C) has even fewer mechanisms of support than RE for Heating. As a result, experience of what works and what doesn't is far less than that for RE electricity or fuels>

The supply and servicing infrastructure relevant to RES-H and RES-C technologies in most countries is immature, though there are significant exceptions to this, with some nations being advanced in terms of manufacturing, integration and infrastructure, often in technology specific areas. Examples include solar water heating in a number of nations, most especially China but with significant uptake in some Mediterranean nations, and geothermal energy in Iceland, where it accounts for over 90% of national heat demand.

There is considerable scope for learning from the RES-E policy experience but proper attention is needed in applying them to RES-Heating/Cooling due to significant differences in the generation, delivery, metering, trading and regulatory environment and use of heat and cooling. Policy instruments for both RES/H and RES-C need to specifically address the much more heterogeneous characteristics of resources including their widely varying range in scale, varying ability to deliver different levels of temperature, widely distributed demand, relationship to heat load, variability of use and the absence of a central delivery or trading mechanism (Connor, Bürger et al., 2009a). It should also be noted that RES-H technologies vary in technological maturity and in market maturity, for example some solar water heating systems are closer to being competitive in China or Israel than in Europe (Xiao, Luo et al., 2004), while solar water heating is more technologically and market mature than, for example, biomass based substitute natural gas, (Connor, Bürger et al., 2009a). Policy instruments which acknowledge this as well as other relevant local differences are likely to be more effective (Haas, Eichhammer et al., 2004).

Policy mechanisms currently in place to promote renewable heat include regulatory mechanisms, such as bonus mechanisms and quotas; fiscal instruments such as tax-credits, tax-reductions and tax-exemptions and accelerated depreciation; and educational efforts (as discussed in 11.6). There is significant potential for other instruments to also be applied. (DEFRA/BERR, 2007; Bürger, Klinski et al., 2008; Connor, Bürger et al., 2009a).

This section describes mechanisms which are suitable for both heating and cooling. There is one short section later on which talks about issues relevant to cooling on.

11.5.5.1 Regulatory Mechanisms

Bonus Mechanisms and Quotas

The bonus (or tariff) mechanism and the quota or renewable portfolio standard (RPS) are the two key variations in providing support to RES-H. The bonus mechanism (roughly, the equivalent to the RES-E FIT) has been characterised as a “purchase/remuneration obligation with fixed reimbursement rates” (Bürger, Klinski et al., 2008). It legislates a fixed payment for each unit of heat generated, with potential for setting different levels of payment according to technology. Payments can be capped either for a fixed period, or for a fixed output, and can be designed to vary with technology and building size to complement energy conservation efforts. Digression may be applied to reduce the level of the bonus payment annually to allow the capture of cost reductions for the public purse. Digression has been cited as ‘best practice’ in the consultation document for the adoption of a renewable heating tariff in the UK, based on experience with RES-E tariffs in Europe (RES, 2009) .

Currently, no RES-H/C centred quota mechanism has been applied in practice nor are any planned. Efforts to legislate a RES-H quota mechanism in the UK in 2005 were unsuccessful and the UK has now adopted legislation for a RES-H bonus mechanism with a projected April 2011 adoption (DECC, 2009) largely on the grounds of the greater projected cost associated in a comparison of quota ad tariff mechanisms . Germany also favoured a bonus mechanism for RES-H, but finally adopted mandatory installation of RES-H in new buildings. The Australian Government’s Mandatory Renewable Energy Target (MRET) was established on 1 April 2001 to encourage additional RES-E generation and achieve reductions in greenhouse gas emissions. The MRET includes solar hot water systems as eligible sources for certificates where solar water heating displaces electrical energy use. Owners of solar water heaters can either: assign their RECs to an agent in exchange for a delayed cash payment or upfront discount, or register RECs online to be sold and transferred to a registered agent during the life of the scheme .

Key differences between an electricity FIT and the RES-H bonus/tariff include the many more renewable heat generators expected and that heat generation will generally be used at the same site as the load. This has the potential to add substantial complexity and costs due to metering and administration. Applying the UK’s RES-E quota mechanism at the micro scale doubled administrative costs for an increase in renewable energy generation of only 0.05% (Bürger, Klinski et al., 2008), One proposed solution is consolidation, that is, including a third party organisation to aggregate and distribute benefits for output. This is likely to be combined with a policy of only paying out the bonus funds on a limited number of occasions, perhaps 2-3 over the lifetime of an installed technology (Bürger, Klinski et al., 2008), reducing administrative costs but potentially reducing access to funds for the investor.

Subsidy can be given either as a result of metered output or some form of estimation of output. Where metering is not applied it is essential to have a robust procedure for assessing likely useful heat and load to restrict overpayment from the public purse. A system for ensuring quality of installation and of installed systems will also be essential for the same reason. Given the relative costs of energy efficiency improvements against renewable energy subsidy costs good practice should ensure that installation of RES-H systems follows proper investment in energy efficiency.

Mandating Connection Technology

One simple application is to mandate the inclusion of the basic connection technology in new buildings, which would allow for later integration of RES-H/C. However, this option is limited by the potential for meeting the requirements of different forms of technology, by the increases in the costs it would engender. Integration of the technology for later connection to district heating or cooling is one potential application that might have a good fit with later investment (Connor, Bürger *et al.*, 2009b).

'Use' Obligation

More significantly in terms of expanding demand and growing support infrastructure for RES-H technology applications of building regulations can be used to compel the adoption of RES-H/C technologies, as in the case of the 'Use Obligation' instrument. A use obligation effectively compels spending on renewable systems, either by the initial builder who effectively passes costs to the purchaser or, in more advanced approaches, by compelling retro-fitting of new systems.

Initially adopted in various municipalities in Spain, Germany, Italy, Ireland, Portugal and the UK, this mechanism has been expanded to apply at the national level in Spain and Germany and the process of adoption is underway in the UK, where integration of renewables into new buildings will form a part of the Code for Sustainable Homes, following increasingly tough energy efficiency standards . Basic or first stage applications of this instrument tend to compel developers of new buildings to ensure a specified fraction of energy use is from renewable sources, with variations as to the eligible technologies, the fraction of energy to come from renewable sources and whether the energy has to be on site or can be located elsewhere. One useful element of the use obligation is that it can be applied at different levels of governance and for district heating as well as individual decentralized systems. The goal is the stimulation of an initial market for the technology and of the attendant necessary infrastructure, such as training of personnel. Use obligations may be applied to a single or multiple technologies, with the option to have different minimum fractions attach to adoption of different technologies producing either RES-E, RES-H or RES-C or some combination of these (Bürger, Klinski et al., 2008; Puig, 2008).

Such regulations are justified on the grounds that renewable heating technologies or their enabling technologies are more cost-effective if installed during construction rather than retro-fitted. The impact on the total building cost is therefore relatively low. Such a mechanism offers benefits in terms of growing the scale of public demand, and there is an argument that they might operate most effectively by steadily increasing the level of the obligation over time in order to ensure both that demand is maintained and occurs on a graduated basis allowing for realisation without unjust punishment for obligated parties unable to source material or skills to meet their obligations (ESTIF, 2006).

Standards and Building Regulations

The application of a system of standards to ensure a minimum quality of hardware, installation, and design planning when implementing obligations for renewable heat is likely to be essential to ensuring proper compliance with the mechanism; a monitoring system including periodic examinations of installations and/or minimum quality standards is advisable, though this will increase administrative costs (Connor, Bürger *et al.*, 2009a). Restriction of non-compliance is fundamental to the success of the use obligation (Bürger, Klinski et al., 2008).

Where additions to buildings are compulsory through 'use' obligations, good regulatory practice should offer protection on the grounds of economic, technical and environmental feasibility incorporated (as for example, with the European Building Performance Directive). Compulsory refurbishment should ideally also include protection for the economically vulnerable (Connor, Bürger *et al.*, 2009a).

National planning regulation regimes also have the potential to significantly hamper growth of RES-H/C technologies, as has sometimes been the case for RES-E. Different territories have very different approaches to planning and zoning as regards RE; despite this, there are clear examples to inform good practice (Upreti and Van Der Horst, 2004; Loring, 2007). A District Heating system requires strong oversight if the consumer is to be protected from being locked in to high energy prices. As seen in Box 11.12, Sweden provides an interesting example of a successful DH system using a significant share of biomass. it (Ericsson and Svenningsson, 2009).

Box 11.12 Sweden's Experience with Biomass District Heat

Sweden's experience with district heating illustrates how policy and other factors can shape the development of an enabling infrastructure as well as a shift to RE sources. The biomass share in district heat production has increased from zero in 1980 to 44 percent (90 PJ) in 2007 (see Figure 11.10). An additional 12 PJ of biomass was used to co-generate 3 TWh of electricity in 2007. Underlying drivers since 1980 have included Sweden's ambitions to reduce oil dependence and utilise indigenous RE sources, replace nuclear power, and reduce GHG emissions. (Ericsson and Svenningsson, 2009).

Virtually all Swedish towns have a district heating system, and district heating now accounts for about 50 percent of heating in the residential and service sectors. The main expansion took place in the period 1965-1985 when municipal administrations and companies built, owned and operated the district heating systems. It was facilitated by strong local planning powers and high acceptance for public sector led solutions. Important motivations included opportunities for combined heat and power (CHP) production, fuel flexibility, economic efficiency, and better pollution control compared to individual boilers. High oil prices and taxes on oil products instigated a major shift away from oil in the 1980s to a variety of fuels and energy sources, including coal, municipal solid waste (MSW), industrial waste heat, and electricity. (Ericsson and Svenningsson, 2009)

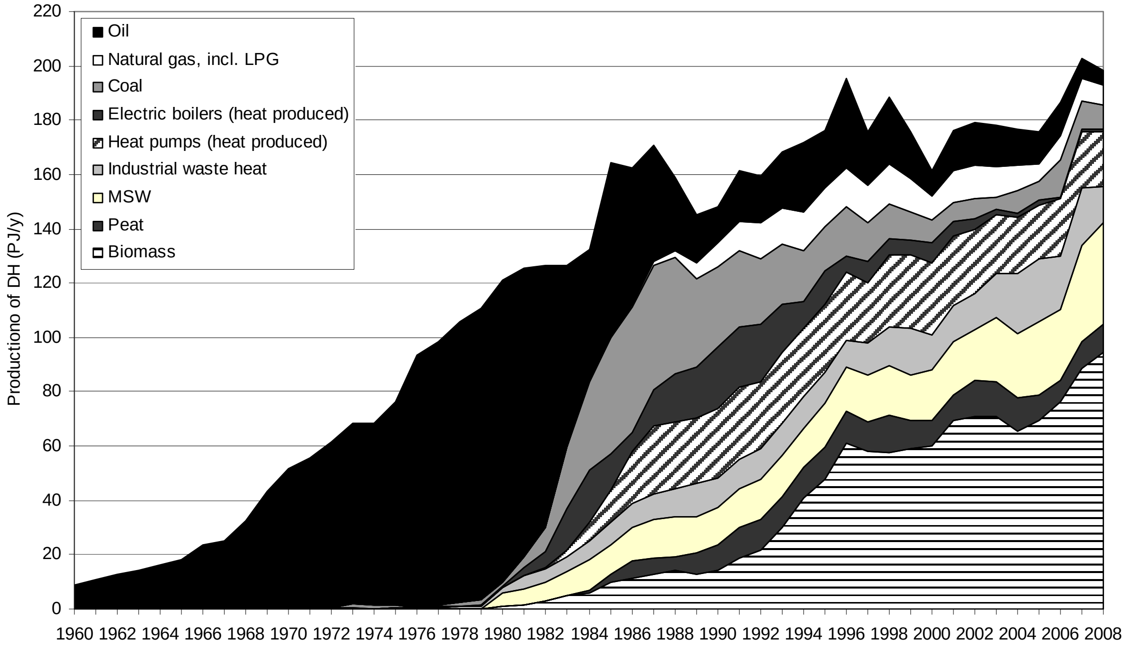

Figure 11.10 District heat production in 1960-2008, broken down into fuels and energy sources. (Ericsson and Svenningsson, 2009)

Curves are not corrected for outdoor temperature variations.

The second major shift took place after 1990, in response to the 1991 energy tax reform, which included a carbon tax at 41 USD_{2005} per tonne of CO_2. This tax has gradually increased and reached 130 USD_{2005} per tonne in 2007. As a result, the use of biomass expanded rapidly, from 14 PJ in 1990 to 60 PJ in 1996. Energy recovery from MSW incineration produced 35 PJ (half or more of this is considered as RE) in 2007, partly in response to bans on landfilling combustible and organic waste (Ericsson and Svenningsson, 2009).

CHP production has not been used to its full potential since the nuclear power expansion 1975-1985 resulted in an electricity "surplus" and large electric utilities were able to mount disincentives to municipal power production. Instead, electric boilers and heat pumps came into use, as seen in the figure. The ambition to replace nuclear power, however, motivated biomass based CHP investment subsidies 1991-2002 and the green certificates scheme introduced in 2003. In response, electricity from CHP increased from about 2 TWh in 1990 to 7.5 TWh in 2007; of this, 41 percent was from biomass and 20 percent from MSW. Electricity from biomass based CHP in the district heating sector and the forest industry accounted for more than two-thirds of the tradable certificates under the Swedish quota based system in 2007 (Bergek and Jacobsson, 2010).

11.5.5.2 Fiscal Instruments

Ireland, Italy, Portugal, Sweden and the Netherlands have all applied some form of tax break to support different RES-H technologies *(Bürger, Klinski et al., 2008)*. Likewise, indirect support, as exemptions from eco-taxes, carbon and energy charges levied on conventional heating fuels, provides a comparative advantage for RES-H. A clear example is Sweden's fuel switch to bio-energy driven by high CO_2 tax (*(Ericsson and Svenningsson, 2009)*.

Additionally, accelerated depreciation against investment in RE can also be a useful instrument in improving the economics of investment. The Netherlands VAMIL programme, Canada's Accelerated Capital Cost Allowance (CCA) and the UK's Enhanced Capital Allowance Scheme are examples (Worrell and Graus, 2005; IEA, 2007a).

11.5.5.3 Public Finance

Capital Grants

Capital grants and rebates assist directly with reducing plant capital investment , with a government typically contributing a specified level of financial support, for example a refund per megawatt of installed capacity or a percentage of total investment, up to a set limit. They can apply from the small-scale, for example a domestic solar thermal system, through to large-scale generating stations such as biomass combined heat and power (CHP). Grants are the most commonly applied instrument for RES-H (and RES-C to a lesser extent), with various applications in multiple countries and regions including Austria, Canada, Greece, Germany, Ireland, the Netherlands, Poland and the UK *(Bürger, Klinski et al., 2008; Connor, Bürger et al., 2009a)*.

Grants generally also require some form of oversight to ensure spending occurs based on set conditions and continued operation post-deployment to be effective and that the quality of new generating capacity achieves at least a minimum standard. They can be vulnerable to fluctuations in budgets to the detriment of stable demand growth, as with the German Market Incentive Program (MAP) and the UK's Low Carbon Building Programme. Conversely, the opposite has been observed from the French experience, where the implementation of the 2005 Finance Law provided a successful ex-post incentive method with no subsidy pre-approval required, and suggesting an easy-to-administer, simple and straightforward promotion system *(IEA, 2007a; Roulleau and Lloyd, 2008; Walker, 2008b; Gillingham, 2009)*.

Soft Loans

Soft loans, provided for example, through a government directed bank or other agency, may come with low or zero interest rates, with delays on repayments or with long-term repayment periods. They can be easy to apply at the administrative level, though there is potential for political difficulties in territories without histories of providing public funds in this manner (IEA, 2007a). Soft loans have long been a feature of German efforts in support of RES technologies and the Environment and Energy Saving Program has included RES-H since 1990, though the bulk of funds has gone to PV and wind. Norway and Spain also have loan programs relating to heat, and Japan and Sweden have both employed soft loans previously (IEA, 2007a).

The adoption of RES-H/C at the domestic level has the potential to be severely hampered by the initial capital barrier to system purchase. The available policy instruments discussed here address this to particular extents. Both the quota and tariff mechanisms provide regular payments over the lifetime of a project, the latter with perhaps greater predictability than the former. Soft loans address both the initial capital problem while also widening the scope of potential consumers who can benefit from any available subsidy, rather than the focus lying with those with access to sufficient capital.

