INTERGOVERNMENTAL PANEL ON climate change

Chapter 11

Policy, Financing and Implementation

Chapter:	11				
Title:	Policy, Financing and Implementation				
(Sub)Section:	All				
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Remarks:	First Order Draft				
Version:	01				
File name:	SRREN_Draft1_Ch11.doc				
Date:	22-Dec-09 13:59	Time-zone:	CET	Template Version:	9

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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 108 pages: a total of 23 pages over target.

Expert reviewers are kindly asked to indicate where the Chapter could be shortened in terms of text and/or figures and tables.

Reviewers are also asked to note that a number of references in the text are not yet reflected in the reference list. At times in the text reference titles appear as full names (e.g. International Energy Agency) and others as acronyms (IEA) – this will be made consistent in consecutive drafts.

In addition, all monetary values provided in this document will need to be adjusted for inflation/deflation and then converted to USD for the base year 2005.

Chapter 11: Policy, Financing and Implementation

CONTENTS

EXECUTIVE SUMMARY

Government policies are required for a substantial increase in deployment of renewable energy. Market signals alone - 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. 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 of RE into the existing energy system. After more than 30 years of policy experience, there is now a clear understanding of what does work and what does not. Some policies has proven efficient and effective, others have 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, none have proven themselves superior thus far.

Instrument design is key for effective and efficient policies. 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 systems long-term nature, the necessary investments in renewable energy plants, in manufacturing facilities, in infrastructure for integration and R&D rely on stable and predictable policies and frameworks. Clear, long-term, consistent signals and robust 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. Market deployment is a crucial element of any successful policy since only then can results from R&D be transferred into practice, 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 renewable energy. 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 increase the rate of deployment needed is a systemic and evolutionary process. Thus, coordination among policies and the sub-components of the enabling environment, whether economics, technology, law, institutional, social and cultural , is essential.

The global dimension of climate change and the need for sustainable economic development call for a global partnership on deploying renewable energy that recognizes diversity of countries, regions and business models. Deployment of renewable energy provides opportunities for international cooperation. New finance mechanisms and creative policies on all levels are needed to stimulate the technology transfer, investment and deployment of renewable energy. 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. With higher shares of renewable energy, 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. Today's energy system was designed primarily for fossil 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 RE to become the standard energy provider in a low carbon energy economy. This implies important changes in societal activities, practices, institutions and social norms, and government policy can and must play a role in driving this transformation.

11.1 Introduction

Capturing the potential of the globe's renewable energy (RE) resources depends on a wide spectrum of factors. The previous chapters have explained the state of technological understanding and described the required issues of integration. This chapter sets out the issues surrounding the policies, financing and implementation of renewable energy.

As noted in previous chapters, RE capacity and production of electricity, heat and fuels have increased rapidly in recent years, although most technologies are growing from a small base. RE policy trends, toward an increasing number of policy mechanisms in place in a growing number of countries, have played an important role in advancing renewables. This rapid growth has occurred mostly in a limited number of countries that have enacted strong policies to promote the development and use of RE technologies. Wherever there has been significant installation of capacity, production of RE, and investment in manufacturing and capacity to date, there have been policies to promote RE.

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, best practice policy design suited to a country's characteristics and needs, and other enabling factors. This chapter examines the policy options that are available for rapidly increasing the uptake of RE (See Table 1). It looks at which policies have been most effective and efficient to date and why, and other factors (the enabling environment) that can help to overcome the many barriers to RE and increase the effectiveness of policies.

However, the rate of installation has to increase rapidly in order to mitigate 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 have experienced limited implementation and limited policy support despite its enormous potential ((IEA, 2007; Seyboth, Beurskens *et al.*, 2008)).

11.1.1 The Importance of Tailored Policies and an Enabling Environment

There is now clear evidence of success, and the chapter highlights several case studies throughout in boxes. Although there are very limited examples of countries that have come to rely primarily on RE without supportive policies (such as Iceland with geothermal and hydropower), in most cases targeted policies are required to advance RE technology development and use, and they have played a critical role in each of the cases highlighted in this chapter.

Further, while each of these country and community case studies has seen success to date, not all policies enacted to advance RE have worked effectively and/or efficiently. The IEA (2008) 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 policies is not enough. Some countries (e.g., Germany) with relative low RE resources have achieved high levels of implementation, while some high resource countries (e.g. the UK) have not, despite the existence of government policies to advance RE.

Overall, policy is more important than resource potential in determining success (Meyer, 2003; test, 2009), and policy design and implementation are critical to this success (International

Energy Agency (IEA), 2003). 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, and robust, 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 combines economic, technological, social and cultural, institutional and financial dimensions, including both the public and private sectors. Coordination with policies related to other key and inter-linked sectors—including agriculture, transportation, construction, technological development, and infrastructure—is also important.

11.1.2 Innovation and Structural Shift

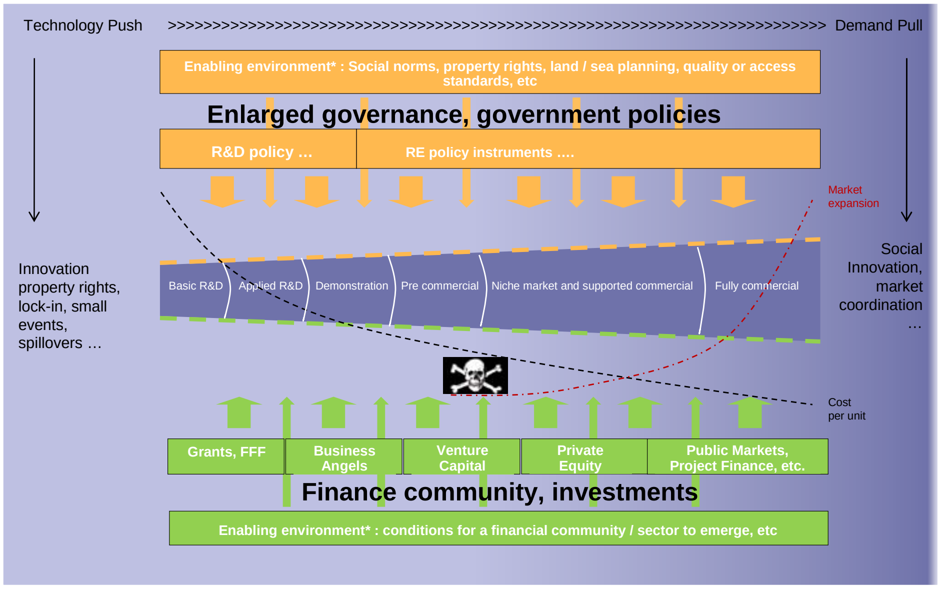
Finally, achieving a sustainable energy system, one in which RE becomes the standard energy provider in a low-carbon energy economy, will require a structural shift to a more integrated energy service approach that takes advantage of synergies between RE and energy efficiency.

To enable this shift, a combination of innovative 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 therefore a central component for the successful fulfilment of RE policies. 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 scale of innovations can be incremental (building on and improving existing technologies or practices), radical (entirely new technologies or practices), or structural (economy-wide technological shifts) (Fagerberg, 2005). Thus, while innovation is seen as important for encouraging economic, and sustainable, growth and as a means of developing competitive advantage for industry, it is increasingly understood that innovation will be necessary for addressing both adaptation and mitigation of climate change (Stern, 2006; Department for Innovation Universities & Skills (DIUS), 2008; van den Bergh and Bruinsma, 2008).

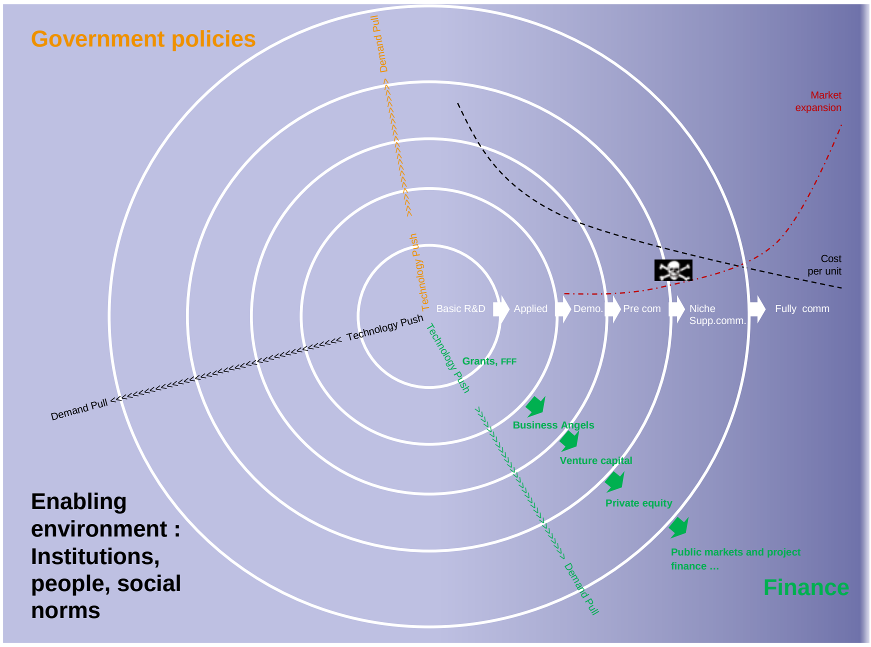
To a greater or lesser degree, the private sector is likely to pursue innovative technologies or practices in order to gain competitive advantage (Freeman and Soete, 2000). However, government also has a role to play in encouraging the development and deployment of successful innovations in the context of climate change. In other words, if they want to encourage environmentally desirable innovations, governments must use public policy in order to create supportive environments in which innovations can develop and mature (Alic, Mowery *et al.*, 2003; Foxon and Pearson, 2008). Implementation of well-designed RE policies and the creation of an enabling environment conducive to successful policy implementation would inherently be conducive to innovation (Mitchell, 2008).

Figure 1 shows that innovation is a process over time, with different phases. These include basic R&D at the front end of technology development, with a move through a number of phases to being fully commercial at the other end. However, a linear progression fails to capture the complexities of the innovation process. Figure 2 attempts to illuminate the difficulties of taking an idea or a product to full commercialization. Innovation is as much a ‘demand pull’ process as it is a ‘technology push’ process. The transition from one stage of technological development to another is not automatic; and many products and ideas fail. This has long been understood within the technology, firm and market sphere (Dixit and Pindyck, 1994; Freeman and Soete, 2000; Moore, 2002).



The innovation chain and the technology “valley of death”

Figure 1: Interaction of innovation processes between different scale levels



The innovation chain and the technology “valley of death”

Figure 2: The enabling environment of RE technologies

Government is able to encourage innovation through its R&D policies and its renewable policy instruments, but the success of an idea or technology is also linked to private investment in it. The financial community has different products and sectors to match the differing requirements of the stages in technology development. These products will be all the more successful within an environment of favourable social innovation and acceptance. Thus, Figure 2 also illuminates the importance role of individuals and society in the transformation. This is the case in both developed and developing countries.

11.1.3 Fundamental Principles of RE Development and Deployment

This chapter comes to a number of fundamental principles about RE deployment:

- Targeted RE policies are required to overcome numerous barriers that limit uptake and investment in private R&D and infrastructure and to accelerate RE deployment. Market signals alone—even when incorporating carbon pricing—have been insufficient 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. Good practice exists and it is important to learn from it.
- To be as effective as possible, policies must be well-designed and –implemented, taking into account the state of the technology, available RE resources, and responding to local political, economic, social and cultural needs and conditions.
- Well-designed policies are more likely to emerge, and they will be more effective in rapidly scaling up RE, in an enabling environment. An enabling environment combines technological, social, institutional and financial dimensions, and recognizes that technological change and deployment come through a systemic and evolutionary (rather than linear) process.
- The global dimension of climate change and the need for sustainable economic development call for new international partnerships on deploying RE that recognizes the diversity of countries, regions and business models. RE deployment can contribute to sustainable development, and new finance mechanisms are required to stimulate technology transfer, investment and RE deployment.
- A structural shift is required if RE is to become the standard energy provider in a low-carbon economy. Political will and effective policies for RE deployment will be required, in concert with improvements in energy efficiency, and important changes in societal activities, practices, institutions and social norms will be needed.

11.1.4 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 barriers to deployment of RE technologies. 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.

Table 1: List of RE Policy Mechanisms and Definitions (Metz, Davidson et al., 2007; Pachauri and Reisinger, 2007; REN21, 2007)

Policy	Definition
Biofuels blending mandates	Mandates for blending biofuels of total transportation fuel in per cent or million liters; Ethanol (E) and Biodiesel (B)
Capital subsidies, grants or rebates	One-time payments by the government or utility to cover a percentage of the capital cost of an investment
Feed-in tariff (FIT)	A policy that sets a fixed guaranteed price at which power producers can sell RE power into the electric power network. Some policies provide a fixed tariff; others provide fixed premiums added to market- or cost-related tariffs.
Energy production payments/ production tax credits	Provide investor or owner of qualifying property with an annual tax credit (against income) based on the amount of electricity generated by that facility
Green power purchasing	Voluntary purchases of renewable electricity by customers, directly from utility companies, from a third-party renewable energy generator, or through the trading of renewable energy certificates (RECs).
Hot water/ heating policies	Mandates and programmes for solar hot water/heating and other forms of renewable hot water/heating in new construction
Investment tax credit	Allows investments in RE to be fully or partially deducted from tax obligations or income
Net metering	Allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation. The customer pays only for the net electricity used
Production tax credit	Provides the investor or owner of qualifying property with an annual income tax credit based on the amount of electricity generated by that facility
Public competitive bidding	Tendering system for contracts to construct and operate a particular project, or a fixed quantity of RE capacity in a country or state.
Public investment loans or financing	Provides preference to RE in government procurement, infrastructure projects and use of public benefits, funds, loans, etc.
Renewables obligation	See Renewable portfolio standard
Renewable portfolio standard (RPS)	Also called renewables obligations or quota policies. A standard requiring that a minimum percentage of generation sold or capacity installed be provided by RE. Obligated utilities are required to ensure the target is met.
Sales tax, energy tax, excise tax or VAT reduction	Reduction in taxes applicable to the purchase (or production) of renewable energy or technologies
Subsidy	Direct payment from the government or tax reduction to a private party for implementing a practice the government wishes to encourage.
Tender scheme	See Public competitive bidding
Tradable renewable energy certificates (RECs)	Each certificate represents the certified generation of one unit of RE (typically one megawatt-hour). Certificates provide a tool for trading and meeting renewable energy obligations among consumers and/or producers, and also a means for voluntary green power purchases.

Table 2: Policy Mechanisms by Category and End-Use Sector

			END-USE SECTOR	
	Policy Mechanism	**Electricity**	**Heating/Cooling**	**Transportation**
Regulatory	Feed-in tariff	X	X	
	Quota/RPS	X		
	Tendering/Bidding	X		
	Mandate - installation, capacity or blending	X	X	X
	Green power purchasing	X		
	Tradable green certificates	X	X	
	Priority access to distribution/transmission network and market	X	X	?
	Low-carbon standards?			
Fiscal	Accelerated depreciation	X	X	X
	Reduction in sales, VAT, energy or other taxes	X	X	X
	Energy production payments	X	X	
	Production tax credits	X	X	X
	Capital/investment grants, subsidies or rebates	X	X	X
	Investment tax credits	X	X	X
Govt Finance	Low-/no-interest loans	X	X	X
	Loan guarantees	X	X	X
	Capital grants	X	X	X
Other	Government procurement	X	X	X

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 or heating requirements and feed-in tariffs; fiscal policies including tax incentives and rebates; and financing mechanisms. A range of mechanisms is provided and defined in Table 11.1, while Table 11.2 summarizes what types of policies have been applied to RE in each of the three end-use sectors of electricity, heating and cooling, and transportation.

The number of RE policies, and the number of countries with RE policies, is increasing rapidly around the globe. They are also spreading from focusing almost entirely on electricity to covering the heating/cooling and transportation sectors as well. These trends are matched by increasing success in the development of RE technologies and their manufacture and implementation (See Chapter 1), as well as by a rapid increase in annual investment in RE and a diversification of financing institutions. This section describes the trends in RE policies; in R&D; and in financing and investment.

11.2.1 Trends in RE Policies

Growth in RE capacity and energy production have increased rapidly over the past several years (International Energy Agency (IEA), 2008a), with several technologies experiencing average annual growth rates in the double digits.(REN21, 2009a; United Nations Environment Programme (UNEP) and New Energy Finance Limited (NEF), 2009) Although renewable technologies still account for a relatively small share of total global energy use, in 2008 alone the world added an estimated 65 gigawatts (GW) of new renewable electric capacity, accounting for 41 percent of total capacity additions that year.(United Nations Environment Programme (UNEP) and New Energy Finance Limited (NEF), 2009) Several factors are driving this rapid growth in RE markets, but government policies have played a crucial role in accelerating the deployment of RE technologies (Sawin, 2001; Meyer, 2003; Sawin, 2004b; Rickerson, Sawin *et al.*, 2007; REN21, 2009a).

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, and municipal levels (REN21, 2005; REN21, 2009a). Initially, most policies adopted were in developed countries, but more recently a growing number of developing countries have enacted policy frameworks to promote RE (Wiser and Pickle, 2000; Martinot, Chaurey *et al.*, 2002). In 2005, an estimated 45 countries—including 10 developing countries—had policy targets for RE (REN21, 2005); by early 2009, the number of countries with policy targets had increased to at least 73 (REN21, 2009a). (See Figure 3) Many of these policies and targets have been strengthened over time and several countries have more than one policy in place.

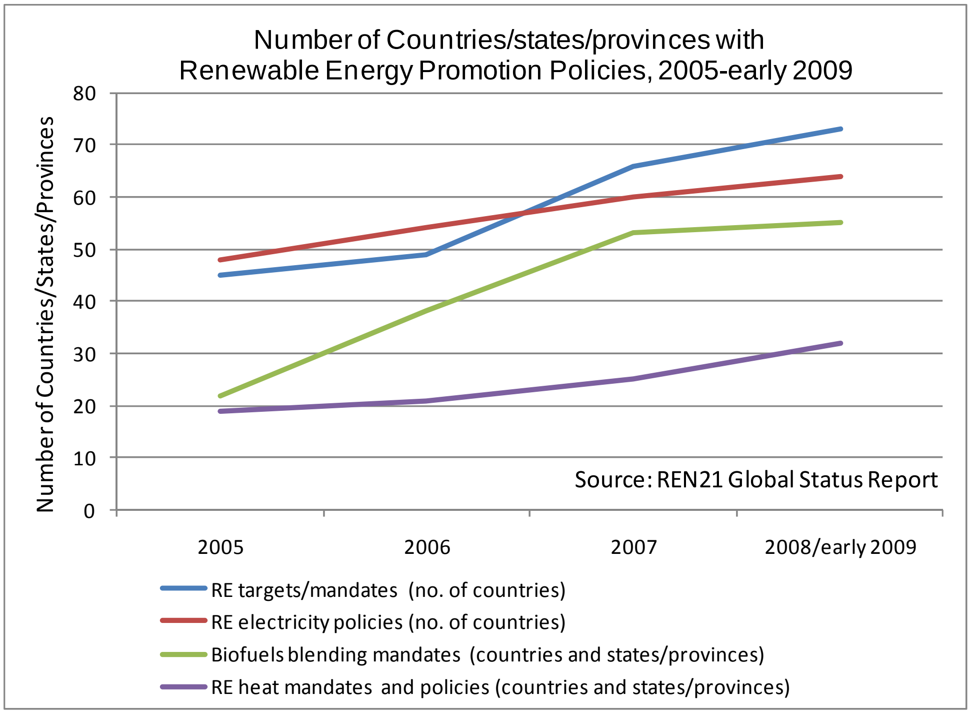


Figure 3: Number of Countries, states and provinces with RE Promotion Policies, 2005-early 2009 (REN21, 2005)[1]

Most of these targets and promotion policies have focused on electricity generation from renewable sources, with at least 64 countries adopting some sort of policy to promote renewable power generation by early 2009 (REN21, 2009a). Of these, the most common electricity policy to date has been the feed-in tariff (FIT); by early 2009, feed-in tariffs had been enacted in at least 45 countries (including much of Europe) and 18 states, provinces or territories (Mendonça, 2007; Rickerson, Sawin *et al.*, 2007; Rickerson, Bennhold *et al.*, 2008; REN21, 2009a). Renewable Portfolio Standards (RPS) or quotas are also widely used and, by early 2009, had been enacted by an estimated 9 countries at the national level and by at least 40 states or provinces (REN21, 2009a). As seen in Figure 4, RE's share of new global electricity generation has risen in line with the increase in FIT and RPS policies. The 40 GW of additional capacity in 2008, shown in Figure 4 below, represents 23 percent of the additional total global generation increase (UNEP and NEF, 2009). Many additional forms of policy support are used to promote renewable electricity, including direct capital 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).

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[1] 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; and GSR 2009 Update, pp. 17-20. Note that all numbers are minimum estimates. Not all national renewable energy targets are legally binding. Overall renewable energy 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 renewable electricity promotion policies is average of 2005 and 2007 data from REN21.

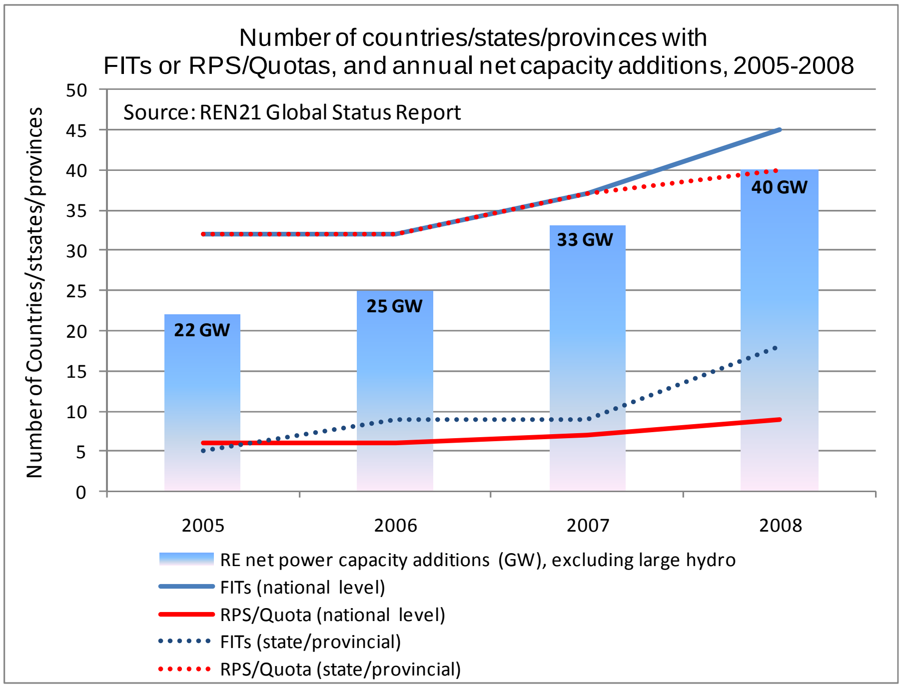

Figure 4: Number of countries/states/provinces with feed-in tariffs or RPS/Quotas, and annual net electric capacity additions (excluding large hydropower), 2005-2008. (REN21, 2005; REN21, 2009a; United Nations Environment Programme (UNEP) and New Energy Finance Limited (NEF), 2009)

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, 2009a; Rickerson, Halfpenny *et al.*, 2009). For example, in the 12 countries analysed for the 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 (International Energy Agency (IEA), 2007). According to REN21, the number of countries, states and provinces with RE (mostly solar) heat mandates increased from an estimated 19 in 2005 to more than 30 in 2008 (REN21, 2005; REN21, 2007; REN21, 2009a). By early 2009, all European Union countries had adopted biofuels targets (most of these mandated) and several other countries and states had targets or blending mandates (REN21, 2009a).

Many countries or regions have established targets for multiple end-use sectors, or for shares of final energy consumption. Perhaps the best example is the European Union, which in 2008 confirmed its commitment to a binding target for renewable sources to provide 20 percent of final energy by 2020; member states have all established individual targets as well (REN21, 2009b).

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, 2009a). 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 percent sustainable energy systems (Droege, 2009; Sawin and Moomaw, 2009).

And, as mentioned in Section 11.1, several countries are also demonstrating that transformation can happen quickly even on a national scale. Germany, for example, had relatively little renewable electricity capacity in the early 1990s, but had become a world leader within a decade. In 2000, just over 6.3 percent of Germany's electricity came from renewable sources; by the end of 2008, the share had exceeded 15 percent thanks primarily to the German FIT (German Federal Ministry for the Environment, 2009). China was barely in the wind business in 2004 but ranked second after the United States for new installations in 2008, doubling its cumulative wind capacity for the fourth year in a row (Global wind Energy Council (GWEC), 2008; Global Wind Energy Council (GWEC), 2009b; Global Wind Energy Council (GWEC), 2009a; Global Wind Energy Council (GWEC), undated). Decentralized RE capacity, in terms of number of households with electricity access, has also been increasing rapidly (REF).

According to REN21, as of early 2009, 6 countries—China, the United States, Germany, Spain, India and Japan—represented roughly 70 percent of the world market for wind, solar and other renewable power (excluding large hydropower) generating technologies; the top four countries account for more than 61 percent of the world market for these technologies (REN21, 2009a). A handful of countries lead in the production and use of biofuels, while China alone has installed about 70 percent of total global solar heating capacity and represented 75 percent of the world market in 2008 (REN21, 2009a).

11.2.2 Research and Development Trends

11.2.2.1 Government spending on R&D

Figures collected by the International Energy Agency (International Energy Agency (IEA), 2008b)are a good guide to RE R&D spending in OECD countries up till the middle of this decade. (IEA, 2008) 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), 2008a), 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 (Jawaharlal Nehru National Solar Mission (JNNSM), 2009)and Singapore (Solar Energy Research Institute of Singapore (SERIS), 2009). But there are important exceptions to the rule. The European country whose government spends most on R&D into photovoltaic technology, Germany (EC, 2009), does so with a view to growing a competitive export industry (IEA, 2008).

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, solar energy for heating and cooling. Ocean energy has been the Cinderella of R&D funding throughout, barely receiving more R&D support than hydropower, despite the latter's greater technical maturity, demonstrated by its vastly greater presence on the market. 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 spending patterns the years since climate change began to hit the headlines routinely. Spending on wind, solar PV and concentrating solar thermal power and bioenergy averaged 431 M EUR_{2005}[TSU: Needs to be presented in 2005 US$]annually in the EU Member States over the 2002-2006 period, compared to 182 M EUR_{2005}[TSU: Also needs to be presented in 2005 US$]in the US and 77 M EUR_{2005}[TSU: Needs to be presented in 2005 US$]in Japan during the same years (EC, 2009). The International Energy Agency (IEA, 2008) notes that averaging figures over this period hides some steep increases in spending, which have occurred in UK, France, Hungary and China. Roughly speaking, the sum of Chinese spending on solar and wind R&D, which stood between 37 and 42 M USD_{2005} in 2006, approximated to that of Spain.

In Europe, the large majority of public R&D money is paid out by national governments to research teams in their country rather than entrusted to a central body empowered to fund projects across the whole region. Only 12-17 percent of public funds for RE R&D and handled by bodies other than national governments, and they are administered by the European Commission. The Commission downplays the extent to which it is valid to consider Europe as a single, unified bloc in RE R&D funding, saying that "pan-European cooperation is limited and synergies between Member States in the development of new energy technologies have so far not been fully exploited," but the EC has plans to change that (EC, 2009 and SETP, 2007).

The European Commission (EC, 2009) reports how country-level spending on nuclear energy has evolved in Europe since 1985 (it now accounts for 40 percent of all such spending on energy, down from three quarters in the mid 1980s), and provides a snapshot of how nuclear energy, fossil energy and RE spending compared against each other in 2007 (35 percent, 8 percent and 22 percent 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, 2008). The dominance of nuclear energy spending is apparent.

11.2.2.2 Private sector spending on renewables 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 the nations of the European Union (LISBON, 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 rates of 0.6 percent and 0.3 percent, respectively, which the Commission rationalizes by saying these industries are "supplier dominated".

11.2.3 Financing trends and implications for future growth

In response to the increasingly supportive policy environment, the RE sector has seen rapidly increasing levels of financing in the past few years, with $116 billion of new financial investment in 2008, up from 15.5 billion USD_{2005} in**,** as shown in Figure 5[2].

