A Global Renewables Investment Plan

Scaling up investments in renewable energy technologies

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EXECUTIVE SUMMARY

In the coming decades, we are likely to witness a profound technological transformation. This transformation will entail a switch in the global electricity system, from primarily relying on fossil fuels to relying on renewable energy sources. The transformation to renewable energy is already gaining momentum, and the fast growth of renewables in the last years has led to falling costs and greater capacity in the design, manufacture and installation of renewable energy technologies. In 2009, nearly one quarter of all global electric generating capacity was renewable, and China alone invested some $34 billion in renewable electricity. The perception of renewable energy is changing and it is now increasingly seen as an important part of the global energy economy. The proposed Global Renewables Investment Plan (GRIP) is intended to strengthen this perception and to emphasize renewables as a promising investment opportunity. The GRIP aims to provide a common vision for international coordination to scale up renewable energy investments globally.

Renewable energy technologies offer many country-level advantages including: greater energy security (locally produced), higher long-term pricing reliability, local job creation, national balance of trade improvements, reduced environmental and climate change risks and cost-effective off-grid deployment opportunities for rural electrification. Several of these benefits still require more research to fully quantify their effects. In principle, these effects apply to all countries, industrialised as well as developing, but the pressure and desire to invest in renewables differ depending on a number of factors, such as a country's endowment of fossil and renewable resources, its economic strength, attitudes toward climate and environmental protection, and so on.

There are several barriers to investment in renewables that have to be addressed. These include the cost structure of renewables compared to fossil fuel technologies, the intermittency of renewable energy supply, and levelised costs of electricity, which are often still higher for some renewables. Direct and hidden subsidies for fossil fuels are additional important considerations in assessing the viability of renewables.

Government policies in different regions of the world have proven that private investment money is available for renewable energy deployment if the conditions are attractive. The most effective policy instruments to attract investment that have been used to date are feed-in tariffs, tax credits and quota systems. Based on European and North American experience, the primary considerations for attracting investments are:

- Transparency – governmental policies need to be easily understood.
- Longevity – programs need to support long financial payback periods.
- Certainty – programs need to be stable and predictable.
- Competition – competition among investors, as well as between developers and producers, keep program costs low.
- Cooperation – international coordination for a macroeconomic environment that is advantageous for global renewable growth

For analytical purposes, this paper considers five categories of countries, ranging from industrialised countries with limited amounts of fossil fuel resources to developing countries with large amounts of fossil resources. Each of these country groupings has different drivers and incentives to invest in renewable power. By taking into account these differences and linking them more closely with discrete policy options for scaling up investments in renewables, it should be possible to develop a global plan that can attract and support greater investment in renewables across the world in the coming years.

The time to do this is now. In addition to the pressing energy demand and environmental pressures mentioned above, prime lending rates are also currently at historically low levels. Trillions of dollars of investment capital are waiting for appropriate investment opportunities. Although more work is needed to develop a GRIP that can completely unlock this funding, developing a coordinated vision and plan is an essential pre-requisite to bringing about the energy transformation in the coming decades.

INTRODUCTION

In the decades to come, we will witness a transformation as profound as the shift from horses to cars, steamships to aeroplanes, or typewriters to computers. This new transformation will be a switch of the global electricity system from one relying primarily on fossil fuels, to one relying primarily on sunlight and its immediate offspring – wind, falling water, and plant growth – as well as other sources of renewable energy, such as geothermal and tidal power. This transformation is desirable for a number of reasons. It offers the potential to deliver reliable electricity and energy services to more people, at more stable cost, and to avoid environmental, safety, and health risks associated with burning fossil fuels.

There is evidence that the transformation to renewable energy is starting to gain momentum. Growth in the most promising technologies has been fast over the last decades, especially in the last fifteen years. This has led to falling costs, and a greater capacity to design, manufacture, and install the key components. Perception of renewable energy is beginning to change from seeing it as a market niche to being an important part of the overall energy system, and a promising investment.

To continue this promising development, however, there are still barriers to overcome. The market may overcome some of these barriers on its own. Other barriers will require concerted and continuous action on the part of governments, civil society, and industry. Continuing the momentum towards an energy system based on a large share of renewable energy will require large financial outlays.

The purpose of this input paper is to focus on the need to scale up renewable energy investments in order for this transformation to happen sooner rather than later. The paper focuses attention on the value of making these investments at a global scale, identifying the key barriers to a massive expansion of these investments, and suggesting a framework for government action to address this challenge. This framework is to be formulated as a "Global Renewables Investment Plan" (GRIP). The GRIP seeks to provide a common vision for scaling up renewable energy investments and concrete ways of doing so. It emphasises that efforts to support the scale-up of investments need to be viewed as long term investments in a sustainable future, rather than as short term costs.

After providing an overview of current renewable electricity investments and growth potentials for different technologies, Chapter 2 highlights some key country-level benefits from a higher share of renewable electricity supply. Chapter 3 addresses some of the major challenges at the microeconomic level associated with renewable electricity investments and ways to overcome them. The effectiveness of different policy frameworks to tackle these challenges and to successfully support a rapid expansion of renewable electricity is examined in Chapter 4. This analysis, combined with several case studies of specific regions and countries then help to build the vision for a GRIP in Chapter 5. By showing possible pathways for countries with different profiles, we identify key elements for successful implementation of government action to support renewable electricity investments. First, government action needs to be built around the guiding principles of transparency, longevity, certainty, competition, and cooperation. Second, progress needs to be sustained in those highly industrialised countries that have proven themselves leaders, as this will help to lay the groundwork for similar policy development across a wider group of countries over the coming ten to fifteen years.