11.5.5.4 Policy for Renewable Energy Sources of Cooling (RES-C)

Policy aiming to drive uptake of RE sources for cooling (RES-C) is considerably less well-developed than that for RES-H, even in nations with a higher cooling load and that tend to have higher potential for location of RES-C technologies. The relative lack of diversity and greater homogeneity of existing RES-C technologies in comparison with RES-H means that development and application of policy instruments is less complex (IEA, 2007b; Desideri and Proietti, 2009).

Many of the mechanisms described above will be able to be applied to RES-C, generally with similar advantages and disadvantages, though with a continuing need to account for the particular characteristics of the technology and its application. Most renewable cooling is based on the use of heat initially produced from RES, though not all RES-H technologies are yet at a stage where they might be useful as RES-C sources. The reduced scope for use should mean a comparatively greater level of homogeneity and thus less potential problems in applying the instruments to RES-C (DG TREN, 2007). The key areas of crossover are likely to be in the application of heat exchangers and in the area of district cooling.

11.5.6 Polices for Deployment - Transportation

This section describes policies designed to encourage the deployment of renewable options in the transport sector. First it analyzes policy instruments that have been enacted to promote the direct use of RE, in the form of biofuels. It then examines policies to promote the indirect use of RE for transportation, via intermediate storage media (batteries and hydrogen). It concludes with a brief look at low-carbon fuel standards.

Table 11.4 Direct Use of RE for Transport - Biofuels

Policy	Target	Example
Renewable fuel standards	Biofuels	RFS1 (USA)
Tax incentives	Mostly biofuels	Excise tax exemption on biodiesel (Germany)
R&D	Biofuels and intermittent technologies	US
ZEV mandates	Intermittent technologies	California
GHG emission standards for mobile sources	To second degree intermittent technologies & biofuels	EC No 443/2009 (EU); EPA regulation (USA)
Low carbon fuel standards	All fuels, incl. biofuels & electricity/ hydrogen from ren. sources	S-01-07 (Califronia); COM-2007-18 (EU)
Emission Trading	All fuels	Proposed for California
Preferential government purchasing & urban policies	Intermittent technologies (electric cars)	London, Malmo

A range of policies have been implemented to support the deployment of biofuels in countries and regions around the world. Robust biofuels industries exist only in countries where government supports have enabled them to compete in markets dominated by fossil fuels. An example of this is Brazil (see Box 11.13). There are many countries where basic regulations for the production, sale, and use of biofuels do not yet exist (FAO/GBEP, 2007; PABO, 2009). Some countries, like Mexico and India, have implemented national biofuels strategies in recent years (Altenburg, Schmitz *et al.*, 2008; Felix-Saul, 2008). The most widely used policies include volumetric targets or blending mandates, tax incentives or penalties, preferential government purchasing, and local business incentives for biofuel companies.

11.5.6.1 Regulatory Policies

Renewable Fuel Mandates and Targets

National targets are key drivers in the development and growth of most modern biofuels industries. Blend mandates have been enacted or are under consideration in at least 27 countries surveyed by this report, and 40 countries have some form of biofuels promotion legislation. (A Blueprint for Green Energy in the Americas Strategic Analysis of Opportunities for Brazil and the Hemisphere Featuring: The Global Biofuels Outlook 2007. Prepared for the Inter-American Development Bank by Garten Rothkopf). Among the G8 +5 Countries, Russia is the only one that has not created a transport biofuel target (FAO/GBEP, 2007). Voluntary blending targets have been common in a number of countries. However blending mandates enforceable via legal mechanisms are becoming increasingly utilized and with greater effect (Canadian Food Grains Bank, 2008).

The distinction between voluntary and mandatory is critical since voluntary targets can be influential, but do not have the impact of legally binding mandates. This was evident in Europe, for example, when all but two of the EU member countries failed to achieve the voluntary biofuels for transport blending target of 2 percent by 2005 (FAO/GBEP, 2007).

The EU currently has a target of 10 percent RE in transport by 2020 (Official Journal of the European Union, 2009). Brazil has had a mandatory ethanol blending requirement for many years and more recently created biodiesel blending mandates (citation and details). India set a five percent national ethanol blending mandate, then increased it to ten percent, and then in 2008 set an additional indicative target of a minimum 20 percent ethanol and biodiesel blending nationally by 2017 (Altenburg, Schmitz *et al.*, 2008; IGovernment, 2008; Ritch, 2008).

Governments do not need to provide direct funding for blending mandates since the costs are paid by the industry and consumers. Mandates have been quite effective in stimulating biofuels production, but they are very blunt instruments and should be used in concert with other policies, such as sustainability requirements, in order to prevent unintended consequences (Sustainability Science Program; Lee, C.Clark *et al.*, 2008).

Sustainability Standards

Although environmental quality is regulated in most countries, comprehensive sustainability laws for biofuels are in place only in Europe where individual government efforts (especially in the Netherlands, the United Kingdom, and Germany) led to an EU-wide mandatory sustainability requirements for biofuels that was put into law in 2009. These include biodiversity, climate, land use and other safeguards (Hunt, 2008; Official Journal of the European Union, 2009).

At the international level, there are no legally binding sustainability regulations for biofuels that address the potential negative social and environmental impacts of biofuels (such as habitat conversion, water and air pollution, and land-use conflicts). However, a number of requirements that aim to ensure the sustainable development of biofuels are being developed.

Some countries have attached certain sustainability requirements to their biofuels support policies. For example, Mexico’s Law for the Promotion and Development of Biofuels, passed in 2008, includes an explicit prohibition of changing land from forest to agricultural land for the production of biofuels feedstocks (Felix-Saul, 2008).

In order to avoid competition with food, India’s 2008 National Biofuels Strategy mandates that biofuels come from non-edible feedstocks that are grown on waste, degraded or marginal lands (Altenburg, 2008) (Ritch, 2008)}.

There is a requirement in the United States’ renewable fuel standard that biofuels (except grandfathered production) reduce GHG emissions relative to conventional fuels, based on full life-cycle accounting, and that feedstocks not be grown on previously forested land (US Congress, 2007).

Brazil developed a Social Fuel Seal as part of its biodiesel program whereby producers can receive the seal and the associated tax benefits and credit only if they enter into a legally binding agreement with them producers to establish specific income levels and guarantee technical assistance and training (Governo Federal, 2006).

Box 11.13 Brazilian ethanol: Lessons learned

Brazil first mandated the blending of ethanol with gasoline in 1931, but ethanol was not used there in significant quantities until the mid-1970s, when Brazil was hit hard by the first world oil crisis. Taking advantage of its position as a leading sugar producer, in 1975 the government established the Brazilian Alcohol Program (PROALCOOL) to promote sugarcane ethanol as a gasoline alternative in order to reduce oil imports. The program, which set production goals and included producer subsidies, has created environmental, economic and social benefits for Brazil (Goldemberg, 2009).

Initially ethanol was available for ethanol-only engines or as an octane enhancer, and the government mandated that it be blended with gasoline in ranges from 20-25 percent. In the mid-1980s, low gasoline prices, high sugar prices and a shortfall in ethanol production led to a serious crisis and the gradual abandonment of ethanol-only cars. Responding to government pressure, auto manufacturers introduced flex-fuel motors in 2003, solving the problem associated with fluctuating supply and prices. Flex-fuel cars, which can run on any blend of gasoline or ethanol, allow drivers to make price-driven fuel choices. Today more than 95 percent of all new cars sold in Brazil are flex-fuel (Goldemberg, 2009). About 60 percent of ethanol distilleries in Brazil are dual-purpose, producing sugar when world sugar prices are high, and converting it to ethanol at other times (Ministry for Agriculture Livestock and Supply, 2008).

Other early challenges included the need for a national network for transport, distribution and refueling with ethanol. Initially the Brazilian government undertook all activities related to purchasing, transporting, storing, distributing, and blending ethanol. But the private sector eventually took over and there is now an extensive network associated with ethanol production and use (Goldemberg, 2009).

Although ethanol production in Brazil was initiated as a highly subsidized program, over time, improvements in technology and economies of scale drove down production costs. By 2004, ethanol in Brazil had become economically competitive with gasoline without subsidies (Goldemberg, 2004a).

As of 2010, Brazil was the world's second largest producer of ethanol, after the United States. Brazil produced 569 million tons of sugarcane during 2008-2009, resulting in 27.5 billion liters of ethanol; in the domestic market, ethanol replaces 50 percent of gasoline for transport (UNICA - Sugarcane Industry Association, 2010).

Bagasse, residue from sugarcane, is used for heat and power generation in the refining process, reducing environmental impacts, lowering associated carbon emissions, and improving the economics of ethanol production (Cerri, Easter *et al.*, 2007). The mills not only meet their own energy needs but sell excess electricity to the grid, which provides another source of income. Early production was stimulated through incentives; today, owners of mills can sell directly into the grid through contracts or auctions. In 2010 the installed bagasse capacity was approximately 4,831 MW (ANEEL (Agência Nacional de Energia Elétrica), 2010).

The growth of ethanol produced from sugarcane in Brazil to supply an expanding market as well as exports to other countries has raised concerns over its sustainability regarding soil quality, water consumption, agrochemical inputs and social impacts. Several measures have been enacted to address such problems including ecological and economical zoning laws that dictate where sugarcane and ethanol production can occur (Goldemberg, Coelho *et al.*, 2008).

11.5.6.2 Fiscal Policies

Taxes

Taxes are one of the most widely used and most powerful policy support instruments for biofuels because they change the cost competitiveness of biofuels compared to fossil fuel substitutes in the marketplace. In theory at least, tax incentives or penalties can be gradually increased or decreased as technologies and supply chains develop and as markets evolve. Governments either forgo some tax revenue – in the case of tax breaks – or gain revenue, from added taxes on competing, non-renewable fuels, or on CO_2 emissions from competing fuels for example example (Deurwaarder, 2007).

There are several disadvantages to using tax policy, including: tax breaks can be quite costly to governments, and tax increases can be quite difficult to implement politically (USDOS, 2008). In addition, tax policy can be difficult to modify over time. A partial solution to this could be tax structures that are linked to fuel prices in the market so that they self-adjust. In recent years, the European countries and several of the other G8 +5 countries have begun gradually abolishing tax breaks for biofuels, and are moving to obligatory blending (FAO/GBEP, 2007).

In some cases, like in Germany, the impacts on industry have been dramatic. Prior to August of 2006, German consumers paid no excise tax on biodiesel and the industry flourished, selling 520,000 tons of biodiesel in 2005 (Hogan, 2007). In 2006 the government began to tax biodiesel at a rate of 9 euro cents per litre (0.109 $USD_{2005/}$litre) with plans to scale up the tax up to 45 euro cents/litre (0.548 USD_{2005}/litre) by 2012, the same rate at which fossil diesel is taxed. As of late 2009, German biodiesel was taxed at a rate of 18 euro cents/litre (0.219 USD_{2005}/litre (tentatively deflated by 2008 deflator)] and sales had dropped to an estimated 200,000 tons (Hogan, 2009). This tax policy is responsible for the reduction in biofuels' share of German total fuel consumption from 7.2 to 5.9 percent between 2007 and 2009 (BMU, 2009).

A more dramatic case is the introduction of flex fuel vehicles in Brazil.. For example, reduced taxes on flex fuels cars, and the capability to run on any blend of ethanaol or gasoline, from 100% ethanol to 100% gasoline, resulted in these vehicles accounting for 73% new cars sales in just 18 months (Rothkopf, 2007).

The above examples represent incentives in the demand side. Tax can also be used as a financing tool from supply side as in the case of production tax credit in the tax-equity market of the USA. However, biomass and biofuels are tradable and the market can be international causing a problem in competitiveness. This means that issues like trade policy around import of feedstock or fuels, or policies/subsidies in other another country which might affect the competitiveness of imported products, are also very important. (Hamilton, 2009).

Other Direct Government Support for Biofuels

Governments issue grants, loan guarantees, and other forms of direct support for biofuel production and use systems. In fact most countries that are encouraging biofuels development are using some form or forms of direct loan or grant supports (FAO/GBEP, 2007). It is common for state/province or local governments to give incentives for the construction of domestic/local biofuel production plants to stimulate job creation and economic activity. Direct supports are being used in a number of countries specifically to help accelerate the commercial development of second-generation biofuels. Direct financial supports have the advantage of easily quantified results, however, their outcomes tend to be limited to individual projects, as opposed to broader reaching support instruments. These supports are generally paid for directly by governments (FAO/GBEP, 2007).

11.5.6.3 Indirect Policy

Policies, other than those that are focused on renewable energy, can also be supportive for renewable transport fuels. This section briefly touches on agricultural policies (discussed further in Chapter 2); on storage (discussed further in Chapter 8) ;and on non-RE specific transport policies (for example, urban transport policies, also discussed in Chapter 8); and low carbon fuel standards.

Because nearly all liquid biofuels for transportation are currently produced from conventional agricultural crops, agricultural policies have significant impacts on biofuels markets. This is discussed in more detail in Chapter 2.

Renewable energies such as wind or solar can power vehicles for transportation indirectly with electricity/batteries or hydrogen. Storage technologies are crucial for large-scale deployment of RE to match the variable nature of some renewable sources with demand such that the system improves in responsiveness, flexibility and reliability while reducing capital and operating costs (Schaber, Mazza *et al.*, 2004; Kintner-Meyer, Schneider *et al.*, 2007). Making these secondary forms of energy carriers cost-effective and efficient is one condition for providing renewable energies for transport. This is discussed in more detail in Chapter 8, the technology integration chapter but has implications for policy.

Urban transport policies can facilitate deployment of RE in transportation. Price signals such as parking fees and congestion charges mostly try to regulate transport demand (Prud'homme and Bocajero, 2005; Creutzig and He, 2009), but can induce rapid shift to alternative fuel vehicles by tax or fee exemptions, e.g. by 10 percent discount on the London congestion charge for alternative fuel and electrically-propelled vehicles (Transport for London (TfL), 2009), or free parking for electric cars (Williams, 2008).

Increasingly policies are put in place to reduce the carbon intensity of fuels. For example, in Europe, there is a framework for reducing emissions of new cars from the average 153.5 gCO2/km to 130 gCO_2/km by 2015; and a commitment to further reduce this to 95gCO2/km by 2020 (Arnold, 2009; EC, 2009; UNFCCC, 2009) Similarly, as of January 2010, California is mandating a low carbon fuel standard (LCFS) for an emission reduction of 10 percent from the entire fuel mix by 2020 (CARB (California Air Resources Board), 2009). A price subsidy so called Feebates of California for low-carbon emission vehicle is also an incentive from the demand side (Bunch and Greene, 2010).

11.5.6.4 Infrastructure Policies

Alternative fuels, including electricity, hydrogen and biofuels all require new infrastructures and capital investment to supply transport users with propellants. The dynamics underlying competition between fuels are crucial. Conventional fuels and power trains represent sunk investments, and with experience and economics of scale they have developed down their respective technological learning curves for 100 years; alternative fuels and technologies are naturally disadvantaged. Hence, policies addressing infrastructure investments are needed to overcome fossile fuel dependence. The degree of these investments, however, varies among alternative fuels.

First Generation Biofuels

Most first generation biofuels require among others investments into low-carbon crops, low-carbon agronomic practices , biorefinery construction, biofuel distribution and fueling infrastructure and flex-fuel vehicles. The last three are most relevant from an infrastructure point of view. A price signal on GHG emissions is insufficient to induce construction of biorefineries, for the lock-in effect described enough. Policies addressing fuel producers directly, such as renewable fuel standards or low carbon fuels standards, however, require fuel producers to invest into biorefineries, and hence, are inadequate for this purpose. Biorefinery and co-product utilization, as well as crop management, are decisive in overall life cycle GHG emissions of biofuels. New biorefineries and practices can make ethanol production effective with respective to climate change mitigation (Liska et al, 2008). Hence, policies need to incentivize specifically those infrastructures that enable biofuel production with low global warming potential (e.g., the Californian low carbon fuel standard).