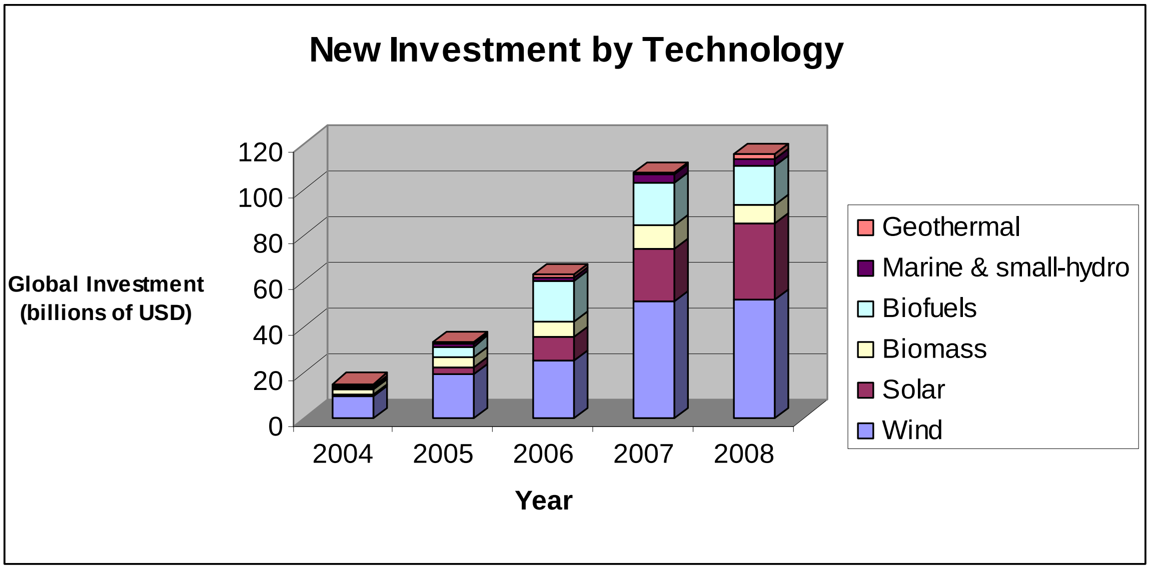

Figure 5: Global Investment in RE, 2004 – 2008, source: (United Nations Environment Programme (UNEP) and New Energy Finance Limited (NEF), 2009)

Financing has been increasing into the five areas of i) R&D (which is covered in the previous subsection); ii) technology development and commercialization; iii) equipment manufacturing and sales; iv) project construction; and v) the refinancing and sale of companies. The trends in financing going into these areas represent successive steps in the innovation process (see Figure 11.1 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 mid- to long-term expectations for the sector – investments are being made that will only begin to pay off several years down the road.
- 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, since increasing refinancing activity over time indicates that larger more conventional investors are entering the sector, buying up successful early investments from first movers.

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[2] 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.

Each of these trends is discussed in the following sub-sections. Table 3 provides information about the variety of financing types, arranged by phase of technology development.

11.2.3.1 Financing technology development and commercialization – Venture Capital Investment

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).

Table 3: Table of Financing Types Arranged by Phase of Technology Development

Table of Financing Types arranged by Phase of Technology Development	
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 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 (i.e. projects/corporate finance, bonds), 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 purchase agreements (PPA). 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, not the creditworthiness of the project sponsors. 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.
Refinancing and Sale of Companies	Mergers & Acquisitions involve the sale and refinancing of existing companies and projects by new corporate buyers.

Energies accounting for only 1-3 % 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 $204 million in 2002 to $3.456 billion in 2008[3][TSU: Needs to be presented in 2005 US$], representing a compound annual growth

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[3] 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.

rate of 60%. This capital has mostly been used to finance the commercialisation of new technologies that have been developed through R&D programmes in government, academia and industry. This growth trend in innovation investments now appears to be a leading indicator that the finance community expects continued 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 (United Nations Environment Programme (UNEP) and New Energy Finance Limited (NEF), 2009).

11.2.3.2 Financing equipment manufacturing facilities – Equity Investment

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. Private and public equity investment in RE has grown from $0.168 billion in 2002 to $18.07 billion in 2008 [TSU: Needs to be presented in 2005 US$], representing a compound annual growth rate of 118 percent (United Nations Environment Programme (UNEP) and New Energy Finance Limited (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 the first 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 (United Nations Environment Programme (UNEP) and New Energy Finance Limited (NEF), 2009).

11.2.3.3 Financing Project Construction – Asset Investment

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 to $97 billion in 2008[TSU: Needs to be presented in 2005 US$], representing a compound annual growth rate of 59% (United Nations Environment Programme (UNEP) and New Energy Finance Limited (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 (United Nations Environment Programme (UNEP) and New Energy Finance Limited (NEF), 2008). The financial markets have also started to value RE companies more highly than conventional energy companies, based on expectations of future market growth [Authors: Reference missing]. This is borne out by the trend started in 2007 for European utilities to spin out their RE divisions and finance them as free-standing corporate entities. The largest financial transaction globally in the RE sector in 2007 was the $7.2 billion[TSU: Needs to be presented in 2005 US$] initial public offering for Iberdrola Energias Renovables, a spin-out from the Spanish utility Iberdrola. If Iberdrola had chosen to raise capital through a share offering from the parent company, investors would have valued the business at about one-third of the value it was given as a separate listing. By listing separately three times as much money was raised, essentially based on the expectation that this business would be worth three times as much in future due to expected higher growth of the renewables sector as compared to the slower growth of conventional electricity companies.(United Nations Environment Programme (UNEP) and New Energy Finance Limited (NEF), 2008).

11.2.3.4 Refinancing and the Sale of Companies – Mergers and Acquisitions

In 2008, $64 billion[TSU: Needs to be presented in 2005 US$] worth of mergers and acquisitions (M&A) took place involving the refinancing and sale of RE companies and projects, up from $6 billion[TSU: Needs to be presented in 2005 US$] in 2002 or 48 percent compound annual growth (United Nations Environment Programme (UNEP) and New Energy Finance Limited (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

The above-mentioned financing trends are being 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. The glossary explains definitions (see Chapter 1 and Annex 1), but broadly this chapter is differentiating drivers—as factors that are pushing for the deployment of RE policy (for example climate change and the need to reduce fossil fuel emissions from the energy sector), from opportunities (which, for example, lead a country to invest in RE with the explicit goal of developing a new domestic or export industry, irrespective of the drivers), and from the benefits of promoting RE, which are generally the flip side of the drivers or opportunities (for example, reduced emissions, improved health, more jobs, better skills and so on). The distinctions among these factors are necessarily close and overlapping.

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, 2004).

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.

11.3.1 Climate change mitigation

RE is a major tool for climate change mitigation, its potential being the focus of this report. The degree to which RE mitigates climate change depends on many factors, addressed in the various sections of this chapter and report.

As a result, RE is an integral aspect of government strategies for reducing carbon dioxide (and other) emissions in many countries, including all member states of the European Union (e.g. (European Parliament and of the Council, 2009); BMU, 2006). Several U.S. states, including California (CEC and CPUC, 2008) and Washington (CTED, 2009), and numerous U.S. cities, from Chicago (Parzen, 2009) to Miami (Miami, 2008), have adopted RE targets and policies to advance their strategies for addressing climate change.

Developing countries are also enacting RE policies in order to address climate change, among other goals. In June 2008, in launching India’s National Action Plan on Climate Change, Prime Minister Dr. Manmohan Singh said that: “Our vision is to make India’s economic development energy-efficient. Over a period of time, we must pioneer a graduated shift from economic activity based on fossil fuels to one based on non-fossil fuels and from reliance on non-renewable and depleting sources of energy to renewable sources of energy (GOI, 2009).” 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 [Authors: Reference missing].

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 modern energy services, including lighting 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 also reduces 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 they can be constructed to any size 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. 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 [Authors: Reference missing].

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 China [Authors: Reference missing], Bolivia (REN21, 2009a), Tonga, Bangladesh (Urmee, Harries et al., 2009), India (Hiremath, Kumar et al., 2009), Nepal (MEST, 2006b), Pakistan (Government of Pakistan, 2006a) (Government of Pakistan, 2006), 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. 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 (Boardman, 2009). Examples of these programmes include the Weatherization Assistance Program in the United States [Authors: Reference missing] and the Carbon Emission Reduction Target in the UK (DECC, 2009).

11.3.3 Energy security

The definition of energy security, or energy insecurity, tends to alter from person to person, company to company, and country to country [Authors: Reference missing]. Energy security issues encompass

- the technical underpinnings of the energy infrastructure so that it seemlessly transports and delivers energy without failure or threat of failure;
- concerns that incentives within markets and economic regulation will not encourage sufficient investment in the energy system to ensure enough infrastructure (whether generation facilities, ports, storage and so on) to meet energy demand;
- concerns that a physical resource (i.e. oil or natural gas) will not be delivered as contracted, thereby limiting energy use and raising prices;
- concerns that the price of a physical resource, such as oil or gas, may rise to such an extent that it becomes unaffordable to increasing numbers of people, thus causing social unrest or difficulty;
- concerns that supply chains will not be able to deliver the technologies, parts and skills to enable deployment or operation of technologies, including RE;
- and concerns that the international relationships and foreign policies between countries may exacerbate concerns of resource access, including energy.

The addition of RE technologies to the broad energy mix alters these concerns 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 et al, 2006). Some U.S. states rely on solar power, wind and other distributed generators for public safety and emergency preparedness purposes (Sawin et al, 2006).

RE can diversify energy supply portfolios. 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 (Lee, Mogi *et al.*, 2009); (Katinas, Markevicius *et al.*, 2008); (Chien and Hu, 2008); (Lipp, 2007). 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). For small non-oil producing economies, RE combined with reductions in total energy demand and/or improvements in the efficiency of its use, offers the best opportunity for reducing dependence on imported fuels [Authors: Reference missing].

Even countries that are rich in fossil fuel reserves are recognizing that their fuel production could peak and begin to decline in coming years [Authors: Reference missing]. 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; Department of Trade and Industry (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 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. 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 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 current 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). The Obama Administration in the United States is promoting RE to create jobs [Authors: Reference missing].

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 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).

It is clear that 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 so on (e.g. (Sastresa, Usón *et al.*, 2009).

Rural development is often tied with the deployment of RE in developing countries. The SNV/Biogas program and AEPC in Nepal links the deployment of RE with its socio-economic development program. Slurry, 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 rope-ways (?). In much of the world, the development and availability of ICT devices and equipment have prompted companies and communities to develop electricity supply, and the easiest way is often through RE (REF). Biogas systems in Shaanxi 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[TSU: Needs to be presented in 2005 US$] (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). Rizhao in China saw the number of tourists increase by 48 and 30 percent in 2004 and 2005, respectively, after enacting policies to increase use of RE and improve the local environment (Bai, 2007).

11.3.5 Non-Climate Change Environmental Benefits

The benefits of sustainable RE 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 [Authors: Reference missing]; 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); and South Africa (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 a harmful impacts on biodiversity of plant and animal species (Intergovernmental Panel on Climate Change (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).

11.4 Barriers to RE Implementation

IPCC-WGIII (2007; AR4 Glossary) defines an RE barrier as “any obstacle to developing and deploying a RE potential that can be overcome or attenuated by a policy, programme or measure” (Intergovernmental Panel on Climate Change (IPCC), 2007b). Barriers to RE deployment range from intrinsically natural properties of particular RE sources (for example intermittency and diffuse incidence of solar radiation) to artificial, unintentional or intentionally constructed, impediments (for example badly oriented, shadowed roof surfaces; a tilted (ie not having an equal playing field) power grid access conditions against independent generators). RETD (2006: 32) adopts the IPCC approach (Renewable Energy Technology Development (RETD), 2006): “only barriers that may be overcome by human actions are examined” with omission of “intrinsically non-competitive attributes and lack of natural resources in some regions of the world .” IPCC-WGIII (2007: 810) completes its barrier definition with: “Barrier removal includes correcting market failures directly or reducing the transactions costs in the public and private sectors by, for example, improving institutional capacity, reducing risk and uncertainty, facilitating market transactions, and enforcing regulatory policies.”

Barriers to RE deployment were introduced in Chapter 1, and Section 11.6 sets out what we have called an ‘enabling environment’ which is conducive to RE deployment through the removal of hurdles or barriers to development. This section focuses on the specific literature on barriers to RE supplies[4] that is developing (Moskovitz, 1992; Nogee, Clemmer *et al.*, 1999; Jacobsson and

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[4] RE supplies are resulting from combining RE resources that are tremendously large (Moomaw, 2008) with operational energy technologies for harvesting the available resources (Twidell and Weir, 2006). “Supplies” as flows of energy (power; light) or accumulation of stocks (biofuels; reservoirs) emphasizes actual effectiveness in delivering energy or energy services.

Johnson, 2000; Painuly, 2001; Beck and Martinot, 2004; Margolis and Zuboy, 2006; Renewable Energy Technology Development (RETD), 2006; Stern, 2006; Willis, Wilder *et al.*, 2009). It broadly corresponds to the nine areas below:

- There is no ‘level playing field’ for RE technologies, meaning that RE has to compete against other sources which have preferential treatment, whether in markets or network rules,
- RE have to exist in regulations which maintain status, including avoiding stranded assets in existing infrastructure
- The incentives for Governments and private companies to support RE development are insufficient
- Financing is either scarce or unreasonably costly for RE technologies
- Technology standards are lacking for (some) RE technologies and fuels
- Import tariffs and technical barriers impede trade in renewables
- Permits for new RE plants are difficult to obtain
- Energy markets are not prepared for RE
- RE skills and awareness is insufficient

This short section does not discuss these barriers one by one; this is left to Section 11.6. Rather this section places market and policy barriers and failures in context (Section 11.4.1); then it touches on policy barriers and failures (Section 11.4.2). Finally, in section 11.4.3, it discusses financing barriers.

11.4.1 Market and Policy Barriers[5] and Failures in context

The goal is to maximise deployment of the RE supplies (Verbruggen, Fischedick *et al.*, 2009), and this means maximising the potential of renewable energy supply. Barriers and failures are factors, or attributes of factors, that operate in between the actual development and deployment of RE and the, often much higher, potential of RE supply. Policies address the failures and barriers which cause this gap between actual deployment and potential, while being subjected to their own failures.

A diagram helps to clarify the links among various components in the RE potentials-barriers-policy chain. Figure 6 highlights the main components and relations in the policy cycle for deploying RE supplies. In reality governments, markets, innovations, energy systems are many times more complex and intertwined than a diagram can show (Grubler, 1998; Foxon, Gross *et al.*, 2005a; Foxon and Pearson, 2008; Mitchell, 2008).

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[5] Depending on the goals pursued, the term “barriers” may refer to facts and conditions that should be maintained or strengthened to avoid the realization of perverse goals: for example, public opposition against nuclear power risks and weapons proliferation is a barrier for the nuclear renaissance (IEA, 2006: 134; GIGATON Throwdown, 2009: 97).

The rest of this section explains Figure 6 in more detail. However, this figure does not explicitly mention the barriers concerned with the means of accessing finance. This is discussed in greater detail in Section 11.4.4, which examines three areas: the availability of capital; financing for large scale projects; and financing for small-scale projects.

Figure 11.4: Barriers and Failures in Realizing Renewable Energy Supplies

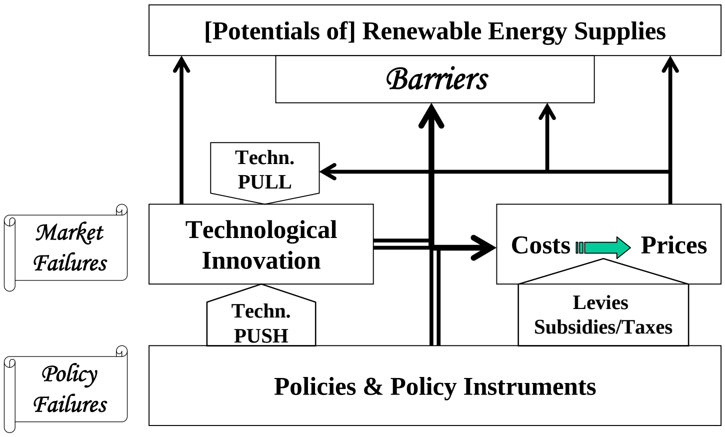


Figure 6: Barriers and Failures in Realizing RE Supplies

11.4.1.1 Market Failures

The economic literature discusses a number of important market failures (Bator, 1958; Arrow, 1974; Williamson, 1985). The bliss equilibrium of Arrow-Debreu competitive markets (Debreu, 1959; Becker, 1971) remains an ideal for some or a “gigantic once-for-all-higgle-haggle” for others (Meade, 1971).

- In practice it is not workable to organize complete “futures” and “contingent” markets to extend static market equilibriums for appropriately covering time and uncertainty (Arrow, 1974).
- Williamson (1985) criticizes that the role of institutions is suppressed in favour of the view that firms are production functions, consumers are utility functions, the allocation of activity between alternative modes of organization is taken as given, and optimizing is ubiquitous.
- The existence (predominance) of monopoly or monopsony powers in actual markets, limiting competition among suppliers or demanders, free entry and exit. Natural monopolies occur when in relation to the size of the market costs are sub-additive (Baumol, Panzar *et al.*, 1982), as in interconnected network industries (in particular electric grids). Monopoly and oligopoly power is also factual by deliberate concentration, control and collusion

- The existence of public goods and/or the absence of strictly defined and enforced property rights (Bromley, 1986). Two major cases are widely discussed and accepted as being market failures:
  - Underinvestment in invention and innovation because initiators cannot benefit from exclusive property rights on their efforts (Margolis and Kammen, 1999; Foxon and Pearson, 2008)
  - Un-priced environmental impacts and risks because economic agents are freed from internalizing in an exclusive way the full costs of their actions (Coase, 1960; Baumol and Oates, 1988; Beck, 1995).

Apart from the economics doctrine that delivers Pareto optima for whatever distribution of wealth and income, other social sciences point to the disturbing impacts of skewed distributions (Pen, 1971; Rawls, 1971; Thurow, 1971; World Commission on Environment and Development (WCED), 1987; United Nations Development Programme (UNDP), 2007). For example, poor regions of the world with abundant RE sources lack financing capacity for rolling out the apt technologies, in particular Africa (Painuly and Fenhann, 2002).

All the above standard market failures are present in actual energy markets where RE supplies compete against incumbent fossil fuels and nuclear power (International Energy Agency (IEA), 2009b). Energy markets are dominated by incumbent monopolies or oligopolies (Glachant and Finon, 2003; Thomas, 2003). Innovation of the energy systems is disrupted and retarded (Jacobsson and Johnson, 2000; Unruh, 2000; Mitchell, 2008). Major externalities and risks from fossil fuels and nuclear power are only partly priced, while non-sustainable energy supply and use often get significant subsidies (International Energy Agency (IEA), 2008b). Unequal distribution of governance, wealth and technology across and within countries blocks global progress in climate change mitigation (United Nations Development Programme (UNDP), 2007).

Failures endanger the performance of markets as efficient allocation institutions, for example monopolies exclude or limit market entry and competition, and externalities misplace incentives. Failures require repairs by market supervising authorities as governments or their appointed regulators (Kahn, 1970).

11.4.1.2 Market Barriers

Market barriers cause shortfalls to the competitive ideal. Generic market barriers stated in economics are agents pursuing satisfaction rather than optimization in production and consumption behaviour (Leibenstein, 1966), bounded rationality, principal-agent conflicts, moral hazard, and free-riding (Laffont and Martimort, 2002). Most market barriers are interwoven with institutional, social and cultural barriers. Frequently observed barriers in energy supply and use are the following (Nogee, Clemmer *et al.*, 1999; Jacobsson and Johnson, 2000; Unruh, 2000; Painuly, 2001; Fuchs and Arentsen, 2002; Global Network on Energy for Sustainable Development (GNESD), 2002; Neuhoff, 2005; International Energy Agency (IEA), 2006a; Margolis and Zuboy, 2006; Global Network on Energy for Sustainable Development (GNESD), 2007):

- **Factors favoring incumbents**: Educational assets, R&D spending, information processing and dissemination unduly support incumbent technologies and firms as distinct from potential ones failing to react quickly enough to the emergence of new generic technologies. Sequentially causing: inadequate workforce skills and training to develop, construct, repair and maintain RE installations; lacking testing and certification standards, equipment and centres; technological inertia and lockout; insufficient data and knowledge on emerging options; low awareness and slow acceptance by authorities, companies and the public.

- **Asymmetry in information and political influence**: Information asymmetry in access to data and knowledge, available staff, linked in networks, lobbying power, organizational strength, etc., across market parties, for example: incumbent centralized energy suppliers versus independent decentralized suppliers; energy suppliers versus end-users; industrialized versus developing countries; donors versus beneficiaries.
- **Split incentives and failure to internalize costs**: Cost accounting practices, tariffs for energy use with fixed and variable terms not reflecting real costs and often stimulating higher energy intensity, split incentives across market parties (building owners and tenants; owners of water rights and riverside villages; officials living in the capital and rural populations), practices of rewarding consultancy services, risk premiums imposed on new options.
- **Incumbents and sunk costs**: Incumbent interests with monopoly power stick to established technologies and practices. Their efforts to hinder new options depends on the extent of sunk investments that may strand, on disparity between existing and challenger solutions (carbon capture and storage is preferred above RE; within RE biomass is often preferred above wind and solar), on controllability of new developments via centralized capital markets. Their success rate is dependent on the strength and independency of public authorities.

11.4.2 Policies to address market failures and barriers

Section 11.5 addresses policies for RE development. This section endeavours to explain the role of different policies in relation to market failures and barriers. Governments set up institutions, policies and instruments to care for the public good. Among others this requires good designs of markets with levelled playing fields within social and environmental boundaries, ordered by transparent and enforced rules (Kahn, 1970). Stern (2006) labels climate change “the greatest and widest-ranging market failure ever seen” and recommends policies composed of “three essential elements: carbon pricing, technology policy, and removal of barriers to behavioural change”.

Public authorities must price externalities by levies (Baumol and Oates, 1988). In practice, the transformation of private and social costs in prices to be paid by end-users is mingled with subsidies, taxes and monopoly rents (Verbruggen et al., 2009). A non-sustainable energy (NSE) policy is placing significant externalities and risks on the environment and on future generations (IPCC, 2007), while RE deployment itself has relatively few externalities and risks.

Resetting the balance of the end-use energy prices between NSE and RE is a key route for developing RE market and economic potentials, directly and indirectly. Market failures and barriers will be redressed or reduced. In particular a more attractive pricing balance of RE in energy markets will pull technological innovation towards RE options (Fri, 2003; Reichman, Rai *et al.*, 2008).

‘Pulling’ RE innovations via various policies, such as a FIT or quota, is complemented by ‘pushing’ such innovations through deliberate public R&D policies (ref.), in helping to overcome underinvestment in public knowledge on social goods like RE. Technological innovation has direct impact on achieving the RE potentials (for example improved technology allows the concentration of diffuse energy flows or the better management of power grids). Indirectly, the impact of lower costs of RE technologies will contribute to re-establishing the price balance between NSE and RE, further boosting the deployment of RE and strengthening technological pull forces. “Although continued research is needed to pin down the precise magnitudes, it seems clear that economic motivations—operating directly through higher energy prices and indirectly through falling costs of technological alternatives due to innovation—are effective in promoting the expanded market penetration and use of more energy-efficient, GHG-reducing technologies” (Jaffe, Newell *et al.*, 1999). In combination with targeted policy initiatives, innovation directly reduces or removes barriers to RE deployment, for example: enhanced awareness of the values of RE, attracting researchers, improving skills and capacities; attracting venture capital, raising understanding; establishing new entrants, prime movers and organisational power which counter incumbent interests.

11.4.3 Policy barriers and failures

Governments and policies maintain a crucial position in addressing market failures and barriers that impede RE deployment. However, deployment of RE may be obstructed by policy failures as well as the aforementioned market failures. For example, governments may pick and adhere to technological options conflicting with a sustainable development of society [Authors: Reference missing], subsidize NSE (International Energy Agency (IEA), 2008a), be slow and reluctant in levying externalities and risks of NSE [Authors: Reference missing], be weak in addressing monopoly power and enforcing transparent equitable market conditions, fall short in redistributing opportunities and wealth over constituencies. Resistance to governments’ role can be due to ideology; different interests; but also to observed wide-spread policy and political shortcomings and failures.

The last decade has shown the importance of the role of institutions and regulations in transforming pervasive societal activities like energy supply and use [Authors: Reference missing]. “This new focus on regimes recognizes that firms and technologies are embedded within wider social and economic systems (Rip and Kemp, 1998). Some of the reasons cleaner technology is not diffusing rapidly through firms relate to overarching structures of markets, patterns of final consumer demand, institutional and regulatory systems and inadequate infrastructures for change” (Smith et al., 2005: 1491).

We look at policy barriers in terms of design, creation and execution. Policy design starts at the identification, recognition, and formulation of the core problems. Standard policy thinking still accepts a narrow correlation between economic growth and commercialized energy consumption (fossil fuels, grid electricity), with little attention for ambient energy supplies and for small-scale on-site extraction (Twiddell and Weir, 2006) (Global Network on Energy for Sustainable Development (GNESD), 2002). Neoclassical growth mantras are not yet balanced by institutional, evolutionary, and ecological thinking (Williamson, 1985; Gowdy and Erickson, 2005; van den Bergh and Kallis, 2009). Renewable energy is gaining acceptance as an important part of future energy supplies, but its positioning needs further clarification regarding complementary energy efficiency pathways, regarding other low-carbon energy supply options (fossil fuels with CCS, nuclear power), and regarding infrastructures in secondary energy converters (electricity, hydrogen) (International Energy Agency (IEA), 2006b; Gigaton Throwdown, 2009).

Despite many authoritative authors arguing for the necessity of “urgent and drastic” change in energy systems (Hennicke, 2004; Stern, 2006; Intergovernmental Panel on Climate Change (IPCC), 2007a), policy makers may continue follow advice by architects and beneficiaries of the foregoing energy paradigm (Mitchell, 2008). Cost-benefit analyses remain bounded by temporal, spatial and value myopia (Sawin and Moomaw, 2009). This practice delays the transition to renewable energy and may make it many times more costly than necessary (Stern, 2006; Stern, 2009). As a corollary, government choices and plans for urgent and drastic turnover to an increasingly efficient and predominantly based RE system are vacillating. Clear goal setting also implies boosting sustainable innovation regimes and operational dialoguing with stakeholders and global constituencies.

Policies and policy instruments can be ex-ante and ex-post evaluated on criteria, generally assembled under the headings of effectiveness, efficiency and equity (Verbruggen and Lauber, 2009). Performance is contingent on the goals (objectives, targets) adopted. A first and major policy failure may be setting the wrong or too weak goals. The latter case may be particularly valid in climate change mitigation policies, where understanding is developing and spreading that only the full transition from NSE to RE systems will suffice if realized swiftly (ref.). Temporally and spatially short-sighted policies do not advance such transitions, but may become a barrier in itself. 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.

Policy execution requires solid administrative capacity. It is observed for RE deployment that public administrations are inadequately capacitated, and that coordination in countries and between international and national financial institutions is ineffective [Authors: Reference missing].

The transition in knowledge basis from NSE to RE options follows natural decay patterns of NSE expertise, moreover resisted by incumbent influence in assigning R&D money to second-best low-carbon options (International Energy Agency (IEA), 2008a). In educational curricula, energy is often taught as purely technical. RE deployment needs more disciplines than mechanical engineering (Twiddell and Weir, 2006), but today’s academic metrics do not necessarily promote multi- and interdisciplinary research and teaching. RE specialized research centres are few, as are diffusion and training centres and networks. Collection and verification of site-specific data on natural resources availability (micro climate, land use, topography, water flows, etc.) is available in state-of-the-art countries moving clearly to the RE transition. There, analysis and modelling, standards and certification, monitoring and control services, access to reliable data, and replication of best practices are supporting RE deployment. CDM RE projects can take off when host countries have implemented long term regulations to encourage RE projects, as did China and India but not the most deprived countries (Willis, Wilder *et al.*, 2009).

Energy sector regulatory institutions play a decisive role in designing and imposing on incumbents, transparent and RE transition oriented rules and terms of grid access and of integrating distributed electric power. Regulation can enforce fair tariffs for delivering surplus power and for acquiring back-up and complementary power (also named balancing power) by independent RE generators (chapter 8), or can be responsible for allowing barriers (SDC, 2007). Regulators often are responsible for RE support systems (section 11.5). Many countries have no, or under-staffed , regulatory offices. In other countries, governance relations between political authorities and regulators are blurred or problematic. Also capture of regulators by incumbent energy corporations is a documented phenomenon [Authors: Reference missing].

11.4.4 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. It looks first at the availability of capital; then moves on to financing for large scale projects; and lastly examines financing of small scale projects.

Private and public sources contribute to RE financing. When risks to investors are significant, public investment, or significant subsidies, or public-private partnerships (or other types of mixed financing / ownership) may be needed. This is discussed in the next section.

Most RE projects have, what is known as ‘upfront’ requirements (with an exception for biomass). This means that financing is relatively more important than for competing NSE projects. The availability of finance depends on general economic conditions, on the state of development of the capital markets in various countries, on the rating of the investor, on the type and characteristics of the RE project, etc. Even CDM envisioned for technology transfer does not address the point “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 participant in the project” (Willis, Wilder *et al.*, 2009).