1 OVERVIEW OF GLOBAL RENEWABLE ELECTRICITY INVESTMENTS

This paper focuses on renewable energy investments in the electricity sector. Electricity currently accounts for about a third of total final energy consumption, a proportion that is rising and expected to continue rising as electricity powers more and more applications, and as electricity storage technologies – mainly batteries but also capacitors – continue to become smaller, lighter, and less expensive.

1.1 Recent growth in renewable energy technologies and investments

Renewables have emerged as a new centre of gravity in the electricity markets across the world. Increasing amounts of investment are funnelled into renewables, and renewable capacities have grown rapidly in many parts of the world. In 2009, despite the financial crisis, both Europe and the United States added more renewable power capacity than nuclear and fossil fuels combined. At a global level, 78 GW of renewable capacity were added in 2009, only slightly less than the 83 GW of new fossil fuel capacity that was installed worldwide. Moreover, global investments in utility-scale renewable energy capacity were $101 billion[1], excluding large-scale hydro. Another $19 billion were invested in small-scale renewable capacity. These investments – adding the $39 billion invested in large-scale hydro – were higher than investments in fossil fuel capacity, which amounted to around $140 billion (UNEP et al., 2010).

Renewable electricity is no longer a small niche in wealthy countries. Rather, renewable electricity is already providing a substantial part of our global energy needs and will keep gaining importance in the future. At the end of 2009, nearly one quarter of all global electricity generating capacity, 1,230GW, was renewable capacity (IEA, 2009b). Globally the United States and European countries were the early leaders, but things are changing quickly. In 2009, China invested more in renewable electricity than any other country, making it the world leader not only in installed capacity, but also in renewable power growth. Excluding large scale hydro power, China invested some $34 billion in new renewable capacity, the vast bulk of which was in

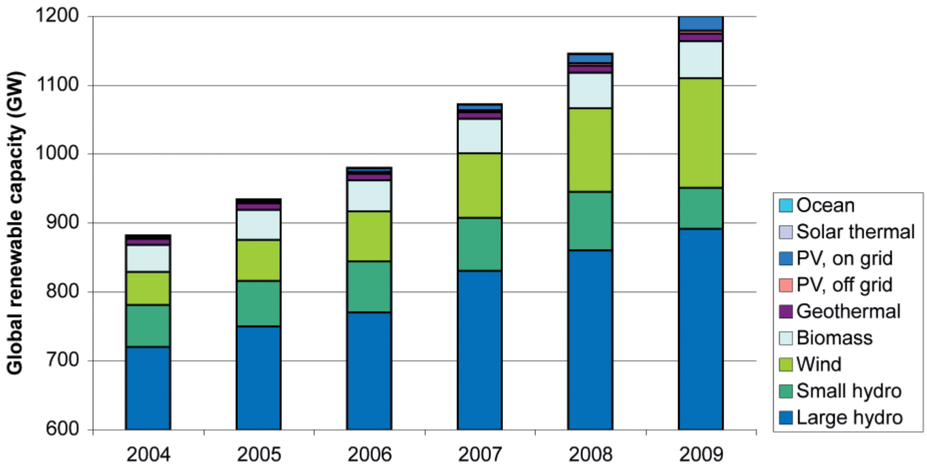

Figure 1: Global Renewable Capacity in GW. Data for 2009. Sources: (REN21, 2005; 2006; 2007; 2009; 2010).

1 Throughout this paper, we will use an exchange rate of 1 € = $1.30.

wind (Pew, 2010; UNEP et al., 2010). As Figure 1 shows, by the end of 2009, China counted 226 GW of installed renewable capacity, and had caught up with the United States and the European Union.

As increasing amounts of renewable capacity are installed, their costs are reduced due to learning and scale effects: typically, installation costs for renewables are reduced by 10–20 % per doubling of global capacity (Neij, 2008). Thus, we can expect the less mature technologies to reduce costs considerably – likely 50 % or more in the coming 10–15 years – at current expansion rates. As the costs of generating electricity using renewable sources has fallen in recent years, the number of countries using renewable energy has grown. But while China's pace of investment has been remarkable, there remain large and important differences between countries, and most of the investments in new renewables (except large hydro) up to 2008 were made by a handful of European countries and the United States. Section 2 lists a number of hurdles that primarily developing countries are facing, among them high upfront costs for renewables. Consider, for example, that diesel generators remain an important source of electricity in many countries. They are inexpensive to manufacture and install, but then entail high fuel and maintenance costs. The amortised total – the so-called levelised cost of electricity (LCOE) – is often higher than for renewable sources such as solar photovoltaic (PV) panels. The initial investment for PV is higher, and people in poorer countries of the world have inadequate access to capital and credit to invest in PV, even though investment in PV may save money in the long run. A (traditional) perception of renewables as expensive or very difficult to integrate into the power system may also be important factors in such choices.

How does government support for renewable energy relate to these market development figures? Today, over 100 countries have policies in place to promote the development of renewable energy. In 2009, Germany and China each induced investments of $25–30 billion, the US had $15 billion of investment and Italy's and Spain's renewables support schemes led to about $5 billion of investment in renewable energy (REN21, 2010). The drivers for this growth are manifold, depending on the economic and energy situation in each country. In the past, environmental and climate concerns were the main drivers for industrialised countries to invest in renewables, but economic development, energy access and energy security are becoming increasingly important drivers. For instance, following the energy price spike of 2008, which saw a barrel of oil reach over $147, concerns about access to cheap fossil fuels have grown. Coupled with the effects that energy price volatility can have on energy investments as well as energy costs, price stabilisation is emerging as a new driver for countries across the world to invest in renewable electricity.