Flex fuel vehicles allow the utilization of biofuels in the vehicle fleet. An increase in the proportion of flex fuel vehicles increases the attactiveness of biofuel production (ESMAP, 2005). Brazil is the world's largest market for flex fuel vehicles with all gas stations also offering biofuels. In the US, car producers can earn fuel efficiency credits for selling flex fuel vehicles. Sweden jump-started a flex fuel vehicle market by a combination of measures, including a) an initial order of 2000 flex fuel vehicle by the city of Stockholm in 1998; b) tax exemptions for biofuels until 2009; c) demand side instruments such as cash incentives for buyers of flex fuel vehicles and exemptions from the Stockholm congestion charge. As a result, Sweden also provides more E85 fuel stations then all other EU countries combined.

Drop-in Renewable Fuels

An array of technologies are being developed to produce what are being called "drop-in" fuels because they are completely compatible with existing liquid transport fuel distribution and use infrastructure. These fuels include several types of renewable hydrocarbons that can be substituted for, or blended with, conventional gasoline, diesel and jet fuels. These fuels will require significant investments in research, development, and deployment, but no investment in new distribution or end use infrastructure. (Kagan, Joshua and Travis Bradford. Biofuels 2010: Spotting the Next Wave. The Prometheus Institute. GreenTech Media Inc. 2009.)

Electricity and hydrogen infrastructures

Some new renewable transport energy technologies require huge front-up costs, mostly to be paid by the public sector. Electric cars can be slowly phased in as plug-in hybrid electric vehicles, and battery electric vehicles with fuel extender. There will be considerable investments required whether informational or energy efficiency incentives to charge at night to minimize capacity requirements or charging stations (Shinnar, 2003; Romm, 2006). Investments into an hydrogen infrastructure are considered to be in the range of \$200-500 billion USD_{2005} for the US (Hammerschlag and Mazza, 2005). Under uncertainty on the future benefits and costs, these investments could constitute a technological lock-in. Multiple equilibria, corresponding to different fuels, are possible; some of them could be far away from the global optimum. It has been warned that a hydrogen economy could be such a suboptimal equilirium (Keith and Farrell, 2003; Ogden, Williams *et al.*, 2004; Hammerschlag and Mazza, 2005). [More research needed].

11.5.6.5 Conclusions

A plethora of instruments address the inclusion of renewable fuels into the transport sector. Success of instruments crucially depends on the evaluation metric. Notably, renewable fuel standard - both volumetric and blending mandates – achieve a rapid augmentation in renewable fuel production and are the most important instrument evaluated in terms of quantity targets. However, renewable fuel standards have limited potential for GHG mitigation (the cheapest biofuels have often the highest life cycle emissions), and are rarely sustainable (competition with food production, rainforest loss). However, renewable fuels standards can be coupled with sustainability criteria. In contrast, low carbon fuel standards are so far less dominant but successfully incentivize low carbon fuels (example: biobuthanol refinery just opened in California). Furthermore, starting market penetration of alternative fuel vehicles, particularly, PHEVs and BEVs, gives leeway for electricity from renewable sources.

Renewable fuel transport policies are challenging for policy makers as a number of diverse and often interacting fuel supply chains, and existing and potential future infrastructure investments are or can be result in unwanted path dependencies. A clear recommendation here is to not support specific favourite fuels (‘fuel du jour phenomenon’, (Sperling and Yeh, 2009), but to chose policies that are technology neutral and provide a level playing field across all (renewable) fuels and focus on performance , e.g. global warming potential (GWP) or some measure of sustainability. Policies that fulfil these criteria are a) LCFSs, b) GHG standards for mobile sources, and c) emission trading schemes that include the transport and electricity sector. These instruments put a consistent price signal on fuels, and hence harmonize incentives.

A second related challenge involves sustainability issues of and emissions from the agricultural sector that are related to transport fuels. In contrast to other sector, emissions are geographically diffuse, vary significantly across production methods, and are plagued with indirect market force effects (ILUC). Similarly, agrofuels can have significant impact on food security, biodiversity and rainforest destruction, potentially compromising its sustainability. More than for other sectors, hence, it is unclear how to comprehensively address the agricultural sector. A way forward is the Californian LCFS which tries to measure ILUC and European sustainability standards. A combination of other instruments, including REDD and a forced transition to second and third generation biofuels may further ameloriate the issue.

A third challenge is the provision of infrastructures. Price signals and technology-neutral instruments deliver a level playing field at one point in time. However, this is not sufficient to achieve intertemporal optimality with respect to our target criteria (GHG emissions and sustainability). For example, a price signal can simply increase the slope of the learning curve of conventional technologies which have a temporal comparative advantages compared to alternative technologies. Measures to address this issue including R&D and protected nurturing areas for new technologies. [more research needed here].

11.5.7 Key Lessons for Policy Design and Implementation

The sections above have described the policy options. This section explains key lessons about their design.

Viable, clear and long-term government commitment and policy frameworks are critical.(International Energy Agency (IEA), 2008). This lesson is demonstrated by the recent history of wind power industries and markets in several countries. Langniss and Wiser (2003) concluded that the early success of Texas renewable policy was based on strong political support and regulatory commitment (Langniss and Wiser, 2003). Agnolluci (2006) pointed to the importance of the German political commitment to wind power development in its success (Agnolucci, 2006). In the case of Sweden, Soderholm et al. (2007) showed that policy uncertainties limited development for a time, in spite of an economically favourable set of policy instruments (Söderholm, Ek et al., 2007).

Ensuring that policies are investor grade will attract more private investment and free-up public finance for other purposes or mechanisms.

Effective and efficient RE policies are based on an extensive and balanced qualification of the diverse renewable sources and technologies, taking into account all relevant variables, including size and ownership (Verbruggen and Lauber, 2009). This means that incentives can decline over time. An appropriate incentive is one that guarantees a specific level of support that varies according to technology and level of maturity.

Policy-makers should try to learn from results of policy mechanisms and stay flexible, changing them when necessary.

A combination of policies will enable a wider group of participants.(Sawin, 2001; REN21, 2005; California Energy Commission and California Public Utilities Commission, 2008; REN21, 2008; van Alphen, Kunz et al., 2008; Sovacool, 2009) The combination of policies needed depends on the costs of the technologies used and their levels of maturity, as well as location and conditions, including local circumstances and available resources (Sawin, 2004b; International Energy Agency (IEA), 2008).

The effectiveness of policies in promoting RE will depend on their design, enforcement, how well they address needs and national circumstances, and the extent to which they are reliable and sustained (Sawin, 2004b; Lipp, 2007; REN21, 2008). Even government policies that are enacted to promote RE technologies can have negative impacts on RE and slow the transition to a low-carbon energy economy if they are not well formulated, inappropriate, inconsistent, or are too short-term (Sawin, 2001; Mendonça, 2007). Further, there must be coherence between RE policy and broader energy policies – for example, subsidies for fossil fuel production and use are incompatible with policies to promote RE (REN21, 2008).

11.6 Enabling Environment and Regional Issues

Energy systems are complex. They are made up of interrelated components. The process of developing and deploying new energy technologies follows systemic innovation “pathways”: innovation most often occurs in concert with several other associated or overlapping innovations. This pathway has been described as a succession of phases from R&D to full market deployment, but these phases are not linear.

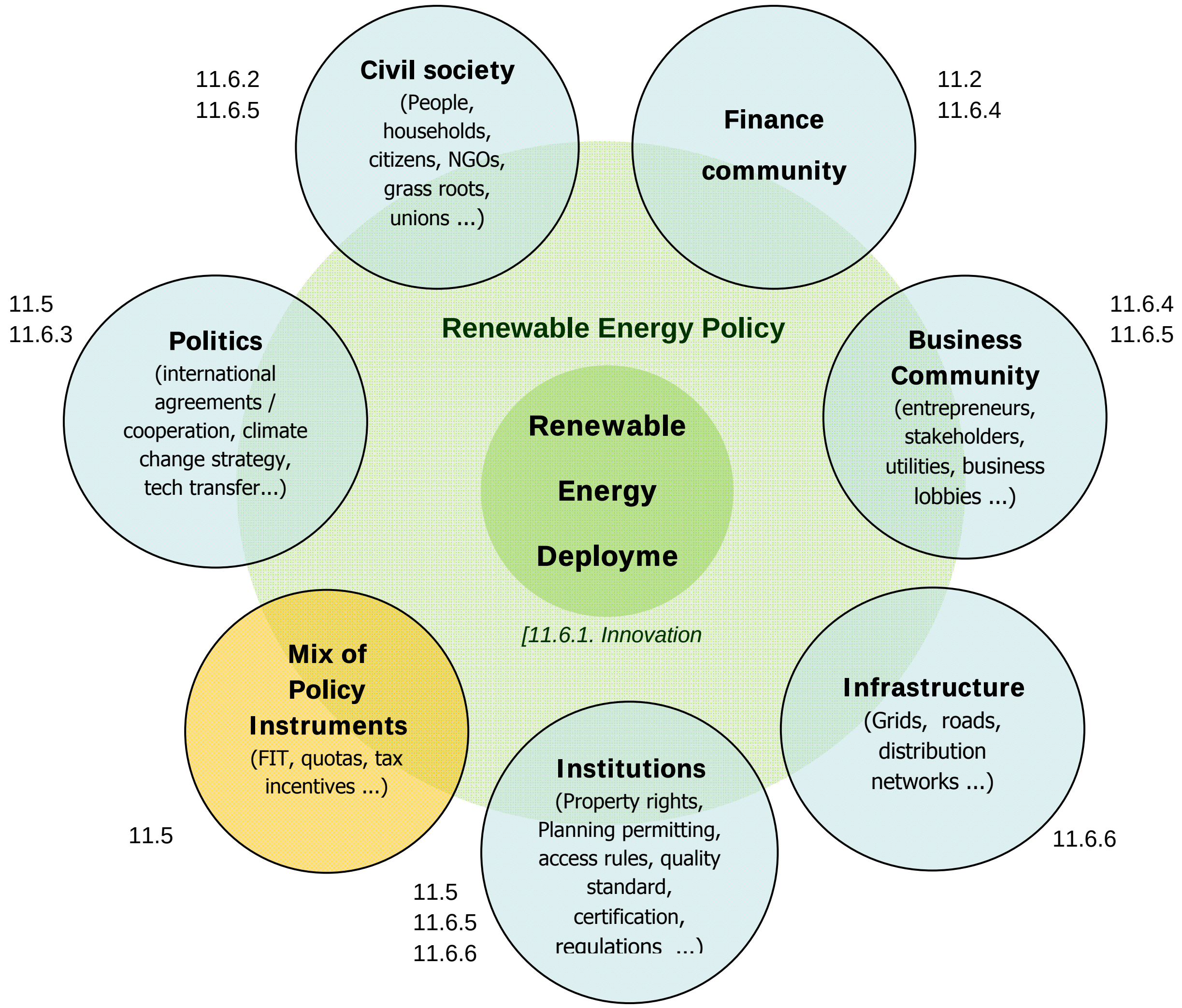

Figure 11.11 RE technology is embedded in an enabling environment, RE policy is one decisive dimension of this environment, but not the only one

The scale of technology development is conditioned by an "enabling environment", which interlinks with RE policies (i.e. enables targeted RE policies to be more effective and efficient). The enabling environment includes institutions, regulations, the business and finance communities, civil society, material infrastructures for accessing RE resources and markets, and international agreements for facing the challenge of climate change or developing technology transfer (see Figure 11.11).

The Enabling Environment is defined as:

"A network of institutions, social norms, infrastructure, education, technical capacities, financial and market conditions, laws, regulations and development practices that in concert provide favorable conditions to create a rapid and sustainable increase in the role of renewable energies in local, national and global energy systems"

Section 11.5 has illuminated the importance of RE policies. These policies are necessary for RE to get deployed. They can be successful on their own in certain context. For instance, British Columbia and Norway provide examples of countries or jurisdiction with large endowments of renewable energy resource, that RE policies have brought on the way to high penetration of renewable energies (see Box 11.14) (British Columbia Ministry of Energy, 2007).

However, as renewable energy deployment increases, the enabling environment – whether gaining planning permission, gaining access to financing or to the grid – can make renewable energy deployment easier. On the whole, the barriers set out in various parts of the SSREN Report relate to one or several aspects of an enabling environment. If that enabling environment is in place then its related barriers should be overcome or reduced.

So, while RE policies can start very simply, with a mix of the various policy instruments discussed in section 11.5, successful experiences also suggest that developing such an enabling environment contributes to the emergence of well-designed policies and to their success, which in turn contributes to an increasing flow of private investment.

Box 11.14 Norway: Sustainable Hydropower and Balancing Variable RE

Hydropower, "the white coal of Norway" has been a strong driving force in the industrialization of the country (Skjold, 2009). Plants in isolated grids in the bottom of fjords gave rise to energy intensive industries in local fast growing communities. The later national hydropower system was designed for energy security and to deliver base load energy, but with the ability to peak when needed. In early 2010, installed capacity was about 29 GW and the average yearly generation is about 122 TWh, meeting 98-115 percent of Norway's annual electricity demand, depending on rainfall (Norwegian Water Resource and Energy Directorate (NVE) [Norges vassdrags- og energidirektorat], 2009). Reservoir capacity is about 84 TWh, accounting for nearly 50 percent of Europe's total (Norwegian Ministry of Petroleum and Energy (MPE), 2010; Stensby, 2010).

For about a century, hydropower was developed without a coordinated plan. After intense exploitation during the 1970s and 1980s, heightened environmental awareness led to a period of relative standstill in large hydro development and in 1973 the initial national protection plan was adopted. In 1986, the first version of a master plan for hydropower was passed; it categorizes potential projects according to economic and technical viability, but strongly emphasizes potential environmental and social conflicts (Thaulow, Tvede *et al.*, 2010). Approximately 400 rivers are now protected. Of the estimated feasible potential of 205 TWh of hydropower from Norway's rivers, 122 TWh are utilized, 46 TWh are protected, and about 37 TWh are sorted in acceptable/not acceptable projects in the National Master Plan for hydropower (Thaulow 2010). The last 30 years have seen improved environmental and social impact assessment (EIA/SIA) procedures, guidelines and criteria, increased involvement of stakeholders, better licensing procedures; all efforts to make hydropower more sustainable for the long term.

The perceived role of the Norwegian hydro system is now changing. This followed from the deregulation and establishment of the common Nordic market for electricity in the 1990s and establishment of the power exchange Nord Pool (Nord Pool Spot, 2009). Ambitious European goals for RE power generation will be achieved largely through the introduction of significant amounts of variable wind power into the European power system. A system with possibilities for energy storage and balancing services would enable a higher penetration of wind power in the system without compromising the security of supply (Sachverständigenrat für Umweltfragen (SRU), 2010). Today, especially for Denmark, storage hydro from Norway is a prerequisite for a high level of variable sources (>20 percent), and cabling from Norway (1 GW) makes this possible (Jørgensen 2010).

Preliminary investigations indicate that some power stations can already be converted from base load to peak load, giving an additional 7-8 GW peaking capacity. From a technical viewpoint, Norway has a long-term potential to establish pumped storage facilities in the 10 – 25 GW range, enabling energy storage over periods from hours to several weeks in existing reservoirs, and more or less doubling the present installed capacity of 29 GW (IEA-ENARD, 2010).

11.6.1 Innovation in the energy system

The threat of climate change and the need to change the energy system in the span of just a few decades means that the required energy transition is different from past transitions (Fouquet, 2008). It is thus important for policy makers to understand how energy systems change and to ensure that such change is encouraged.

11.6.1.1 Energy systems as socio-technical systems

Energy systems are socio-technical systems. They are made up of mutually dependent set of practices, skills, technologies, infrastructures, coalitions of actors and institutions (e.g. energy lobbies, rules, standards, ways of defining and framing problems ...).