Developing nations with the largest potential for distributed, small-scale RE projects face the most and the highest financing hurdles due to “affordability for users and entrenched attitudes in some financial institutions. Affordability is a compound problem of low income, high upfront investment cost to obtain RE technologies, and no adequate financing mechanisms” (Global Network on Energy for Sustainable Development (GNESD), 2002). In developing and undeveloped economies, RE deployment will grow if users are able to pay for their energy services. But there are not that many financial schemes and income generating activities that allow people to pay for investment and maintenance of RE options.

The “chequered history” of donor sponsored failing RE projects causes financial institutions to perceive a lack of reliability and long-term viability of RE technologies (GNESD, 2002). This implies a strong call for robust quality control on all future RE investments especially in developing countries. However, donors providing capital continue to add strict preconceived conditions on the technology to be applied and how projects are to be managed, usually not matching the needs and priorities of recipient communities. The latter often prefer local mechanical and thermal power supplies above expensive grid power (Painuly and Fenhann, 2002). Access to funding by international institutions is difficult, even to GEF funds earmarked for RE. It continues that significant shares of the funds are spent on studies and reports, leaving too little money for actual equipment and installations on the ground and strengthening local capacity. “The transaction costs of developing smaller scale RE projects such as CDM projects (including the costs of external auditors, registration fees, consultants’ fees and legal fees for the negotiation of CER purchase agreements and power purchase agreements) may be prohibitively high compared to the volume of CERs expected to be generated” (Willis, Wilder *et al.*, 2009). Project appraisal studies often fail to incorporate important local aspects and values, also due to limited local stakeholder involvement (Jacobs, 1997; Lovins, Datta *et al.*, 2002; van de Kerkhof, Cuppen *et al.*, 2009).

In various countries, a stimulating RE policy contributed to easing of financing bottlenecks for large-scale RE projects (for example wind parks onshore and off-shore). During the 2008 financial crisis maverick developers were threatened by bankruptcy (for example Econcern, NL,…). Banks are said to lack the technical analysis capacity needed for assessing expected performance and risk of innovative RE projects (Lisbon Council, October 22, 2009).

Smaller-scale and independently owned distributed installations face more restrictive financing offers. Institutional creativity by co-operative ownership, micro-financing, energy service suppliers, and the like is still limited to niche experiments, and community-owned projects face several barriers (Walker, 2008a).

As observed for energy efficiency and other distributed small-scale mitigation options, RE investments are also facing the “pay-back gap”: private investors and micro-financing schemes require higher profitability rates from innovative distributed projects than from established ones. Imposing a x-times higher financial return on RE investments is equivalent to imposing a x-times higher technical performance hurdle on delivery by novel RE solutions compared to incumbent NSE expansion (Verbruggen, 2003). The pay-back gap is often hidden in the addition of high risk premiums to the time discount rates applied in project appraisal and cost-benefit studies.

11.5 Experience with and Assessment of Policy Options

Policies are necessary to overcome the large number and variety of economic, technical, institutional, social and other barriers outlined in Section 11.4. This section focuses on the range of policy options available for developing and promoting RE, including government RD&D, and regulatory, fiscal and financial instruments summarized in Tables 11.1 and 11.2. The innovation required to stimulate the take-up of new technologies encompasses government policies from basic RD&D through to those that move niche technologies to being fully commercial. This is inter-linked with various policies and investments within the private finance community which match these government policies. In addition, technologies are ‘pulled’ by social innovations and market co-ordination. And all of this occurs within the enabling environment, discussed in Section 11.6.

To the extent that literature is available, the section provides analysis of policy design and what makes various policies most effective. It covers only those specifically targeting RE advancement; a full discussion of other policies required to create an enabling environment and to drive innovation for RE is provided in the next section.

This section begins with an overview of RD&D policies and their significance for RE technology development in 11.5.1. The next three subsections examine policies to promote deployment of RE electricity (11.5.2), heating and cooling (11.5.3), and transportation (11.5.4), respectively.

Subsection 11.5.5 then looks at cross-cutting issues including government procurement and financing. The section concludes with 11.5.6 and a brief overview of lessons learned to date.

11.5.1 Policies for Technology Development

This section explores the importance of different polices for RE development that broadly fit within the overall classification of RD&D. Besides the creation of markets that stimulate private sector investment, and support for R&D, direct government intervention is needed in several areas to help technologies move through several hurdles from the innovation phase to commercial development. This section covers expenditure in Basic R&D, Applied R&D, Demonstration and Pre-Commercial as shown in Figure 1.

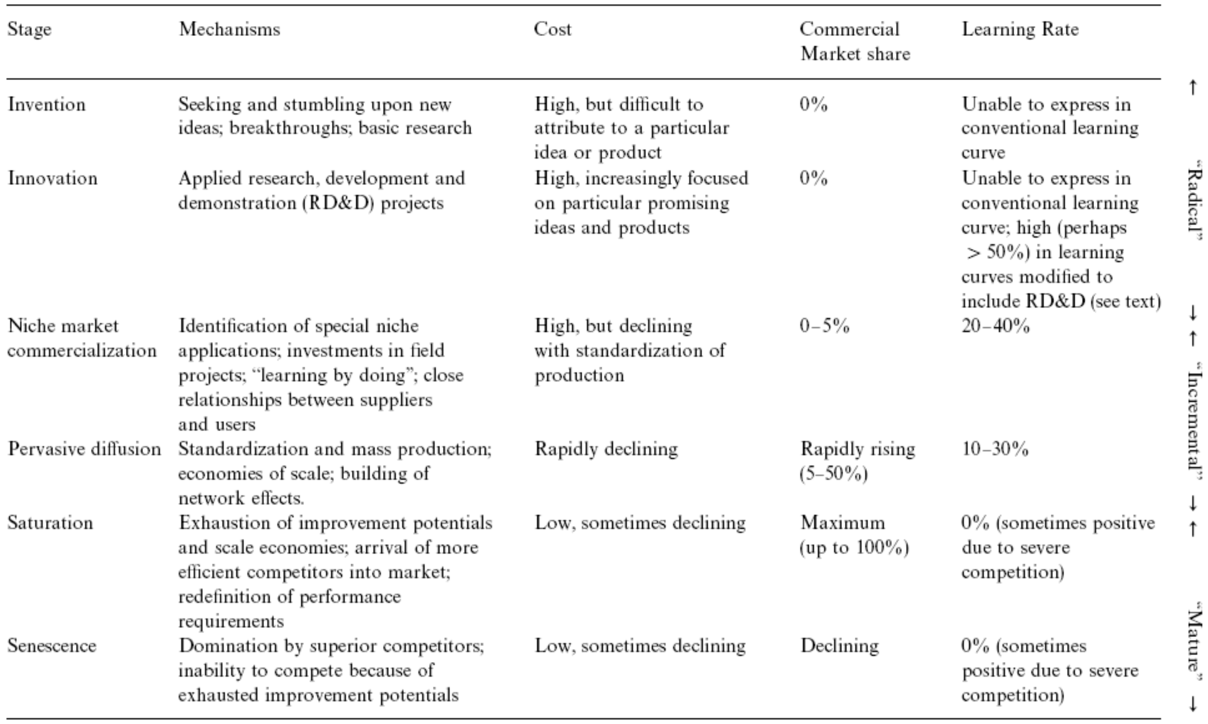
Table 4 below explains the stages of technological development; the type of RD&D policies or mechanisms that suit them. Gone are the days when R&D was seen as a primarily linear task which was the responsibility of governments alone. Now it is recognized that all sections of society, whether governments, private companies or individuals, play an important role in technology development. Government’s primary role is to create an environment conducive to innovation and to fill gaps in a technology’s development while stimulating input from other sectors where possible, as shown in Figure 7 (Smith, 2005) [TSU: Reference missing from reference list](International Energy Agency (IEA), 2008a).

11.5.1.1 Technology Development’ – an integrated for the society, public and private sectors

‘Technology Development’ is carried out to improve an attribute of a technology. The attributes most often targeted in RE technologies are the performance as well as the cost of the delivered kWh or Btu of energy. Governments that choose to embark on a program to cut the cost of RE technology will aim to do so in a way that balances the benefits they can gain against the short-term financial burden they must put on their citizens. Among the more concrete benefits associated with technology development is the acquisition of know-how in the design and manufacture of technologies that will become increasingly important in the energy supply mix. Among the costs will be the economic costs of public support for research, development and demonstration—‘technology push’—and incentives employed for achieving economies of scale in manufacturing, such as Renewable Portfolio Standards (RPS) or FITs—known as ‘market pull’ (discussed later in Section 11.5).

Both the process of RD&D and the enabling of economies of scale through increasing volumes of manufacture are needed for cost reduction. Table 4 outlines the technology diffusion process and shows how different mechanisms support the roll-out of a technology at different stages. Here “invention” and “innovation” phases are characterized by basic and applied research, sometimes building on a serendipitous discovery.

Table 4: Generalized illustration of the technology diffusion process (Grubler, Nakicenovic *et al.*, 1999)



Stage	Mechanisms	Cost	Commercial Market share	Learning Rate	
Invention	Seeking and stumbling upon new ideas; breakthroughs; basic research	High, but difficult to attribute to a particular idea or product	0%	Unable to express in conventional learning curve	↑ "Radical" ↓
Innovation	Applied research, development and demonstration (RD&D) projects	High, increasingly focused on particular promising ideas and products	0%	Unable to express in conventional learning curve; high (perhaps > 50%) in learning curves modified to include RD&D (see text)	
Niche market commercialization	Identification of special niche applications; investments in field projects; "learning by doing"; close relationships between suppliers and users	High, but declining with standardization of production	0–5%	20–40%	↑ "Incremental" ↓
Pervasive diffusion	Standardization and mass production; economies of scale; building of network effects.	Rapidly declining	Rapidly rising (5–50%)	10–30%	
Saturation	Exhaustion of improvement potentials and scale economies; arrival of more efficient competitors into market; redefinition of performance requirements	Low, sometimes declining	Maximum (up to 100%)	0% (sometimes positive due to severe competition)	↑ "Mature" ↓
Senescence	Domination by superior competitors; inability to compete because of exhausted improvement potentials	Low, sometimes declining	Declining	0% (sometimes positive due to severe competition)	

At a later stage, when a technology is in the early and mid-stages of commercialization, both R&D and economies of scale through market deployment result in cost reductions, each driving the other in a "virtuous cycle" (International Energy Agency (IEA), 2003) (See Figure 7) In this virtuous cycle, investors have confidence in the technology and capital becomes easy to access, leading new companies to enter the market and to increased competition for market shares through additional R&D investment for technological improvement. It becomes possible to draw learning curves for energy technologies in this stage, which show the correlation between declining technology costs and the capacity installed (Busquin, 2003). 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).

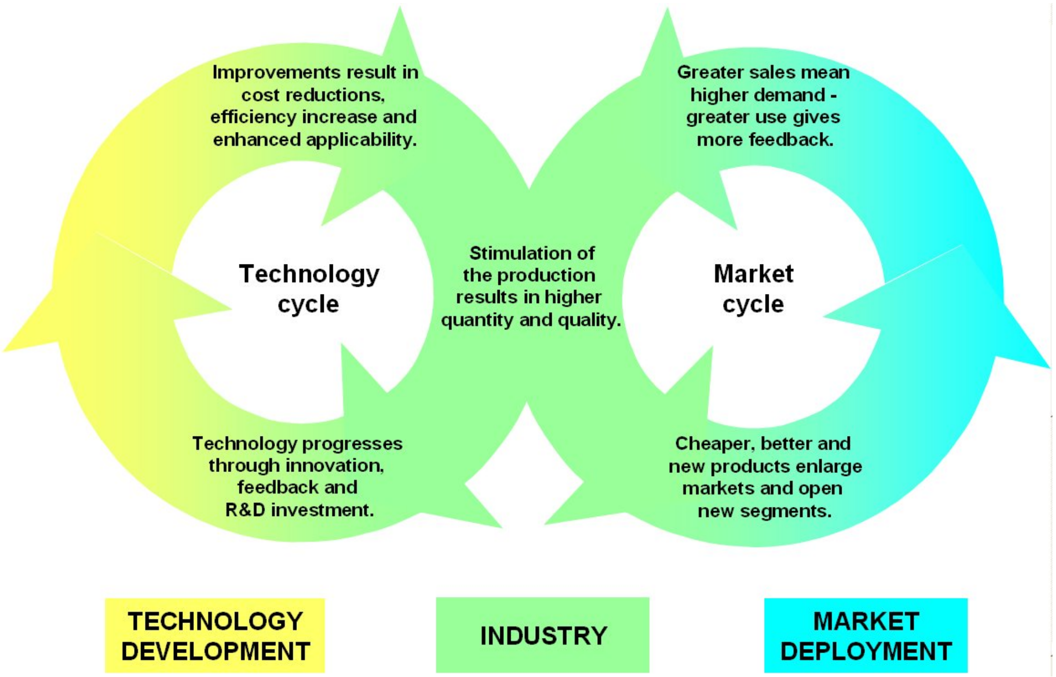


Figure 7: The mutually-reinforcing “virtuous cycle” of technology development and market deployment drives technology costs down (IEA, 2003)

To retain or increase market share, a company in the sector might choose to work on its technology to refine it, and launch an improved version. A technology sector that is in this phase can therefore take on responsibility for funding a share of its own R&D, A company is typically prepared to do this if it considers that the improved version can be launched within five years. Direct public support will still be needed for research with less certain prospects for commercialization (European Photovoltaic Technology Platform, 2009).

11.5.1.2 Policy Measures Specifically Targeting Technology Development

This section explores collaborative R, D&D, which may be all public (i.e. international centres of excellence); or may involve public private research (i.e. co-funded research; road mapping, open innovation) or stimulation (i.e. prizes). It shows that RD&D is becoming more innovative itself, as it seeks new means of tapping into potential innovators.

11.5.1.2.1 Crossing “Valleys of Death” with Public-Private Partnerships in Demonstration

As with any new technology, RE technologies are likely to traverse a period 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). This is the phase in which a technology is generating a large and negative cash-flow. In Figure 8, the maturity of the technology is on the horizontal axis, and the blocks represent measures that can help technologies to cross the valley (UNDP). The definitions of these terms are found in Table 4.

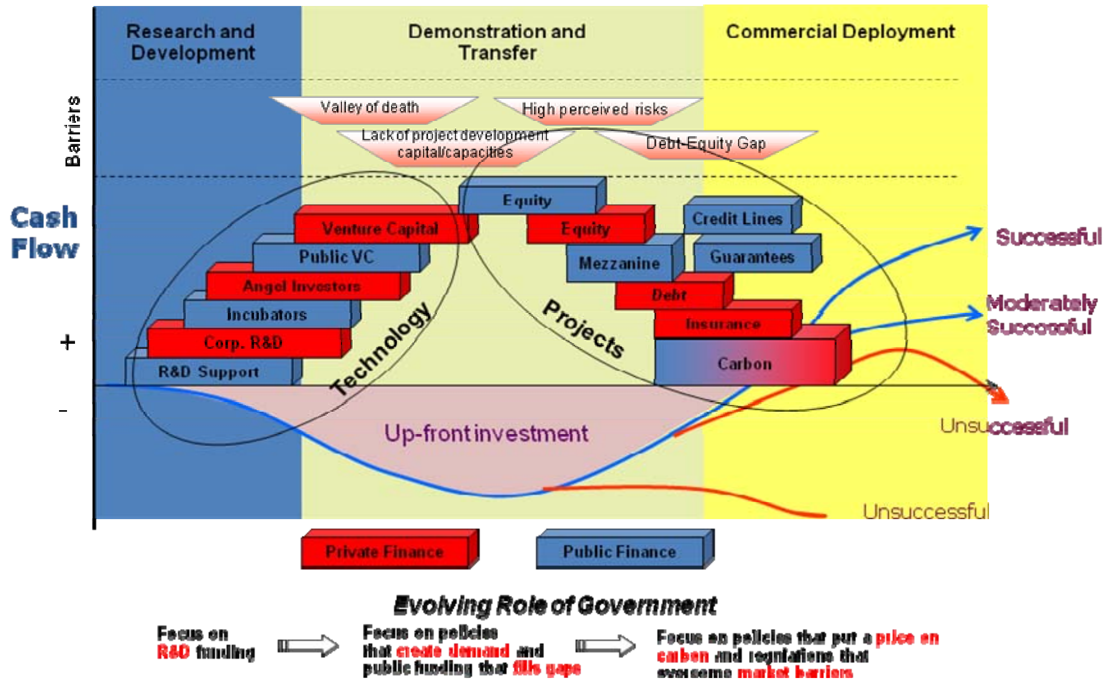


Figure 8: The Valley of Death (Kammen/UNEP/Carbon Trust)

Continued support from governments is necessary in this phase (House of Commons - Innovation, 2008). In the United States and Europe, public-private partnerships in demonstration, meaning industry-led projects to 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).

11.5.1.2.2 Government Co-funded Research

Public-private partnerships have also been developed beyond demonstration projects in order to bring incremental improvement to existing new RE technologies, such as the introduction of new material in design or changes in manufacturing processes (International Energy Agency (IEA), 2008a). In such cases, public support (e.g. grants to research or industrial consortia) is often conditional upon the research being conducted collaboratively, i.e. by a partnership of companies and not-for-profit research centres. For instance, in the EU, support to collaborative research is a policy strategy aimed at (FP7, 2006) building excellence and attractiveness, and strengthening the European industrial and technological base.

A variety of rules can govern how intellectual property is managed in these projects, with each set of rules being specific to each funding instrument. As research centres tend to be reluctant to cede the intellectual property of their discoveries, specific property right regimes, such as an exclusive licence for a fixed period, can be associated with co-funding (http://cordis.europa.eu/fp7/dc/index.cfm?fuseaction=UserSite.CapacitiesDetailsCallPage&call_id=138#infopack [Authors: need another reference]).

11.5.1.2.3 Road Mapping

Collaborative R&D 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 (International Energy Agency (IEA), 2008a). Governments can then scrutinize and adopt these plans. Road mapping has been outlined in Japan for photovoltaic technology, and in the European region (Strategic Energy Technology Plan, 2007; NEDO, 2009).

11.5.1.2.4 Internationally-Spread Publicly-Funded Research Centres

The publicly funded Fraunhofer Institute for Solar Energy Systems has long been a force in solar energy research and in technologies for efficiently using and converting energy. In 2008 it formed a partnership with the Massachusetts Institute of Technology and with the Solar Energy Research Institute of Singapore. This was followed in late 2009 with a Memorandum of Understanding creating a partnership with a science park belonging to the University of Hyderabad (Fraunhofer ISE, 2008; Solar Energy Research Institute of Singapore (SERIS), 2009; SolarIndiaOnline.com, 2009).

11.5.1.2.5 Open Innovation

'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; Jawaharlal Nehru National Solar Mission (JNNSM), 2009). Analysts have pointed to the need for financial support from governments in order to sustain the emergence of 'Open innovation' (CORNET, 2007). SMEs tend to have a short-term focus that neglects the importance of R&D, a tendency that persists in associations of SMEs which would potentially be able to contract R&D on their behalf. The offer of government money enables them to look beyond their short-term concerns and gives governments leverage in controlling the innovation strategy of a sector. (CORNET, 2007)

11.5.1.2.6 Prizes

Prizes are sometimes used to foster technology development. For example, by late 2009, ten prizes of more than $1m [TSU: Needs to be presented in 2005 US$] existed in the United States (Next Prize, 2009); a one million USD [TSU: Needs to be presented in 2005 US$] prize was on offer from the U.S. Department of Energy for storage materials for hydrogen ; and Virgin had offered $25 million[TSU: Needs to be presented in 2005 US$] for material advancement to the reduction in anthropogenic emissions (Virgin, 2009) In December 2008, the Scottish Government launched the 10 million Pound[TSU: Needs to be presented in 2005 US$] '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 Atc, 2010)

11.5.1.3 Lessons Learned from R&D

As with policies and the enabling environment, successful outcomes from R&D programmes relate not only to the total amount of funding. Carnoe 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; moreover, the Danish Government required that all those who had benefited from public money were required to provide data about reliability and output which was then published, further supporting the reliable turbines Carnoe (Carnoe REF; Sawin, 2001) –In a funding scheme for installations of innovative renewable energy technology and CCS soon to be launched as part of the European Union's revision of its Emissions Trading Scheme, proposers will be obliged to share knowledge (Directive 2009/29/EC new Article 10a(8) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0063:0087:en:PDF), specifically on reliability and performance[TSU: URLs are to be cited only in footnotes or reference list.] [Authors: Reference NEED TO WAIT FOR OFFICIAL VERSION OF CALL TEXT FOR QUOTABLE REFERENCE. CALL EXPECTED Q1 2009]

11.5.2 Policies for Deployment - Electricity

To date, far more policies have been enacted to promote RE for electricity generation of electricity 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, 2009a). A variety of support mechanisms exist for promoting renewable electricity. In developing countries, rural and off grid projects with renewables are considered in national poverty reduction strategies, energy strategies and developing plans as an adjunct to access to energy needs, a standard option of electrification (REN21, 2007).

Financial instruments compensate for the various market failures (see Section 11.4) that leave RE at a competitive disadvantage compared to conventional energy, in particular the negative externalities of fossil fuels and insecurity of energy supply. Financial instruments include investment support (capital grants, tax exemptions or reductions on the purchase of goods) and operating support (price subsidies, green certificates, tender schemes and tax exemptions or reductions on the production of electricity). Market-based instruments that provide operating support can be divided into instruments that fix a quantity of renewable electricity to be produced and those that fix a price to be paid for renewable electricity (Commission of the European Communities, 2008).

This section begins by discussing the two main types of regulatory policies that have emerged for promoting renewable electricity in developed countries and that are increasingly being adopted in developing countries. Feed-in tariffs guarantee price, while quotas or RPS (Renewable Portfolio Standards) ensure market share through government-mandated targets or quotas. It then discusses net metering and fiscal incentives for promoting renewable electricity both on- and off-grid.

11.5.2.1 Regulatory Policies

11.5.2.1.1 Feed-in Tariffs

The most prevalent national policy for promoting renewable electricity is the feed-in tariff (FIT) (REN21, 2009a), also known as Feed Laws, Standard Offer Contracts, Minimum Price Payments, Renewable Energy Payments, and Advanced Renewable Tariffs (Couture and Gagnon, 2009). FITs have driven dramatic renewable electric capacity growth in several countries—most notably Germany and Spain—over the past 15 years, and have spread rapidly across Europe and around the world (Christensen, Denton *et al.*, 2006; Mendonça, 2007; Rickerson, Sawin *et al.*, 2007; Girardet and Mendonca, 2009; REN21, 2009a).

Under feed-in laws, fixed payments, or tariffs, are paid for each kilowatt hour of renewable electricity fed into the grid, usually over a period of several years. There are several forms of FITs in operation, with the two main categories being market independent (government sets full fixed prices) and market dependent (premium price on top of the retail rate), and all have different impacts on investor certainty and payment, ratepayer payments, the speed of deployment, and transparency and complexity of the system (Couture, 2009). The costs of the FIT 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.

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). After enacting its first FIT, Germany's share of electricity from renewable almost tripled between 1991 and 2002, rising from 2.8 percent to 7.8 percent, to 15 percent by the end of 2008 (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 9 and Figure 10) Germany's system is often held up as a model, but several other countries have also experienced success with FITs. Before Spain passed a feed-in tariff in 1998 the country had little wind capacity; by the end of 2007, Spain ranked third in the world in wind installations and generated 10 percent of its electricity with the wind. Denmark, which also had a FIT in place until 2000 now generates more than 20 percent of its electricity from wind and has long been the world's wind-turbine manufacturing leader (REN21, 2009b; Sawin and Moomaw, 2009).

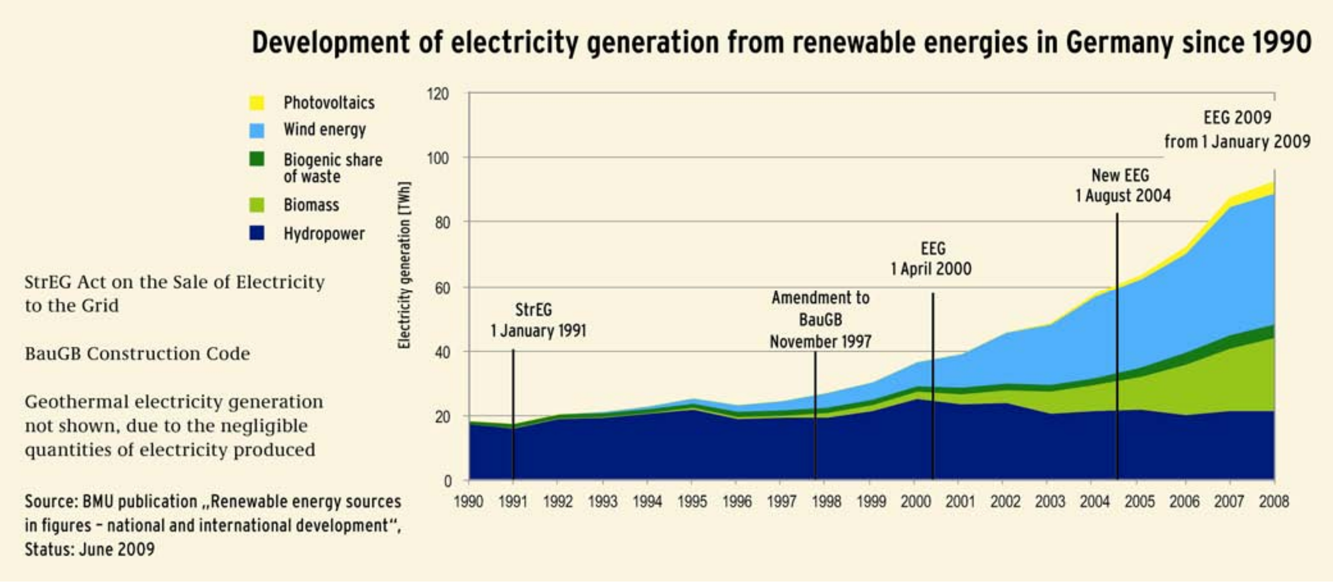


Figure 9: Development of Electricity Generation from RE in Germany, 1990-2008 (German Federal Ministry for the Environment, 2009) [TSU: Figure will need to be redrawn.]

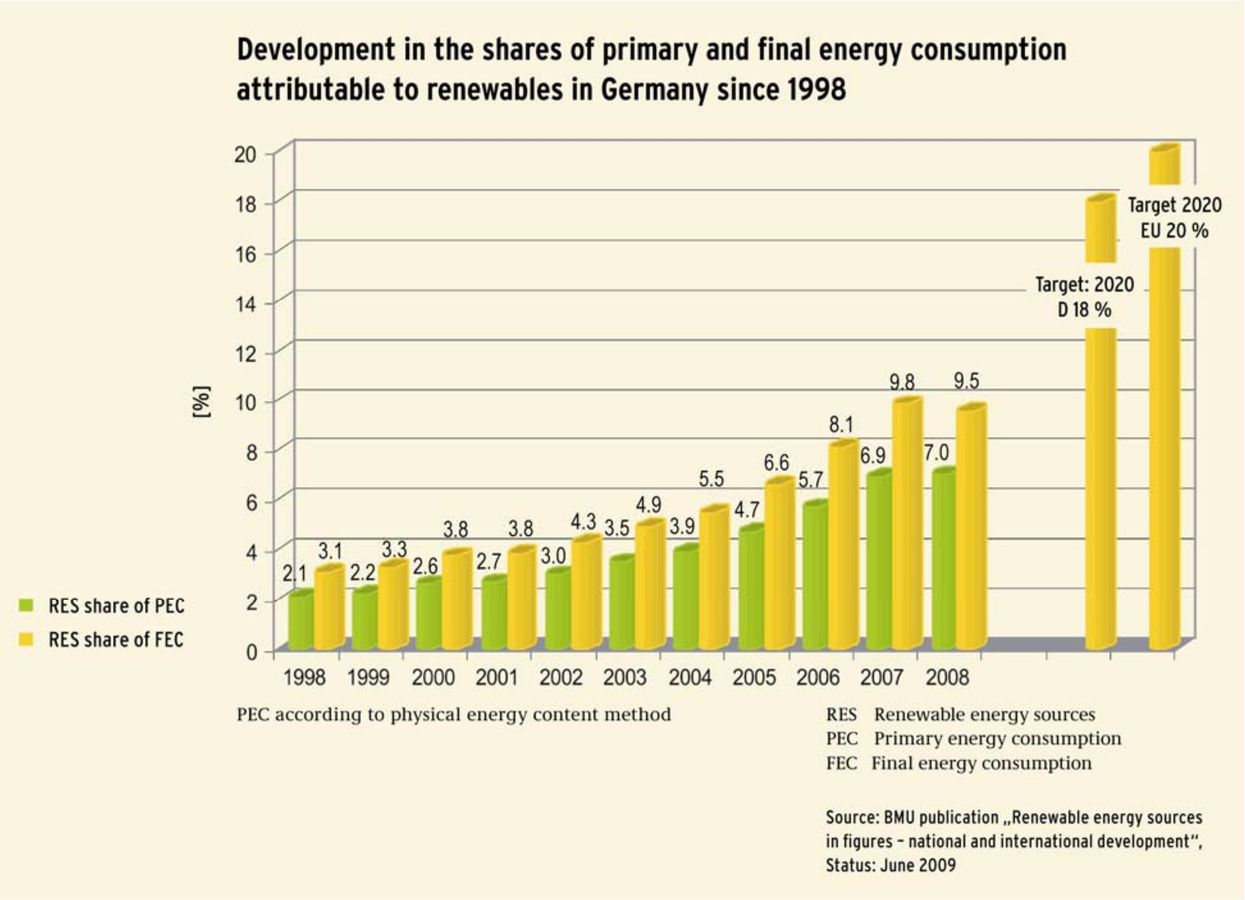


Figure 10: Development in the Shares of Primary and Final Energy Consumption Attributable to RE, Germany, 1998-2008 (German Federal Ministry for the Environment, 2009). [TSU: Figure will need to be redrawn.]