1.2 A suite of technologies

A limited suite of technologies accounts for most of the current renewable electricity generation capacity, and will likely account for growth in the future. To complete the overview on global renewable electricity investments, the major technologies with their future investment potentials are outlined below:

- Hydro. In 2009, 150 countries utilised 11,000 hydro power stations with a total capacity of 980 GW to generate 3,270 TWh of electricity, which represented over 16 % of global electricity generation (BP, 2010; IHA, 2010) and nearly 80 % of global renewable electricity capacity (REN21, 2010). China is the country with the highest installed hydro power capacity, followed by the United States, Canada, and Brazil. The costs of hydro power depend very much on location. The investment in new hydro power is limited and geographically concentrated, as the potentials for large hydro are largely exhausted, especially in the industrialised countries, although upgrades of existing facilities may increase the capacity slightly. Instead, the bulk of new hydro power projects is likely to take place in China, India and South America (IHA, 2010). These limitations have already been felt, as growth in hydro power has been slower over the last 10–20 years than in other renewable technologies. Still, across the world, small hydro power has some unexploited potential, and in 2009, $4 billion were invested in small-scale hydro (UNEP et al., 2010).

- Wind power has emerged to become the second largest source of renewable energy, despite the challenges associated with its intermittency. At the end of 2009, global installed capacity stood at 159 GW. Alone in 2009, 38 GW of wind capacity were added globally, which was more than any other renewable energy (GWEC, 2010), at a total investment cost of $67 billion (UNEP et al., 2010). An important reason for the rapid growth in onshore wind power is the reduction in costs; the current LCOE in Europe may be as low as 0.085 $/kWh, approaching cost parity with new coal and gas power (Schellekens et al., 2010). Offshore wind has typical LCOE values about 50 % higher (Heal, 2009; Schellekens et al., 2010). Currently, there are no signs that the rapid wind power expansion will slow down, but a shift from the traditional markets (Germany, Spain, Denmark) to new markets (China, other EU countries) may be observed.

- Biomass has become the third largest source of renewable electricity. In 2007, the global biomass, biogas, waste-to-energy and other biomass-based power capacity was 46 GW, producing 260 TWh/a of electricity, or 1 % of world power demand (IEA, 2009b). Biomass-fuelled generation has doubled globally since 1990, with the industrialised countries driving the expansion; since 1990, the German biomass power production has increased by 1000 % (BMU, 2010b). Globally, some $11 billion were invested in biomass and waste-to-energy in 2009 (UNEP et al., 2010). In recent years, biomass power is growing also in developing countries, with Brazil, India and Thailand experiencing rapid growth. In years to come, significant increases in biomass generation can be expected, much due to its low costs compared with other renewables. The IEA forecasts a doubling of biomass electricity capacity by 2020 (IEA, 2009b). Competition with other land and water uses may limit the increased use of biomass for power generation in the future.

- Solar. Sunlight itself can be turned into electricity using either photovoltaic panels (PV), or by concentrating it to produce the high heat necessary to spin a turbine (Concentrating Solar Power, CSP). PV has emerged as the fastest growing of all renewable power technologies, with annual growth rates exceeding 40 %. 2009 was a record year, with 7 GW added; at the end of 2009, the global PV capacity was 23–24 GW, 16 GW of which are in the European Union (EPIA, 2010; REN21, 2010). The LCOE for PV has fallen by over 50 % in the last few years, although it still remains higher than for wind. Expectations are that the market could be 30 GW in size by 2014 (EPIA, 2010), with some share of this being off-grid generation in developing countries. CSP has so far lagged significantly behind PV, although there are signs that this could change, first because its LCOE is already lower than that of PV, and second because the option for thermal storage enables CSP to provide base load power. Entering 2010 there was 1 GW of CSP capacity in operation, almost all of it in the US and Spain (Richter et al., 2009), but this is likely to have doubled by the end of the year. In California alone, 5 GW have entered the permission process with another 4 GW announced (California Energy Commission, 2009; Ilgten and Mhya, 2009). Because it requires direct sunlight, CSP is only appropriate in arid climates, and so its future growth depends not just on investment in generation infrastructure, but also transmission lines to link the world's deserts to centres of demand.

Figure 2 compares the typical current cost ranges for these different technologies, with the median cost represented by the white bars. These costs are derived by the literature, but they are typically published with 1–2 years delay; given the remarkable learning in especially PV, this may thus be an overestimation of actual current LCOEs. The PV industry claims that the cost of PV is today significantly lower than expressed in the graph and that grid parity is imminent or already achieved in a number of countries (Breyer and Gerlach, 2010). Invest-