Such systems are very stable because of their strongly interlinked elements. They support the existing technologies by making it easier and cheaper to develop and deploy them, or to develop technologies that do not require a profound transformation of the energy system (e.g. see chapter 8, the bio-fuel vehicle versus the electric vehicle) (Grubler, Nakicenovic *et al.*, 1999; Unruh, 2000)

Energy systems are not value-free. Actors, institutions and even the very structure of the economy end up depending to some degree on the existing technological pathways (Nelson and Winter, 1982). For instance, high fixed costs make large, incumbent firms resistant to technological innovations that might revolutionize the industry – even if these are generated within their own firm – because these might render obsolete their existing equipment, processes and infrastructure. Low carbon energy policies are not business as usual for those already established within the fossil fuel economy. Existing lobbies and vested interests need to be taken into account, because RE are integrating into a system that has built up around the characteristics of fossil fuels and nuclear power (e.g.(Verbong and Geels, 2007).

These reasons explain why changes of system take time, and it is systemic change rather than a linear change. It also explains why an important dimension of RE deployment is the implementation of an enabling environment which is conducive to change.

Policy-makers should thus expect unexpected consequences from their policy implementation rather than expect the transition to be smooth. The practical implication of this is that policy must take account of this by being flexible and reflexive: learn from what happens, experiment, look for best practice, re-evaluate and so on (Smith, Stirling *et al.*, 2005; Stirling, 2009).

The intricacies of technological change means that while all levels of government (from local through to international) can and should play an important role in encouraging RE development through policies, other actors are also important. Policy action is more efficient when state actors include non-state actors, networks and coalitions in building guiding visions, as well as in formulating and implementing public policy (Rotmans, Kemp *et al.*, 2001; van den Bergh and Bruinsma, 2008).

11.6.1.2 Accessing RE technology and capacity building

Even if all the RE technologies were offered free of charge today, most countries in the world – dozens of small developing countries – would not be able to effectively utilize them because of a lack of ‘capacity’. In managing RE technological change, a useful meaning of capacity is the ability to make informed decisions regarding RE technology. The technological capacity of countries depends to a large extent on the National Innovation System (NIS). Such systems constitute the scientific and technological infrastructure of a country, and support their capacity to innovate. The state of the NIS includes the level of development of standards, norms, intellectual property rights, technical and scientific education, research financing, incentives, venture capital, foreign direct investment, foreign aid, personal mobility, business models, opening to the world, access to information, capital goods industry, policy, legislation, regulations, etc. Different countries have innovation systems at different levels of maturity and evolving at different paces. For specific RE technologies it is possible to measure the growth of capacity via learning curves over time(Trindade, 1994). And learning curves can be shortened by leapfrogging.

Studies on technology leapfrogging for RE and other low carbon technologies are just emerging. For example, a comparative evaluation of wind technology transfer in India and China, noted that both strong domestic policies, but also the corporate approach to technology transfer has significant influence on the speed and scale of technology advancement and growth of the locally owned business in both domestic and international markets (Lewis and Wiser, 2007). Taking advantage of a global network of subsidiaries allows more rapid technology advancement as well as expanding international sales (e.g. reverse technology transfer). In contrast, however, some argue that industrializing nations will be subject to Carbon Lock-In due to the substantial investment in traditional fossil fuel technologies and that leapfrogging may occur within specific technology or industrial areas, but at a scale insufficient to mitigate future climate change (Unruh and Carrillo-Hermosilla, 2006).

It is possible to reduce the time required to transform the energy system and attain a much increased RE deployment, if the above are taken into account and if long-term strategic thinking and commitment is exerted about the needs of a changing energy system, for example in relation to infrastructure. Developing countries without modern energy systems are undergoing significant change anyway, so ensuring its compatibility with RE provides greater flexibility.

Box 11.15: Lessons from Nepal: Importance of Up-front public investments in capacity development for scaling up RE

The National Micro-Hydropower Programme in Nepal aims to enhance rural livelihoods by accelerating the achievement of the Millennium Development Goals through, primarily, community-managed micro-hydropower systems (MHS). Field experiences under this programme during the 1996-2006 period revealed that capacity development is central to successfully scaling up decentralized energy access programmes and attracting private funding.

An analysis of the Nepalese programme found that upfront, long-term publically funded investment (from government and donors), is essential to developing the functional capacities needed to scale up rural energy programmes and to enable market transformation to occur. More than 90 percent of the early programme costs went to capacity development, which went far beyond traditional notions of typically defined by 'training' and/or 'management'. Functional capacities included: planning, oversight, and monitoring; situational analysis; facilitation of stakeholder dialogue; training; implementation capacities and management support; and the provision of policy advice.

When capacity development is created by systematic interventions, programme successes and maturation over time, it can attract substantial funding from private sector sources in later stages. Indeed, the study found that the share of public financing for the micro-hydro programme gradually declined to about 50 percent. This indicates the important role of public investment in capacity development for attracting private financing sources, particularly decentralized sources among a project's many users/beneficiaries. Communities provided cash, acquired bank loans, and supplied in-kind labour contributions—by digging channels for the MHS, for example—making up a significant portion of the overall financing needs.

Encouraging private sector participation requires promoting ownership of the MHS and productive use of the energy services it provides. In Nepal, productive uses fueled rural economies and increased the possibility for attracting private investments, including micro-finance. Fostering ownership also proved to be a necessary sustainability component, providing an incentive for users to use and maintain the technology properly.

The study also determined that although the functional capacity 'policy development and advice' made up only a small proportion of the total capacity development cost, it is a vital activity that plays a major role in informing policy and regulation development, supporting overall programme success and sustainability. Other steps taken in Nepal to support rural energy service delivery scale up include: the enactment of a rural energy policy in 2006; the development of a rural energy subsidy arrangement and delivery mechanism; the establishment of rural energy funds at different levels; and the exemption of mini-hydropower systems (up to 1,000 kW) from certain taxes, royalties, and licensing requirements.

11.6.2 Sustaining Social Innovation

An important dimension of the enabling environment is that related to 'social innovation' – meaning that individuals and institutions can play an important part in helping to make renewable energy deployment easier, quicker and greater in total (Kok, Vermeulen *et al.*, 2002).

Social innovation concern the ability of people and/or institutions to change the way in which they do things so as to adapt and to support the emergence and the deployment of RE technolgies. However, general lessons can be derived from these different areas about how policy can sustain and ultimately benefit from social innovation, as part of an enabling environment. These lessons relate to how institutions learn, or change; as well as to how policies and social aspects integrate to most effect.

11.6.2.1 How institutions learn and change

Collaborative approaches in policy making provide room for interaction between a multitude of stakeholders with diverging problem definitions. In such processes, it has been shown that knowledge is actively constructed through social interaction (Burningham & Cooper, 1999).

Over time, this learning is conducive to institutional capacity-building and policy learning at the level of policy design (i.e. choice and design of a policy instrument, as discussed in 11.5) but also at the deeper institutional level where numerous local decisions on siting and investments in energy schemes have to be made (Thelen, 1999, Breukers, 2007). Private actors (e.g. regional energy distributors, small wind power entrepreneurs) and the civil society develop social skills (e.g. management styles, informal contacts) and benefit from existing (or built-in) social conditions (e.g. trust or social coherence) in order to deal with prevailing institutional structure (i.e. electricity regulation, nature conservation norms; planning procedures) and get RE projects developed. The notion of “implementation capacity” (IC) (Agterbosch, Meertens *et al.*, 2009) has been proposed in order to point at this deeper and more diffuse institutional capacity that policy frameworks, such as planning frameworks, can sustain.

Overall, the capacity of the institutional environment (of any level whether international, national, local) to involve various parties into a common policy network makes it easier for the policy framework to (1) better respond to local political, economic, social and cultural needs and conditions; and (2) better ‘learn’ from outcomes and to incorporate them into ‘future’ policy-making (Breukers and Wolsink, 2007a) for Netherlands, United Kingdom and Germany; (Nadaï, 2007) or (Szarka, 2007) for France).

11.6.2.2 How policies and social aspects can integrate to most effect

The social structure of RE projects has been shown to underlay policy success in developing countries. For instance, community based micro-hydro systems accept lower financial returns (Chhetri, Pokharel *et al.*, 2009). Communities investing in these projects get a return on their money in many ways besides the financial interest they receive. In this context, the role of the civil society in making people aware of the benefits of RE technologies, their ease of implementation and management, is a large reason for growing acceptance of RE technologies in developing countries.

Technology cooperation within social networks is another way in which civil society can enhance policy success. Mallet has analysed the diffusion of passive solar heater (PSH) in Mexico city (Mallett, 2007). She has pointed at the ways in which technology cooperation characterised by a high level of consistent communication (continuous meetings, courses, an annual conference, etc.) within heterogeneous networks (academic, private and public-sector actors) has enhanced public policy.

If policy-makers align the enabling conditions for deployment of RE, for example, by ensuring increased awareness or knowledge of RE technologies [and associated infrastructure requirements], clarifying property rights to a RE resource, developing the necessary skills/capacity to deploy RE through education programmes or other means, or establishing technology standards and certification particular to RE, then evidence shows that broad public support has more chances to follow.

Box 11.16 Denmark’s Experience with Wind Power

Since the 1970s, wind power has developed into a mainstream technology in the Danish energy system, generating 20 percent of Denmark’s electricity by 2009. No other country has a higher level of wind power penetration. In 2009, the Danish wind industry was the country’s largest manufacturing industry, employing some 24,000 people (Danish Wind Industry Association

(Vindmølleindustrien, 2010). It accounted for 20 percent of the global market, and had manufactured every third turbine in operation worldwide (BTM Consult ApS, 2010).

At the time of the oil crises in 1973-74 and 1979, about 95 percent of Denmark's energy consumption was based on imported fuels, mainly oil. Concerns about security of energy supply made RE a top political priority, and over the decades since, a majority in the Danish Parliament has strongly supported wind power. In the 1980s and beyond, energy security, creation of domestic jobs and export markets were the major drivers for transformation of the Danish energy sector (Danish Ministry of Energy, 1981).

A combination of policy mechanisms, guided by national energy plans with long-term targets, has facilitated RE development. A publicly funded R&D programme began in 1976 with the goal to design and test megawatt-scale turbines. In 1979, the government introduced its first and most important policy to stimulate the market, based on a 30 percent investment grant to purchasers of "system approved" wind turbines. This programme ran for 10 years, with regular reductions in the grant level as technology improvements and economies of scale reduced costs. In 1985 the government enacted a per kilowatt-hour subsidy for all wind power fed into the grid, funded in part through a tax on CO_2. A voluntary feed-in tariff (equivalent to 85 percent of the retail rate) paid by utilities to wind producers was fixed by law in 1992 (Madsen, 2009{Sawin, 2001 #318)}.

The investment grants to end-users (private investors) created a small but strong industry with some 18 turbine producers by the early 1980s. Through the 1990s, private investors, often organized in small cooperatives, owned more than 80 percent of total installed capacity. This was largely due to a number of government policies, from special tax breaks to ownership limitations, to encourage individual and cooperative ownership. Investors had to live near their turbines, contributing to a general positive attitude toward wind power implementation (Madsen, 2009). In 1994, each municipality in Denmark became responsible for designating specific areas for wind power, eliminating uncertainty about siting while giving communities control over where projects were located (Sawin, 2001).

Also important were Ministry of Energy "contract policies", which required utilities to participate in wind power development. Under the first such contract, initiated in 1985, utilities were required to construct 100 MW of wind capacity over five years. The utility mandate was extended twice, and the first requirement for offshore capacity was issued in 1990 (Sawin, 2001).

Nearly three decades of consistent policy were interrupted in the early 2000s when leadership changed, the per-kWh subsidy was significantly reduced, and deregulation of the electricity sector created uncertainty (See Figure 11.12). Development was on hold with little new capacity added until 2008 because most projects were not economically feasible (except repowering, which received a premium tariff), and changes in planning structure delayed siting and installation of larger turbines (Madsen, 2009).

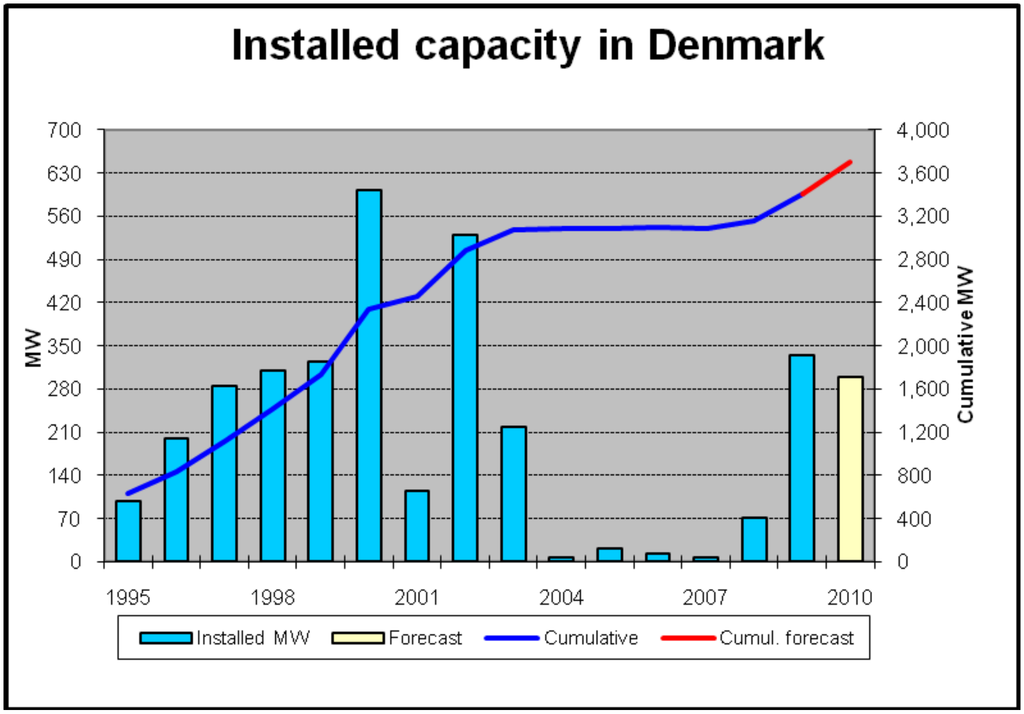

Figure 11.12 Annual and Cumulative Installed Wind Capacity in Denmark (BTM Consult ApS, 2010)

The government has since changed its position, announcing a political target of a "100 percent fossil free" energy system by 2050. As of 2009, Denmark aimed to get nearly 20 percent of total energy from RE sources by 2012 and 30 percent by 2020, with wind power playing a major role (European Union, 2009).

Consistent support for public R&D in Denmark played a critical role in the advancement of wind power technology, education of technical experts, and development of a manufacturing base. Market stimulation in the form of direct grants and later fixed feed-in tariffs, which reduced risk to investors, was essential for increasing installed capacity, reducing costs, and creating a strong domestic industry; but a significant policy changes and uncertainty stalled development for several years. Finally, Denmark's experience demonstrates that if people are involved directly as owners of the turbines, it is easier to implement substantial capacity in a country.

11.6.3 Managing Uncertainty

An important dimension of the enabling environment is its capacity to reduce the risk for RE investors. As risk is reduced, a larger number of projects become attractive in part because the lowering of risk reduces the cost of capital, thereby making the project more competitive. Ultimately, risk has to be reduced to such an extent that the appropriate level of investment, from a suitably diverse set of investors, can occur. Beyond well adjusted policy instruments, such a risk-reward ratio also depends on:

- political stability and commitment;
- institutional setting.

While there are multiple ways in which governments can commit their successors (e.g. by strategically managing public debt, founding independent agencies, amending written constitutions ...) (Persson, Tabellini *et al.*, 2000) , RE deployment has been more successful in the countries where governments have explicitly asserted and enacted strong political support and regulatory commitment to the deployment of renewable energies. Successful examples have been, for instance, Texas (Langniß and Wiser, 2003), Germany (Jacobsson and Lauber, 2006), Denmark approach to wind power policy or Brazil approach to ethanol policy (Teixeira Coelho et al. 2006). Symmetrically, the lack or delayed development of such long-range and stable political commitment (Meyer, 2003 & 2007 for Denmark recently; Soderholm et al., 2007 for Sweden), or the threat to existing political commitment (Agnolucci, 2006; Agnolucci, 2007)for Germany) has been shown to explain differences or slow down in wind power development in different countries.