FITs can also be used to promote RE for mini-grids — small-scale electricity networks based on a local and often isolated distribution system (Mendonça and Jacobs, 2009). Van Alphen et al (2008) note that FITs are more effective than quotas for dispersed markets in small island states and for varying sizes of projects (van Alphen, Kunz *et al.*, 2008).

However, having a FIT mechanism is not necessarily enough per se to increase RE involvment. Not only do the details of the FIT matter (see bullets below) but also the enabling environment discussed in 11.6. It does come down to are not necessarily enough to increase renewable deployment (Commission of the European Communities, 2008; Fouquet and Johansson, 2008). Experiences in France, Greece and elsewhere demonstrate that high administrative barriers can hamper development even under relatively stable policy environments (Commission of the European Communities, 2008; International Energy Agency (IEA), 2008a; Lüthi and Wüstenhagen, 2009). Two studies by Lüthi and Wüstenhagen (2009a and 2009b), that focus specifically on solar PV experiences in several European countries, found that above a certain level of return, risk-related factors play a greater role in influencing investment decisions than do return-related factors. This perhaps explains why even under similar FIT policies, countries experience different outcomes in terms of capacity installations. Beyond a certain rate of return, the level of market diffusion will be highly sensitive to factors such as long administrative processes, the existence of a market cap, numerous unexpected policy changes (Lüthi and Wüstenhagen, 2009), and problems associated with grid access (Lüthi and Wüstenhagen, 2009).

Other studies of FITs have also found that development can be forestalled by lack of grid connection regulations or problems accessing the grid, onerous building approval procedures and capacity limits, lack of standards, high taxation on renewable technologies, and low tariffs or short guaranteed payment periods (Sawin, 2004b; Papadopoulos and Karteris, 2009). If tariffs are set too high, they can encourage significant development and dramatically increase electricity prices; if they are not high enough, little development will occur (Wiser and Pickle, 2000).

Success with the FITs is dependent upon the specifics of the law, and other policies enacted in parallel (Sawin, 2004b; Fouquet, Grotz *et al.*, 2005). 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 purchase
- Establish tariffs based on cost of generation and differentiated by technology type and project size; can also help to differentiate by location/resource time of day
- Ensure regular adjustment of tariffs, with incremental adjustments built into law, to reflect changes in technologies and the marketplace
- Provide tariffs for all potential developers, 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.

11.5.2.1.2 Quota Obligations and Renewable Portfolio Standards (RPS)

After feed-in tariffs, 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, such laws had been enacted 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, 2009b).

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 borne by electricity consumers. With the most common form of quota system, investors and generators comply with the quota by installing capacity, purchasing renewable electricity through a bidding process, paying a penalty or buying-out their obligation (under some systems), or, in many cases, buying "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 utilities and customers to trade, sell, or buy credits to meet obligations—provided there is sufficient liquidity in the marketplace. They can add value to renewable installations by creating a paper market separate from electricity sales, and can allow for trading and expanding RE markets between states or countries (Sawin, 2004b).

Under tendering systems, another type of quota system, potential project developers bid to a public authority for contracts to fulfil their government mandate. Projects that are considered viable and that compete successfully on price terms against other bidders are offered contracts to receive a guaranteed price per unit of electricity generated. The government often covers the difference between the market reference price and the winning bid, and contracts are generally awarded for a period of several years (Sawin, 2004b).

There are significant variations from one scheme to the next, even among various U.S. state policies (Wiser, Namovicz et al., 2007). Some state policies, such as that in Texas, have stimulated RE development at seemingly low cost, while others have not. 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). However, 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
- Set different bands by technology type
- Provide long-term targets, of at least 10 years (van der Linden, Uyterlinde et al., 2005)
- Require long-term contracts to reduce uncertainty for project developers
- 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)

11.5.2.1.3 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, 2009b). 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. The key to success in countries like Germany, Spain and Denmark has been high investment security coupled with low administrative and regulatory barriers (International Energy Agency (IEA), 2008a). This section reviews existing literature regarding effectiveness and efficiency, risk minimisation, impacts on costs and prices, technological diversity and innovation, and participation and equity.

11.5.2.1.3.1 Effectiveness and Efficiency

Because quota systems, particularly those with tradable certificate markets, do not regulate technology choice or price, many policy makers and analysts have considered them to be more competitive and market-oriented than FITs (Lipp, 2007). However, 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), 2008a; 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 (Ragwitz, Held et al., 2005; Stern, 2006; de Jager and Rathmann, 2008). Although they have not succeeded in every country that has enacted them, those countries with the most significant growth and the strongest domestic industries have had FITs (Sawin, 2004a). The IPCC Fourth Assessment Report (2007) concluded that FITs have been more effective than quotas at deploying renewables and increasing production efficiency (Intergovernmental Panel on Climate Change (IPCC), 2007b). However, some feed-in tariff systems have not been as successful as non technology-specific quota systems at developing low-cost options, such as sewage gas and certain types of biomass (International Energy Agency (IEA), 2008a).

Quotas can act as a cap on capacity installations because the value of tradable certificates drops off once the quota is achieved (Sawin, 2004b; Fouquet and Johansson, 2008). 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). In contrast, many countries with FITs—including Germany and Spain—have regularly surpassed national targets (Menanteau, Finon et al., 2003; Meyer, 2003), and some analysts consider them the most effective policy mechanism for meeting national renewable electricity targets (Ragwitz, Held et al., 2005). As a result of its success with the FIT tariff, the German government has increased its electricity target to 30 percent from renewables by 2020 (REN21, 2009b). The German government estimates that renewables avoided 100 million tons of carbon dioxide emissions in 2006, with 44 percent of this attributable to the nation’s FIT (German Federal Ministry for the Environment, 2007).

11.5.2.1.3.2 Risk Minimisation

An important factor of effectiveness and efficiency of is the policy’s accompanying investor risk. The Stern Review on the Economics of Climate Change (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.” (Intergovernmental Panel on Climate Change (IPCC), 2007b).

The higher risk under quota systems comes in a number of forms, including price risk (fluctuating power and certificate prices), volume risk (no purchase guarantee), and balancing risk; all three risks increase the cost of capital (Mitchell, Bauknecht *et al.*, 2006). While quota and tendering systems theoretically make optimum use of market forces, they have a stop-and-go nature not conducive to stable conditions. In addition to private investment-related risks, there is also the risk that low-bid projects may not be implemented (European Commission, 2005). The first wind power tender program launched in the mid-1990s in France is a case in point. It succeeded in achieving only a few MW of capacity installations because projects selected were based on bids that were too low to find investors (Nadaï, 2007).

Relatively high investment risks mean that quotas tend to favour large companies experienced in power trading, and particularly incumbent utilities (Sawin, 2004b; Mitchell, Bauknecht *et al.*, 2006; New Energy Finance Limited (NEF), 2007; Jacobsson, Bergek *et al.*, 2009). Because large players can control the price of certificates, there is a risk of gaming, particularly where penalty money is recycled back to certificate holders, as is the case in the UK (Mitchell, Bauknecht *et al.*, 2006; Agnolucci, 2007); this creates greater investment risk for smaller players (Fouquet and Johansson, 2008).

However, 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). Others have concluded that more challenging targets and better enforcement in the United Kingdom and elsewhere could improve the results of TGC systems (Mitchell and Connor, 2004; Mitchell, Bauknecht *et al.*, 2006; Fouquet and Johansson, 2008), and that quota systems in many states and countries are still quite new and thus in a transitional phase (Wiser, Namovicz *et al.*, 2007; Commission of the European Communities, 2008). The IPCC (2007) points out that quotas with TGCs delivered under long-term agreements can be effective with high compliance rates (Intergovernmental Panel on Climate Change (IPCC), 2007b).

11.5.2.1.3.3 Impacts on Costs and Prices

Quotas are generally credited with dramatically reducing the cost and price of RE through competition, and doing so more effectively than FITs, though there is some debate about the actual causes of price reductions seen to date under some quota systems (Wiser and Pickle, 2000; Espey, 2001; Sawin, 2004b; Rickerson, Sawin et al., 2007; Butler and Neuhoff, 2008; Klein, Pfluger et al., 2008). They promote least-cost projects: the cheapest resources are used first, which in theory brings down costs early on (Sawin, 2004b). According to Kildegaard (2008), "By separating the renewable attribute from the energy itself, and subsequently allowing different eligible technologies to compete in the supply of certificates, TGC markets promise to create a robust competition that minimizes the social cost [marginal cost of production] of any given level of renewable production." (Kildegaard, 2008).

In the United States, there is little evidence of a sizable impact on electricity costs associated with quotas, but cost impacts have varied from state to state and significant REC price fluctuations are possible, impeding development (Wiser, Namovicz et al., 2007). Further, Toke (2007) notes that success of the U.S. quota in states like Texas, and their ability to achieve targets cost-effectively, is greatly due to the federal production tax credit (Toke, 2007).

Most evidence shows that, at least in Europe, the higher risk present under many quota systems relative to FITs calls for higher expected returns, resulting in excess profits (Fouquet, Grotz et al., 2005; New Energy Finance Limited (NEF), 2007; Jacobsson, Bergek et al., 2009; Verbruggen and Lauber, 2009). Excessive profits are distinguished in this study from acceptable profits where higher risks are real and so required returns are higher.

Such profits primarily benefit incumbent actors and relatively mature, low-cost technologies, and can be costly for consumers (Jacobsson, Bergek *et al.*, 2009). The UK's RO scheme was intended to bring about a significant reduction in RE costs although this has not occurred (Mitchell and Connor, 2004; Jacobsson, Bergek *et al.*, 2009). Instead, several studies have shown that the UK and other European quota systems have generated renewable electricity—from wind, biogas and small-scale hydropower—at higher cost than the FIT (European Commission, 2005; Toke, 2007). A European Commission (2005) study found that, despite better wind resources in the United Kingdom, wind development there has been more costly than in any other European country (European Commission, 2005). In 2008, the German FIT premium for onshore wind ranged from 5.3-8.4 euro cents/kWh[TSU: Also needs to be presented in 2005 US$/kWh]; in contrast, in the UK, where there was a quota system, the premium was higher, with wind power at 12-14 euro cents/kWh[TSU: Also needs to be presented in 2005 US$/kWh] (Fouquet and Johansson, 2008). The IEA (2008) found that in 2005 the average remuneration levels in countries with FITs were lower than those with quotas with TGCs, due most likely to high non-economic barriers in these countries as well as intrinsic problems with design of existing tradable certificate programs (International Energy Agency (IEA), 2008a).

A 2008 analysis found that market competition (number of players) was stronger among wind turbine producers and constructors under the German FIT than under either quota scheme used in the United Kingdom (Butler and Neuhoff, 2008). FITs encourage competition among manufacturers rather than investors (Held, Ragwitz et al., 2007). They have been found to encourage development of domestic manufacturing industries, which leads to a large number of companies which creates competition (Sawin, 2004b). FITs shift competition from electricity price to equipment price, which some analysts have argued is more appropriate competition for capital-intensive RE technologies (Wagner, 1999; Hvelplund, 2001). Higher investor security (under fixed price models, in particular) enables investors to obtain capital at a lower cost, which also helps to reduce the costs of RE deployment (Couture and Gagnon, 2009). Verbruggen and Lauber (2009) demonstrate that well-designed FITs provide dynamic incentives to reduce long-run marginal costs of a variety of RE technologies because investment money is assigned to investors accordingly; more efficient producers obtain greater rents by lowering costs, and rates are regularly adjusted to avoid excessive rents. Van Alphen et al (2008) found that, in small island states with dispersed markets, FITs are also more cost-effective than tradable RE credits or tendering systems.

11.5.2.1.3.4 Technological Diversity

Quota systems have been found to benefit the most mature, least-cost technologies (Espey, 2001; Sawin, 2004b; Jacobsson, Bergek et al., 2009). As a result, on their own they cannot create markets for less mature technologies to help drive them down their “learning curves” (Sawin, 2004b). Under quota systems 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, 2008). Solar-specific RPS designs, under which utilities must purchase a certain number of solar RECs to meet their mandated quotas, are becoming more common in the United States.(Wiser and Barbose, 2008) However, without a floor price, many small companies have found it difficult to estimate a revenue stream and to obtain financing for projects, and some states have thus far fallen short of their targets (Lacey, 2009).

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). While most of the new renewable electric capacity in Germany has been wind, other renewable technologies—including biomass and solar (both small-scale distributed and centralized)—have also experienced significant growth. By the end of 2008, Germany accounted for 42 percent of the world’s grid-connected PV capacity (REN21, 2009a). Verbruggen and Lauber (2009) argue that success of the German FIT is due primarily to the careful categorizing of sources and technologies (Verbruggen and Lauber, 2009). Spain has also become a world leader in solar PV installations through its FIT (REN21, 2009a).

11.5.2.1.3.5 Technological Innovation

Quota systems involve high risks and low rewards for equipment industry and project developers, slowing innovation (Sawin, 2004b). As Unruh notes, incumbents are rarely the source of radical innovations (Unruh, 2000). Jacobsson et al (2009) found that profits attained under quotas with TGC systems are captured by incumbents, investing in the most mature technologies, rather than acquired as a reward for entrepreneurship and innovation (Jacobsson, Bergek et al., 2009). According to Lauber (2008), the high internal rate of return and windfall profits associated with quotas "divert resources from innovators to incumbents while the extra risk leads to emphasis on cheapest, short-term solutions; this discourages innovations with longer time horizons" (Lauber, 2008).

Innovation is also discouraged in cases where quotas create on–off cycles (due to bidding rounds), deterring continuous market development and making it difficult to establish a strong domestic industry as investment in production facilities will take place only with a short-term perspective. This in turn limits potential domestic job growth and economic development benefits associated with RE (Martinot and Reiche, 2000; Wagner, 2000). In contrast, FITs have been found to be the most successful mechanism for creating new jobs and strong domestic manufacturing industries (Menanteau, Finon *et al.*, 2003; Lewis and Wiser, 2005).

Under FITs, the combination of a guaranteed market and long-term minimum payments has reduced investment risks, making it easier to obtain financing and more profitable to invest in renewable technologies. By creating demand for renewable electricity and technologies, well-designed FITs have attracted private investment for R&D and manufacturing capacity, spread the costs of technology advancement and diffusion relatively evenly across populations, and enabled the production scale-ups and the installation, operation, and maintenance experience needed to bring down the costs of renewable technologies and generation (Sawin, 2004a).

Except in the case of Spain, where the premium option attracts mostly incumbent power generators, FITs have been more successful at bringing new players into the market (Verbruggen and Lauber, 2009). Stenzel and Frenzel review renewable energy generators in the UK, Spain, Germany and Sweden. They showed that in the UK, 85 percent of renewable energy generation is owned by the ex-monopoly companies etc etc. However, in Spain where an ex State company is the main renewable energy developer, 50 percent of the market share is made up of small, new entrant companies (REF).

Bürer and Wüstenhagen (2009) found that, because FITs effectively reduce risk, venture capital and private equity investors perceive FITs to be the most effective policy to stimulate investment in RE technologies. They surveyed 60 European and North American cleantech investors who rated FITs higher than any other of 12 policy options provided, while quota mechanisms ranked among the least preferred market-pull options, followed only by the Kyoto trading mechanisms (Bürer and Wüstenhagen, 2009).

11.5.2.1.3.6 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) Further, 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). 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). The most important benefits associated with community ownership are that "it increases public acceptance of wind generation, represents an additional source of capital to build the industry, and increases the potential for distributed generation benefits."(Barry and Chapman, 2009).

Many analysts argue that quota systems primarily benefit incumbent actors, which enables them to continue controlling the market and introducing RE at their own pace (Girardet and Mendonca, 2009; Jacobsson, Bergek *et al.*, 2009; Verbruggen and Lauber, 2009). In contrast, 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 broad public support for renewables (Damborg and Krohn, 1998; Sawin, 2001; Sawin, 2004b; Hvelplund, 2006; Mendonça, Lacey *et al.*, 2009). Mendonça (2007) compared the UK RO to the German FIT and found that the UK system has low public acceptance, while public acceptance in Germany is high (Mendonça, 2007).

Alongside the debate about FITs versus quotas, in which the assumption is that the two policies are contradictory, are several other schools of thought. Some experts propose that FITs might be most appropriate for smaller-scale projects and emerging technologies, while quota systems might be best used to promote near-market renewable technologies that are well-established and compete favourably with conventional energy (Sawin, 2004b; Midttun and Gautesen, 2007; Rickerson, Bennhold *et al.*, 2008). In other words, it is argued, which policy mechanism is most appropriate depends on the level of maturity of the technology in question. Yet others argue that institutional settings (Dinica, 2008), are more important than the policy instrument.

The European Commission (2008) and others find that the clear distinctions between the two mechanisms have faded somewhat and there is a convergence of policies as countries learn from past experiences and improve their policies (van der Linden, Uyterlinde et al., 2005; California Energy Commission and California Public Utilities Commission, 2008; Commission of the European Communities, 2008) For example, states and countries with quota systems have begun enacting technology-specific obligations and requiring long-term contracts, including a number of U.S. states, while some with FIT policies adjust payments over time to account for changes in the market place and to encourage cost reductions (Commission of the European Communities, 2008). Generally, however, FITs are added to quota mechanisms rather than the other way around.

FIT policies on top of existing quota mechanisms, such as Renewable Portfolio Standards, can potentially provide: a steady stream of revenues required for obtaining project financing, and a high enough rate of return to support the additional risks that come with new or emerging technology projects; cost-effective procurement alongside or in place of competitive solicitations; a hedge against project delays and cancellations, since any qualified generator can obtain a supply contract; and rate-payer backing, which reduces risks to utilities (Couture and Gagnon, 2009; Couture and Gagnon, 2010). In the United States, several states now have fixed-price systems in place alongside RPS laws (Rickerson, Bennhold *et al.*, 2008; Cory, Couture *et al.*, 2009). FITs are being used or are under consideration to help meet RPS goals and/or to target specific policy goals, including advancing emerging technologies such as solar PV, enabling small-scale residential or community projects, and promoting in-state manufacturing, just as FITs have done in Europe(Rickerson, Sawin *et al.*, 2007) . Flanders moved PV out of the TGC mechanism in 2002 (Verbruggen and Lauber, 2009). The UK is implementing a FIT from 2010 for under 5 MW power plants. It is not that the two systems are combined, but they work in parallel.

Such developments demonstrate that policy makers are willing to consider using both mechanisms side-by-side and that FITs and quotas can function alongside one another. (Rickerson, Sawin *et al.*, 2007). Existing programs have rather simple structures and have seen limited success, although most are fairly new policies and time and research will be required to determine how effectively the mechanisms interact (Cory, Couture *et al.*, 2009).

11.5.2.1.4 Net Metering

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).

Net metering is considered a low-cost, easily administered tool for motivating customers to invest in small-scale, distributed power and to feed it into the grid (U.S. Department of Energy, 2008). According to the U.S. Department of Energy, “It increases the value of the electricity produced by renewable generation and allows customers to ‘bank’ their energy and use it a different time than it is produced giving customers more flexibility and allowing them to maximize the value of their production. Providers may also benefit from net metering because when customers are producing electricity during peak periods, the system load factor is improved.” (U.S. Department of Energy, 2008).

Because laws differ greatly from place to place and are intertwined with other policy mechanisms and incentives, it is difficult to demonstrate specific cause and effect. 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).

According to Rose *et al* (2008), the best results are achieved when net metering laws do not limit system size or overall capacity, allow monthly carryover of excess electricity and permit customers to keep their RE credits, permit all renewable technologies and customer classes to participate, and protect customers from unnecessary red tape (Rose, Webber *et al.*, 2008). In this way, net-metering is an important stimulus for small-scale RE projects supported by a FIT, because other ways of integrating such projects (their surplus, back-up and make-up electricity flows) may grow cumbersome and become a way for incumbents to reap a significant share of the benefits (Verbruggen and Lauber, 2009).

11.5.2.2 Fiscal Incentives - Investment and Production Subsidies

Financial incentives of various forms—based on investment or production, and including tax credits, rebates and grants—can reduce the costs and risks of investing in RE by lowering the up-front capital costs associated with installation, increasing the payment received for energy generated with renewable sources, or reducing the cost of production.

Such incentives have been used extensively over the years in Europe, Japan, the United States and India, and more recently in several other developing countries, including Argentina, China and the Philippines (Sawin, 2004b). They can be used to promote centralized and/or distributed power generation, for both on- and off-grid systems—for example, Uganda offers an investment subsidy for off-grid solar PV (REN21, 2009a).

The impacts of production and investment support instruments like investment grants and tax rebates are difficult to measure as they are generally used as supplementary policy tools (European Commission, 2005; Klein, Held *et al.*, 2008). In the European Union, for example, only Finland and Malta use tax incentives and investment grants as their main support schemes (Klein, Held *et al.*, 2008). They have also been used as the primary means of support at the national level in the United States (Database of State Incentives for Renewables & Efficiency (DSIRE), 2009).

Tax credits can include income tax deductions or credits, VAT reductions, or property tax incentives, among others. To encourage investment in renewables in the 1980s, the U.S. government and state of California offered investors credit against their income taxes, allowing them to recoup a significant share of their investment in the first few years, thereby reducing their risk. The tax credits played a major role in a California wind energy boom, and the lessons learned and economies of scale gained through this experience advanced wind technology and reduced its costs (Sawin, 2001). India experienced a similar boom a decade later, sparked by a combination of investment tax credits, financing assistance and accelerated depreciation (Sawin, 2004a). But in both cases, investment-based subsidies combined with a lack of technology standards or production requirements encouraged wealthy investors to use wind farms as tax shelters, and many projects performed poorly; some in California never generated a kilowatt-hour of electricity (Cavallo, Hock *et al.*, 1993).

The European Commission (2008) determined that the effectiveness of fiscal incentives such as tax reductions or exemptions (e.g., from carbon taxes) depends on the applicable tax rate. In the Nordic countries, which apply relatively high energy tax rates, such tax exemptions can be sufficient to stimulate the use of renewable electricity; however, in countries with relatively low energy tax rates, they must be combined with other measures (European Commission, 2005). The current U.S. federal investment and production tax credits (which provide a credit against income tax for each kilowatt-hour of electricity produced), first enacted in the 1990s, have created strong growth in the nation’s wind and solar markets, but only when the credits have been in place for multiple years (Farrell, 2008), and only in those states with additional incentives (Sawin, 2004a).

Accelerated depreciation has been successful in encouraging small-scale wind in Sweden and Denmark, in particular, with depreciation rates of 30 percent. In Denmark, this policy contributed to a significant increase in farmer-owned wind turbines during the mid-1990s (Buen, 2005; Barry and Chapman, 2009).

In general, those countries that have relied heavily on tax-based incentives have often struggled with unstable or insufficient markets for wind power or biogas, for example (Lewis and Wiser, 2005). In the United States, this is due in part to the on-off nature of the tax credits, but could also result from the fact that only a small number of players have enough tax liability to take direct advantage of the credits, particularly the production tax credit (Metcalf, 2008). This challenge can be addressed by making tax policies more inclusive or finding other policies that encourage broader participation.(Mendonça, Lacey *et al.*, 2009)

Beyond tax measures, some countries, like Japan and several U.S. states, have subsidized investment through grants or rebates and have been successful in promoting increased capacity (Sawin, 2004a). Grants and rebates can play a significant role in increasing market penetration of small, customer-sited projects particularly for emerging renewable technologies (Wiser and Pickle, 1997). They do not require a long-term policy and financial commitment to each specific project (Wiser and Pickle, 1997), but they have often failed to provide the stable conditions required to promote market growth and thus may not be effective at driving broad adoption of RE (Lantz and Doris, 2009). Rebate programs function well when the rebate amount is tailored to existing market and policy conditions, when they are matched with a clear set of goals, and when used to advance technologies from the prototype stage to mass production (Lantz and Doris, 2009).

Financial incentives tend to be most effective when combined with other policy mechanisms (International Energy Agency (IEA), 2008a). Japan’s solar roofs program of the 1990s and early 2000s combined rebates that declined over time with net metering, low interest loans and public education. As a result, during the period 1993- 2003, PV capacity in Japan increased at an average annual rate of 43 percent, system costs dropped by more than 80 percent, and Japan became the world’s leader manufacturer of solar PV (Sawin, 2004a).

Experience to date suggests that payments and rebates may be preferable to tax credits because the benefits of payments and rebates are equal for people of all income levels and thus promote broader investment and use (Sawin, 2001). Also, because they are generally provided at or near the time of purchase or production, they result in more even growth over time (rather than the tendency to invest in most capacity toward the end of a tax period) (Sawin, 2001). The European Commission (2008) has found that tax-based incentives tend to promote only the most mature and cheapest available technologies (Sawin, 2001). In addition, according to a 2009 UN Environment Program report, the global economic slow-down of 2008-2009 made clear that markets driven by tax credits are generally not effective in a downturn (United Nations Environment Programme (UNEP) and New Energy Finance Limited (NEF), 2009).

Incentives that subsidize production are generally preferable to investment subsidies because they promote the desired outcome—energy generation (Sawin, 2001). However, policies must be tailored to particular technologies and stages of maturation, and investment subsidies can be helpful when a technology is still relatively expensive. Many have argued, for example, that wind power never would have taken off in California in the 1980s without investment credits because the risks and capital costs were high. Alternatively, production incentives can be paired with other policies that help to reduce the cost of capital (Sawin, 2001).

11.5.2.3 Integration and Market Access for RE Electricity

Chapter 8 is focused on cross-cutting integration issues, and this section does not replicate that discussion. However, there are policies that promote RE access to networks and successful incorporation with markets, and this section briefly discusses that topic.

11.5.2.3.1 Connection, charging and grid access.

RE projects need to connect to networks in order to sell their electricity. The ease, and cost of doing this, is also central to the ability for projects to raise finance..Once connected, the generation has to be sold or ‘taken’ by the network. These two requirements: connection and then sale of generation are two different requirements and it is important that barriers to both are overcome.

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 offtake 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 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). 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 (Verburggen and Lauber, 2009; Jacobbson et al, 2009).

11.5.2.3.2 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. 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 policy 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, 2008). 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 (Rodriguez, JM et al., 2008). In parallel, it helps RE if electricity markets incorporate shorter timescales relative to the traditional model of long-term bilateral contracts, through spot markets, and shorter gate closure times within such markets enable faster response to fluctuating supply and demand. An increasingly flexible approach to trading reduces the impact of forecast errors, both in supply and demand, and increases access to the existing flexibility resource, reducing the need for additional fast response power plants, interconnection or storage [IEA, 2008]. 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 O., et al, 2008].

11.5.2.4 Policies for Rural and Off-grid Electrification

Although success stories for off-grid electricity programs are still limited, there are examples of successful mini-grid programs in rural areas. 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. Benefits of this system included creation of a large market to provide critical mass for commercially sustainable business 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. The government subsidized 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 et al, 2000). This system has been duplicated in a number of other developing countries, including Benin, Cape Verde, South Africa and Togo (Osafo and Martinot, 2003; Reiche et al, 2000).

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).

In the early 2000s, the Chinese government undertook an ambitious program to electrify—with mini-grids—more than 1,000 townships within 20 months. The effort began with township "seats," followed by an additional 20,000 administrative villages (Ku et al, 2003).

11.5.3 Policies for Deployment - heating and cooling

Currently, heating and cooling processes account for 40-50 percent of global energy demand *(IEA, 2007; Seyboth, Beurskens et al., 2008)* with consequent implications for emissions from fossil fuels. Historically, renewable energy policy has focused on renewable electricity initially, with increasing activity in support of biofuels for transportation over the last decade. However, renewable energy sources of heat have gained support in recent years as awareness of its potential has been increasingly recognized.