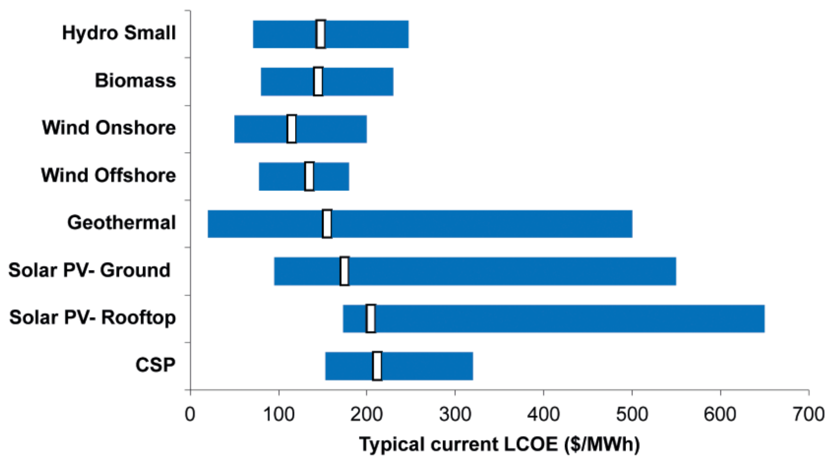

Figure 2: Typical current levelised costs of electricity generation from different technologies, in $c/kWh. Sources: own calculations and (IEA, 2010c; d; e; Krohn et al., 2009; Schellekens et al., 2010).

ment banks involved in the sector also confirm this. Still, it is clear that site characteristics and site quality are extremely important, much more so than for fossil energies: when expanding renewables, great care has to be taken to build the right technology at the right site.

There are also a number of other renewable technologies, which are at a rather early stage of development, or which have serious capacity constraints associated with location. Geothermal power is in some locations reliable and cost effective, whereas it is less economically attractive in other areas with less favourable geological conditions. There are currently 11 GW of capacity in 24 countries; while this is mainly in the US, the Philippines and Indonesia, the small country of Iceland supplies 25 % of its electricity from geothermal power stations (GEA, 2010; REN21, 2010). It will likely continue to grow (GEA, 2010). Wave power results from wind, while tidal power from the orbits of the Earth and Moon; currently, one tidal power station of 240 MW is operational in France, and a small number of experimental tidal and wave power facilities exist in different countries. Estimates for the total economic potential of both are low, compared with the other renewable sources, and it remains to see whether these technologies can play a role in the future or not.

All of the renewables listed are improving rapidly due to technological improvements and economies of scale. It is worth noting, however, that despite their recent success, the research and development (R&D) scales have still not tipped in their favour. Of the $9 billion recently spent on energy R&D, $5.5 billion went to nuclear research, $2.7 billion went to fossil fuels research, and only the remaining $1.8 billion was spent on renewable energy, hydrogen, and fuel cells combined (IEA et al., 2010).

2 COUNTRY LEVEL BENEFITS FROM RENEWABLE ELECTRICITY

Countries have different sets of drivers to invest in R&D and support the deployment of renewable electricity. Often, one key benefit is medium- to long-term promise that today's investments will result in renewables' LCOE falling to below that of fossil fuels; this will result in lower electricity costs for consumers and higher returns to investors. Beyond that, there exist various other beneficial effects at the country level. Therefore, some of the immediate consequences of increased renewable electricity investments are examined below. These benefits are important drivers for policy makers to improve the environment for renewable investments in their jurisdiction and to allow the financial markets to enable a country to achieve these benefits. At the same time, these benefits illustrate why these efforts to support and accelerate the expansion of renewables are to be seen as a favourable investment in the long-run.

2.1 Electricity access and reliability

Almost 1.5 billion people across the world lack access to electricity, most of whom live in South Asia and sub-Saharan Africa (IEA, 2010b). There is a large literature showing how the lack of access to electricity stands in the way of human development and fulfilment of the Millennium Development Goals. As Figure 3 shows, the picture is changing as many of the countries in these regions now see electrification as a national priority. Some countries, for example in North Africa, have made large progress in the last decade. China has brought electricity to an additional 700 million people over the last two decades; today, over 99 % of Chinese households have access to electricity (Peng and Pan, 2006).

Across the world, off-grid renewables – in particular PV and small hydro power stations – have been a cornerstone of the rural electrification process and are likely to remain important due to three characteristics. First, this form of renewable electricity generation is modular and well suited for off-grid or mini-grid solutions. Second, most renewables are fast to build, and can be erected within weeks. Third, most renewables are rather easy to operate, and do not cost much once they have been installed. These off-grid and small-scale installations have often not attracted traditional investors and instead, local banks and local investors have provided much of the financing. Typically, larger funds build off-grid systems directly or indirectly through microcredit organisations (REN21, 2010).

For developing countries, off-grid applications are especially attractive when the alternative is no electricity at all. At the same time, however, these countries may have challenges associated with substantial on-grid application of renewables, if they lack the infrastructure and storage capacity to ensure continued system reliability. Electricity interruptions may cause significant damage, especially in the industrialised world, where the electricity dependency is extremely high: economic life effectively stops during blackouts as computers and industrial machines fail. The value of lost load (VOLL) is hard to quantify and varies greatly depending on when and where blackouts occur and how long they last, but in industrialised countries it is often estimated to be on average around 9–10 $/kWh lost (Bliem, 2005; de Nooij et al., 2007). Developing countries, in which blackouts are frequent, are better adapted to handling blackouts and have a lower VOLL. Still, as economic and social development progresses, a highly reliable electricity system will gain in importance and an unreliable power supply may hamper economic development.