Institutional settings, such as long-term contracts play a decisive role in stabilizing investors' expectations in the RE sector (Langniß and Wiser, 2003). Public institutions can get directly involved into public-private partnerships, as they did for wind power in Spain , where high investment risk in the first versions of the Spanish FIT was mitigated through the implication of a specific public agency acting as an investing partner into the wind power projects (Dinica, 2008).

Innovative business models (i.e., partnerships between global companies and government, local enterprises, donors or NGOs) have recently been tried in order to develop support for starting up and scaling up business activities that are aimed at the 4 billion poorest people in the globe (Hart and Christensen, 2002; Prahalad, 2006; Kandachar, 2008; Wilson, 2008). Recent cases show that multinational companies targeting these markets can contribute to poverty alleviation and to energy access (IIED, 2009). In certain contexts, community ownership is a way of reducing the risks for private household and micro-generation. Changing energy systems faces private household with uncertainty and budget constraints. Some developing countries (e.g. Vietnam, Nepal, Pakistan) have supported community ownership in micro-hydro power project management and operation as a way for people to share risk through collective decision. There are already a significant number of micro-hydro systems financially supported by local communities, local banks or local entrepreneurs (Pokharel, Chhetri *et al.*, 2008).

11.6.4 Easing Access to Financing

A broader enabling environment includes a financial sector that can offer access to financing on terms that reflect the specific risk/reward profile of a RE technology or projects. The cost of capital of such financing - the interest rates charged by banks or the return that investors require on their investments - depends both on the broader financial market conditions prevalent at the time of investment, and the specific risks of the technology, the project and the actors involved. The broader conditions generally determine the minimum cost of capital, which is then increased by a risk premium specific to the financing opportunity. The cost of capital has become more closely linked to financial markets with the shift from public to private sector investors.

Although the public sector has traditionally been the principal investor in energy supply infrastructure, usually through national utilities, in the RE sector investments have tended to originate from the private sector (Asian Development Bank, 2007). In 2005, the private sector accounted for well over 90 percent of all investment in the RE sector (UNFCCC, 2007).

11.6.4.1 Drivers for RE investments

The universe of private capital sources most relevant to the RE sector include corporate investors such as utilities, banks, institutional investors, and the capital markets more broadly. The development, expansion, and globalization of the capital markets since 1980 have created significant and growing pools of internationally mobile institutional investor capital. The managers of these institutional funds are under constant pressure to find high-quality investment opportunities that deliver adequate returns and manageable risks. Where institutional structures, regulation and incentives for RE technologies match the requirements of these institutional investors then the opportunity exists for capital deployment to the sector (Asian Development Bank, 2007). However the various classes of capital each have their own drivers, expectations and appetites for risk.

Non-RE specific issues that directly affect access to and cost of financing include political, country and currency risks as well as energy-sector related issues such as:

- Energy sector reform agendas: many countries have undertaken power sector reforms since the 1980s in an attempt to improve sector efficiency and to augment public resources with private sector financing. In most circumstances such reforms, particularly the establishment of independent regulatory institutions, have encouraged greater private sector participation and improved access to commercial financing (Asian Development Bank, 2007). However progress of these reforms has not always been smooth.
- Competition for investment – Investors that target the energy sector have, to date, tended to be drawn toward conventional energy investments as they have tended to yield a better return per unit of effort invested given the size of deals and, generally, clearer policy objectives and regulatory frameworks.
- Credit Risk – A fundamental determinant of the cost of capital for a project is the credit risk of the payment counterparty, that is, the customer. Often this is the state utility that may not be considered credit worthy by private investors.
- Ability to exit – Investors require identifiable exist opportunities to eventually sell-on their investments, usually either to a strategic investor like a utility or by way of a listing on a public stock market. Exit opportunities are usually more restricted in developing countries, both due to the macro financial conditions but also sometimes to specific policies. For example, governments may restrict the transferability of shares to protect domestic interests.

The fundamental principle of modern global capital markets is that private capital will flow to markets where policies and related regulatory frameworks that govern investment are well considered, clearly set out, and consistently applied in a manner that gives investors confidence over a time scale appropriate for their investment life cycle (Asian Development Bank, 2007).

11.6.4.2 The recent evolution of the RE financial sector

For the RE sector these conditions have been met in many countries, to varying degrees. Around 2004 the capital markets began to change the enabling environment for technological innovation in several RE sectors. Up until that time renewables, like most other technology sectors, relied on government and corporate R&D to drive innovation, and on large corporates to self-finance the commercialization of technologies that were market ready. In 2004 a number of solar and wind companies in Denmark, Germany and Japan began to generate significant revenues, in the hundreds of millions and eventually billions of dollars per year. These strong revenue figures signalled heightened interest from the investment community for the first time.

With financiers now keen to engage, RE entrepreneurs could raise financing more easily from the capital markets than from the large corporates which they were so dependent on previously. This change meant that between 2004 and 2006 much of the RE technology leadership shifted from large diversified corporates to dedicated renewable-only companies. Easy access to venture capital to finance technological development, to equity financing to build manufacturing facilities, and to cheap debt to finance projects meant that the very capital intensive RE sector was about as enabled as it could be from the financial point of view. In other words, access to finance was not a problem for any well prepared project or technology opportunity. This situation changed in 2008/2009, when the financial and broader economic crisis cut off the access to debt financing, particularly for long term, capital intensive investments like renewables.

However, policies support and strong government interferences helped lots of companies to survive the hardest year. For example, in US, the government introduced the Investment Tax Credit, to replace the (at least temporarily) dysfunctional Production tax Credit, which was facing huge difficulties due to the lack of any large financial institutions that needed to shield hundreds of millions of dollars from tax. In Europe, government grants and policy driven banks helped to finance some of the projects. Utilities also financed some new projects off their own balance sheets (UNDP, 2006; Deutsche Bank, 2009). .

11.6.5 Planning, Permitting and Participation

Few areas in the world are truly devoid of/lack traditional uses, conservation values or existing commercial interests. As a result, the growing deployment of RE technologies may create tensions. Rules are needed to resolve conflicts over access to RE resources. This section addresses the general lessons learned from the planning and permitting of renewable energies. Technology issues for planning are in the relevant technology chapters

Evidence shows that spatial planning (land / sea space, landscape) processes are social processes. They can bring parties into negotiation and open public consultation. In doing so, they enhance social wishes and contribute in clarifying social acceptance or conflicts of usage. Planning runs the risk of making administrative procedures more complex but an appropriate planning framework can reduce hurdles at the project level, making it easier for RE developers, communities or households to access the RE resource and succeed with their projects.

11.6.5.1 Planning challenge and hurdles

A main challenge for policy makers is to design a balanced planning regulation that broadly supports the deployment of RE technology while at the same time establishes procedures that ensure public insight and environmental protection. This, in many countries, calls for institutional reforms as well as changes in planning practices at different levels of decision making.

This holds for large-scale RE technologies (e.g. wind turbines, ocean energy technologies, concentrated solar power...) and for smaller scale technologies (e.g. individual solar panels, small-scale biomass...) even if the environmental and social impacts and corresponding planning issues vary a lot between different types of RE (See Table 11.5).

Table 11.5 Environmental and social issues that planning and planning and permitting face

Renewable energy	**Environmental and social impact in relation with spatial planning**
Biomass	Emissions from combustion Visual impact of energy crops
Biogas plants	Smell (distance)
Solar	
• Installation on buildings	Aesthetics and architectural design
• Large solar plants	Land use & landscape aesthetics challenges
Hydro	
• Large scale	Social impact and impact on local ecosystems
• Small-scale	Impact on local ecosystems
Geothermal energy	Air and water pollution Local seismicity
Marine energies	Impact on marine life Conflict of usage
Wind power	Visual impact and landscape aesthetics Noise Impact on birds and marine life (offshore)
New supporting infrastructure (often in remote areas) Electricity grids District heating pipelines	Visual impact, landscape aesthetics, conflicts of usage

Lengthy permitting processes, high applications costs, lack of data or low access to data, lack of local or regional capacity, or local public opposition can make planning and permitting processes can become prohibitively long. This has favoured proposals for streamlining planning and permitting procedures (California Energy Commission and California Public Utilities Commission, 2008); OPTRES, 2007). While some project developers may regard this system as a ‘barrier’, for others it provides protection against overenthusiastic developments that may not be beneficial to the local community or local environment at all. Hence, planning and permitting, even if it is sometime assimilated to mere administrative barriers, also has a potential as social a process (Ellis, Cowell *et al.*, 2009).

11.6.5.2 Why planning and permitting can support the sustainable deployment of RE technologies

The sustainable deployment of RE technologies is a long-term transition process. It involves (radical) changes in the relationship between (energy) technology and society, and raises questions about how people can become engaged in and committed to these systemic changes (Guy and Shove, 2000)(Hodson et al, 2007). Spatial/land use planning plays an important role, because they structure the socio-technical and political processes that enable changes in our spatial environment (including the deployment of RE technologies).

It is often in the process of preparing, designing, planning, deciding and implementing a specific project, that differences in perspectives, expectations and interests become manifest. The system of spatial/land use planning provides for a framework - a set of legal, formal rules and procedures - to address these differences and mediate conflicting interests and values (Owens and Driffill, 2008; Ellis, Cowell *et al.*, 2009). This framework is in line with the political culture of a country and reflects historically evolved 'ways of doing' – e.g. traditions of administrative coordination between levels of government, with more or less autonomy for local governments in taking decisions on local land use. Renewable energies, because of their often decentralized dimension, face planning institutions with issues as regards to the allocation of decision making (Kahn, 2003; Söderholm, Ek *et al.*, 2007; Bergek and Jacobsson, 2010) for wind power and decentralized institutions in Sweden; (Nadaï, 2007) for wind power and centralized institutions in France).

Planning systems are thus historically and culturally embedded. There are wide differences between countries. The same goes for permitting procedures. Whether conflict is likely to occur depends very much on the specific context and on the type of project development under consideration. For instance, where landscape amenity is a cultural-historical value this may be a huge issue for a wind project (e.g. (Cowell, 2010; Nadaï and Labussière, 2010), this may be less the case in countries where this is not the case (Toke, Breukers *et al.*, 2008).

The *sustainable* deployment of RE technology means that social acceptance and commitment are sought for. While the articulation between the national and the local level seems decisive in achieving this (e.g. (Smith, Stirling *et al.*, 2005; Nadaï, 2007; Bergek and Jacobsson, 2010), universal procedural fixes – e.g. "streamlining", speeding-up legislation or directive measures – are unlikely to resolve conflicts between stakeholders at the level of project deployment (Breukers and Wolsink, 2007b; Agterbosch, Meertens *et al.*, 2009; Ellis, Cowell *et al.*, 2009)because they would discard the place - and scale specific conditions. However, it is still useful to point out those conditions that have shown to be favourable for arriving at a sustainable deployment of RE technologies in various studies.

11.6.5.3 How planning and permitting can support the sustainable deployment of RE technologies

For each condition, we indicate how spatial planning can create/support this favourable condition.

Aligning stakeholder expectations and interests

Several case studies have shown the importance of alignment of interests between various stakeholders (Warren et al., 2010; Devine Wright, P., 2005). This can be done through several ways such as adopting procedures for project development that are judged fair by the different parties (Gross, 2010) or by identifying (creating, negotiating) in the ‘pre-application process’ multiple benefits that a RE project may bring for different stakeholders (Ellis et al 2010:538 ; Heiskanen et al, 2008).

Learning about the context

A more pro-active effort could be taken to learning about the local societal context in which a RE project is going to be proposed (Breukers and Wolsink, 2007a); Raven et al, 2008). In particular, the recent case of wind power opposition has proved that opposition cannot be dismissed as ignorant or misinformed instead it must be acknowledged that objectors are often very knowledgeable (Ellis et al., 2007). Public attitudes and responses to wind power should not then be examined in order to mitigate potential future opposition, but rather in order to understand the social context of renewable energy (Aitken, 2010; Gee, 2010).

Adopting benefit sharing mechanisms

Benefits can be social (e.g. local control, ethical and environmental commitment, feeling of positive contribution to society ...), environmental (e.g. contribution to global environment...) or financial /economical (e.g. creating local revenues, market for local wood, agricultural wastes ....) (Rogers, 2008; Walker, 2008; Madlener, 2007). However, in the current state of affairs, benefits related to RE projects mostly accrue to the global community as whole – CO2 reduction – and to the project developer – financially (e.g. Bell et al. 2005). An acknowledgement that benefits, costs and risks are unequally distributed can be followed by efforts to arrive at a more equitable distribution. Evidence shows that when local economic involvement is high the overall opposition to developments tends to be lower (Jobert, Laborgne *et al.*, 2007; Maruyama, Nishikido *et al.*, 2007).

Benefits sharing encompasses mechanisms for the local communities to participate in the benefits generated by the development. They may include: co-ownership (Meyer, 2007 for Danish wind power ; Walker, 2008 ; Deepchand, 2002 for the Bagasse Transfer Price Fund and Sugar Investment Trust in Mauritius); local employment by making use of / setting up local contractors and services (Faulin et al., 2008 for wind power in Navarre, Spain; Heiskanen et al, 2008; Agterbosch and Breukers, 2008); benefits in kind through direct re-investment of part of the benefits by the developers in local community infrastructures (Upreti, 2004 , for glasshouse development in relation to the Elean Power Station in Ely, Cambridgeshire, UK) ; transfer of benefits through lump sum or business tax to local communities (Faulin et al., 2008; Nadaï, 2007 for wind power in France) ; energy price reduction (e.g. Deepchand, 2002), environmental compensation (Cowell, 2003 negotiation about an amenity barrage across the Taff-Ely estuary in Cardiff).

Timing: pro-active national and local government

Clear procedural rules (e.g. requirements for permitting, ground for court appeal, allocation of responsibilities and timing of the process ...) are important to reduce risks for the developer and to ensure legal security for stakeholders.

National planning policies sometimes lag behind initiatives of those deploying innovative technologies and therefore hamper these innovations. Legislative changes or case by case approach might be required. In the UK, recent legislative changes have been adopted in order to ease micro-renewables development (McAllister, Scott *et al.*, 2009). In many countries, marine energy projects at an early commercial stage find themselves in a "Catch-22" situation, where regular permitting regime requires project impact data that could only be produced if a temporary authorization was granted to them (IEA, 2009a) : project license lease, pilot development zones or specific site agreements have been used as tailored solutions.

Local governments are also often caught by surprise when a project developer presents a RE project proposal (Agterbosch and Breukers, 2008; Breukers and Wolsink, 2007; Nadaï & Labussière, 2010). Organising local participation in the development of comprehensive plans, where main siting areas can be identified before any project is planned makes it easier to create an open and non-polarised discussion (Sussman, 2008).

Last, the articulation between the local and national level is often decisive for the way in which RE project get politicized at the local level. Lack of political support to RE from the national level can favour local polarization by making RE impact be perceived as a private rather than a public issue (Bergek and Jacobsson, 2010).

Building collaborative networks

The success of a RE technology project depends on multiple actors and conditions. Building collaborative networks is part of the sociotechnical change process towards a more sustainable energy system. Involving relevant stakeholders and making them part of the solution is more likely to result in long-term acceptance and lasting commitment than taking an approach that overlooks and excludes them. Networks are furthermore important 'vehicles' for exchanging experience and knowledge and hence support learning processes (Breukers and Wolsink, 2007; Heiskanen et al, 2008; Negro et al, 2007; Suurs and Hekkert, 2009; Dinica, 2008; Mallet, 2007). They can also support radical innovation in "ways of doing" such as the renewal of landscape values or bird protection approaches in relation to wind power (e.g. Nadaï in Ellis et al., 2009; Nadaï & Labussière, 2009 and 2010).

Mechanisms for articulating conflict and negotiation

The deployment of a RE project usually will not serve everyone's' interest. Existing formal avenues to voice opposition usually only offer room to object to a ready-made project proposal (Wolsink, 2000). Such decide-announce-defend strategy, which is traditionally associated with technocratic decision-making, is both questionable on democratic grounds and counterproductive (Healey, 1997). Discussions tend to get stranded in polarised pro-contra controversy, leaving little room for constructive deliberation. It is useful to create room for the articulation of conflicting perspectives in order to be able to subsequently jointly seek for solutions or compromises (Cuppen et al, 2010).