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 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., 2009)*. A significant complicating factor as regards application to heat is that care must be taken to ensure that subsidies are not spent on generation that does not meet demand. 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 biomass based substitute natural gas, for example *(Connor, Bürger et al., 2009)*. 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 various investment incentives; regulatory policies (including mandates); and educational efforts (as discussed in 11.6) and there is significant potential for other instruments to also be applied. *(DEFRA/BERR, 2007; Bürger, Klinski et al., 2008; Connor, Bürger et al., 2009)*

11.5.3.1 Investment incentives

There are a wide variety of financial incentive instruments that can be applied with the aim of addressing the investment cost gap between RE and current conventional direct or indirect heating or cooling technologies. These can be categorized into financial incentives and fiscal incentives.

Financial instruments include capital grants and rebates, operation grants, soft loans, fixed bonus payments against generation and tradable certificates earned for renewable generation.

11.5.3.1.1 Capital Grants and Rebates

Capital grants and rebates assist directly with reducing the capital investment of a plant, with a government typically providing a certain level of financial support, for example a refund per megawatt of installed capacity or a percentage of total investment, up to a specified 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 instruments applied 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., 2009)*. They are easy to apply but their relative economic efficiency has led to recent efforts in some nations to devise new instruments. 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, 2007; Roulleau and Lloyd, 2008; Walker, 2008b; Gillingham, 2009)*.

11.5.3.1.2 Bonus Mechanisms and Quotas

The bonus mechanism and the quota or renewable portfolio standard (RPS) are the two key variations for RES-E. The bonus mechanism (roughly, the equivalent to the RES-E feed-in tariff) 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.

The quota mechanism awards tradable certificates per unit of renewable energy generated while at the same time obliging energy supply companies to purchase a minimum amount of energy, represented by the certificates, thus creating a market and a demand for the certificates. Funding of this nature is beneficial in that it incentivises developers to maximise energy output, a considerable advantage over grants. The comparative usefulness of tariffs and quotas has been the subject of considerable debate as regards application to RES-E, with growing evidence to suggest that tariff mechanism may have the advantage as regards delivery and economics *(IEA, 2008; Couture and Gagnon, 2010).*

Currently, no RES-H/C centred quota mechanism has been applied in practice. Efforts to legislate a RES-H quota mechanism in the UK in 2005 were unsuccessful. The UK has now adopted legislation for a RES-H bonus mechanism with a projected April 2011 adoption (DECC, 2009). Germany also favours a bonus mechanism for RES-H, but legal issues have prevented adoption as yet.

Key differences between the RES-E tariff and the RES-H bonus include the many more renewable heat generators expected and the fact that generation will generally be at the same site as the load. This has the potential to see substantial complexity and costs due to metering and administration. The proposed solution is via 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).* Assessment of the level of subsidy on this basis will require either metering (more appropriate for large-scale application) or some form of estimation of output, and of how this matches demand, based on assumptions about load, weather conditions, location and other factors in order to draw conclusions concerning about the level of subsidy that should be applied *(Bürger, Klinski et al. 2008).*

11.5.3.1.3 Financing

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, 2007). 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, 2007).

11.5.3.1.4 Tax Policies

Fiscal incentives include tax credits, reductions and exemptions and accelerated depreciation of capital expenditure. Fiscal incentives are another tool for lowering the financial burden of investing in RE, as with financial instruments setting the correct level of incentive requires care to ensure expansion without an excessive public burden (IEA 2007).

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. 2009)*.

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.

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, 2007).

Parallel to the level of support, it is important to consider the level of technological and market maturity of the RET at issue. Some support instruments will be more appropriate to early growth while others will be more useful as technologies approach commerciality *(Foxon, Gross et al., 2005b; Connor, Bürger et al., 2009)*. For example, investment tax credits might be more appropriate for an early deployment of high cost, emerging technologies; whilst production tax credits would apply to more mature technologies, providing tax relief for the amount of heat actually produced, and therefore, also favouring target achievement *(Foxon, Gross et al. 2005)*.

11.5.3.2 Regulatory Issues

There are a number of ways for regulation to impact on development of renewable heating and cooling.

One simple application is to mandate the inclusion of the basic 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. Integration of the technology for later connection to district heating or cooling is one potential application that might have a better fit with later investment *(Connor, Bürger et al. 2009)*.

Applications of building regulations can go as far as compelling the adoption of RES-H/C technologies, as in the case of the ‘Use Obligation’ instrument. 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. Early applications tend to compel new buildings to ensure a specified fraction of energy use is from renewable sources, with variations as to the eligible technologies. The goal is the stimulation of an initial market for the technology and of the attendant necessary infrastructure. More stringent variations may compel that RE sources be included in refurbishment. The main criticism is that the instrument can place costs arbitrarily and unfairly, with particular stakeholders bearing the brunt of stimulating new technology. 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 (Bürger, Klinski *et al.*, 2008; Puig, 2008).

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. Moreover, the obligation on new buildings can help to create a minimum critical mass within the market, thus leading to lower costs and higher use of renewable heating technologies *(ESTIF 2006).*

As with other support instruments, 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 ensure proper compliance with the mechanism; a monitoring system including periodic examinations of installations and/or minimum quality standards is advisable *(Connor, Bürger et al., 2009)*. Restriction of non-compliance is fundamental to the success of the use obligation (Bürger, Klinski *et al.*, 2008).

While appropriate application of building regulations could assist with the growth of renewable heating and cooling there is a potential for conflict concerning application of building regulations concerning energy efficiency. Where efforts are being made to compel increases in the energy efficiency standards of new buildings or upgrades of old buildings, optimal benefit is likely to result from a coherent approach that ensures regulations are complementary and avoids potential unnecessary costs through, for example, overcapacity (Connor, Bürger *et al.*, 2009).

Where additions to buildings are compulsory, 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.*, 2009).

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).*

One interesting 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. District heating (DH) is the grid based delivery of heat energy to domestic or other premises, with the aim of improving efficiency of energy use, with grids varying from the small- and local-scale to city-wide installations. Despite considerable potential there are a number of potential problems with expansion of DH. Much of the costs associated with DH come from the initial investment in infrastructure for heat (or cooling) delivery, making the technology unattractive to investors. Since ensuring a return on this investment will require some years of supplying heat, the question of regulation becomes a complex choice of whether to allow closed or open competition, including allowing third party access to the grid, or to allow consumers to use other heat sources *(Grohnheit and Mortensen, 2003)*. Third Party access, that is, allowing other heat generators access to sell their heat, is a complex with regards to the infrastructure investor seeing a return, but also of the potential for increased competition to the benefit of the consumer. Sweden has previously rejected such access on the grounds of the potential additional costs it might imply for all system users, but is again considering it *(Ericsson and Svenningsson, 2009)*. A DH system requires strong oversight if the consumer is to be protected from being locked in to high energy prices. As seen in the relevant case study box, Sweden provides an interesting example of a successful DH system using a significant share of biomass.

11.5.3.3 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 means that development and application of policy instruments is less complex *(IEA, 2007; Desideri, Proietti et al., 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.

District cooling is likely to be subject to considerations very similar to district heating as regards the problems of potential lock-in to heating systems, third party access and high initial investment again, with similar need for protection of both investors and consumer. The economics of its application will tend to favour its use where there is a corresponding demand for a district heating system (Pöyry/Faber Maunsell, 2009).

11.5.4 Policies 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.

11.5.4.1 Direct Use of RE for Transport - Biofuels

A range of policies have been implemented to support the deployment of biofuels in countries and regions around the world. 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. Currently, robust biofuels industries exist only in countries where government supports have enabled them to compete in markets dominated by fossil fuels. 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 et al 2008; Felix 2008).

11.5.4.1.1 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 [Authors: Reference is missing].

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 [Authors: Reference is missing]. 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 liter[TSU: Also needs to be presented in 2005 US$/liter] with plans to scale up the tax up to 45 euro cents/liter[TSU: Also needs to be presented in 2005 US$/liter] 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/liter[TSU: Also needs to be presented in 2005 US$/liter] 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 (German Federal Ministry for the Environment (BMU), 2009).

11.5.4.1.2 Renewable Fuel Mandates and Targets

National targets are key drivers in the development and growth of most modern biofuels industries. In fact, 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 [Authors: Reference is missing].

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 EU 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 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 [Authors: Reference is missing].

11.5.4.1.3 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).

11.5.4.1.4 Sustainability Standards

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 EU, 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 et al, 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 (U.S. 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).

11.5.4.1.5 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 et al., 2004; Kintner-Meyer, 2007). Making these secondary forms of energy carriers cost-effective and efficient is one condition for providing renewable energies for transport. Again, this is discussed in more detail in Chapter 8, the technology integration chapter but again 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 (e.g., 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 (TfL, 2009) [TSU:Reference missing from reference list], or free parking for electric cars (Williams, 2008) [TSU:Reference missing from reference list].

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 gCO2/km by 2015; and a commitment to further reduce this to 90gCO2/km by 2020 (EC, 2009; Arnold, 2009; CCC, 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, 2009).

11.5.5 Cross Cutting Issues

This subsection discusses additional issues that are not end-use specific. These include public procurement of RERE technologies and electricity, heat and fuels, as well as policies to finance deployment of RE and related infrastructure.

11.5.5.1 Public Procurement

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, 2009).

Public procurement of RE has multiple benefits to the private sector. First, it can guarantee a stable market. Second, mass produced technologies exhibit a consistent ‘learning curve’ where 10-30 percent cost declines are routinely observed for every cumulative doubling of the total number of units produced. This relationship, with a central tendency of a 20 percent decline can be a powerful stimulus for public purchases, and for forward pricing to expedite movement to lower cost (See Figure 11).

Recent examples of this approach include the 2009 European Council and the European Parliament adoption of a new directive on the promotion of clean energy and energy efficient road transport vehicles. Similar efforts have been undertaken in the United States, and have also been used to lower up-front costs of not only RE systems, but also compact fluorescent lighting, and efficient appliances [Authors: Reference is missing].

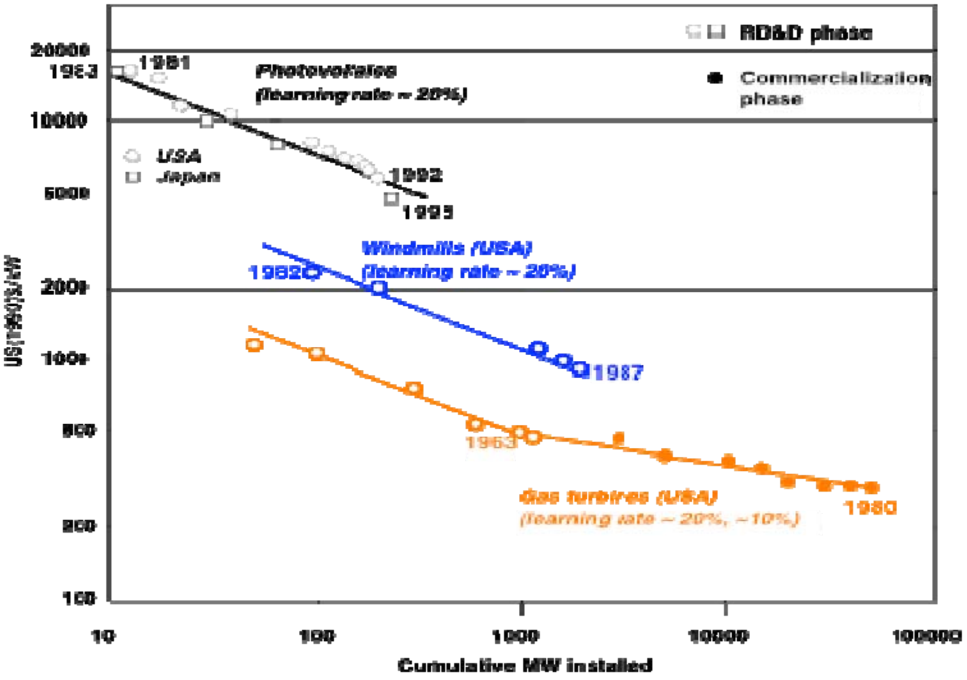


Figure 11: Cost Curves for Several Energy Technologies [TSU: Figure will need to be redrawn, presented in 2005 US$, and cited with a source]

11.5.5.2 *Policies to Finance Deployment and Infrastructure*

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). Uncertainties inherent in new technologies drive up the cost of capital which, in turn, decreases the net present value of projects to the point where many become uneconomic. All of these factors highlight the importance of government financing for RE deployment and infrastructure.

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). Developed country governments can also provide support for new technology development and deployment through strategically targeted Public Finance Mechanisms (PFMs) aimed at leveraging private sector financing, for example, by using government credit ratings to spur low-cost capital flows to private sector players.

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.

11.5.5.2.1 Investment Decisions and Public Financing

RE infrastructure 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 (Sonntag-O'Brien and Usher, 2004).

Financiers make lending and investment decisions based on their estimation of both the risks and returns of a project. Financial institutions want to make a return proportional to the risk they undertake: more risk means a greater return will be expected. The RE sector utilises finance from across the entire risk-reward spectrum. All financiers will want to understand risks they may face, and set up legal or other means for minimising or managing these issues.

For many RE projects, gaps in commercial financing can often only be filled with financial products created through the help of PFMs. Public financing can also be required for helping the commercial investment community gain experience with the new types of revenue streams that RE projects provide, including carbon, but also “green“ revenues (e.g. renewable premiums) that may be 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.

11.5.5.2.2 Elements of Project Financing

This section provides an overview of the various types of financing needed to plan and build RE projects, and the public financing mechanisms often required to fill gaps in this commercial financing continuum.

Table 5 provides an overview of the described mechanisms, the barriers they help to remove and the circumstances in which they are typically applied.

11.5.5.2.2.1 Project Development Capital

Project preparation for RE infrastructure projects is generally carried out by large energy companies or specialised project-development companies. Energy companies finance project preparation from operational budgets. Specialised companies are expected to finance project development work through private finance, capital markets, or with risk capital from venture capitalists, private equity funds, or strategic investors (e.g. equipment manufacturers). However infrastructure development is risky and can take several years and significant resources to prepare. In less mature financial markets it can be difficult to secure financing from commercial investors, and therefore the need for public support arises. Public finance mechanisms can help developers make it to financial closure by cost-sharing some of the more costly and time intensive project development activities, such as permitting, power purchase negotiations, grid interconnection and transmission contracting. These project development facilities can be on a grant, contingent grant, or soft loan basis and must be carefully structured to target the right projects and align interests on project development (UNEP Finance Initiative, 2009). Rather than directly supporting project developments, some facilities also channel project development support through private intermediaries[6].

11.5.5.2.2.2 Equity Finance

If a concept successfully passes through the development stages, the project developer will usually then need to attract external financing. To secure loans, developers and their equity sponsors will generally need to provide 25-50 percent of the capital required for a project in the form of shareholder equity. As the risk (real or perceived) associated with a project increases, lenders will require that equity play a larger role in the financing structure since more equity means a lower risk of loan default. This not only strains a developer’s capital resources, it raises the cost of the entire project, since the cost of equity capital is always higher than the cost of debt capital.

Due to the many risk- and capacity-related challenges involved, there are significant gaps in the availability of equity financing for RE projects 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. Thus, there is a need for equity-focused public financing mechanisms that are structured 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.

11.5.5.2.2.3 Debt Finance

The bulk of the financing needed for infrastructure projects is in the form of loans, termed debt financing. 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 RE infrastructure projects require. In these situations PFMs 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.

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[6] Some examples include the seed finance company E+Co, the Seed Capital Assistance Facility, and the infrastructure companies Infraco and InfraVentures.

Credit lines can be an effective means of providing the needed liquidity for medium to long-term financing of RE 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.

11.5.5.2.3 Risk Management

An integral element of deal structuring is financial risk management. This process entails using financial instruments to transfer specific risks away from the project sponsors and lenders to insurers and other parties better able to underwrite or manage the risk exposure. Among other important factors, financial risk management is one of the keys to deployment of RE technologies.

Applied correctly, certain financial risk management instruments can help mitigate the perceived risks associated with RE and affect the degree and terms of investment into such projects. However, there are currently constraints on the availability of such risk management instruments, which relate to factors such as the willingness and capacity of insurance and capital markets to respond (United Nations Environment Programme (UNEP), 2004).

There are still many insurance gaps. Projects of less than US $15 million[TSU: Needs to be presented in 2005 US$] have difficulty finding insurance cover and, as a result, financing. Only niche insurance operations with low overheads are able to service small-scale developers and even then, there is a steep learning curve and indeterminate risk reward ratio for many projects. For emerging markets, targeted enhanced political risk insurance is needed that covers the risk in the case of default in performance of obligation by government or other entity. Such insurance can come from government or from public-private entities, for instance export credit agencies.

Public guarantees are another option, and often needed where commercial financial institutions have adequate medium to long-term liquidity, yet are unwilling to provide financing 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 in the credit risk of project loans that commercial banks make with their own resources. Guarantees are generally appropriate only in financial markets where borrowing costs are at reasonable levels and where a good number of commercial banks are interested in the targeted market segment.

Typically guarantees are partial, meaning they cover a portion of the outstanding loan principal (50-80 percent is common), thereby ensuring that the commercial banks remain at risk for a certain portion of their portfolio to ensure that they lend prudently, and take responsibility for remedial action in the event of loan default.

Table 5: Overview of Public Finance Mechanisms for RE Deployment[7]

Mechanism		Description	Barriers	Financial Markets
Debt	**Credit Line for Senior Debt**	Credit line provided by Development Finance Institutions (DFIs) to Commercial Finance Institutions (CFIs) for on-lending to projects or corporations as senior debt	CFIs lack funds and have high interest rates	Underdeveloped financial markets where there is lack of liquidity, particularly for long-term lending, and borrowing costs are high
	Credit Line for Subordinated Debt	Credit line provided by DFI to CFIs for on-lending to projects with subordinated repayment obligations	Debt-Equity gap, whereby project sponsors lack sufficient equity to secure senior debt	Lack of liquidity in both equity and debt markets
	Guarantee	Shares project credit (i.e. loan) risks with CFIs	High credit risks, particularly perceived risks	Existence of guarantee institutions & experience with credit enhancements
	Project Loan Facility	Debt provided by DFIs directly to projects	CFIs unable to address the sector	Strong political environment to enforce contracts and enabling laws for special purpose entity
Equity	**Private Equity Fund**	Equity investments in companies or projects	Lack of risk capital; restrictive debt-to-equity ratio	Highly developed capital markets to allow equity investors to exit from the investee
	Venture Capital Fund	Equity investments in technology companies	Lack of risk capital for new technology development	Developed capital markets to allow eventual exits.
Grants	**Project Development Grants**	Grants "loaned" without interest or repayment until projects are financially viable	Poorly capitalised developers; costly and time consuming development process	Can be needed in any financial market context
	Loan softening programmes	Grants to help CFIs begin lending their own capital to end-users initially on concessional terms.	Lack of FI interest in lending to new sectors; limited knowledge of market demand.	Competitive local lending markets
	Inducement Prizes	"Ex-ante prizes" to stimulate technology development. Unproven in climate sector.	High and risky technology development costs and spill-over effects	Sufficient financing availability to deploy winning technologies

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[7] Adapted from UNEP, Public Finance Mechanisms to Mobilise Investment in Climate Change Mitigation, Paris, 2008.

Risk Transfer	**Currency Risk Management Instruments**	Establishment of Currency Exchange Funds by Donors, DFI, CFI	Volatility of local currency; Investment costs, loans and revenues in different currency	Most emerging markets
	Power Purchasing Guarantees	Guarantee by developing country government for non-prolongation of PPA by local utility	Very limited duration of power purchasing agreement or renewable premium	In immature policy environments
	Exploitation Risk Insurance	Risk Mitigation Fund set-up to cover costs of drilling	Poorly quantifiable up-front risk for initial investment for	Specific to some types of renewable like geothermal energy
Revenue Support	**RE Premiums**	Partial funding of renewable premiums by DFI e.g. as part of a nationally appropriate mitigation actions (NAMAs) via Trust Fund	Lack of project development capital; lack of cash flow for additional security;	All countries in which a given technology is lacking a sufficient cash-flow to ensure economic viability
	Carbon Finance	Monetisation of future cash flows from the advanced sale of Carbon Credits to finance project investment costs	Lack of project development capital; lack of cash flow for additional security; uncertain delivery of carbon credits	Availability of underlying financing for projects. Adequate institutional capacity to host CDM/JI project and to enforce contracts.
	Carbon Transactions in post-2012 credits	Contracting for the purchase of Carbon Credits to be delivered after 2012	Lack of regulatory framework and short-term compliance driven buyers.	Availability of underlying financing. Adequate institutional capacity to host CDM/JI project and to enforce contracts.

11.5.6 Overview of Cross-cutting Lessons Learned to Date

In conclusion, RE policies are required for their deployment, but simply enacting policies is not enough. Support schemes are often assessed using two main criteria: one measuring effectiveness (for example, the ability to deliver an increase of the share of renewable electricity consumed) and the other criterion measuring efficiency (e.g., comparison of the total amount of support received and the generation cost, or new capacity or generation relative to amount of support received). Details of design and implementation are key for policies to be effective and efficient. Overall, the effectiveness and efficiency of RE policies requires the following elements (International Energy Agency (IEA), 2008a).

- **The removal of non-economic barriers to renewables.** To date, as mentioned in Section 11.2, only a handful of countries have implemented effective support policies that have accelerated the diffusion of renewable technologies. The International Energy Agency concluded in a major study of RE policies that, although there exists a wide variety of policy mechanisms that can be used effectively to promote renewables, non-economic barriers have impeded their effectiveness and driven up costs in many countries (International Energy Agency (IEA), 2008a).

- **A steadily growing market and fair rate of return to attract investment, create strong industries, and drive down costs.(Sawin, 2004b; REN21, 2005)** For RE to make a significant contribution to lower greenhouse gas emissions as well as other goals such as economic development, job creation, and reduced oil dependence, it will be essential to improve the efficiency of technologies, reduce their costs and develop mature, self-sustaining industries to manufacture, install and maintain RE systems. The goal must not be simply to install capacity, but to provide the conditions for creation of a sustained and profitable industry, which, in turn, will result in increased RE capacity and generation, and will drive down costs (Sawin, 2004b; REN21, 2005).

- **To achieve this end, a viable, predictable, clear and long-term government commitment and policy framework are critical**.(International Energy Agency (IEA), 2008a). 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).
- **Transitional incentives that decline over time, and appropriate incentives that guarantee a specific level of support that varies according to technology and level of maturity.** 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).
- **A mix of instruments is essential for success.**(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), 2008a).

Increasingly, analysts are also noting that transparency and broad participation and ownership are critical to the expansion and long-term sustainability of RE (Bolinger, 2004; Sawin, 2004b; Farrell, 2008; Mitchell, 2008; Mendonça, Lacey *et al.*, 2009). As the density of RE projects increases, the need for local and political acceptance of RE will be even more important (Hvelplund, 2006). "Ownership can change the perspective of citizens by creating energy producers instead of energy consumers, as well as unlocking a deeper interest in energy efficiency and local energy solutions." (Farrell, 2008)

Ultimately, 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).

Finally, there is also 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 (Nitsch et al, 2001/2002; Fischedick et al, 2002) [TSU: References missing from reference list]. Jacobsson 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 (Jacobson and Delucchi, 2009).

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. This pathway has been described as a succession of phases from R&D to full market deployment, but these phases do not happen in a linear way. Their development requires market as well as social and institutional changes. Technology is thus best pictured as being embedded in these dimensions and technological change is conditioned by an enabling environment, which encompasses RE policies. It includes other institutions, such as other policies and regulations, the business and finance communities, the civil society, the material infrastructures for accessing RE resources and markets, the politics of international agreements for facing the challenge of climate change or developing technology transfer.

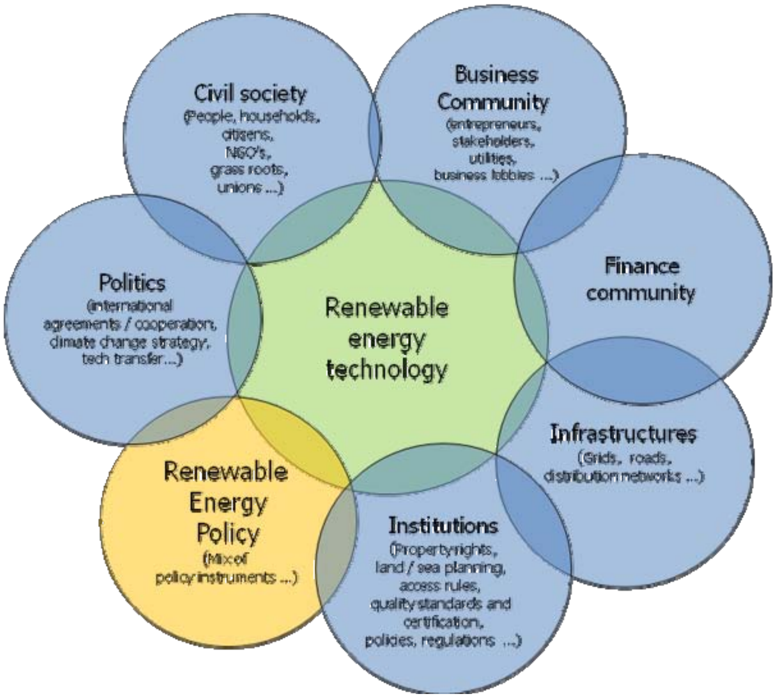

Figure 12: RE technology is embedded in an enabling environment, RE policy is one decisive dimension of this environment, but not the only one

A critical issue in deploying clean energy innovations relates to this environment. RE policies cannot be developed in isolation of other policies. Thus, such an environment must address the social and global dimension of the energy transition and the articulation of RE policies with other policies such as climate policy. And in such an environment, well-designed policies are more likely to emerge and they will be more effective in rapidly scaling up RE. This "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).

We utilize the term and concept of 'enabling environment' to reflect a larger set of issues operating at a higher level than individual policies such as the precise form of a carbon price or a RE subsidy provided. As such, this notion points at a larger framework which, if developed and settled, greatly facilitates the sustainable emergence and the development of a new technology or set of practices. Section 11.7 takes this one step further, and examines the requirements beyond the energy system to enable the structural shift to RE as the standard energy provider.

This does not mean to say that such an environment has to be set before any policy is put in place. It is often necessary to proceed with a policy before an enabling environment is established. Successful experiences suggest that developing such an environment largely contributes to the emergence of well-designed policies and their success. A number of important enabling conditions exist. We first describe the main issues associated with the systemic dimension/character/property of innovation pathways. We then analyse these enabling conditions, organizing them by broad themes – i.e., risk and uncertainty, access to financing, social innovation, fair access to RE resources and market, technology transfer and articulation to climate policy - in order to evaluate the extent to which each of these conditions is present or absent in the context of RE technologies.

11.6.1 System change and innovation pathways

It is often argued that the success of a radically different technology requires a change in the overall momentum of the technological system. What this means is a change in the social, institutional and economic arrangements and infrastructures that have grown up to support the existing pattern and technological use, sometimes described as the technological regime [Authors: Reference is missing]. The process of changing technological regimes is described as a transition or transformation (Geels, 2005c).

The current transition is different from earlier ones in that it has to be deliberate, meaning that action must be taken to make it happen because it will not occur on its own in a business-as-usual energy system, and it must happen on a short time scale The current view about how this should, or could occur ("transition management") suggests exploring various options (niches) for guiding variation-selection processes in more sustainable directions. It is about transformative change in societal systems though a process of searching, learning, and experimenting that relies on modern types of governance.

It is assumed that all levels of government play an important role in facilitating the necessary changes (Rotmans, Kemp et al. 2001b; van den Bergh and Bruinsma 2008 XX) but individuals and communities are also important. The state being embedded within wider networks in civil society and market systems, state actors rely upon non-state actors in the formulation and implementation of public policy. In turn, managing transition plays on different modes of collective action; it critically involves networks and coalitions in order to build guiding visions and transfer skills

Such a view draws upon an evolutionary understanding of technological paths and the approach to strategic niche management (e.g. Smith et al. 2005; Kemp et al., 1998 XX). According to this understanding, transition might occur thanks to the interplay between deep structural trends (also termed ‘landscape’) such as: economic growth patterns, immigration, predominant political positions and cultural values), technological regimes and technological niches (radical novelties). Regimes are stable because of their strongly interlinked elements. In stable situations, regimes select and retain preferred niches so that innovation tends to be incremental. If the regime is confronted with changes at the level of structural trends, the linkages may become looser and actors are able to search for new solutions or new ways of doing things. This creates opportunities for ‘niche break-out’ (Geels, 2006) meaning new ways of doing things or for strategic niche management, as described in the above. New technologies may develop with the old, there are reconfigurations and a chance for more change. In this way, niche applications gradually increase and further reinforce change.