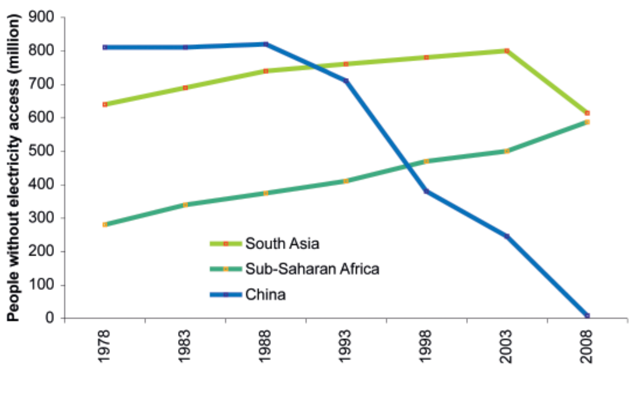

Figure 3: Electricity access in south Asia, sub-Saharan Africa and China. Source: (IEA, 2002; 2010b)

2.2 Energy security and national balance of trade

The definition of energy security is relative to cultural needs and dependency. A plethora of scientific and political definitions of energy security exist. Measuring security of supply, and the cost or value of it, is at least as difficult (Chester, 2010; Jansen and Seebregts, 2010; Kruyt et al., 2009; Löschel et al., 2010). It is often argued that import dependency is a prime risk indicator, which assumes that domestic supply is geopolitically secure. If this is true, one way to mitigate this risk is to use domestic renewable resources for electricity generation. This would have the added benefit of reducing the dependency on imports and for poorer countries would save scarce foreign reserves from being used for expensive purchases of foreign fossil fuels.

As Figure 4 shows, the price of fossil fuel imports, relative to overall trade balances, is large. The United States imported $460 billion of fossil fuels in 2008, representing 65 % of its trade deficit (Census, 2010; EIA, 2009). The EU exceeded this, and spent $550 billion on energy imports (Eurostat, 2010b). However, expenditures on fossil fuel imports are below 5 % of GDP in both the EU and the United States, as Figure 5 shows. For some developing countries without domestic fossil resources, however, these expenditures are more difficult to sustain, as large percentages of export earnings and total GDP are used to pay for energy imports. Among the major countries with the highest net import spending on energy as a share of GDP are countries like India, for which the value of net fossil fuel imports amounts to 10 % of total GDP. It is even higher for countries such as Belarus, Ukraine, Kyrgyzstan, Jordan and Cote D'Ivoire.

Unlike energy generated from fossil fuels, the major cost associated with renewables is capital related. Thus, if the supply chain is built up domestically, large shares of the costs for renewable electricity are spent and remain within the country instead of being used to import fossil fuels or equipment from foreign regions. Renewables are thus important, as they can significantly improve the trade balance of importing countries.

It is important to note that fossil energy exporting countries may also have a long-term interest in investing in renewables too, especially if their fossil resources are being depleted. OPEC countries are exceptionally depend-

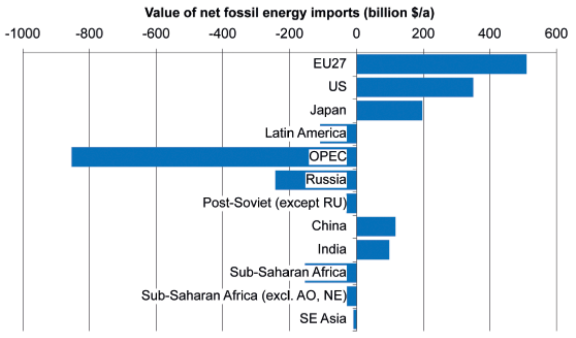

Figure 4: Value of net imports (i.e. total imports minus total exports) of fossil energy (coal, gas, oil) for selected countries and regions[2]. Sources: (BAFA, 2010; BMWi, 2010; CGI, 2010; CIA, 2010; EIA, 2010b; IEA, 2008; USDA, 2010; WTRG, 2010).

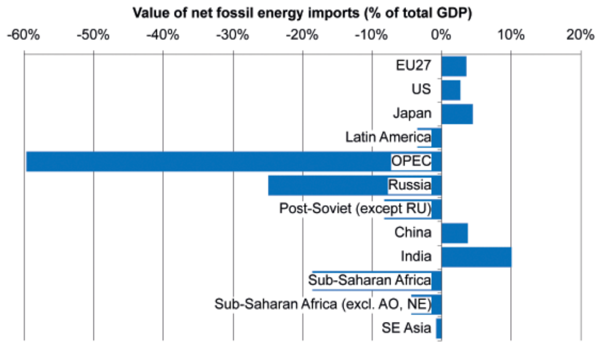

Figure 5: Value of net imports (i.e. total imports minus total exports) of fossil energy (coal, gas, oil) for selected countries and regions, expressed as % of total GDP. Sources: (BAFA, 2010; BMWi, 2010; CGI, 2010; CIA, 2010; EIA, 2010b; IEA, 2008; USDA, 2010; WTRG, 2010).

Box 1: India: Renewables for electricity access and reduced import dependency

As a consequence of the strong economic growth and social changes, Indian energy and power demand is increasing rapidly. In 2009, India ranked fourth among the world's oil consumers, after the US, China and Japan, see also Figures 4 and 5 (EIA, 2010a). The Indian government is fully aware of the great challenge of efficient power supply for all of its citizens. In the last years India has doubled installed capacity to 164 GW, much of which has come from renewables. In 2010, India was with a total capacity of 17.6 GW amongst the world leaders in installed renewable energy capacity (CEA, 2010; MNRE, 2010). Still, there are large un-electrified parts in the country: in 2008, some 400 million people had no access to electricity (IEA, 2010a). Ensuring power supply, including in remote areas, and reducing the dependence on fossil fuel imports are currently the two main drivers for India to invest in renewables.