11.6.5.4 Pro-active, positive, place - and scale-sensitive planning and permitting approaches

Overall, the lessons learned stress the extent to which sustainable energy transitions and spatial and urban planning are interwoven. It point towards the need for evolving planning and permitting towards a pro-active, positive, place - and scale-sensitive systems. It also points at the lasting benefits of social innovation, as a strategy developed and implemented within and together with society. Such a planning and permitting strategy includes:

The development of planning policy that reflects on the various democratic mechanisms in place and crosses sectoral boundaries (energy, agriculture, transport, etc) in order to foster a more integrated approach towards energy transitions and facilitates the aligning of interests at a supra-local level - e.g. by providing support to foster collaborative networks between spatial planners, technology developers, technology implementers, end users, and other societal stakeholders –;.

The development of strategic planning upstream from project development at scales which fit the specificities of each RE technology and the differences in local and national contexts.

The fostering of institutional capacity, with the required resource (finance, knowledge, know-how ...) and power endowments at the level(s)(national and local) where projects are planned, decided and sited, in order to create institutions that are able to: anticipate and sustain the emergence of new RET projects; set timely local participation for collaborative networking and co-construction of plans; identify multiple benefits and benefits sharing mechanisms in relation to local needs, concerns, ambitions and expectations.

Additional knowledge is needed, especially, in relation with the experiences in developing and transition countries, where RE policies are in place, deployment can be already significant (e.g. China, India) but context-specific understanding of planning processes has not been analyzed.

11.6.6 RE Access to Networks and Markets

RE needs to be sited and then its output used, whether on-site or sold. In the latter case, RE projects need to connect to networks in order to sell their electricity or heat. Once connected, the generation or heat has to be sold or 'taken' by the network. These two requirements: connection and then sale of energy are two different requirements. The ease, and cost of fulfilling them, is central to the ability for projects to raise finance and get a chance to be developed. Chapter 8 approaches these dimensions by focusing on cross-cutting integration issues. This section discusses these issues in relation with different dimensions of the enabling environment such as its institutional (e.g. spatial and energy planning) and infrastructural (e.g. grid development) framing, but only for electricity.

11.6.6.1 Connection charging and network access

RE projects often need to be located in areas where the electricity grid is weak. This raises difficulties in connection as, once planning consents are achieved, RE projects can often be constructed in shorter timescales than that of the associated infrastructure reinforcement. In addition variable-output RE such as wind requires back-up in the form of flexible conventional generation, giving rise to the need for RE and conventional generation to "share" available grid capacity, depending on whether renewable resource is available or not. The deployment of RE therefore challenges traditional concepts of grid management; a new paradigm is required to deliver flexibility in design, operation and market rules.

In the EU, the Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources, states that EU Member States must ensure that transmission and distribution system operators guarantee grid access for electricity generated by RE (EU, 2001). This is both connection and off-take. In general, but not always, the fundamental design feature of FITs is a project's connection to grid, and the off-take of the electricity, according to a defined process and cost. As a result of the EU Directive, some European countries, particularly those which have FITs, have implemented connection regulations that guarantee access to the grid. These regulations ensure that transmission and distribution system operators guarantee grid connections for RE electricity.

However, despite the EU Directive requirement of providing 'priority access' for RE, some countries (i.e. the UK) have argued that they have fulfilled the Directive through its market mechanism without ensuring both connection (and its cost) and off-take of the renewable generation (Baker, Mitchell *et al.*, 2009). Connection to the grid in the UK is a very time-consuming and costly requirement, which acts as a significant barrier to RE deployment (Baker et al, 2009).

'Priority' grid access is, at it says, when RE generation is given priority access to the grid, before other forms of generation. This requires a purchase obligation, which requires grid operators, energy supply companies, or electricity consumers to buy the power generated from RE at the moment it is offered. It has been argued that such a requirement is not compatible with the market because it requires electricity purchase independent from demand (Ragwitz, Held *et al.*, 2005). Others argue that RE (other than dispatchable resources like biomass and some dam hydropower) should receive priority access because the short-term marginal cost is close to zero (Jacobsson, Bergek *et al.*, 2009; Verbruggen and Lauber, 2009).

11.6.6.2 Increasing Resilience of the System

One of the biggest challenges for the integration of renewable electricity into the system is to deal with the variability, given that the output varies with the availability of the resource of some RE technologies such as wind, solar, run-of-river hydro, and ocean. The resilience of an energy system is its capacity to integrate variable energy output while keeping matching the energy demand. Again, this is the focus of Chapter 8 and we do not replicate the much deeper discussion there. However, we put forward a few key policies related to integration and market access to highlight the importance of institutional adjustment in this area.

As the percentage of renewable energy increases there is an increasing requirement of resilience within the energy system (UKERC, 2009b). Smoothing the effects of the variability can be improved through: aggregation, forecasting and integration in the market (IEA, 2008a). Spain has chosen to promote this as a means to encourage RE by requiring the mandatory aggregation of all wind farms in Delegated Control Centres which are in on-line communication with the National Renewable Energy Control Centre (Tongsopit, 2010). The introduction of variable-output RE will also increase the volatility of energy prices, particularly in those markets that do not reward capacity explicitly. This could impact particularly on investment in high capital-cost low carbon generation such as CCS and also flexible conventional generation required in the medium term for back up purposes. Increasingly volatile energy prices may therefore bring forward the need for further direct support measures in order to deliver the capacity required (GB Treasury, 2010; Ofgem, 2010).

As variable output RE such as wind cannot forecast output with any accuracy until close to the event, it cannot be expected to participate in the traditional forwards market model. Electricity markets will need to develop intra-day trading, shorten gate-closure timescales and provide efficient, liquid and cost reflective balancing arrangements to ensure the most effective use of RE . An increasingly flexible approach to trading reduces the impact of forecast errors and will encourage demand-side participation, thereby reducing the need for additional fast response power plants, interconnection or storage (IEA, 2008a). The different uses of flexibility resources will determine the flexibility of the system (IEA, 2008). Measures, such as the increase of the interconnection capacity within systems or demand side management measures would help to integrate more wind power, for example, especially in extreme situations (Alonso, Revuelta *et al.*, 2008).

11.6.7 Integration of RE policies with other sector policies

RE policies interact with many other sector policies. Some of these have been described within the discussion of the enabling environment in this section, for example RE and planning policies. RE also interacts with climate change policies (See Box 11.17). General RE integration issues are addresses in Chapter 8.

Box 11.17 The economic implications of interactions between climate change mitigation policies and renewable energy support policies

The logic for renewable energy policy in addition to carbon policy

It is well-understood that climate change involves two major market failures (Stern, 2006). First, polluters do not pay for the damage caused by greenhouse gas emissions, so government intervention is required to put an explicit or implicit price on emissions (Pigou, 1932). Second, research and development, innovation, diffusion and adoption of new low-carbon technologies creates wider benefits to society than those captured by the innovator (Jaffe, 1986; Griliches, 1992; Jaffe, Newell *et al.*, 2003; Edenhofer, Bauer *et al.*, 2005; Jaffe, Newell *et al.*, 2005; Popp, 2006a), so without government intervention there will be too little low-carbon innovation. With at least two market failures, it follows that at least two broad policy approaches are required (Tinbergen, 1952), namely carbon pricing (by carbon trading, carbon taxes, or implicitly through regulation) and support for research and development and diffusion of low-carbon technology. Otherwise, the two objectives have to be traded off against each other, and one of the objectives would have to be sacrificed to some extent. For instance, carbon pricing on its own is likely to under-deliver investment in R&D of new technologies (Rosendahl, 2004; Fischer, 2008).

In this context, there are three broad reasons that may be advanced for support of renewable energy (RE) alongside climate-change policy. First, governments have not yet implemented “ideal” carbon pricing or “ideal” low-carbon technology support. Carbon prices are often non-existent or lower than estimated social costs (Stern, 2006)Tol, 2009), and have not provided a sufficiently credible basis for a large-scale shift towards low-carbon investment (Helm et al, 2003). As such, there is role for additional “second best” government intervention, including RE policies, to better address the climate externality.

Second, even if governments were to implement “ideal” carbon pricing and “ideal” research and development support, there are a range of other relevant market failures, including financial market failures, oligopoly and imperfect competition, information failures and labour market failures (Sjögren, 2009) that might justify additional intervention. For instance, if fossil energy is provided by a cartel which extracts rents from consumers, carbon taxes might merely shift rents from fossil energy producers to governments, without changing producer prices and without reducing emissions. To take another example, financial market failures may imply that perceived risks of RE investment are greater than actual risks, resulting in too little investment. These other market failures can imply that additionalis (Sjögren, 2009) policies, such as RE policies, may be justified to complement climate-change policies.

Third, RE yields a range of other non-market benefits, including reductions in local air pollution, heath benefits, safety benefits, and job creation relative to fossil-fuel based energy production.

Without government policy to account for these benefits, the supply of RE will be too low even if carbon prices are "ideal". These benefits might be internalised by other policies (e.g. local pollution regulations), but if they are not, direct support for RE is an alternative way of achieving these objectives.

In the presence of multiple market failures, a variety of models suggest that an optimal portfolio of policies can reduce emissions at a significantly lower social cost than any single policy (Popp, 2006a; Popp, 2006b; Grimaud and Lafforgue, 2008; Acemoglu, Aghion *et al.*, 2009; Schmidt and Marschinski, 2009). The policy portfolio might include an emissions price, an R&D subsidy, a RE subsidy, and potentially also fossil-fuel taxes and emissions or energy performance standards. It appears that an optimal policy mix would use emissions pricing to incentivise the bulk of the emissions reductions (Fischer, 2008; Fischer and Newell, 2008; Otto, Löschel *et al.*, 2008; Richels and Blanford, 2008).

Potential perverse outcomes from RE and climate-change policy

These reasons suggest a role for policy providing support for RE in addition to climate-change policy. However, given the close relationship between RE policy and climate-change policy, policies need to be designed carefully. Perverse outcomes are possible from RE or climate-change policies alone, before considering their interactions.

First, both climate-change and RE policies create risks of "leakage". RE policies in one jurisdiction reduce the demand for fossil-fuel energy in that jurisdiction, which *ceteris paribus* reduces fossil-fuel prices globally and hence increases demand for fossil energy, to some extent, in other jurisdictions. Similarly, climate-change policies in one jurisdiction increase the relative cost of emitting in that jurisdiction, providing firms with an incentive to shift production from plants facing carbon prices or regulation to plants in countries with weaker climate change policy (Ritz, 2009).

The scope of offset provisions within a carbon cap-and-trade system (the Clean Development Mechanism or Joint Implementation, for example) can also affect the renewable objective by reducing the incentive to deploy renewables technologies within the borders of the renewable mandate (del Río González, Hernández *et al.*, 2005).

Second, both climate-change and RE policies apply over long periods and require careful consideration of "dynamic effects". The prospect of future carbon price increases may encourage fossil fuel owners to deplete current resources more rapidly, undermining policy-makers' objectives for both the climate and the spread of renewables technology (Sinn, 2008). If this holds true, the optimal carbon price trajectory is not a steady rise at the rate of interest, or the discount rate plus the rate of decay of greenhouse gases in the atmosphere, often assumed in models of optimal climate-change mitigation policy (Paltsev, Reilly *et al.*, 2009). Rather, a downward time profile of carbon prices would persuade resource owners at least to delay extraction (Sinn, 1982; Sinclair, 1992; Sinclair, 1994).

However, this result may not hold for several reasons. First, Edenhofer et al. (2010) note that Sinn's model rests on the assumption that all fossil resources are extracted, yet an emissions trading scheme could set a cap that restricts the total extracted. There is an time profile for carbon taxes that will have the same effect (Kalkuhl and Edenhofer, 2008). Second, as an empirical matter it is unclear whether fossil fuel resource owners would rush to deplete their resources. Pindyck (1999) found that the standard model of exhaustible natural resource pricing

(Dasgupta and Heal, 1980), which underlies Sinn's argument, applies reasonably well to behaviour in oil markets, but less well for coal and natural gas. Other theories of behaviour – such as those emphasising geopolitical and fiscal factors, particularly the need to finance public spending – may be appropriate, especially when the owners are sovereign governments (Slaibi, Chapman *et al.*, 2005). Third, it is possible to construct general dynamic models accounting for these effects, which still show optimal carbon prices first rising before eventually declining (Ulph and Ulph, 1994; Hoel and Kverndokk, 1996).

Interactions between RE policy and climate-change policies

If both climate and RE policies are administered simultaneously, their impacts are unlikely to be the same as expected of each alone (de Miera, del Río González *et al.*, 2008; de Jonghe, Delarue *et al.*, 2009) and while they can potentially work together (Popp, 2006b; Popp, 2006a; Grimaud and Lafforgue, 2008; Stankeviciute and Criqui, 2008; Schmidt and Marschinski, 2009), they can also undermine the efficiency of each other (Sorrell and Sijm, 2003; Rathmann, 2007).

For instance, if a RE quota-based scheme is combined with a carbon market, and one market is notably more stringent than the other, the price in the weaker scheme could fall to zero (Unger and Ahlgren, 2005; De Jonghe et al., 2009). Conversely, if one price-based (e.g. RE subsidies) and one quantity-based measure (e.g. emissions trading) are combined, the price instrument could affect the market price of the trading scheme. For instance, RE subsidies added to an existing carbon cap-and-trade scheme would be unlikely to reduce emissions, but would instead reduce carbon prices, thereby deterring private investment in non-RE abatement technologies (Blyth et al., 2009). This suggests that impacts of RE policies should be factored into setting the carbon cap. More generally, it implies that RE and carbon policies should be carefully coordinated both at the initial stages and subsequently as circumstances change (De Jonghe et al., 2009; Rathmann, 2007; Blyth et al., 2009; Verbruggen and Lauber, 2009).

11.6.8 Conclusion and key messages

The scale of technology development is conditioned by an enabling environment. As renewable energy deployment increases, the enabling environment – whether gaining planning permission, gaining access to financing or to the grid – can make renewable energy deployment easier.

Many countries in the world – including dozens of small developing countries – do not currently have the necessary 'capacity' for RE policy-making, financing and implementation.

Energy systems are complex socio-technical systems which are very stable, because of their strongly interlinked elements, and are not value-free. As a result, system change takes time, and is systemic rather than linear.

Because of the complexity of the energy system, Policy-makers should expect unexpected consequences from their policy implementation rather than expect the transition to be smooth, and counter the unexpected consequences by being flexible and reflexive

An important dimension of the enabling environment is that related to social innovation Social innovation concern the ability of people and/or institutions to change the way in which they do things so as to adapt and to support the emergence and the deployment of RE technologies. Policy can sustain and ultimately benefit from social innovation, as part of an enabling environment.

An enabling environment can reduce the risk for RE investors. Risk has to be reduced to such an extent that the appropriate level of investment, from a suitably diverse set of investors, can occur and the financial sector can offer access to financing on terms that reflect the specific risk/reward profile of a RE technology or projects.

Rules are needed to resolve conflicts over access to RE resources. Spatial planning (land / sea space, landscape) processes are social processes. They can bring parties into negotiation and open public consultation. In doing so, they enhance social wishes and contribute in clarifying social acceptance or conflicts of usage. Planning runs the risk of making administrative procedures more complex but an appropriate planning framework can reduce hurdles at the project level, making it easier for RE developers, communities or households to access the RE resource and succeed with their projects.

Non-on-site RE electricity and heat projects may need to connect to a network in order to sell their energy. Once connected, the energy has to be sold within a market or 'taken' by the network. These two requirements: connection and then sale of energy are two different requirements. The ease, and cost of fulfilling them, is central to the ability for projects to raise finance and get a chance to be developed.

RE policies interact with many other sector policies, as well as with climate change policies and its important to ensure, by careful co-ordination, that they complement each other rather than lead to perverse outcomes.

11.7 A Structural Shift

This section closes Chapter 11 with some broader considerations about the implications for policy, financing and implementation if a rapid and large-scale deployment of RE is to be enabled.