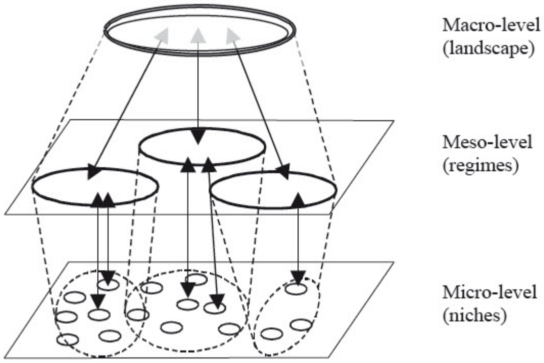

Figure 7:Interaction of innovation processes between different scale levels (Geels and Kemp, 2000)

Figure 13: Interaction of innovation processes between different scale levels (Geels and Kemp, 2000) [TSU: Figure needs to be redrawn – eliminating original figure title]

The way a country views innovation, or the process of change, is thus very important for a country’s ability ‘to do things differently’ and engage into the transition (Mitchell, 2008). If the specific goal is to innovate and rapidly disseminate RE technologies throughout the world in the span of just a few decades, the innovation system – that is the evolution from micro-level (niche) to meso-level (part of the new technological regime) - must be understood and exploited by a host of key actors, including policy makers, international agencies, businesses, regulators, RE technologists, financial institutions, educators and urban and regional planners. Collectively, these actors must provide the “enabling environment” for advancing a “RE technology innovation system.”

The key challenges posed by innovation relate to its systemic nature. Researchers in technological innovation increasingly depict the innovation process as an “innovation system.” By this they mean that, even if a pathway can be followed (such as R&D, demonstration, deployment, diffusion, and commercial maturity) (Haites et al, 2008) [TSU: Reference missing from reference list] this rarely occurs in a linear sequence that starts from a single invention of an individual innovation to its dissemination in the marketplace. Instead, a given innovation is more likely to occur in concert with several other associated or overlapping innovations, each providing “spillover” benefits to the development of the other. It is in this sense that the literature sometimes refers to “innovation clusters,” “innovation pathways,” and “innovation webs.”

(Smith et al, 2005) Awareness of this "system" character of technological innovation can help policy makers avoid some of the less successful approaches of the past, such as one sided or isolated "product push" (financial and/or regulatory support to the developers and producers) or "demand pull" approaches (support to market demand). Such supports have more chance of long-run success if they do not ignore other critical characteristics and components of the innovation system (Grubler, 1998, Mowery and Rosenberg, 1989).

The main challenges posed by innovation systems are the following.

First, technological innovation refers not only to "inventions" of hardware (equipment, structures, artifacts), but also the software (scientific knowledge, design and operating specifications, wisdom) and the "orgware" (institutions, organizations, social networks, human relations) associated with a particular idea or thing. "Innovation" is thus successful when it meets a private or societal want or need. Second, technological innovation is the consequence of at least three distinct drivers: R&D (or RDD&D)[8], learning-by-doing[9] and spillovers[10] (Freeman, 1994; Grubler, 1998). Because spillovers benefits are uncompensated, the RD&D effort that created the innovation has public good (positive externality) attributes and will generally be underprovided by private markets alone, thereby providing a rationale for public expenditure on R&D (Arrow, 1962).

Third, incumbent technologies usually benefit from "economies-of-scale"[11] which reduces their cost. High up-front costs make it difficult for a small firm with a technological innovation to enter the market even if its innovation could eventually be cost-competitive were it to gain a large enough market share to realize its own economies-of-scale. At the same time, as noted in Section 11.4, the high fixed costs make large, incumbent firms resistant to those technological innovations that might revolutionize the industry – even if these are generated within their own firm – because these might render obsolete their existing investments in equipment, industrial processes, buildings and even infrastructure. In electricity, some long-run forecasters believe that renewables-based, decentralized electricity production (especially solar) might one day pose a similar threat to the massive capital investments in fixed electricity distribution lines.

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[8] [Authors: To be submitted to SRREN Glossary] "R&D": R&D extends along a continuum from fundamental research at one end to applied research at the other. To the extent that the latter is intimately associated with the commercial appearance of a new product, process or idea, it is sometimes referred to as RDD&D (research, development, demonstration and deployment).

[9] [Authors: To be submitted to SRREN Glossary] "Learning-by-doing": refers to the technological advances, usually of a cost saving nature, that result as the innovation is adopted in growing numbers. The effect of learning by doing is sometimes depicted by "experience curves,"

[10] [Authors: To be submitted to SRREN Glossary] "Spillovers": Spillovers is cited as one of the primary sources of knowledge that drives innovation (Klevorick et al., 1995). Spillover is the knowledge benefits that transfer deliberately or inadvertently from the originator of an innovation to other entities – often to competing companies.

"Experience curves": Experience curves show the decline in cost of a technological innovation as its production levels rise (Argote and Epple, 1990; Yelle, 1979 XX). Such curves have even been estimated for some energy technologies (McDonald and Schrattenholzer, 2001 XX).

[11] [Authors: To be submitted to SRREN Glossary] "Economies-of-scale": Economies-of-scale are associated with production and/or delivery systems that have high fixed costs, such as a distribution networks (in electricity delivery). As these fixed costs are spread over many customers, average costs fall, meaning that large firms can provide the good or service more cheaply than several smaller firms.

Fourth, technological innovations that are “evolutionary” tend to have an advantage over innovations that are “disruptive” or “revolutionary” – the former can diffuse within the existing technological system while the latter require a profound transformation of that system (Mackay and Metcalfe, 2002). A new hybrid gasoline-electric car (“evolutionay”) can mesh with the existing refuelling infrastructure, while a hydrogen fuel-cell car (“disruptive”) requires major new investments to produce hydrogen and a new network infrastructure to deliver it. If society wants the hydrogen outcome for some reason, it must overcome economies-of-scale and other challenges to revolutionary technological innovation. All these elements confer advantage to incumbent technologies not only at the hardware level, but also at the “software” and “orgware” levels. Actors (e.g. researchers, engineers, technicians, business managers, entrepreneurs, educators, policy makers ...), institutions (e.g. codes, standards ...) and even the very structure of the economy (e.g. industrial organisation, population location ...) or the social norms and values (e.g. consumer preferences, political expectations and perceptions of investment risk ...) end up depending to some degree on the existing technological path (Nelson and Winter, 1982[TSU:Reference missing from reference list]). This is why analysts of technological change use terms like “path dependence” and “lock-in” to describe the systemic advantages that incumbent technological systems have over revolutionary technologies (Grubler et al., 1999; Unruh, 2000; Arthur, 1989).

Overcoming these advantages requires both an understanding of just how systemic they are as well as an ability to mobilize a wide diversity of resources and agents for wholesale change.

Entrepreneurs, the finance community, decision makers, elites and civil society all have decisive roles to play in structural change, but they should not pursue separate paths. Entrepreneurs cannot make miracles happen. For example, if their innovation has a great social value in one respect (for example, zero greenhouse gas emissions) but this value is not recognized in the market place (because of unpriced externalities) and not recognized in policy (e.g., emissions pricing, capping emissions or restricting the use of emitting technologies), or if the changes in tastes and social norms required for this technology to be adopted are not addressed by existing policy frameworks, then it won’t be taken up. R&D is a critical component of technological innovation, but R&D that is not intimately connected via social and institutional networks (government, researchers, entrepreneurs, consumers) to the commercialization and deployment process, is not likely to benefit from spillovers from these other activities and actors. Decision makers and elites play a key role in signalling social and technological goals, even though such a statement might initially be vague, and then in ensuring the existence of favourable market conditions, notably the “artificial niche market”[12] that helps renewables-based technological innovations cross the “valley of death” (see Section 11.5.1).

Finally, the disruptive change implied by a dramatic increase in the market share of RE requires the general mobilisation of financial and human resources necessary to sustain and legitimize the new technological innovation system. This mobilisation involves not only financial, technical and educational resources, it also requires innovative policies by government, education efforts by societal leaders and the counter resistance to the dominant technological system by fostering

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[12] [Authors: To be submitted to SRREN Glossary: “Valley of death”: The valley of death the tenuous phase between the introduction of the first commercial products – which therefore do not yet benefit from economies-of-scale and economies of learning – and widespread market diffusion (Grubb, M., 2004 XX)

coalitions of entrepreneurs, environmentalists and technology advocates who will support it (ensuring access to land for wind turbines and to land and water for small-scale hydropower).

11.6.2 Addressing Risk and Uncertainty

Reducing risk for RET investors is central. 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, has to occur. This is the notion of the *risk reward ratio*, where the risk is reduced such that the reward is acceptable to induce investmentRecent evidence, notably in relation with the development of wind energy, has pointed at two important lessons: i) Beyond well adjusted policy instruments such as taxes, FITs or quotas, political stability and inventive institutional setting can significantly contribute to policy success by reducing the risk for investors; ii) Clear, long-term, consistent signals and robust policies often result in high rates of innovation, policy compliance, and the evolution of efficient (low-cost) solutions.

Three different dimensions of the enabling environment can reduce uncertainty: political stability, political commitment, inventive institutional settings.

11.6.2.1 Political stability

Political stability relates to the stability of a political vision, so that the policy frameworks which are adopted in order to sustain the deployment of renewable energies can be perceived, by investors, as stable and credible enough over the term needed for this deployment. Political stability ranges from mere regime stability to the uncertainty implied by political alternation. For instance, Van der Horst & Evans (forthcoming 2010) have explored farmers' choice in the context of recent developments in biomass energy in the Yorkshire region in the UK. They point at the technical risk incurred by farmers in opting for biomass plants (e.g., Miscanthus or Willow) which have expected lifecycles that are much longer than that of the (agricultural) policies that seek to persuade them to do so. Thus, the perception of the risk associated with this change is clearly dependent on the stability of a political vision beyond the current political power and the currently implemented energy or agricultural policies.

11.6.2.2 Political commitment

Commitment relates, in a stable political context, to the commitment to both a vision and a definite policy framework in favour of RE. RE deployment has been much more successful in the countries where governments have 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 & Lauber, 2006 XX) or Denmark approach to wind power policy. The recent experience with these successful cases proves the critical character of political commitment. Even in these stable environments, any threat to the political commitment has resulted in a direct slowdown in the deployment of RE capacity. This was the case in Denmark when political uncertainty ruled the debate over the recent change in wind power policy (from FIT to incentive based system) (Agnolucci, 2007a XX). It was also the case in Germany, in three instances when either national factors or the political vision of the European Commission increased uncertainty as regards to the future of the RE policy framework (Agnolucci, 2006 XX). Symmetrically, the lack or delayed development of such long-range and stable political commitment has been shown to explain the differences in wind power development in different countries (Meyer, 2007, Soderholm et al., 2007 XX).

11.6.2.3 Innovative institutional settings

Innovative institutional settings are a third and important factor for risk reduction. They are for instance long term contracts, new investment vehicles, or community ownership. The development of these settings often relies on the initiative of the private sector but, combined with RE policy incentives, they succeed in securing investment channels.

Long-term contracts, for instance, have played a decisive role in stabilizing investors' expectations, such as in Texas (Langniss and Wiser, 2003). Without such contracts, RE developers are faced with highly uncertain returns and electricity retailers risk not being able to procure the requisite number of certificates per year. Supply constraints or market manipulation might result in certificate prices that are too high prices for the market?? Long-term contracts also ensure developers a stable revenue stream, which eases their access to low-cost financing. The contract terms can also penalize project construction lags or operational problems, as they did in Texas, which helps to accelerate RE deployment.

The broader institutional environment can foster the emergence of these new institutional settings in many ways, be it only by providing reliable institutions for their enforcement and flexibility for private parties to innovate in this area. Public institutions can also get directly involved into public-private partnerships, as they did in Spain for wind power (Dinica, 2008). The high investment risk in the first versions of the Spanish FIT was mitigated through the implication of a specific public agency, which acted as an investing partner into the wind power projects.

Risk reduction is also decisive for private household- and micro-generation. Changing energy systems presents 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 and local banks as well as local entrepreneurs (Pokharel et al., 2008). However, if risks are lower, households prefer to have their individual choice. Best examples can be taken from community owned micro-hydro systems and individual solar home systems. Micro-hydro has higher investment and risk could be high, however in the case of solar home systems, investment requirements are lower and risk is thus relatively low. So policies must also be formulated accordingly.

Inventive business models have become part of the new institutional settings. Emphasis has recently been put on the role of new business models (i.e., partnerships between global companies and government, local enterprises, donors or NGOs) in reaching the 4 billion poorest people, the “base of the pyramid” (BoP) (Hart & Christensen 2002; Prahalad 2006; Kandachar & Halme 2008; IIED, 2009 XX). Since 2000, a number of projects have been launched to meet the demands in the BOP markets. Collaborations with non-traditional partners have been tried in order to understand the cultural values in the potential market, to adapt cost structures, distribution channels and marketing approaches. The cases show that business targeting BOP markets can contribute to poverty alleviation and to energy access (e.g., IIED, 2009). A key challenge for policies is to develop support for starting up and scaling up business activities that are aimed at the poorest people.

While the majority of the BOP cases have focused on activities of multinational companies in developing countries, less is known about the dynamics of models deriving from small and medium-sized enterprises (SME) that constitute most of the private sector. Smaller local firms are often the ones that reach the poor more effectively and shall be associated with these new business models. Social enterprises or social investments tied to a core business also play a decisive role.

Finally, in spite of encouraging outcomes, more knowledge shall still be gained about the actual departure in sustainability practices of these experiences.

11.6.3 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 [ADB, 2007]. In 2005 the private sector accounted for well over 90 percent of all investment in the RE sector [UNFCCC, 2007].

The universe of private capital sources most relevant to the RE sector include corporate investors such as utilities, banks, institutional investors[13], 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 [ADB, 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 and country risks* – concerns regarding political risks can influence investor attitudes, capital allocation strategies of fund managers, and risk premiums.

- *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

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[13] Institutional investors are most commonly pension funds, insurance companies or sovereign wealth funds – entities with a mandate to make long term investments for their shareholders.

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.
- *Currency risks* – the risk of currency devaluation in cross border and cross currency investments can hinder access to financing particularly in less developed economies. Currency hedging instruments exist to help investors manage this risk, but only in the more developed financial markets.
- *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 [ADB, 2007].

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

11.6.4 Sustaining Social Innovation

Social innovation is about the ability of people and/or institutions to adapt to the emergence of new social norms or institutional organisation. The process of technological change and deployment is a systemic one; national government plays an important role in this process but civil society (individuals and communities) is also important. The reasons why people do not change or are able to change differs. This is also true for institutions; they can continue with the way they do policy or follow a more reflexive path and learn from the outcome of policies that have already been implemented. These dimensions are interlinked. The way in which civil society and the institutional dimension are combined into enlarged governance, or undertake some sort of reciprocal empowerment, is decisive for the ability of the system to foster technological deployment. Social innovation, especially in the implementation phase, is a resource for policy success. In the following subsections, social innovation is analysed along three dimensions: the factors that influence changes in people's values and attitudes (evolving social norms); factors behind institutional learning, and the role of civil society in the implementation of RE policies

11.6.4.1 Changing values and attitudes, evolving social norms

RE policy has typically focused on policies that create obligations or alter incentive structures for innovation and diffusion (e.g., regulation, price mechanisms, and R&D support). We focus here on information and education-based approaches that seek to create an enabling environment for RE. These "new tools for environmental protection" have been widely used in the energy sector but in the context of energy demand and efficiency rather than RE (Dietz & Stern, 2002).

11.6.4.2 Values and Attitudes: Targets for Education and Information Policies

Public education on RE is typically targeted at a general audience through mass media channels. It seeks to change values through moral suasion 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 (Poortinga et al. 2004; Gatersleben et al. 2002). 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, Abel, Guagnano & Kalof 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 (see Ajzen 1991 and Oskamp 2000 respectively). Positive attitudes are further reinforced by public commitments and targeted feedback (Staats, Harland & Wilke 2004).

A number of recent reviews discuss the role of information and attitudes in behavioural models and settings relevant to the environment (Jackson 2005; Halpern et al. 2005; Wilson & Dowlatabadi 2007; Darnton 2008). 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 1995; Armitage & Connor 2001).

For RE, key elements of context include capital costs and availability, and regulations on, for example, local planning, grid connections and power sales. The alignment of, and consistency among, the various components of a RE policy framework are also important (Owens & Driffill 2008; Stern 2000). Other contextual constraints relevant to RE include capital availability, perceived landscape values, and community governance traditions. Past experiences and habits of residential customers also explain their reluctance to switch electricity suppliers, even when information on the benefits of switching is provided to them (Brennan 2007). More generally, systems of energy provision and use are deeply embedded in household routines and social practices (Shove 2003; Shove 2004). 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 et al. 2009).

11.6.4.3 Passive and Active Behaviours, and Energy Citizenship

Behaviours targeted by education and information-based policies may involve either ‘active’ or ‘passive’ support for RE (Stern 2000). Examples of passive support include subscribing to a campaigning NGO, or supporting a policy to increase the share of RE in the supply mix. Examples of active support or engagement include adopting a distributed RE technology (Sauter & Watson 2007), or switching to a RE electricity supply at a premium over conventional tariffs (Brennan 2007).

Context exerts a stronger influence on active forms of engagement that require specific and deliberate behavioural choices. This creates 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 DG and RE (McGowan & Sauter 2005; Bell et al 2005). This gulf is particularly evident in the outright opposition to wind power projects (discussed with examples in the case of New Zealand - Graham 2009 and in the UK - van der Horst 2007).

The concept of “energy citizenship” describes a further deepening of active support for RE into an active participation within the energy system (Devine-Wright 2007). “Energy citizenship” is enabled by a decentralisation of energy system governance which in turn allows hitherto consumers to take on a variety of roles including that of producer (Sauter & Watson 2007).

Active behavioural support for RE can “spillover” into other energy and environment behaviours (and vice versa). As examples, individuals may be more likely to install micro-generation at home if they are already involved in community-based RE projects, or may reduce residential energy use to a greater extent if they have already installed a PV system (Devine-Wright et al, 2007; Preston et al, 2009).

11.6.4.4 Social Norms and Social “Visibility”: Other Policy Targets

Education and information may also target social norms. These are shared rules and expectations about behaviour. They may or may not be tacitly sanctioned (Cialdini 1990). Norms are transmitted through personal networks of peers, reference groups and role models. Consequently, normative approaches are often focused at the community level (McKensie-Mohr & Smith 1999). Research has found social norms to explain and also influence energy-related behaviour (Wilson 2008; Nolan et al. 2007).

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 (Rogers 2003, Archer et al. 1987; Jager 2006). The literal visibility of residential wind or solar may help RE become a normative talking point (Hanson 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 (Jager 2006; Kaplan 1999).

11.6.4.5 Allowing for institutional learning

RE policies are most effective when they are tailored to the local needs and conditions. Coordinating RE policies with other policies in key development sectors contributes in achieving this. The capacity of the institutional environment to involve various stakeholders and policy communities in the policy process, so as generate collective learning and new institutional capacity, has been highlighted as a favourable factor behind policy success. Bringing different communities (e.g. energy, environment, land planning, expert, NGOs, pressure groups ...) into a common policy network enables policy making to become more comprehensive and reflexive. When policy communities are heterogeneous it is easier to evolve and adapt policies so as to better respond to local political, economic, social and cultural needs and conditions [Authors: Reference is missing].

Breukers at al. (2007) have compared wind power policy processes and institutions in three European countries (Netherlands, United Kingdom and Germany). They have analyzed the ways in which the energy, planning, environmental communities and policy domains were (or not) integrated into a wind power policy community in each of these countries. The comparison points to a positive relationship between successful wind power deployment and the emergence of a heterogeneous policy community, whose demands are taken into account at the various levels of the government (national, regional, local). This was, for instance, the case in Germany (state of North Rhine Westphalia) where the policy approach was very responsive to the wind sector and to the strong pro-wind grassroots movement, and allowed the early consolidation of a mixed policy community. In the Netherlands or the United Kingdom, this did not take place partly because of a dominance of the conventional energy sector or because of a more fragmented, less committed approach to wind power policy.

Similar types of evidence have been shown in other countries in which centralized energy institutions, techno-institutional lock in into some type of conventional energy or a tradition of corporatism reserving the access to the policy arena to certain groups, have also made the emergence of such policy community more difficult (e.g. Nadai, 2007; Szarka, 2007 for France).

Such institutional capacity can also be fostered at the international level. In the field of bio energy, the Global Bioenergy Partnership (GBEP, http://www.globalbioenergy.org [TSU: URLs are to be cited only in footnotes or reference list.]) provides a forum for high-level policy dialogue on bioenergy. It aims at supporting national and regional bioenergy policy-making and market development, and at facilitating international cooperation. Partners can organize, coordinate and implement targeted international research, development, demonstration or commercial activities, with a particular focus on developing countries. GBEP also provides a forum for implementing effective policy frameworks, identifying ways and means to support investments, and removing barriers to collaborative project development and implementation.

Table 6: The integration of policy domains into the German wind power policy community (adapted from Breukers and Wolsink, 2007)

Energy policy domain >>	No dominance of the energy sector . Not involved in wind power, trying to impede development	Late liberalisation . 1998 -> Limited impact on wind policy	Grass roots citizens' projects . Later less locally based ownership (companies, investors funds)	Successful Turbine industry . Strong home market, export product	Stable Financial support . Focused on yield, encouraging diversity
Planning policy domain >>	General tendency . Decentralised with a centralising tendency	Local planning . Local authority obliged to take pro-active decision	Wind power planning policy . Privileging wind turbines, focus regional	Project planning approach . From grass-roots, tendency to less locally based projects	
Environmental policy domain >>	Grass-roots environmentally inspired local initiatives, increasing leverage, matched with policy priorities and strategy	Environmental concern, early institutionalisation In policy and politics	Policy integration, particularly North Rhine Westphalia		
Policy community formation >>	Early formation network . Bottom up, founded by anti-nuclear movement	Early consolidation on various levels	Local grass-roots Pro-wind strong, anti-wind emerging	Government commitment Federal and state policy, committed to ecological modernization and responsive to the wind sector	

11.6.4.6 Civil society and the implementation capacity

Because of risk aversion, habits, inertia to change or acceptance issues, civil society (the "social") has often been framed by policy analysts as a source of barriers to the deployment of RE technologies. However, recent evidence has also pointed to its positive role, notably in policy implementation. The taking into account of this role is now part of a "new policy paradigm that reaches beyond measures to increase production capacity per se to embrace both the institutional dynamics of innovation processes and the fostering of societal engagement in implementation processes" (Szarka 2006b).

The notion of "implementation capacity" (IC) (Agterbosch 2004, 2009) has been proposed in relation to wind power policy. It points to a set of technical, economic, institutional and social conditions that jointly contribute in enhancing the performance of different types of private actors (e.g. regional distributors, small wind power entrepreneurs). IC is defined as the capacity of these actors to deal with prevailing institutional structure (i.e. electricity regulation, nature conservation norms; planning procedures) through social skills (e.g. management styles, informal contacts) and social conditions (e.g. trust or social coherence) so as to get their wind power project developed. This inside look shows that social relations at the local level facilitate coordinated actions and project development. They add to the scope and structure of knowledge of private actors and to their bargaining position as small private investors on the liberalizing electricity market, and they contribute to clarify implementation and social acceptance.

The key role of non-state actors (i.e. Natural Regional Parks, bird protection NGO's) has also been pointed at in France, where they have contributed to evolving planning and siting frameworks for wind power, notably through the renewal of landscape values or bird protection approaches at the local level (Nadaï & Labussière, 2009 and 2010 XX). The recent politics of wind power has led to the broader view that the acceptance or rejection of RE projects does not result from subjective whim, but that it is governed by a set of norms, related to the national and local contexts. These rules of the game (also called *acceptability*), which frame implementation processes, shall be regarded as a (local) social contract that is constantly evolved under the pressure of collective renegotiation and learning from policy implementation (Szarka, 2007).

Technology cooperation within social networks is another way in which civil society can enhance policy success. Alexandra Mallet has analysed the diffusion of passive solar heater (PSH) in Mexico city (Mallet,). 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 offset the shortcomings of public policy, especially its lack of leadership, coordination and readability.

The social structure of RE projects has also been shown to underlay policy success in developing countries. For instance, community based micro-hydro systems seem to work better than privately owned ones, because the comparatively low but acceptable financial return (low load factor and revenue) of these small projects does matter for a community pursuing socio-ecological welfare enhancement (Chhetri, Pokharel and Islam 2009). Communities investing in these projects get a return on their money in many ways besides the financial interest they receive. They can also implement shared projects faster as there will be less conflict surrounding them. In this context, the role of the civil society in making people aware of the benefits of RET, their ease of implementation and management, is a large reason for growing acceptances of RET in developing countries.

11.6.5 Ensuring Access to and a Fair Distribution of Resources

RE policies are most effective if they are coordinated with other policies (agricultural, construction, transportation, etc.) in order to respond to local political, social and cultural needs and conditions. Innovation, including social innovation, is more likely to occur when conditions are met such that actors can access RE resources and the market for RE under conditions that provide for social and environmental justice. Property rights are decisive for ensuring that this takes place, but other institutional dimensions are also very important. These dimensions include: land use / landscape planning, standards and access rules, and infrastructure policies.

11.6.5.1 Property rights

Since few areas in the world are truly devoid of/lack traditional uses, conservation values or existing commercial interests, it is unavoidable that the growing deployment of RE technologies will create tensions. Where the interplay of stakeholders' interests, technological development and an uneven geography can create challenges for accessing high-yield resources , rules are needed to resolve resource conflicts. Past evidence from common pool resources such as water management, suggests that there is a need to strike a balance between exclusionary property rights and more adaptive frameworks of governance which take wider sustainability issues into account.

Whilst conflicts over large hydro-power schemes have been studied extensively, the rapid developments of other RE technologies are now also resulting in a growing number of conflicts, ranging from the more abstract (e.g. environmental ethics, landscape aesthetics, political ideology) to the more concrete, such as conflicts over rights of way, compulsory purchase, compensation for lost income, and nuisance at the construction or operational phase. Existing interests often receive protection through spatial zoning , but conflicts may also ensue between different users not just of the same space but of the same actual resource within that space. There is also a potential conflict of interest between individual operators who want an unobstructed access to the energy flux their device can capture, and the state, which wants to maximize the total amount of energy captured even if that means that the output of individual operators is somewhat diminished by local resource competition. Resource conflicts over 'new' renewables such as wave and tidal energy are still hypothetical. For on-shore wind they are now emerging, especially where dedicated wind farm zones are filling up. For small-scale solar energy in some urban areas, frequent resource conflicts have already led to the development of solar access laws (Bradbrook, 1989; Rose, 1990; Brown and Escobar, 2007; Cowell, 2010; Ohl and Eichhorn, 2010).

With the exception of biomass, renewables are fugitive or mobile resources. The Justinian Digest in 533AD, declared the five elements: air, water, oil, sea and seashore as free to all, and thus owned by no-one. This question of ownership was first challenged when these elements were starting to be used for specific purposes (Wiel, 1934). The earliest written evidence in Northwestern Europe of using wind for providing mechanical energy is in records of legal disputes relating to the establishing monopoly rights to building and using windmills (Sistrunk, 2006a; Sistrunk, 2006b).

According to the classical (Blackstone, 1832) and more contemporary (Demsetz, 1967) property theory for natural resources, there are three evolutionary stages in the allocation of rights. In the first stage the resource is plentiful. It is open to all and owned by no-one. In the second stage the resource is becoming less plentiful and is therefore appropriated by a group and consequently becomes subjected to somewhat diffuse common property arrangements which are often customary based. In the third and final stage the resource has become scarce enough to be subject to individual property rights.

However, as demonstrated for water mills, not every natural resource follows the evolutionary theory of property rights (Bone, 1986; Rose, 1990). When water as an energy resource was becoming locally scarce as a result of the industrialization in the 19th Century, the scarcity has led to less, rather than more, clearly defined property rights over water in the United States (Horwitz, 1977). In those instances where water was used for operating water mills, instead of human, industrial or agricultural consumption, water usage very soon developed the characteristics of a common pool resource (Ramseyer, 1989; Rose, 1990). In order to ensure the full use of this scarce resource, a legal environment had to be created that could prevent high transaction costs and could manage the natural resource as a partial public good. This historic example demonstrates that there should not be a universal presumption that private individual property rights should always dominate over the systems of collective ownership: courts have in the past considered the nature of the resource and the uses, private or public, to which it can be put under existing and evolving technologies (Rose, 1990; Hart, 1998).

The anomaly of resource management moving towards more common property characteristics when the value of the resource increases, can be explained by distinguishing between exclusion and governance (Smith, 2000). There are many examples of successful solutions to the 'tragedy of the commons' (Hardin, 1968) that rely on rules of use or governance rather than rules of access or exclusive ownership (Smith, 2002). Where RE is stimulated through state intervention, it can be anticipated that rules of governance will have an important role to play in resource allocation. Dedicated RE legislation will have to regulate, amongst others, zoning, planning objections, nuisance, property rights and contract rights. Considering the locally specific nature of many of these issues for smaller scale on-shore renewables, it would make sense for much of this governance to be devolved to the local level; a point that is supported by the Californian experience with modern solar access laws (Bradbrook, 1989).