India has a huge potential for renewable energy. Wind power contributes the lion's share – 10 GW – of the total installed renewable energy capacity in India. Solar power has, so far, played a minor role with only 15 MW installed, despite the very good potentials within the country. Recently, India adopted a target of 22 GW of solar power capacity by 2022 (MNRE, 2010).

The world's first ministry in charge of non-conventional energy sources was launched in 1992 in India. This Ministry of New and Renewable Energy (MNRE) is responsible for all matters relating to new and renewable energy at the federal level. To cover some of the financial issues, the Indian Renewable Energy Development Agency (IREDA) was established to offer financial assistance for renewable energy and energy efficiency projects. During the last years, a number of laws and regulations in combination with different policy instruments and programs (e.g. Rajiv Gandhi Grameen Vidyutikaran Yojana program, Jawaharlal Nehru National Solar Mission (see above)) were implemented to increase the renewable power capacity. India's efforts have had an effect: In 2009, the total financial investment in renewable energy in India was $ 2.7 billion (UNEP et al., 2010). According to a study from Ernst and Young, India ranked as the fourth most attractive country for investments in renewable energy, behind the US, China and Germany (Ernst & Young, 2010). However, in 2009 India's share of capital and private equity investment in renewable energy was very low and the majority – 70 % – came from asset financing (UNEP et al., 2010).

2 Negative values mean that the value of exports is larger than the value of imports. The energy prices used are average border prices for coal and gas imports to Germany/Henry hub (gas only), and the average price for WTI oil. All prices and quantities are for 2008. The import/export data for sub-Saharan Africa is incomplete, and thus these costs are underestimated.

ent on oil and gas exports; as can be seen in Figure 5, the value of their energy exports is roughly 60 % of their GDP. By increasing their renewable generation, they will also free some of the domestically used gas/oil/coal for much more valuable exports, and will also soften the domestic energy supply effects of fossil fuel depletion (Mitchell and Stevens, 2008).

2.3 Electricity price stability

In recent years, two clear energy price trends have crystallised. As Figure 6 shows, there is a general upward trend in fossil energy prices, with the oil price increasing from $20–30/bbl around 2000 to $60–80/bbl today. At the same time, energy prices have experienced remarkable volatility. Oil prices swung from $56/bbl in early 2007 to $147/bbl in mid-2008 and back to $45/bbl in 2009.

The upward price pressure on fossil fuels has had dramatic impacts on energy import expenditures. This is especially grave for many developing countries, many of whom – in addition to facing high import costs – strongly subsidise energy use. If governments lower the subsidies; they expose themselves to the anger of their citizens. If they maintain local prices; they put their already stressed national budgets and trade balance under even more strain.

Theories of investment predict that increased uncertainty about energy pricing will lead to a reduction in investment (Bernanke, 1983). The standard measure for this uncertainty is price volatility. If prices are very volatile with large swings up and down, the market is considered to be more risky, leading investors to demand a greater expected profit, known as internal rate of return, or IRR. This makes investments more expensive and less attractive. Precisely this phenomenon (in the opposite direction) can be witnessed in renewable power markets around the world: the markets without price volatility – mainly those with feed-in tariffs – have seen by far the largest growth in renewable capacity and investment (Couture et al., 2010b; Couture and Gagnon, 2010).

Energy shocks, both in the form of slowly increasing prices and of sudden price spikes, affect the economy by disrupting spending on goods other than energy. For example, auto expenditures tend to be exceptionally hard hit by increases in energy prices (Edelstein and Kilian, 2007). As (Hamilton, 2009) points out, 9 out of the 10 US recessions since World War II were preceded by a spike in oil prices.

Renewables can play an important role in reducing these problems, as their costs are much more predictable than fossil fuels, and their potential is almost always not depletable. Nearly all renewables (except biomass) have very low operating costs as they have no fuel costs. Once the renewable power station has been built, the cost of generating electricity is well known, meaning that increasing the level of renewables in the power mix will reduce overall power price uncertainty and volatility, and decouple the electricity price from world markets for oil, coal or gas (see also section 2). This is beneficial for all economies, but it may be particularly beneficial for developing countries who have suffered most from recent energy price surges.

2.4 Reduced climate change risks

Increasingly, scientific evidence points to anthropogenic climate change as one of the largest global challenges of our time. To avoid the dangerous effects of climate change, it is widely accepted that the global mean temperature increase cannot exceed 2 °C above pre-industrial levels. The mean temperature has already risen by 0.7 °C (IPCC, 2007). Holding the 2 °C level will require global atmospheric CO_2 concentrations to be stabilised at or below 450 ppm (Parry et al., 2007). Scenarios suggest that global CO_2 emissions must be reduced 50 % from their 1990 levels by 2050 in order to accomplish this (Solomon et al., 2007), but ultimately the rise in temperature depends on the total amount of CO_2 emitted into the atmosphere, as every molecule stays there for decades or centuries. The burning of fossil fuels to generate useful energy accounts for over 60 % of total greenhouse gas emissions (Herzog, 2008). As a result, moving to renewable energy sources is a crucial part of the solution of stabilising CO_2 levels and every ton of CO_2 that today's renewables replace will result in lower climate risks over the coming decades.