Section 11.5 of this chapter has set out the available policies and evidence about their success and failures. Section 11.6 has explained the enabling environment which is required to maximise the success of those policies. Together, 11.5 and 11.6 illuminate the ‘best practice’ policies available and their requirements for success. Any country which puts in place both those ‘best practice’ policies and enabling environment could expect success in delivering renewable energy deployment.

RE is a rapidly increasing source of energy around the world. However, in most places, RE is still viewed as a ‘new’ source of energy from a few ‘new’ technologies and provides only a small percentage of the energy used (see Chapter 1). Chapter 10 illuminates the very wide range of expectations for renewable energy deployment over the next decades, including at the higher end (ie 80% of primary energy by 2050) a similar level to fossil fuels now. Even at the lower levels (15-34% in BAU or lower end of scenarios by 2050) RE deployment is predicted to increase greatly from today. This section focuses on how RE can make the transition to where it is considered in the same way as fossil fuels currently are. If this were the case, then RE would be perceived as a ‘standard’ or ‘normal’ form of energy. Addressing this issue allows this section to explore what is required, not only in terms of policy, but also in terms of political and institutional change; economic goals; societal and individual values and so on.

In particular, this section 11.7 explores:

- What the implications are for energy systems if the barriers to RE (set out in Chapter 1 and 11.4) are overcome
- the wider requirements, beyond renewable energy policies and their enabling environments, to enable a structural shift in energy provision to RE and what this means for societal activities, practices, institutions and norms
- some of the key choices that policymakers, companies, investors and consumers face;
- whether, to implement policies which ‘breakthrough’ or enable ‘bricolage’

Section 11.7.1 illuminates what an energy system without barriers to renewable energy would like: 11.7.2 explores what a structural shift would look like and how to do it; 11.7.3; explores what the fundamental factors are in a number of scenarios to a low carbon economy using low CO2 emitting RE; Section 11.7.4; explores incremental versus step change as a way to make the transition; 11.7.5 briefly looks at ways to change societal values and attitudes as a means to move to a low carbon economy; 11.7.6 looks at 100% renewable energy communities, what they have in common and their challenges; 11.7 7 explores what key choices and implications his seems to imply for policy makers and what altered roles this may mean for other actors, such as companies, investors, communities and individuals; and 11.7.8 sums up the key messages from section 7.

11.7.1 An energy system without barriers for RE

Chapter 1 briefly describes the barriers to RE and 11.4 describes the barriers specific to putting in place a RE policy, including its design. An energy system where RE is thought of in the same way as fossil fuels implies that the majority of the barriers to their deployment have been overcome, and taking the categories of Chapter 1, this implies the following:

- Informational and awareness issues will have been overcome - there is an understanding within policy makers; planners and so on about what the characteristics of RE is; how they work; how they should best be integrated into the energy system; and also about the value of RE in relation to climate change emission reduction, access to energy and poverty reduction
- The socio-cultural aspects of RE acceptance and utilisation has altered so that renewable energy is accepted as not only being a ‘normal’ part of life, but an important one which is adding to societal benefit; but also there is an understanding of how individuals connect and adapt to societal requirements
- Technical and structural barriers have been removed because R&D and other support mechanisms have been undertaken; skills and capacities have developed so that it is possible to implement RE
- The economic barriers to RE have been negated or dismantled so that costs of RE have come down relative to other sources of energy because the social costs of fossil fuels and nuclear power have been incorporated; because subsidies or tax breaks for fossil fuels are removed; so that markets and network access complement RE characteristics; so that carbon markets function well; so that the risk of investment have become on a par with other investments within the energy system and financiers

- The institutional barriers are removed

11.7.2 Energy Transitions and Structural Shifts

Transitions from one energy source to another have characterized human development (Fouquet, 2008). A shift from the current energy system to one that includes a high proportion of RE also implies a number of structural changes (Unruh, 2000; Smith, Stirling et al., 2005; Unruh and Carrillo-Hermosilla, 2006; Mitchell, 2008; van den Bergh and Bruinsma, 2008; Verbruggen and Lauber, 2009).

Movements from one energy source to another have occurred as each new source of energy provided a new and desired service which displaced and augmented the services available from the previous ‘standard’ energy source (Fouquet, 2008). The timescales of these energy transitions and their linked infrastructure replacements or developments varied by countries but occurred over several decades (Fouquet, 2008). A transition to a low carbon economy using low carbon emitting RE is different from past transitions because the time period available is restricted, and relatively short compared to the timescales of previous transitions. Further RE is trying to integrate into a system (including policies, regulations and infrastructure) that was built to suit fossil fuels (which have a number of continuing useful qualities such as energy density and portability) and nuclear power. While RE provides different benefits, services are similar. Because of this movement towards the transition has to be deliberate (Stirling, 2009).

There are different approaches to analysing this complex area of how transitions, or innovations, occur. For example the economics of innovation (Freeman and Soete, 2000; Freeman, 2001); innovation systems (Jacobsson and Carlsson, 1997); transition management (Rotmans, Kemp *et al.*, 2001); and business approaches (Winsemius and Guntram, 2002) . Some of these approaches are linear and rational and others argue that policy-making is more ‘based on such things as visions and values, the relative strengths of various pressure groups and on deeper historical and cultural influences’ (Jacobsson and Lauber, 2004). A plausible approach is that socio-technical system occurs by a complex non linear series of adjustments between three different ‘levels’ or ‘settings’ within a country.: that of (1) the landscape of a country (which is made up of the political system; society’s mindset; the underlying economic system; institutions; the broad geographies and infrastructure, such as cities); that of (2) the energy system in place (made up of certain policies, technologies, the enabling environment; the infrastructure, such as networks and power plants); and (3) the level of niches, where innovations within society, companies and institutions occur, and often wither.

Thus, while an energy system can change (if there are sufficient policies and an enabling environment in place) enabling a structural shift to an energy system with fundamentally different characteristics, requires an alignment between these three levels or setting. This requires three, not inconsiderable, steps, set out in Figure 11.13 below:

- First, an understanding of what is needed at the niche or innovative level for a transition, For example, this report is exploring the potential of low carbon dioxide emitting renewable energy technologies to meet the energy services of people in both developed and developing countries. Thus, the understandings set out in this report are one step to fulfilling this knowledge at a global level. More and more understanding is required for all countries

- Second, a translation of this understanding into policies and enabling environments at the energy system level to make it happen (as set out in 11.5 and 11.6); and
- Third, that this understanding at the energy system level becomes aligned at the landscape or country level (ie the political paradigm of the country has to accept RE as the new energy as 'standard'; the economic development model has to match it; the infrastructure – such as cities – has to reflect it; and it has to become part of society, so that individuals, communities, companies and institutions fuse within a new society 'mindset').

Only when this alignment has occurred between the three levels of a country will the structural shift have occurred. At that point, RE would be treated in the same way as fossil fuels currently is and the linkages between the three levels foster a continuing process of adjustments.

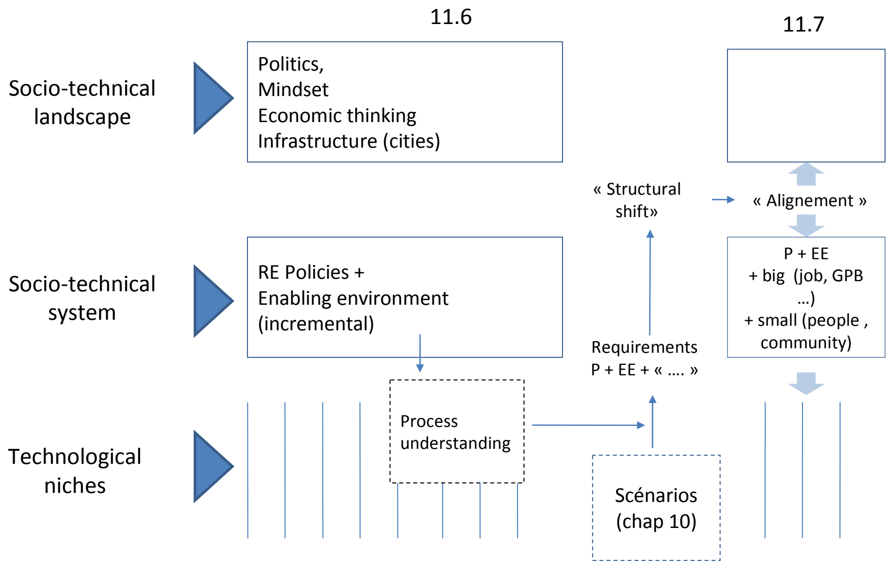

Figure 11.13 Socio-technical requirements of a structural shift.

11.7.3 Exploration of Scenarios

Scenarios create logical future worlds, so that the use of resources and their consequences can be explored, and so that the process understanding of what is required for a transition is understood in greater detail. This report (Chapter 10) reviewed 165 scenarios which represented the most recent integrated modelling literature. It then analysed in depth 4 scenarios, which are representative of those 165 scenarios. From these scenarios, it becomes clear that different desired outcomes, for example a 450 ppm atmosphere in 2050 globe or a global average income level in 2050, require different policy choices and raise critical issues of feasibility in terms of climate change mitigation.

One description of these tensions is given in a recent set of scenarios from Tellus (Tellus, 2010) argue that 'within a conventional economic development paradigm, implementing remedial technologies and policies at the required pace and magnitude would be daunting, indeed, like trying to go up a down escalator. A 21st century world of rising population, consumerism and universal convergence towards affluent lifestyles would create incessant pressure for ever more energy and materials, land and food' (page 14) [TSU: (See 11.3)?].

The importance of policy choices on our future lives is clearly shown in a recent IEA report (IEA, 2009c) RE cities and communities) which set out two imaginary visions of a future: Bleak House and Great Expectations. In these visions, the first reflects a world where the concerns of climate change had not been heeded and technological R&D has not been undertaken. The other is one where concerns of climate change have been heeded and technological R&D has been undertaken. The latter includes a wide range of technologies, including smart information technologies, as well as implementing energy efficient policies. The requirement of individuals to independently change their behaviour and lifestyles is minimised – in other words as much as possible is done for individuals to make the move to a sustainable as easy as possible, although lifestyle and behaviour change is required, and is indeed pushed by the technologies themselves. The IEA report presented these visions to stimulate the reader to contemplate what sort of world they may want to inherit (IEA, 2009) but also to illuminate how technology and behaviour are intimately linked and should be viewed positively together.

These scenarios and vision illuminate central choices for policy makers:

- whether they support a continuation of the current model of economic growth around the world, fuelled by low carbon technologies? And if so, where the energy and resources would come from for it?
- whether policy decisions remain centralised or devolved down to local levels to enable and encourage more local, community and individual involvement in energy system decisions
- whether policy makers will accept a greater amount of global co-ordination to ensure the meeting of global targets - which includes the transfer of financial flows from developed to developing countries, and whether that co-ordination is possible?
- whether policy makers conclude that a more values led movement of society is beneficial to change; and whether that change is possible?

When broken down these scenarios of Chapter 10 and the IEA visions either reflect a technology optimistic route – where low carbon technologies enable a somewhat similar lifestyle across the globe to that enjoyed in developed countries and which don't need much change in societal values or behaviours – or reflect a behaviour optimistic route – where changing individual and societal values are central to the development of a sustainable low carbon emitting economy. The scenarios and models reviewed in Chapter 10 differ greatly in their arguments of which works 'best'; whether by going down one path, negates going down another and so on. Nevertheless, the socio-techno paths are very different; imply real differences for societal values; energy company practices; and institutions; institutional arrangements and government policies.

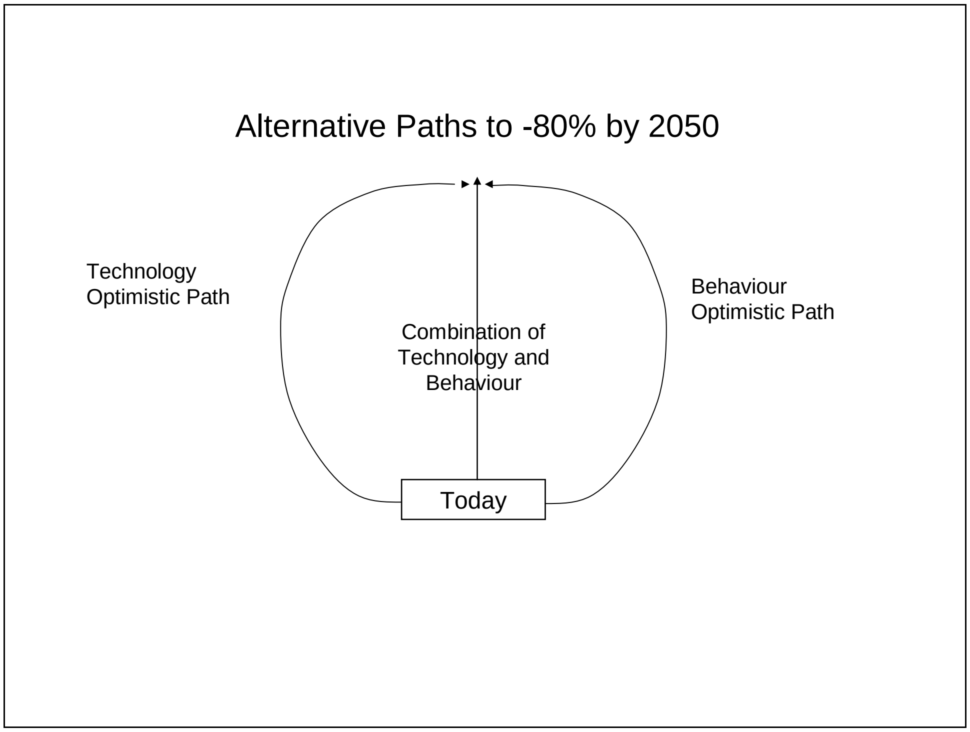

Figure 11.14 Alternative pathways to RE on the standard energy provider

11.7.4 Bricolage versus Breakthrough

When undertaking the transition, and making the choice of which pathway to the low carbon economy to follow, policy makers are able to choose policies which attempt a technological 'breakthrough' or 'step-change or policies which lead to a series of incremental steps, which over time results in a structural shift. As set out in 11.5.2 (Garud and Karnøe, 2003) have termed this choice 'bricolage or breakthrough'. They define bricolage to connote resourcefulness and improvisation on the part of involved actors while breakthrough is taken to evoke an image of actors attempting to generate dramatic outcomes. They argued that 'breakthrough' policies can result in 'dampening the learning processes required for mutual co-shaping' of technology development'. Bricolage on the other hand preserves emergent properties and is a process of moving ahead on the basis of inputs of actors who possess local knowledge but who through their interactions are able to gradually transform emerging paths to higher degrees of functionality (Tellus, 2010; Jacobsson and Lauber, 2004).

This complements the argument that 'agency' or the ability to do something is distributed across actors rather than based in one key actor alone (Bijker et al, 1987). As has been shown, enabling the development and deployment of RE requires all sorts of inputs and changes whether skills, finance and so on (See figure 11.6). Thus, an energy system following a technological path cannot be attributed to one actor, one technology, one policy; or one 'economic' situation. Price, while important, is not sufficient on its own to harness the inputs of distributed actors involved in the development of new technologies (Garud and Rappa, 1994; .

The conclusion to be drawn from this section by policy-makers, business, investors and individuals is that a transition may best be enabled by small, directed steps, building on those taken before. However small the change adds to that structural shift. Thus while the bricolage approach is comforting for policy-makers; it does have to be ‘directed’ towards unlocking or removal of barriers and overcoming of hurdles by combinations of policies (International Energy Agency (IEA), 2008; van den Bergh and Bruinsma, 2008; Praetorius, Bauknecht *et al.*, 2009; UNFCCC, 2009).

11.7.5 Changing societal values and attitudes

This chapter has described policies that create obligations or alter incentive structures for innovation and diffusion (e.g., regulation, price mechanisms, and R&D support). As described above, the value of changing behaviour and values in moving to a low carbon economy is an important element to many of the scenarios reviewed in Chapter 10. This section doesn’t review that literature again, but it does address our understanding of how a social mindset could alter, thereby complementing and helping a structural shift to a low carbon economy occur.