11.6.5.2 Planning, land and sea use (AN)

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 can evolve social norms, enhance social visibility and contribute in clarifying social acceptance or conflicts of usages. Planning certainly runs the risk of multiplying administrative procedures, but an appropriate planning framework can also contribute in reducing hurdles at the project level, making it easier for RE developers, communities or households to access the RE resource and succeed with their projects. 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...), whose cumulative changes also gain in being regulated.

11.6.5.2.1 Wind Power

The local acceptance of wind power has been an issue in many countries. Even Denmark and Germany, which are known for their successful 'civic model' based on local ownership, are starting to face issues of local acceptance (Möller, 2009; Meyer, 2007). Land use / landscape planning is a way to regulate the access to the wind resource while accounting for the concern of the public and the local specificities (e.g. Nadaï & van der Horst, 2009). Its fine tuning is part of the challenges that policy makers face in adjusting the decentralization of energy policy to renewable energies (Kahn 2003; Soderholm & al., 2007 for Sweden; Smith, 2007 for the UK;

Nadaï, 2007 for France). The recent evidence as regards to wind power planning (Ellis & al. 2009 XX) shows that acceptance is a dynamic variable over the course of the planning / project process. Difficulties are increased by poor planning or project management, and insensitive decision-making processes such as: late public consultation, disqualification of opposition, adversarial climate, lack of neutral arbitrage ... (Cowell 2007, Toke 2005, Toke & al 2008, Meyer 2007, Wolsink 2000 XX). Top-down planning processes, because they rely on existing landscape norms/ values, tend to direct wind power deployment towards non-protected, allegedly 'less sensitive', areas and to increase social and environmental injustice (Cowell, 2009 XX). Conversely, planning approaches which are participative (Haggett, 2008 XX; Mclaren Loring, 2007 XX) and attentive to the potential for social innovation at the local level contribute to a fair access to the resource (Nadaï, 2009 JPTP; Labussière & Nadaï, 2009 & 2010).

11.6.5.2.2 Ocean Energy

The planning of sea space is necessary to coordinate national plans for the energy transition, to regulate/mitigate conflicts of usage, and to allow for simpler downstream administrative procedures in the development of RE projects.

The development Marine Spatial Planning (MSP) in Europe is recent. Only a few planning schemes have been completed (e.g. Belgium, Germany and Netherlands). They tend to emphasize the ecological dimension; the social and economic sustainability are not systematically integrated. These approaches still lack the necessary international perspective, notably concerning the Exclusive Economic Zones (EEZ) for which countries by international law have a responsibility towards sustainable use of its resources (Douvere & Ehler, 2009 XX; Stel & Loorbach, 2003).

Different from land planning, MSP was initially rooted in ecosystem and integrated management approaches, with an emphasis on ecology and place-based management. It is only recently that attention has been placed on managing the multiple uses of the marine space, including the production of renewable energies (offshore wind power and ocean energy) and the broader social and economic issues (e.g. Side et al. 2002 for the UK). Recently, guidelines for MSP have been developed under the umbrella of international institutions (Douvere & Ehler, 2009; UNESCO, 2009 XX), which propose an operational framework to conserve the value of the marine heritage while simultaneously allowing sustainable use of the economic potential of the ocean.

The development of MSP is likely to meet some resistance, as do ecosystem approaches to marine resource management (Murawsky, 2007). Indeed, both approaches imply broader stakeholder participation in the overall management of the sea space, which is new. In particular, the importance of the offshore activity to the onshore communities and economies is not always well integrated in these plans. First studies show nonetheless that local stakeholders can be positively disposed to a local MSP process if it incorporates meaningful local involvement (Flannery, 2008).

11.6.5.2.3 Other Renewable Energies

Small scale RE systems raise various types of planning issues. The German and Japanese experiences with solar energy have proved that the lower costs of this technology relied on a large array of factors (e.g. mature markets, lower non-R&D market barriers, improved distribution channels, installation practices, inter-connection) including siting and permitting conditions. In developing countries, the development of small solar systems (cookers, water heaters, PV) depends on the planning of the buildings while under construction (kitchen, veranda, roof). Micro/pico hydro systems also require proper planning in order to protect the quality of drinking water supply and to minimize ecological impacts, landslides and irrigational impacts.

In the case of biomass energy, nature conservation policies and targets for biodiversity protection determine the extent to which nature reserves are protected; they also set standards for the management of other lands. The regeneration of degraded lands (and required preconditions) is generally not attractive for market parties and requires government policies to be realized.

11.6.6 Innovation pathways in the context of a global economy: Supporting Technology Transfer

"Technology transfer" is broadly defined as the flow of technologies and know-how within and between countries resulting from a variety of arrangements and exchanges, including international trade, overseas development assistance, foreign direct investment, international exchanges and cooperation in scientific and technical training (Keller, 2004, IPCC, 2000). The focus in this section is on international technology transfer in keeping with Article 4.5 of the Framework Convention on Climate Change, which states that developed country Parties "shall take all practicable steps to promote, facilitate, and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention," and to "support the development and enhancement of endogenous capacities and technologies of developing country Parties."

The theory and practice of international technology transfer is, in many ways, still in its infancy. There is no dominant view as to the most effective means of transferring technology from developed to developing countries – and in some cases vice versa – although there are case studies of the many efforts that have been relatively ineffective in the past, as well as some of the few, more positive experiences.

A comprehensive framework for evolution of technology transfer has emerged, which recognized the necessary complementary aspects of hard ware, org ware and soft ware as detailed in Section 11.6.2, as well as opportunities for technology leapfrogging[14] Most importantly, the roles of government, the private sector, research and NGO organizations have become increasingly clear, in particular to create the enabling environments, education and investment mechanisms required to create sustainable, scalable businesses that take full advantage of the innovation cycle. As show in Figure 14 below, both technology push and market pull dimensions must be addressed to overcome barriers and enable sufficient technology diffusion at speed and scale via profitable businesses. Within this the role of government in providing not only a supportive policy environment, but also funding, fiscal policies, and the establishment of standards and regulation, is recognized as a critical element.

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[14] Technology Leapfrogging has been defined as the use and development of advanced technologies in emerging economies that explicitly skips generations of technologies. For example, the development of and wide spread use of cellular phones for ubiquitous service, skipping the expansion of traditional physical wire networks.

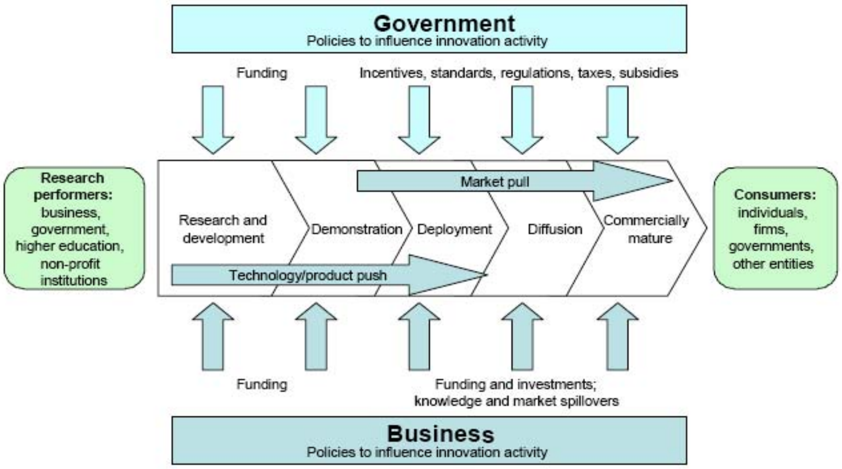

Figure 14: Factors influencing the Innovation Cycle (Metz et al, 2000)

Okwell et al (2008) have proposed a framework for technology transfer for low carbon technologies to developing countries. Principle considerations include:

(1) technology transfer needs to be seen as part of a broader process of sustained, low carbon technological capacity development in recipient countries;

(2) technical maturity as well as localization may be required for successful comprehensive “technology transfer” to occur. For example, photovoltaic lighting in rural emerging economies may be based on mature solar cell technologies, and includes the system design, installation and training that are specific to the local market conditions. Additionally, barriers to transfer and policy responses will vary according to the stage of technology development as well as the specific source and recipient country contexts. That is, less mature technologies may require government development support for maturation and localization, as well as policy and regulatory advances to address the recipient country market barriers.

(3) less integrated technology transfer arrangements, involving, for example, acquisition of different equipment from multiple manufacturers, are more likely to entail knowledge exchange and diffusion through recipient country economies. In this case, system design and integration will predominantly occur in the recipient country and will drive expansion of local knowledge as the market expands. Recipient firms that, as part of the transfer process, strategically aim to obtain technological knowhow and knowledge necessary for innovation during the transfer process are more likely to be able to develop their capacity as a result;

(4) the transfer of Intellectual Property Rights (IPRs) may sometimes be a necessary part of facilitating technology transfer, but they are not likely to be sufficient to lead to success. Business management, technology risk and adaptive capacity may be more critical considerations;

(5) national and international policy interventions have significant influence. For example, aggressive national policies for RE in China and India have provided significant influence on the development of locally-based solar and wind energy companies that are increasingly active internationally.

Further, as reported by the Expert Group on Technology Transfer (FCCC/SB/2009/3), a comprehensive framework for technology transfer includes the following key elements:

(a) Expanded **research, development and demonstration**;

(b) Enhanced **enabling environments and capacity-building** to overcome policy, information, capacity and infrastructure barriers to technology deployment and diffusion;

(c) Increased **financing facilitation and support** to increase the level of investment in technologies;

(d) Integrated industrial and societal **sectoral planning and cooperation** to implement technology transfer initiatives as part of broader programs.

The strength of domestic policy environment is critical to successful technology transfer and may lead to reverse transfers as well. Lewis and Wiser (2007) have looked at policy environments relative to wind industry development and technology transfer. They examine the importance of national and sub-national policies in supporting the development of successful global wind turbine manufacturing companies. Comparing across 12 countries, they report that strong domestic market conditions are critical to the establishment of a domestic industry and that “reverse” technology transfer can occur in instances where the strong developing country industry may then compete internationally.

Further, recent literature also reports on the importance of innovation of both technology and business models with examples from power systems design, manufacture, sales, operations and maintenance, to “segment specific” business and technology solutions. For example, business models such as Grameen Solar [Authors: country?] (Martinot 2001) or Thai Biopower [Authors: country ?] (Forsyth 2005) have been evaluated to show that technology transfer can occur successfully with relatively low technology risk, in combination with financial innovation and business model innovation, within the enabling frameworks of domestic and international policies. Similarly, once businesses are established with sufficient financial resources to support local innovation, opportunities arise for technology and solution development that then lead to expanded technology transfer either to other developing countries or in reverse to developed countries in which the new solutions open up new market segments and solutions. (Immelt, 2009).

Studies on technology leapfrogging* for RE and other low carbon technologies are just emerging. For example, Lewis has completed a comparative evaluation of wind technology transfer in India and China, noting 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, 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, Unruh et al (Unruh 2006) reports that industrializing nations will be subject to Carbon Lock-In due to the substantial investments 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.

11.6.7 The economic implications of interactions between change mitigation policies and RE support policies

Policies to promote climate change mitigation and support RE need to take into account the underlying 'market failures' that stand in the way of these objectives (See Section 11.4). But their interactions with the rest of the economy and each other need to be taken into account if they are to be cost-effective and to avoid or minimize undesirable side effects.

11.6.7.1 The role of multiple 'market failures'

Multiple 'market failures' warrant the use of multiple policy instruments, each targeting a particular failure but taking account of their consequences for the rest of the economy (Tinbergen, 1952). Market failures are phenomena that prevent private economic agents participating in markets producing by themselves a pattern of production and consumption over space and time in which no-one can be made better off without someone else being made worse off; that is, they prevent a 'Pareto efficient' outcome (Bator, 1958). When they are present, public policy interventions can, in principle and if properly designed, enhance overall wellbeing. Policies may also be needed to compensate for the adverse impact of other public actions ('government failures' e.g. due to lobbying).

The market failure underlying anthropogenic climate change is due to the externalities created by greenhouse gas emissions – emitters have no incentive to take into account the damage their emissions do to others. But various market failures also afflict innovation (Stern, 2007, Part IV; Jaffe *et al*., 2005). These include:

- First, there are spillovers from the creation of new knowledge, because its use by its creator does not prevent its use by others (the use of knowledge is 'non-rival').
- Second, the benefits to society as a whole from R&D investment are often much greater than the benefits captured by the firms undertaking the investment (section 11.6.1); in other words, the social returns exceed the private returns (Jaffe, 1986; Griliches, 1992), on average by a factor of four (Popp, 2006). Popp argues that the social returns in environmental and energy R&D are comparable to those in other fields. Some approaches to correcting this problem can create monopoly power, which can give rise to a market failure itself.
- Third, there are externalities from the adoption of new technologies, due to network effects, learning-by-using and learning-by-doing (Jaffe *et al*., 2003; Edenhofer *et al*., 2005). These can lead to path dependence of the choice of technologies and the 'lock-in' of high-carbon plant and equipment discussed in section 11.6.1 (Unruh,2000; Acemoglu *et al*., 2009).
- Fourth, the generation of knowledge is affected by uncertainties and asymmetric information (Böhringer *et al*., 2009).
- Fifth, market failures in the rest of the economy can have implications for climate change mitigation and RE support. For example, Sjögren (2009) and Guivarch *et al.* (2009) explore the interaction of environmental and labour market imperfections.

No single policy instrument can correct fully all the relevant market failures. Indeed, in general, there need to be at least as many policy instruments as there are objectives for policy-makers

(Tinbergen, 1952). Otherwise, objectives have to be traded off against each other, and the costs of achieving any one objective are higher, because other objectives have to be sacrificed to some extent.

Thus, in the context of climate change, carbon pricing on its own is likely to under-deliver investment in R&D of new technologies (Rosendahl, 2004; Fischer, 2008)An optimal portfolio of policies can achieve greenhouse gas emissions reductions at a significantly lower cost than any single policy – although models suggest that the bulk of the emissions reductions will be brought about by the pricing element of the policy package (Richels and Blanford, 2008; Otto *et al*., 2008; Fischer, 2008; Fischer and Newell, 2008).

In Fischer and Newell's model, for example, the portfolio entails an emissions price, an R&D subsidy, and a renewable generation subsidy. Applying their model to the U.S. electricity industry, they find that the use of their assumed RE support policies allows the CO_2 emissions price to be 36 percent lower than it would have to be if hitting the chosen emissions target were to rely on the emissions price alone. The authors find that, using only one policy at a time, emissions pricing is the most cost effective, followed by the tradable performance standard, a fossil fuel energy tax, and finally by a quota (RPS). Popp (2006a) demonstrates that policy-induced R&D in zero-carbon 'backstop' technologies[15], such as RE, increases welfare (compared with when only an emissions price is available), despite the resource costs entailed in R&D activities. The less that R&D elsewhere in the economy is crowded out, the greater the benefits of induced R&D (Popp, 2006b). Grimaud and Lafforgue (2008) also find that the optimal policy portfolio entails both emissions pricing and subsidies to renewables R&D. If a 'green' R&D subsidy is impossible, the carbon tax has to be higher; and if the carbon tax is ruled out, the R&D subsidy has to be higher. The R&D subsidy reduces the adverse impact of climate-change policies on the welfare of younger generations.[16] The advantages of using multiple instruments are also evident when considering mitigation options other than RE, such as carbon capture and storage (CCS). Gerlach and van der Zwaan (2006) examine three emission reduction options – energy savings, transition to low-carbon energy technologies and CCS – and five possible policy instruments – carbon taxes, fossil fuel taxes, RE subsidies, a portfolio standard[17] for the carbon intensity of energy production, and a portfolio standard for the use of RE. They find that CCS helps to reduce the cost of climate policies, but it is still desirable to roll out RE technologies on a large scale. The most cost-efficient policy is a carbon-intensity portfolio standard, with carbon tax revenues being recycled to support RE deployment.

The path dependency of technological choices and its implications for climate policy have also been analysed. Schmidt and Marschinski (2009) note that new technologies (e.g. mobile telephones) have often reached a stage where economies of scale in production, and the incentive

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[15] A 'backstop' technology is a technical process that can be used instead of fossil fuels and can be implemented at constant marginal cost (Nordhaus, 1973).

[16] 'Feed-in' tariffs can be thought of as a form of renewables subsidy, with an element of carbon pricing to the extent that higher tariffs for renewables are reflected in higher average electricity prices to the customer and/or lower profits for the energy utility. The tariff may be differentiated according to the maturity of the renewables technology and hence act as an implicit subsidy to renewables R&D. [Authors: FIT is defined at the front of the chapter. Is this footnote needed here?]

[17] A 'portfolio standard' mandates that the portfolio of processes used to generate energy does not exceed a certain carbon intensity or comprises some particular proportion of RE sources.

of rising returns to R&D as output rises, have started to reduce costs fast enough to permit very rapid diffusion throughout the economy. Using a model of energy generation in which R&D responds positively to rising returns and there are several market failures, they find that multiple equilibria are possible, and policy instruments have to be used to push the world economy towards an equilibrium with high RE use. The optimal policy mix entails a tax on fossil energy, a R&D subsidy, an investment subsidy and a fee for employing initial public knowledge equal to the patent fee charged for private knowledge. Acemoglu *et al.* (2009) examine technical change that responds to the relative incentives across industry sectors, in a growth model with environmental constraints and limited resources. Technical change has to be encouraged in ‘green’ sectors rather than sectors producing greenhouse gas emissions. They show that profit taxes or other instruments are required in addition to a carbon tax, such as taxes on fossil-fuel energy production and innovation. But if renewables and fossil fuels are sufficiently substitutable as inputs to production, fossil-fuel energy production and innovation only has to be taxed temporarily, until the increased incentive for R&D in renewables has reduced their production costs enough to switch the economy on to a low-emissions growth path.

11.6.7.2 Climate change mitigation, renewables support and endogenous fossil fuel prices

Emissions pricing to tackle climate change may not have the desired impact on emissions or the development of RE if it drives down the pre-tax price of fossil fuels. Policy-makers need to take into account constraints and general equilibrium feedbacks throughout the economy when designing policy instruments and should not assume that market prices necessarily reflect resource costs in real-world settings (Dreze and Stern, 1990). An important example in the context of climate change and renewables policies is provided by the market prices of fossil fuels. These reflect not only the resource costs of extracting the fuels but also the rents accruing to their owners due to their scarcity value. Carbon pricing may simply push down the price received by the producers of fossil fuels, without affecting the final price to users; the scarcity rents from fossil fuel owners would then just be transferred to the authorities applying a carbon tax or to the owners of carbon emission quotas and the rate of extraction of fossil fuels would not be affected.

Indeed, if carbon pricing reduces the producer prices of fossil fuels, that will stimulate demand for them in any jurisdictions not applying carbon pricing. The prospect of policies to combat climate change intensifying and the carbon price rising over time may encourage fossil fuel owners to deplete their exhaustible resources more rapidly, undermining policy-makers’ objectives for both the climate and the spread of renewables technology (Sinn, 2008). Insecure property rights – perhaps made more so by the risk of coercive international action to curtail the use of fossil fuels – exacerbate the risk. Hence climate change mitigation policies and RE support policies could undermine each other through their impacts on fossil fuel extraction in the near term.

This analysis suggests that the optimal trajectory for the carbon price for maximising overall social welfare may not be a steady rise at the rate of interest, or the discount rate plus the rate of decay of greenhouse gases in the atmosphere, as often assumed in models of optimal climate-change mitigation policy (e.g. Paltsev *et al*., 2009). More attention needs to be given to the economics of exhaustible natural resources. Some analyses have suggested that the optimal trajectory is downward-sloping when there are negligible extraction costs, which is not a bad approximation for the largest OPEC oil producers. Such a trajectory would persuade resource owners at least to delay extraction, which would be beneficial because of discounting (Sinn, 1982; Sinclair, 1992, 1994). If these are correct, then policy makers risk undermining their objectives, including the large-scale adoption of RE, if they introduce a regime that leads to a rising carbon tax over time. Policies to promote renewables may shift the whole carbon price trajectory downwards, increasing emissions (Hoel, 2009).

But the availability of cheap fossil fuels need not undermine climate-change policies completely.

First, the optimal carbon price is likely to rise for some time, even in models where ultimately all the fossil fuels are extracted (Ulph and Ulph, 1994[TSU: Reference missing from reference list]). Hoel and Kverndokk (1996) show that, if the stabilisation of greenhouse gases in the atmosphere is possible with some residual steady-state greenhouse gas emissions, the carbon price should rise until some moment before stabilisation is reached and then fall, so that fossil fuels are conserved until they can be used cheaply and without harming the environment, alongside RE.

Second, except with very stringent atmospheric stabilisation goals, climate-change policy may actually raise demand over time for oil (especially for transport) , while reducing demand for higher-carbon-content heavy oils and synthetic carbon-based fuels, which are also more costly to produce (Persson *et al*., 2007). Oil exporters would therefore not need to rush to extract their oil prematurely. Meanwhile, policies to promote renewables would have the easier task of making them cost-competitive just with coal and synthetic fuels (Grubb, 2001).

Third, it is an empirical question how fossil fuel resource owners behave. Pindyck (1999) finds that the standard model of exhaustible natural resource pricing (e.g. Dasgupta and Heal, 1980), which underlies Sinn’s argument, works well for oil but less well for coal and natural gas. Fossil fuel owners may not be motivated wholly by profit maximisation, so other theories of price determination – such as those emphasising geopolitical and fiscal factors, particularly the need to finance public spending – may be appropriate, especially when the owners are public authorities such as sovereign governments (e.g. Slaibi *et al*., 2005). Similarly, customers for fossil fuels may affect market prices through their influence on their governments, who may use trade, energy and other policies to promote energy security (defined in terms of reliability of supply or scope for switching among suppliers). The corollary is that the interaction of policy instruments for geopolitical objectives with instruments for climate change mitigation and renewables support also needs to be considered.

Fourth, other policy instruments can be used to complement the pricing of the greenhouse gas externality and support for renewables. Sinn (2008), for example, emphasises the strengthening of property rights in fossil fuel ownership; technical means of decoupling the accumulation of CO_2 from carbon consumption, such as CCS and afforestation; and the advantage of strictly imposed quantitative limits on emissions over a conventionally calculated carbon tax. And OPEC members have argued for compensation for revenue losses incurred if they conserve their oil (Persson *et al*., 2007).

11.6.7.3 Potential problems with policy interactions

In principle, both carbon pricing and support for RE reduce the cost gap between renewable and conventional electricity generation. But if both are applied simultaneously, their impacts may not be the same as the sum of each implemented separately (De Miera et al., 2008; De Jonghe et al., 2009). The interactions of technology-specific policies – including renewable portfolio standards and feed-in tariffs – with market mechanisms such as a carbon tax, if not properly anticipated by policy-makers, can undermine the efficacy of each individual policy tool, and the suite of climate policies overall (Sorrel and Sijm, 2003; Rathmann, 2007).

If quantity-based tools (such as quota-based instruments) are used to pursue both climate-change mitigation and renewables objectives, it is possible that the permit price for one scheme will fall to zero (Unger and Ahlgren, 2005; De Jonghe *et al.*, 2009). Conversely, if one price-based and one quantity-based measure are used (e.g. a carbon tax and a renewable portfolio standard), the fixed price imposed by one measure could influence the market price of the quantity-based measure in undesirable ways. Hence coordination of policy instruments and an appreciation of how they will interact are crucial, both at the initial stages of policy formation and later, when circumstances change and uncertainties diminish (or increase) (De Jonghe *et al.*, 2009; Rathmann, 2007; Blyth et al., 2009; Verbruggen and Lauber, 2009).

11.6.7.3.1 Effects of RE Policies on the Carbon Objective

One way in which renewables policies may affect the carbon objective is through their indirect impact on the carbon price in a market-based cap and trade system. By substituting electricity generation away from fossil fuels, renewable mandates reduce the electric sector's overall CO_2 emissions. If there is an existing cap on emissions, this reduces the sectoral demand for allowances, and along with it the carbon price. A lower carbon price means that electricity producers' costs decrease, the marginal cost curve shifts, and wholesale electricity prices decrease (Rathmann, 2007; De Jonghe *et al.*, 2009; Stankeviciute and Criqui, 2008). That contributes to a 'rebound' effect, tending to increase energy demand. If the potential impact of renewables policies on emissions is not considered at the time that the emissions cap is set, their impact is likely to be entirely offset by this and other induced increases in demand. Introducing financial support for renewables in addition to a carbon price signal, without adjusting the overall cap on emissions, will tend to lower the carbon price, because it reduces the level of abatement required from emissions sources within the trading scheme. The supply of allowances is fixed by the cap and the price of allowances will fall to bring the demand for allowances back into balance with the supply; the renewables support will just have redistributed the sources of emissionsPolicy can therefore fall into a trap in which carbon markets appear more and more insufficient on their own, apparently justifying more and more direct, technology-specific, support (Blyth *et al.*, 2009). The weakened carbon price signal can then point path-dependent technological development and investment away from low-carbon technologies.

11.6.7.3.2 Effects of Carbon Pricing on RE Objectives

The design and stringency of carbon policy has been shown to have significant effects on the efficacy of renewable support policies as well. Fischer (2008) finds that a renewable support policy is much more effective in the context of a carbon price signal. But the stringency of emissions targets under a cap-and-trade scheme (or, in the case of a tax, the level and expected rate of increase) matters as well. It affects not only the expected price of carbon, but also the risks associated with investment in abatement. Also, prices in carbon markets have in general been very volatile, which is not unusual in cap-and-trade schemes to control pollutants because of the inelastic supply of quotas (Metcalf, 2009 [TSU: Only Metcalf, 2008 is listed in reference list – incorrect date?]).

Some of the volatility is likely to be due to the fact that markets such as the EU Emissions Trading Scheme are not yet mature; greater depth and breadth would reduce liquidity problems and the scope for strategic behaviour (e.g. exercise of monopoly power) by participants. Carbon prices also seem to have been correlated with the wholesale prices of natural gas (one of the most volatile commodity prices), oil and coal, reflecting variations in energy demand and the scope for switching commercial energy supplies among sources (Mansanet-Bataller, Pardo and Valor, 2007; Geman, 2005). Such interplay has significant implications for investment in renewable technologies, especially those that may involve technological spillovers, learning-by-doing, or long ramp-up times (Blyth *et al*., 2009; Fischer, 2008). It is difficult for governments to guarantee credibly the high and rising future carbon prices that justify high current expenditure on R&D; governments cannot commit their successors, and private agents are likely to suspect that they will act in a time-inconsistent manner (Helm *et al*., 2003).

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, albeit indirectly, by reducing the incentive to deploy renewables technologies within the borders of the renewable mandate (P. del Rio *et al*., 2005). In a second-best world of below-optimal carbon pricing, stronger public support for innovation and R&D may be justified, particularly if spillover effects are significant (Fischer, 2008; Sorrell, 2003).

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 11.7 differs from the previous sections because it focuses on the requirements of achieving a structural shift from conventional energy sources to renewable energy. It explores what policies are required for RE to become the standard energy provider in a low-carbon energy economy. Section 11.5 set out available policies, and evidence about their success and failures. 11.6 explained the enabling environment which is required to maximise the success of those policies. 11.5 and 11.6 together highlight the ‘best practice’ policies available and any country which put in place both those policies and enabling environment could expect success in delivering renewable energy deployment.

Some countries are fortunate in that they have mainly renewable energy systems based on an extraordinary resource – for example, Iceland, Norway, Costa Rica. Most countries, however, are in the position where they have to develop their available RE resources within an energy system dominated by fossil fuels and/or nuclear. Even those countries which are considered to have successful renewable energy policies in place are still reliant on ‘conventional’ energy sources for the majority of their energy. There are very few towns or communities around the world where renewable energy has moved from a conventional energy system to becoming a standard energy provider (ie where RE is the main provider of energy), and then usually only within a sector, ie within electricity or heat. Rarely is RE the provider of more than 50% of total energy of a community. In this sense, these towns and communities have undertaken a structural shift in their energy use and it is instructive to understand how it came about, and what it means for RE policies and financing.

This section explores:

- what the wider requirements are, beyond renewable energy policies and their enabling environments, to enable this structural shift;
- it highlights some of the key choices that policymakers, companies, investors and consumers face ;
- and what that means for societal activities, practices, institutions and norms.

Section 11.7.1 briefly revisits past transitions between energy systems and discusses lessons that can be learned for enabling a structural shift, as described above.