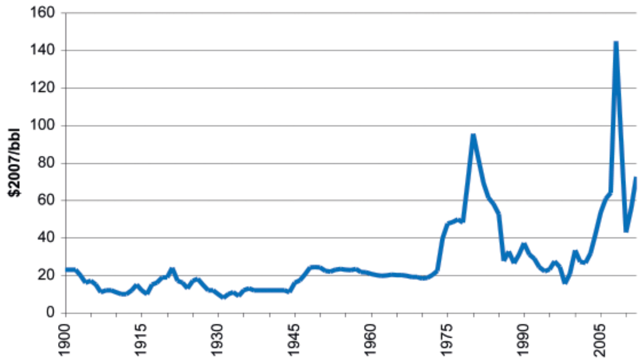

Figure 6: Average yearly oil price (WTI) development 1869-2010 in inflation adjusted US$ (2007). The values for 2008-2010 are the values of July 2008, January 2009 and June 2010. Sources: (WTRG, 2010).

Measuring emissions is relatively straightforward, but it is exceptionally difficult to quantify the economic risks of climate change and apportion responsibility. The Stern Review was the first widely acclaimed study to quantify the costs of the effects of climate change and the comparative costs of climate change mitigation on a global scale. It concluded that holding global warming to 2 °C would avoid vastly larger economic damages in the future. But climate protection comes at a cost (Stern, 2006). As the industrialised world is responsible for most of the historic emissions and the resulting global warming to date, developing countries argue that industrialised nations should move first and lower their emissions. This point is still contended but there is general agreement on the 'common but differentiated responsibilities principle'. This principle holds that all nations have a common responsibility to protect the environment and promote sustainable development; but due to differing economic, social and ecological conditions each nation will carry a different level of responsibility defined by that nations ability to act (Hodas, 2010).

Whereas reducing carbon emissions has been the major driver for the expansion of renewable power in the industrialised world; it is not likely to trigger substantial investments in developing countries as long as renewable electricity is more expensive than traditional sources. For developing countries, the much more immediate problem is expanding energy access. Of lesser importance but still a driver for renewable investment are the effects of direct emissions of dust and other pollutants from traditional biomass burning. Removing these – for example by electrification – would bring immediate health improvements especially to rural populations.

2.5 Effects on employment and social development

Increasing investments in renewable energy capacity will have further direct and indirect macroeconomic effects. Many, including economic development and employment, are difficult to quantify and require a broad methodological approach. However, as the subsequent anecdotal information indicates they can be quite sizable. Further analysis is urgently needed to clarify these positive effects and to create a methodological framework for a comprehensive economic analysis of the macroeconomic effects of a global renewable energy expansion.

The introduction of renewables in an economy will have a direct impact on the job market. Renewables may displace jobs in the conventional energy sector, notably in mines and transport, but it will also create jobs both in the construction and operation phases of the new generation units. Up to today, there has been a net positive effect through renewables, especially in the "first mover" countries, like Denmark or Germany. In Germany some over 300,000 persons work with renewable energy, a net increase of 70–90,000 employees compared to an all-fossil baseline (Lehr and Lutz, 2010). See Box 1 for further details. In Europe, some 660,000 employees work in the renewable energy industry, excluding large-scale hydro and publicly funded jobs. The EU's 2020 renewables targets is expected to create up to 400,000 net additional jobs, compared to a business-as-usual setting (Böhme et al., 2010; Ragwitz et al., 2009).

The benefits are not being felt in Europe alone. For example, the Chinese renewables industry employs an estimated 1 million persons (Renner, 2008). The domestic job-creating benefits of renewables are large, a fact this is acknowledged by an increasing number of countries, and these effects need to be more clearly put in contrast to the costs of the support schemes.

As we have already suggested, improving electricity access has large, but hardly quantifiable, effects on economic growth and societal development. Limited access to electricity directly and severely impedes a country's development. While universal electricity access enables – without directly causing – sustained economic and social progress. The use of renewable electricity can have substantial effects not garnered by the use of fossil fuels. A major positive feature of renewable energy is that it lends itself to decentralised installation. This has an empowering effect on local communities that can act as a major catalyst for local economic growth.

Much of the world's geopolitical tensions are associated with energy access and security. There are countless examples of conflicts arising around geographic areas with energy resources. Not only the tensions in the Middle East, but other regions, including central Asia or parts of Africa, are experiencing similar patterns of conflict. Thus, reducing the world's dependence on imported fossil fuels may have a net positive impact by reducing tensions and conflict potentials currently focused on geographic energy resource locations.

Reducing or removing the income from fossil energy trade will on the other hand affect exporting nations, such as Russia and Middle East countries. For example, Algeria, Libya and Saudi Arabia earn more than 95 % of their export earnings and a very large share of their GDP from oil (Library of Congress, 2005; 2006; 2008). In this perspective, a move to renewable energy could also lead to increased tensions and internal or external conflict. Clearly, it is crucial to find ways to soften the negative effects on the fossil fuel exporting countries and diversify their economies before the fossil fuel income breaks away. If this can be managed, a shift to renewable energy will likely be beneficial to global political stability.

Furthermore, as has been discussed above, an expansion of renewable electricity investment requires functioning capital markets. Today, many developing countries have poor financial systems and stand largely outside the global financial world. If ways are found to attract investments in renewables, this may spill-over into other sectors as well. The first waves of investments in renewables may provide the chance for developing countries to acquire the skills needed to attract and process capital. Examples of such financing schemes are the carbon trading systems, such as CDM, the Clean Technology Fund investments in solar power in North Africa, and Muhammad Yunus´ Grameen Bank, which provides microcredits for renewable energy projects.

Conclusion

The various economic benefits of building up renewables underline the reasoning for scaled-up investment and stress the fact that support for this development should be perceived within this broader context of beneficial impacts away from being regarded as costs. Many of these benefits are still difficult to quantify, which calls for the need of further research in this field. In the next section, the specific hurdles to investing in renewable energy are examined providing the basis for understanding of what kind of support is needed to overcome these hurdles.