Public education on RE is typically targeted at a general audience through mass media channels. It seeks to change values through moral persuasion or to raise awareness of an issue (Gardner & Stern 2002). Impacts on behaviour are diffuse, long-term, and hard to measure because values towards the environment generally correlate weakly with behaviour (Gatersleben, Steg *et al.*, 2002; Poortinga, Steg *et al.*, 2004). Values exert influence through specific beliefs and then personal norms by which individuals take on the responsibility to act in order to protect the things they value (Stern, Dietz *et al.*, 1999).In contrast, information provision is typically targeted at decision points or at particular population segments. It seeks to reinforce positive attitudes or activate personal norms. Both are precursors to behaviour (Ajzen, 1991)(see Ajzen 1991 and (Oskamp, 2000) respectively). Positive attitudes are further reinforced by public commitments and targeted feedback (Staats, Harland *et al.*, 2004).

A number of recent reviews discuss the role of information and attitudes in behavioural models and settings relevant to the environment (Halpern, Bates *et al.*, 2004; Jackson, 2005; Wilson and Dowlatabadi, 2007). A key finding applicable to RE is that the effectiveness of education and information-based policies is limited by contextual factors. Favourable attitudes only weakly explain behaviour if contextual constraints are strong (Guagnano, Stern *et al.*, 1995; Armitage and Conner, 2001).Systems of energy provision and use are deeply embedded in household routines and social practices (Shove, 2003). This characteristic of energy technologies as “congealed culture” with choices “partially limited by ritual and lifestyle” (Sovacool, 2009) cautions a naïve reliance on information and education-based policies to affect change. But neither does it mititate against their use as relatively low cost, uncontroversial, and potentially empowering instruments of autonomous choice, favoured over coercion from an individual standpoint (Attari, Schoen *et al.*, 2009).

Social norms towards RE rely on ‘social’ visibility. This is not a physical attribute (although literal visibility can help), but rather the extent to which people’s attitudes and behaviour towards RE is communicated through social networks (Schultz, 2002). This type of social communication is central to the diffusion process for innovations including many examples of distributed RE (Archer, Pettigrew *et al.*, 1987; Rogers, 2003; Jager, 2006). The literal visibility of residential wind or solar may help RE become a normative talking point (Hanson, Bernstein *et al.*, 2006) and the converse is true of poorly visible technologies such as micro-CHP. Demonstration projects help promote social visibility and allow potential adopters to observe, learn and communicate about, and test RE technologies vicariously. With solar PV for example, demonstration projects helped breed familiarity and reduce perceived risks for Dutch homeowners and U.S. utility managers alike (Kaplan, 1999; Jager, 2006).

For RE, a key element of context is the residential customers' past experience, habit and life style (Brennan 2007). As systems of energy provision and use are deeply embedded in household routines, social practices and life styles (Sovacool 2009), collective action (e.g. through social norms) and systemic approach is an often times more efficient, but more complex, medium for change than individual action (e.g. through individual values, personal attitudes or personal norms ...) (Wilson 2008; Nolan et al. 2007). Favourable attitudes only weakly sustain behaviour change if the contextual constraints are strong (e.g. access to financing, permitting procedures ...) (Guagnano & Stern 1995; Armitage & Connor 2001), so transforming attitudes in behaviours often times calls for coordinated policy action at the level of the system.

11.7.6 100% renewable energy societies

A few towns, local authorities, or communities have moved considerably toward sourcing 100% of their energy from RE (Droeghe, 2009; IEAs Cities Towns and RE; see Box 11.18). On the one hand, those locations that have made this transition offer limited potential for learning because they are at the forefront of energy system. Yet their experiences can provide very useful insights by illuminating how and why such change occurred. The key lesson of whether, and how, these city's and communities were able to do this ultimately depended on the *spatial, environmental, social and economic capacities to implement RE* – and this would only be possible if the concerns of the three main actors – state, market and civil society - are addressed together (Droeghe, 2009). This is the practical representation of the arguments for structural change set out in 11.7.2 – an alignment has to occur between the State; the social mindset and institutions. Issues raised by the 100% communities are:

- only a limited number of cities and communities have shifted, or are in the process of transitioning to, 100%. But this transition was almost unimaginable even a few years ago. These places have been able to achieve the shift rapidly and have seen significant additional advantages result, such as jobs or economic development, and which have become important, reinforcing factors in themselves
- they are technically-literate places – while the technologies are often small scale, the system itself is linked to a greater or less degree to 'active' or 'smart' technologies
- The positive aspects from the case studies reinforce each other once a certain point in the transition has been reached: new companies entering the market place, more jobs, lower costs, better quality of life.
- past scenarios would not have predicted that such step changes were possible (or perhaps economically feasible).

Box 11.18 The Road to 100% RE: Güssing, Austria and Rizhao, China

A small but increasing number of cities, towns and communities from Europe to Asia have started down the path to 100 percent RE. This is the story of two of them.

Güssing in Austria was the first town in the European Union to reduce its carbon emissions by 90 percent (below 1992 levels) and today is a model for environment-friendly energy production based on energy saving, self-sufficiency and environmental protection. Thirty RE plants—solid biomass, biodiesel, biogas and photovoltaic facilities—operate within 10 kilometers of Güssing and meet the town's fuel demands for transportation, residential heating, and electricity. Electricity produced locally and sold into the grid has increased local revenue, with profits reinvested into the community and its RE projects. By 2009, Güssing's renewable profile had attracted 60 companies wanting to run on clean energy, creating at least 1000 new jobs.

The town's transformation began in the late 1980s when a massive fuel debt prompted the local mayor to enforce energy-saving measures and begin phasing out fossil fuel use, replacing it with locally supplied RE. Within two years, energy expenditures were reduced drastically. Policies were implemented to manage and sustain local farms and forests to produce raw material for generating bio-energy. Several local and regional public and private research institutions provided technological assistance. Güssing's specialised centre on RE has helped to raise public awareness about clean energy and energy efficiency as well as broader conservation and climate protection goals. Grants from the European Commission, regional authorities and the national government assisted with the construction of new infrastructure, such as the district heating system. By 2001, Güssing was 100 percent self-sufficient and operating on RE.

In northern China, the city of Rizhao has attracted an increasing level of foreign investment, tourism and migration thanks to RE and efficiency policies that have helped to enhance the city's environmental profile while improving living standards. The local government has mandated the integration of clean energies, especially solar, into all development and modernisation projects in the region. As a result, 99 percent of all buildings in urban areas, and more than 30 percent of houses in rural areas, have installed solar water heaters; almost all outdoor public lighting (traffic signals, street and park lights) is PV-powered.

By supporting local supplier start-ups (through tax breaks and/or preferential land allocation) and subsidising R&D, rather than end users, the city has enabled RE industries to increase efficiency and reduce per unit costs. This is considered more cost-effective than funding the entire city population. To source raw material for bioenergy production, waste minimization policies assist and encourage industries to recycle wastewater and solid wastes for drying processes, or to generate heat and electricity. An urban-rural planning framework ensures equal attention is paid to the self-sufficiency of regional areas, and municipal-run energy advisory centres provide advice for consumers and potential energy providers.

The result has been millions of RMB yuan generated annually from the electricity sold, alongside a considerable reduction in urban water, power, steam and food consumption. Rizhao's eco-agricultural model has helped improve the rural ecology and the livelihood of farmers through organic farming based on RE tapped from local bio-digesters, small-scale hydro and wind power.

11.7.6.1 Factors in Common

Common to both places were the following themes: government leadership; community involvement; access to funding and market incentives; awareness; and research and development (R&D) support. Strong local government leadership was critical, authorities in both cases had to actively facilitate, educate, and promote market transformation of local energy supplies. Clear energy goals were established that were based on fulfilling community needs and addressing local problems such as high energy costs, low living standards, unemployment, old infrastructure and pollution. Policies had to ensure the competitiveness of renewable energy (RE) markets through preferential policy for RE companies, such as tax breaks, feed-in tariffs, fossil fuel tax, or preferential land allocations for RE manufacturers. A local planning framework that involves the cooperation of the state, private businesses and civil society into the decision process was also necessary. Energy and environmental awareness required changes in the local curricula from local schools to technical colleges. External expertise was needed to assist governments with taking stock of the region's social, environmental and spatial capacity to generate and supply renewable energy – an energy mix that would help overcome fluctuations in energy supply due to changing climatic conditions. Sourcing raw material was for example, were reflected into policies enforcing the recovery of local and regional waste material (from farms, landfills or industry) for the generation of clean energy. Naturally, the modernisation of the local infrastructure and the need to mandate energy efficiency and renewable energy integration though policies on urban regeneration or the construction of new development, was also essential. Although the availability of financial assistance from regional and national authorities was key, funds were largely directed towards R&D of renewable energy technology, rather than subsiding end-users in the form of rebates or the like.

11.7.6.2 Key Challenges

The key challenges 100% RE societies face ranged from (Droege, 2009):

- operational difficulties associated with out-of-date planning and funding approval processes,
- to societal scepticism or the lack of awareness by all in understanding the economic, social and spatial implications of changing the town's energy base to sustainable sources.
- Existing processes take up considerable periods of time, more particularly in relation to applying for grants for renewable energy projects, and/or applying for development approval for their actual construction.
- Funding processes sometimes require cities to comply with particular rules (for example such as those set out by the EU) in order to qualify for financial assistance. Timeframes often differ depending on whether funds are sourced locally, regionally or nationally.
- Structural changes to planning regulations, due to changing governments or market fluctuations, or conflict between national and local policies, also cause a slowing down or stagnation in the approval processes.
- A non-competitive market for RE and energy efficiency measures, coupled with high upfront installation costs and the changing values of feed-in tariffs, adds to the prevailing reluctance amongst companies and governments to invest into such projects due to the uncertainty.
- Energy research and technological expertise was required to ensure a town's transformation and to maintain its success; but often this has not been possible due to the lack of funds or general passive resistance from town planners to external, academic advice.
- Becoming energy producers would mean communities themselves undergoing some form of training.

- Existing planning methods require some restructuring, and specific goals in relation to renewable energy and energy efficiency must be clearly expressed in local energy plans – an aspect often missing from local sustainability objectives. For many cities around the world, energy is still addressed only in relation to the provision of infrastructural services. Locally drafted land-use plans often do not address the energetic implications of each land-use typology, be it industrial, residential or commercial (in relation to its environmental footprint or emissions output). They often fail to express the energy-generating potential of sites, nor do they help guide the conversion of buildings associated with each land-use into more energy-efficient, self-sustaining built forms.
- Other critical factors include social attitudes and lifestyles, as fears still prevail amongst industry that new sustainable energy businesses will cause their demise, while communities around fear that they would have to do without. A lack of awareness that generally hinders the take-up of energy efficiency and renewable energy measures, communities often waiting for instructions from the local government before any form of action takes place.

11.7.7 Key Choices and Implications

This section has illuminated the key requirements and choices that policy makers face and which have significant implications for society (Smith, 2000; Unruh, 2000; Garud and Karnøe, 2003; Szarka, 2006; Unruh and Carrillo-Hermosilla, 2006; Smith, 2007; Szarka, 2007; International Energy Agency (IEA), 2009; Praetorius, Bauknecht *et al.*, 2009). Governments are required to orchestrate the deliberate move from fossil fuels to RE use. As is argued in the IEA's Deploying Renewables (2008), success in delivery occurs where countries have got rid of non-economic barriers and where policies are in place at the required level to reduce risk to enable sufficient financing and investment (International Energy Agency (IEA), 2008). In addition, this section has set out that

- RE Policies, the enabling environment and more structural shifts are all on a continuum towards a transition to an energy system with more and more RE.
- A 'breakthrough' or a 'bricolage' policy approach to technology development and system change is a key choice
- Another key choice is the policy priority of whether to support a technology optimistic pathway ; a behaviour optimistic pathway or one that combines both
- the degree to which policies are devolved down from national to local governments, and open to individual choice
- the degree to which the State, the market and civil society are brought together to address, and create, sufficient spatial, environmental, social and economic capacities to enable a move to a low carbon economy

The choices will affect the actors described above so that societal activities, practices, institutions and norms can be expected to change. Thus, choice of policies is central to the success of policies.

11.7.8 Conclusions

This section, chapter and report comes to a number of fundamental principles about RE deployment, financing and implementation:

1**. Targeted RE policies accelerate RE development and deployment**. Targeted policies should address barriers to RE, including market failures, and appropriate market signals are crucial to trigger significant RE growth, but are not sufficient.

2**. Multiple RE success stories exist around the world and it is important to learn from them**. They demonstrate that the right policies have an impact on emissions reductions and the enhanced access to clean energy. They also demonstrate the importance of learning by doing, including learning from mistakes, to achieving success.

3. **Economic, social, and environmental benefits are motivating Governments and individuals to adopt RE.** In addition to mitigation of climate change, benefits include economic development and job creation, increased security of energy supply, greater stability and predictability of energy prices, access to energy, and reduced indoor air pollution. In general, climate change mitigation is a primary driver for developed countries whereas developing countries focus more on energy access and energy security through RE. In low-lying developing countries, RE's potential for climate change mitigation becomes an issue of economic and physical survival.

4. **Multiple barriers exist and impede the development of RE policies to support development and deployment.** These primarily relate to the degree of awareness, and acceptance, of climate change policies; a lack of knowledge of how RE can mitigate the problem and a lack of sufficient public governance capacity to elaborate and make RE policies operational; the momentum of the existing energy system, including policies that were enacted to advance or support the existing fossil-based system and that now undermine RE policy; and a lack of understanding on the part of policy-makers of the needs of financiers and investors.

5. **'Technology push' coupled with 'market pull' creates virtuous cycles of technology development and market deployment**. Public RD&D combined with promotion policies have been shown to drive down the cost of technology and sustain its deployment. Steadily increasing deployment allows for learning, drives down costs through economies of scale, and attracts further private investment in R&D.

6. **Successful policies are well-designed and -implemented, conveying clear and consistent signals.** Successful policies take into account available RE resources, the state and changes of the technology, as well as financing needs and availability. They respond to local, political, economic, social, financial, ecological and cultural needs and conditions. RE deployment policies can immediately start in every country with simple incentives, evolving toward stable and predictable frameworks and combinations of policies to address the long-term nature of developing and integrating RE into existing energy systems.

7. **Policies that are well-designed and predictable encourage greater levels of private investment than those that are not**, thereby reducing the amount of public funds required to achieve the same levels of RE development and deployment.

8. **Well-designed policies are more likely to emerge and to function most-effectively in an enabling environment**. An enabling environment integrates technological, social, cultural,

institutional, legal, economic and financial dimensions, and recognizes that technological change and deployment come through systemic and evolutionary (rather than linear) processes. Also important is coordination across policies, the dimensions of the enabling environment and, where relevant, different sectors of the economy including broader energy policy, transportation and agriculture.

9. **The global dimension of climate change and the need for sustainable development call for new international public and private partnerships and cooperative arrangements to deploy RE. RE deployment is a part, and a driver, of sustainable development**. New suitable finance mechanisms on national and international levels, involving cooperation between the public and private sectors, work to stimulate technology transfer and worldwide RE investment as well as advancing the necessary infrastructure for RE integration. New partnerships would recognize the diversity of countries, regions and business models.

10. **Structural shifts characterize the transition to economies in which low CO_2 emitting renewable technologies meet the energy service needs of people in both developed and developing countries**. When RE is treated as the norm, as fossil fuels are today, a structural shift will have occurred. Political will and effective policies to promote RE deployment, in concert with decreasing energy intensity, are an integral part of the needed energy transition. Further, transitions require important changes in societal activities and practices, business conditions and institutions.

11. **Better coordinated and deliberate actions can accelerate the necessary energy transition for effectively mitigating climate change**. The now required transition differs from previous ones in two primary ways. First, the available time span is restricted to a few decades. Second, RE has to develop within the existing energy system (including policies, regulations and infrastructure) that generally were built to suit fossil fuels and nuclear power. Thus it is important to align attitudes and political actions with the known requirements for effectively mitigating climate change. Critical are combinations of strategic and directed policies established to meet interim and long-term RE targets and advance the required infrastructure. Long-standing commitment is essential alongside the flexibility to adapt policies as situations change.

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