Section 11.7.2 explores energy transitions. However, its discussion of transitions is differentiated from Section 11.2 or 11.6, which provides an overview of the transition management literature. This section reviews what has been written about the enabling of a large structural shifts where the rate of deployment of RE could increase rapidly. This literature is minimal - as opposed to literature on transition change which is large and tends to focus on how a technological change begins and develops (Geels, 2005; Smith et al, 2005, van Bruinsma, 2008; Praetorius et al, 2007)

Section 11.7.3 describes what a world, in which RE is the standard provider, might look like. It assessed what the key components have come together in places, whether small cities and islands or larger examples, where RE has become a standard energy provider.

Section 11.7.4 explains what the key issues and policy choices are to achieve a structural shift in the way we use renewable energy, and what the implications of this are for policymakers, companies, investors and consumers. In doing so, this section explores ideas ofincremental versus step change or ‘bricolage versus breakthrough’ towards a structural shift. As such, this section points to the need for ‘deliberate’ policy.

11.7.1 Energy Transitions

Transition from one energy source to another have characterized human development and a shift from the current energy system to one that includes a high proportions 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).

As Figure 15 shows, movements from one energy source to another have occurred with clear patterns of rapidly increasing use and then a falling back as a new source of energy emerges and develops. Each new source of energy provided a new and desired service which displaced and augmented the services available from the previously dominant energy sources.

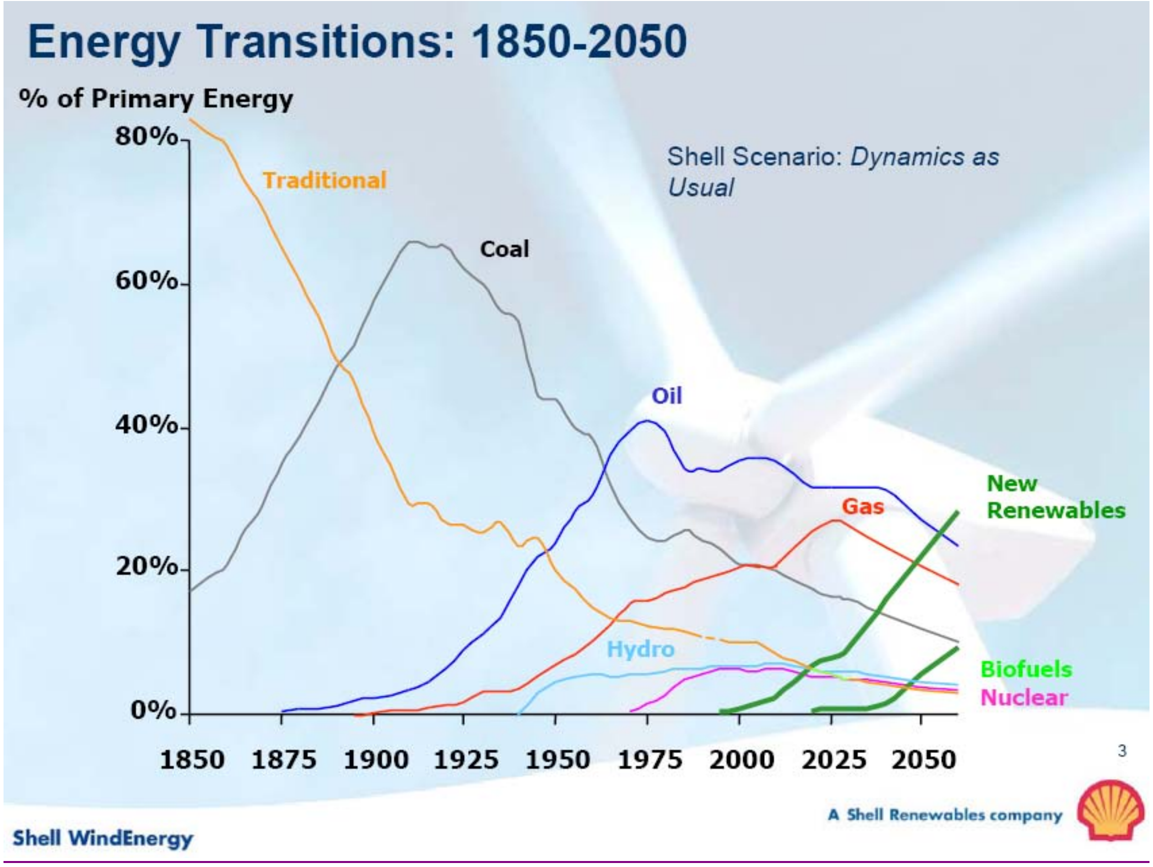

Figure 15:) [Authors: Title missing. SSREN Version of Figure Needed] (Poulson, S. 2002) (http://www.wind-energie.de/fileadmin/dokumente/Themen_A-Z/Ziele/Shell_Vortrag_EE_Strategie_2003.pdf) [TSU: URLs are to be cited only in footnotes or reference list.]

Until the early 18th century, muscles, firewood and charcoal were our main sources of energy, augmented by the limited use of water and windmills, with human lifestyles dependent on living within nature's productive capacity (Girardet and Mendonca, 2009). However, 'new' energy services were required and developed in order that the new indstrial technological innovations could be exploited. Coal is a compact high-density source of energy which was easily transportable and able to fuel the new energy services required by the industrial revolution and also the energy service requirements of the railways which were largely displacing canal and river haulage. Later it was also used as a fuel for electricity. Oil demand developed primarily to fuel automobiles and as another fuel for electricity. More recently, natural gas has displaced coal in certain countries for cheaper and more flexible electricity power plants and for domestic heating.

At the same time, new infrastructures are required to match the energy transition. For example, the societal desire for automobiles and mobility 'drove' the substantial infrastructure building required to satisfy demand. The timescales of these energy source and their linked infrastructure replacements or developments varied by countries but occurred over several decades. Moreover, each transition was supported and strengthened by policy intervention.

Thus, a transition to RE is different from those undertaken in the past because:

- It must occur more rapidly
- because RE provides similar services from other energy sources, except for their environmental benefits which are currently unvalued because most countries have failed to internalise all of their external costs
- while renewable energy have great potential and all countries have domestic resources , fossil fuels have advantages because of its greater energy density and portability

The range of RE sources and technologies can provide the same energy services as conventional energies (for example, light, heating and cooling, mobility). There are market niches around the world where RE has provided new and cheaper services similar to those that helped initiate past transitions to other energy sources (e.g. rural electrification). In addition, a very limited but increasing number of communities, cities and areas now run on 100 percent RE, or aim to do so (International Energy Agency (IEA), 2008a; Droege, 2009; International Energy Agency (IEA), 2009b). The number of these niches or small ‘beacons’ are likely to expand as their ‘different’ value become clearer, as technologies develop, and as the relative prices of conventional energy sources becomes more expensive relative to RE options.

Nevertheless, the move, in this niches, from the existing energy system dominated by non-renewable energies to renewable energies has, for the most part, been the result of deliberate policy intervention and has not been driven by societal demand alone. Further deliberate policies will be required to bring about a structural shift at national and global levels as well. Policy requirements will have to be RE policy and enabling environment focussed. But policy will also has to ensure that the benefits of RE, such as climate change mitigation or energy security, and their linked attributes of new jobs, new manufacturing or industrial opportunities (see Section 11.3) are valued highly enough so that they become viewed to be in the interests by society in order that they, along with Government, businesses and so on reciprocally support eachother to both pull and push RE into being the standard energy provider (Fri, 2003; Foxon and Pearson, 2008).

11.7.2 A Structural Shift

This section discusses the meaning of a structural shift; and explores whether that structural shift occurs as a result of a big step or through incremental, small changes; and how it might be stimulated.

11.7.2.1 What is a structural shift?

Policies and support may be provided which presage a different level, or type, of support. The building of Masdar, the RE powered city in Abu Dhabi, and the successful development of Desertec – the supergrid which is intended to link Europe, the Middle East and North Africa to transport solar power - are both examples of policies and aspirations intended to encourage a new scale of supply side options. Decentralised and distributed generation are other options which, if deployed sufficiently, may also represent a different level of support.

This is an example of a structural shift related to technological use. However, structural shifts may also occur in any of the sub-components of the energy system, which make up the enabling environment, for example a transformation of social norms would lead to a structural shift in society's 'normal' attitude towards energy - thereby delivering a step change in energy use. Structural shifts may within institutions, the political, finance and business sphere (Fouquet and Johansson, 2008; International Energy Agency (IEA), 2008a; Droege, 2009).

It could be argued that Germany has undergone a structural shift in the political sphere in that RE is now so deeply embedded into German policies, that the attitude to renewables is structural to Germany and has moved beyond being a political position. For example, the German Chancellor Angela Merkel said during a speech in 2005: 'Increasing the share of electricity consumption covered by renewable energy sources to 20 percent is unrealistic.' (Pieprzyk and Hilje, 2009)' Yet, the announcement by Angela Merkel of her new Government's continued support for the RE policies in Germany (26/10/2009) combined with the data that Germany is now on its way to achieving its goal of 30 percent by 2020 ((Pieprzyk and Hilje, 2009)' may be viewed that RE is becoming mainstream within the energy policy of a European country. In less than 20 years, Germany transitioned from having substantial coal subsidies and a powerful coal lobby to a nation with broad, multipartisan support for RE that helps to sustain and improve upon supportive policies for RE while phasing out those for fossil fuels.

11.7.2.2 Incremental versus Step-Change

This section argues that even though the energy system and society is likely to look very different, were RE the standard energy provider, it is not a big step which is required to get there rather a number of incremental steps, which over time results in a structural shift Garud and Karnoe (2003) been termed this 'bricolage rather than breakthrough'.

Garud and Karnoe (2003) review the pre-2003 literature concerning big shifts. They analyse in detail the parallel efforts of the USA and Denmark in developing wind technology. They wanted to answer the question how it was that a bricolage approach that begins with a low-tech design but ramps up progressively is able to prevail over a high-tech breakthrough approach.

They argued that the latter has an inherent disadvantage in that in order to generate a breakthrough it ends up stiflying micro-learning processes that allow the mutual co-shaping of emerging technological paths to occur. Co-shaping occurs at several points of interaction between desiners and shop floor workers; between produces and users; and between policy makers and regulators. 'Development of technologies entails not just an act of discovery by alert individuals or speculation on the future but also the creation of a new path through the distributed efforts of many'. Attempts at breakthrough can result in 'dampening learning processes required for mutual co-shaping' of technology development. However, bricolage preserves emergent properties. It is a process ofmoving 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. Garud and Karnoe go on to say that understanding these processes may be particular valuable in situations characterised by complex non-linear dynamics among the actors, artifacts and rules that constitute a technological path.

The conclusion to be drawn from this section by policy-makers, business, investors and individuals is not that achieving a future where RE is a standard provider is difficult, but that each step taken, whoever by and however small, is adding to that structural shift . But to achieve a step change to an energy future that is predominantly renewable and low-carbon will require that the rate and scale (e.g., not only Germany or small towns and communities) of transformation be rapid and broad. These factors are driven by the unlocking or removal of barriers and overcoming of hurdles by combinations of policies (International Energy Agency (IEA), 2008a; van den Bergh and Bruinsma, 2008; Praetorius, Bauknecht et al., 2009; UNFCCC, 2009).

11.7.2.3 Characteristics Where RE is the Standard Energy Provider

It is possible to sketch out conceptually the characteristics of a place, society or world where RE is the standard energy provider. We might expect that:

- the enabling environment set out in 11.6 is in place:
- an enabling environment combines technological, social, instiutional (including regulatory) and financial dimensions and recognises that technological change and deployment comes through a systemic and evolutionary, rather than linear, process.
- RE has become cost-competitive, if not cheaper, with non-RE sources through technology advances, economies of scale, and the incorporation of environmental externalities;
- fossil fuels are not eligible for tax breaks, or any other economic breaks/subsidies;
- companies also have ‘environmental’ bottom lines in addition to monetary valuations, so that companies, along with countries, can be assessed in terms broader than their economic value;
- an international system of technology and capacity transfer is in place to ensure the take-up of the most energy efficient technologies globally;
- individual behaviour and lifestyles reflect environmental and and understanding that countries and peoples around the world are inter-linked and dependent on eachother
- waste resources, agricultural practices and energy use fit seamlessly together;
- energy is used in the most efficient manner appropriate for a place or country

11.7.2.4 RE as the Standard Energy Provider

Although a great many towns, local authorities, small countries have decided to move toward sourcing 100% of their energy from RE, there are few examples of a structural shifts to RE (combined with energy demand reduction measures) that have actually occurred to date, where renewable energy is the standard energy provider. On the one hand, those locations that have made this transition offer limited potential for learning because they are at the forefront of an energy system change are unlikely to be representative of broader society; moreover, what worked for them may not work for wider global society. And yet their experiences can provide very useful insights by illuminating how and why such change occurred.

The chapter has a number of case study boxes (ie Box 1) of successful examples of RE deployment. Each box explains the key factors in how this has occurred. The primary sources for the examples are Droeghe’s 100% Renewables and the IEA’s Cities, Towns and Renewable Energy.

The lessons learnt from these Case Studies in terms of a structural shift are as follows:

- 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 have a number of factors in common: political will; broad-based support and stakeholder involvement; have taken advantage of synergies between RE and energy efficiency; they have targetted policies to support RE; they have generally relied on a variety of RE resources and technologies
- 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 eachother 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).

A recent IEA survey of RE cities and communities 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 there 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. These two visions are presented to stimulate the reader to contemplate the question of what sort of world people may want to inherit (IEA, 2009, p30). The key point is that technology and behaviour are intimately linked and should be viewed positively together. The case studies of the ‘beacon’ cities and communities supports this view and is represented in Figure 16 below.

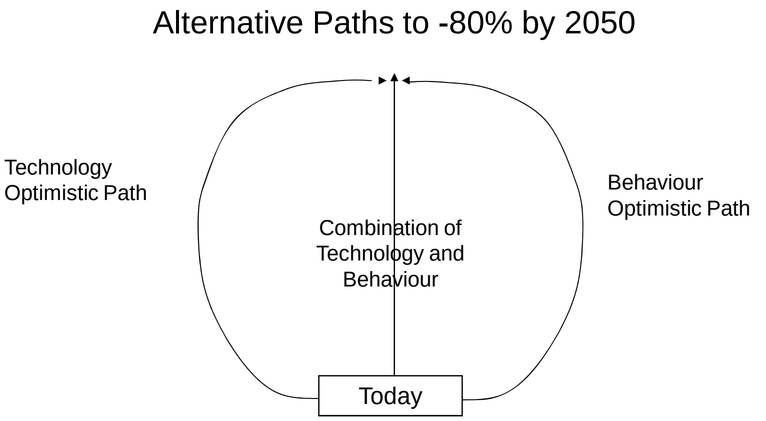

Figure: Alternative Pathways to RE on the standard energy Provider

Figure 16: Alternative pathways to RE on the standard energy provider [TSU: Repeated exactly in figure – caption drawn into figure can be deleted.]

11.7.3 Key Choices and Implications

Although to date RE has become the standard energy provider in only a few locations, a much broader shift is possible and it is possible to draw lessons from their experiences. Policy makers/governments face several key choices that will 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), 2009a; Praetorius, Bauknecht et al., 2009):

- the extent to which policy makers decide to undertake a ‘step change’, in other words become determined to increase RE deployment. If this occurs then other policies will follow: for example, the removal of non-economic barriers; the implementation of clear, consistent policies appropriate to technologies and place; and ensuring that an enabling environment occurs.
- the policy priority – whether this is for a technology optimistic view; whether one that sees individuals and lifestyles at its future, or one that sees them as needing to be inter-related
- the degree to which policies are devolved down from national to local governments, and open to individual choice
- the degree to which ‘spillovers’ or the side effects of renewables are a priority for example job creation, new company entrants to the energy world, manufacturing ability

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.

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), 2008a).

11.7.4 Conclusions

This chapter comes to a number of fundamental principles about RE deployment:

- Targeted RE policies are required to overcome numerous barriers that limit uptake and investment in private R&D and infrastructure and to accelerate RE deployment. Market signals alone—even when incorporating carbon pricing—have been insufficient 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. Good practice exists and it is important to learn from it.

- To be as effective as possible, policies must be well-designed and –implemented, taking into account the state of the technology, available RE resources, and responding to local political, economic, social and cultural needs and conditions.

- Well-designed policies are more likely to emerge, and they will be more effective in rapidly scaling up RE, in an enabling environment. An enabling environment combines technological, social, institutional and financial dimensions, and recognizes that technological change and deployment come through a systemic and evolutionary (rather than linear) process.

- The global dimension of climate change and the need for sustainable economic development call for new international partnerships on deploying RE that recognizes the diversity of countries, regions and business models. RE deployment can contribute to sustainable development, and new finance mechanisms are required to stimulate technology transfer, investment and RE deployment.

- A structural shift is required if RE is to become the standard energy provider in a low-carbon economy. Political will and effective policies for RE deployment will be required, in concert with improvements in energy efficiency, and important changes in societal activities, practices, institutions and social norms will be needed.

Box 1: Germany

(Droege, 2009; Sawin and Moomaw, 2009)

Germany enacted its first feed-in law in the early 1990s and within a decade was a world leader in RE capacity and production, despite the fact that its renewable resources are a fraction of those available in many other countries. Between 2000 and 2008, the share of Germany's electricity from RE increased from just over 6 percent to more than 15 percent (German Federal Ministry for the Environment, 2009). Over the past decade, electricity generation from wind in Germany has increased by a factor of 10, and from solar PV by a factor of more than 100 (Pieprzyk and Hilje, 2009). The contribution of renewables to the nation's final energy demand has tripled (Pieprzyk and Hilje, 2009), to almost 10 percent of final energy demand in 2008 (Pieprzyk and Hilje, 2009).

Box 2: Denmark

(Droege, 2009; Sawin and Moomaw, 2009)

Denmark's economy has grown 75 percent since 1980, while the share of energy from renewables increased from 3 percent to 17 percent by mid-2008.[18] In 2007, the country generated 21 percent of its electricity with the wind, and wind power occasionally meets more than 100 percent of peak demand in areas of western Denmark (Kanter, 2007). As part of the European Union's energy package that was finalized in 2009, the Danes aim to get nearly 20 percent of their total energy from renewable sources by 2012 and 30 percent by 2020 (Official Journal of the European Union, 2009). During the 1973-74 OPEC crisis, Denmark was 99% dependent on imported energy. Now, Danish firms currently produce one-third of the world's wind turbines - nearly a $6 billion export industry. The Danish government covered 30% of wind investment costs from 1979 to 1989, with loan guarantees later being provided for large turbine export projects. On the demand side, the government established utility purchase mandates at above market prices. The government also funded research support for wind turbine design and manufacturing improvements. Moreover, financial incentives such as tax free income for wind generated by cooperatives has led to a high degree of citizen participation in the wind industry, with 80% of Denmark's turbines owned by over 150,000 Danish families. This example illustrate that building a successful domestic renewable industry is a long-term investment that requires sustained consistent policies but that can lead to a thriving industry and export opportunities (Engel and Kammen, 2009; Garud and Karnoe, 2003).

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[18] Denmark's economy quoted in European Wind Energy Association, "With Increased Research, Renewable Energy Can Supply More than 20% of Europe's Energy Demand," press release (Brussels: 3 April 2008); renewable share in 1980 from Ministry of Climate and Energy of Denmark, "The Danish Example—The Way to an Energy Efficient and Energy Friendly Economy" (Copenhagen, Denmark: February 2009), available at www.cop15.dk/en/menu/About-Denmark/The-Danish-Example; 2008 share and 2011 and 2020 goals from Karl Larsen, "Denmark Continues its Renewable Tradition," Renewable Energy Focus, July/August 2008, p. 66; Geoffrey Lean and Bryan Kay, "Four Nations in Race to be First to Go Carbon Neutral," (London) The Independent, 30 March 2008.

Box 3: China

(Droege, 2009; Sawin and Moomaw, 2009)

China leads the world in the use of solar water heating, small hydropower, and production of solar cells (REN21, 2009a). The nation has experienced explosive growth in its wind industry, with installed capacity increasing more than fivefold between 2005 and 2008, and China's wind capacity will soon surpass its nuclear capacity (REN21, 2009a).[19] In 2009, the government tripled its 2020 wind target, from 30 gigawatts (GW) to 100 GW, and recently pushed its 2020 solar target from 1.8 GW to 20 GW (Mendoza, 2009).

Box 4: Israel

(Droege, 2009; Sawin and Moomaw, 2009)

Israel is a world leader in per capita use of solar water heating. The technology has become mainstream thanks to a 1980s law requiring the use of solar energy for water heating in all new homes (European Solar Thermal Industry Federation, 2007).

Box 5: Güssing

(Droege, 2009; Sawin and Moomaw, 2009)

Güssing, Austria changed from being economically depressed to beng an an energy self-sufficient town that produced biodiesel from local rapeseed and used cooking oil, generated heat and power from the sun, and operated a new biomass-steam gasification plant that sold surplus electricity to the national grid (Austrian Federal Ministry for Transport, 2007).. This is an example of an 'active' choice for sustainable economic development.. Since the early 1990s, this town of 4000 inhabitants has reduced its carbon emissions by 90 percent, has created 1000 new jobs and attracted 60 new companies. It was kick-started by economic need: the town had a large electricity debt and set out to become self-sufficient in energy. Situated in a largely agricultural and wooded area of Austria, town leaders decided to move towards RE but with energy savings measures at its centre. Farmers are seen as the main energy providers, and have reportedly gained satisfaction at this community role. Güssing was transformed over a 15-year period to a community with high living standards, low unemployment and green tourism (IEA, 2008; Droege, 2009; IEA, 2009; Sawin and Moomaw, 2009).

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[19] REN21, Renewables Global Status Report 2009 Update, pp. 8–9; China installed capacity from Shi Pengfei, "Wind Power in China," presentation in Guangzhou, China, 23 March 2007; Shi Pengfei, "2006 Wind Installations in China" (Beijing: China General Certification Center, 2007); GWEC, "US, China & Spain Lead World Wind Power Market in 2007," press release (Brussels: 6 February 2008); GWEC, Global Wind 2008 Report op. cit. note 5, p. 37; surpassing nuclear from "China to Have 100 GW Wind Power Energy Capacity by 2020," People's Daily, 4 May 2009.

Box 6: Kenya

(Droege, 2009; Sawin and Moomaw, 2009)

Kenya has achieved widespread acceptance and use of solar PV through informal information collection about performance of existing systems. Individual solar energy systems (20 watts or less) are now the largest form of rural electrification in Kenya (Kammen and Jacobson, 2005). Solar energy purchases have continued to grow in Kenya, with more than 35,000 systems sold each year aided largely by programs to improve consumer information, and only later with government support.

Box 7: Nepal

(Droege, 2009; Sawin and Moomaw, 2009)

Nepal - Domestic biogas development efforts has been started in early 90 in Nepal. The initiative has adopted public private partnership model. Only after implementing few thousand domestic biogas plants government has incorporated it into its programme policies and created a permanent institution in 1996. Renewable Energy policy has been promulgated in 2006 only. So in few developing countries like in Bangladesh, Nepal policies have been formulated only after few years of programme experiences.

Box 8: Bangladesh

(Droege, 2009; Sawin and Moomaw, 2009)

Bangladesh has brought the renewable energy policy in 2008, however, programme activities are already initiated before that. Policy is still not fully in place but Bangladesh is installing more than 12 thousands solar home systems monthly.

Box 9: El Hierro

(Droege, 2009; Sawin and Moomaw, 2009)

El Hierro, westernmost of the Canary Islands, aims to achieve 100 percent RE status by the end of 2010, a goal first set only 6 years earlier. The island is rich in wind, hydro, organic waste and solar resources and has been aided by European Commission subsidiesand Spanish support policies, including FITS. It is built on a background of positive experiences with RE and ‘active’ choice from an early solar energy programme, also supported by the regional Spanish ministry. This has been very successful from the point of view of jobs and skills for the island. From the 1980’s onwards, El Hierro had investigated an economic development model which was not based on mass tourism and real estate values; and it was declared a World Biosphere Reserve by UNESCO in 2000. RE suited these other factors. It has a population of more than 10,600 people. The target is for all electricity, heat, and much of transport needs. Island inhabitants wanted to move away from mass tourism and needed model of development that would support their heritage. Policies included public education through publications, workshops, etc. and technical visits, training, etc. El Hierro is an example of achieving this goal on an island with weak, isolated grid. Expect to save >1.8 million euro/year in fuel imports and reduce CO2 emissions by 19000 tons/year. (Droege, 2009, pp. 94-97; IEA, 2008; IEA, 2009).

Box 10: Samsø Island

(Droege, 2009; Sawin and Moomaw, 2009)

Samsø Island in Denmark has been an inspiration for other 100% RE islands around Europe. It won a Danish Government sponsored contest, as part of the 1996 Danish Energy Action Plan, to abandon fossil fuels. The islanders were not particularly pro-environment themselves at the beginning. Real effort on the part of those funded by the Action Plan gradually created a community spirit in support of it. Electricity was reasonably easily generated with wind power, but in order to fulfill the heating demand (with biomass, correct?), houses have been renovated to become energy efficient. Within an 8 year period from 1997-2005, heat demand declined by 10 percent while the share of demand met with RE increased from 25% to 65%Islanders now meet more than 100 percent of electricity demand with the wind and export the rest into the Danish grid. The positive 'spillovers' for Samsø's inhabitants include energy security, a booming ecotourism industry, income from sale of excess power, and expansion and diversification of the labor market (IEA, 2008; Droege, 2009; IEA, 2009)..

Box 11: Rizhao

(Droege, 2009; Sawin and Moomaw, 2009)

Rizhao, the 'solar city' of China set about in 2001 to adopt several policies and measures to popularize renewable technologies, including requiring solar water heating on all new buildings. Today, 99 percent of households in the city's central district use the sun to heat their water, most public traffic signals and streetlights are powered with solar PV, marsh gas from agricultural waste water is used to displace some coal for electricity generation and as cooking fuel, and more than 6,000 families use solar cookers (Bai, 2007). Rizhao has 3 million inhabitants. Air quality has improved considerably since the provincial government began investing in the industry to drive down costs of solar (esp. thermal); belief among city's leaders that cleaner environment will advance social, economic and cultural development {Xumei, 2007 #571. Also, solar heating is used for local greenhouses; marsh gas is captured and used as biogas for cooking.]

Box 12: Sweden

(Droege, 2009; Sawin and Moomaw, 2009)

Sweden has seen a major shift from fossil fuels to biomass for district heating over the past two decades (Sommestad, 2008). Thanks to taxes on energy and CO2, about 51 percent of the country's district heat is produced in combined heat and power (CHP) plants, and biomass and waste now account for 61 percent of total district-heat production. Although the first Swedish District Heating system was put in place in 1948, the rapid build-up started in the 1960's and now provides 86 percent and 69 percent of multi-dwelled and non-residential premises, respectively.

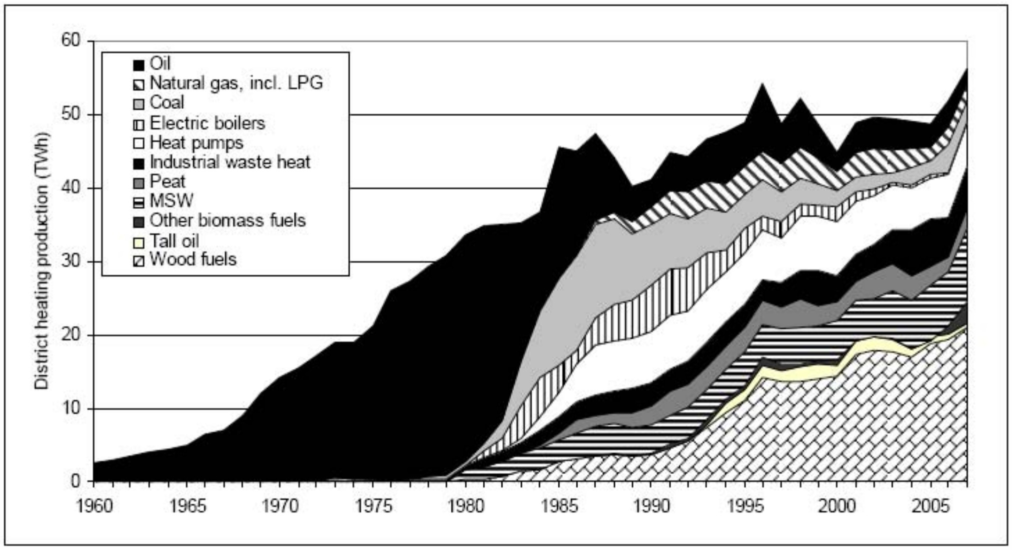

Figure 1 DH production in 1960-2007, broken down into fuels and energy sources. The curves have not been corrected for outdoor temperature variations

Source: 1960-69: approximations from DHA (2001); 1970-2007: SEA (2008a)[20]

Source taken from (Fig 3 taken from KEricsson, via Lars Nilsson)

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[20] Lars J. Nilsson, Lund University, Sweden, e-mail to Catherine Mitchell, University of Exeter, U.K., 23 October 2009.

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