Box 2: Germany: The economic impact of renewables

After the oil crisis, Germany began to support renewable energy but there was little momentum until the Chernobyl nuclear power station accident in 1987. That changed public opinion against nuclear power and with growing alarm about the risks of climate change the government was forced to rethink its energy strategy. Renewables became a big part of that strategy.

The first feed-in tariff law was enacted in 1990 and since then renewable electricity has expanded massively from 3.1 % of gross domestic electricity consumption to 16.1 % (see Figure 7) in 2009 (BMU, 2010b). During that period Germany has added over 40 GW of renewable energy capacity and has become the leading producer of electricity from PV and biogas as well as becoming one of the leading wind energy producers in the world.

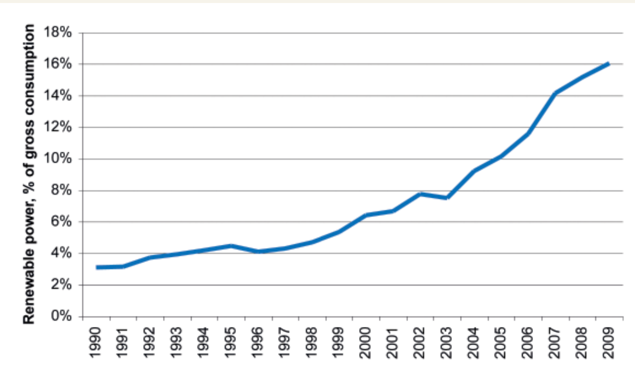

Figure 7: Installed renewable capacity in Germany, 1990–2009. Source: (BMU, 2010b).

The success of the renewable expansion owes much to the Renewable Energy Sources Act which is based on a feed in tariff support scheme combined with guaranteed access to the grid. This is paid by consumers as a tariff on their electricity bills (Couture et al., 2010a). For 2008, the gross cost of the feed-in tariff was $5.9 billion which represents approximately 5 % of the cost that a domestic user paid for electricity in that year (BMU, 2009). At the same time, besides increasing renewable power capacity, the economic benefits have been substantial:

IMPROVED ENERGY SECURITY

The growth of renewables has had the impact of reducing Germany's energy import needs and thus improved its energy security situation. Germany actually became a net exporter of electricity in 2008, compared to 2000 when it had to import electricity (Gronwald and Loppelt, 2010).

REDUCED COSTS OF ELECTRICITY GENERATION

The merit order effect, or the economic benefit from not having expensive conventional power units producing electricity due to the priority feed-in of renewable electricity, has been measured at approximately $6.5 billion in total (Sensfuß et al., 2008).

DECREASED GREENHOUSE GAS EMISSIONS

The production of energy using renewables has enabled Germany to avoid greenhouse gas emissions of 74 million tonnes (BMU, 2010b). If the current carbon price is applied (around $20/t) then this saving is worth $1.3 billion. Renewables have been important in Germany being able to reduce its energy related emissions by 21 % since 1990 (BMU, 2009).

BALANCE OF PAYMENTS BENEFITS

One of the impacts of the increase in renewable electricity has been a reduction in the need to import electricity and fuels. One study put these savings for 2008 at $3.8 billion (Wenzel, 2009). The introduction of FIT policies has also enabled Germany to become an incubator of renewable technologies and innovation as well as creating export opportunities (Couture et al., 2010a).

INCREASE IN EMPLOYMENT

Germany has been a first mover in the renewable energy space and has created world leaders in the space such as Enercon in wind and Solarworld in PV. At the end of 2009, there were some 340,000 people employed in the German renewable energy sector, which is nearly double that of 2004, see Figure 8 (BMU, 2010a; b).

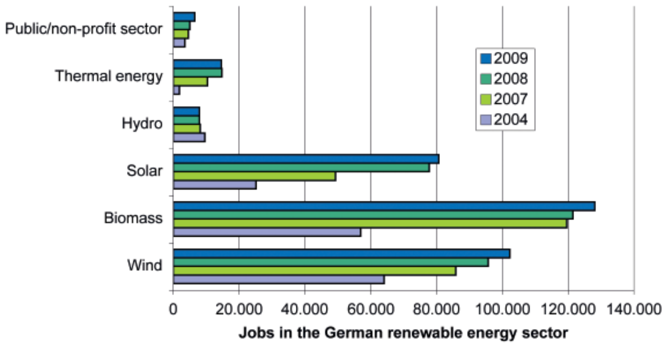

Figure 8: Jobs in the German renewable energy sector, 2004-2009. Source: (BMU, 2010a).

3 SPECIFIC HURDLES FOR INVESTMENTS IN RENEWABLE ELECTRICITY

The global potential supply of renewable electricity is an order of magnitude larger than all credible scenarios of future power demand (Resch et al., 2008). Nevertheless, increasing the share of renewables in the power supply faces three main barriers. First, the variability of many renewable sources makes it difficult to guarantee that electricity supply will meet the demand at any time. Overcoming this will require investments in transmission capacity, the careful management of demand load, and the optimal use of dispatchable sources such as hydro, three things the current market design and incentive structure does not accomplish. Second, the LCOE from renewable sources is still higher for most renewable technologies than for the least-cost fossil fuel alternative, especially if one leaves out many external, hidden, costs associated with fossil fuels, such as their local impacts on air pollution, health and climate change, as well as the still existing subsidies for fossil and nuclear power. Third, the cost structure of renewables is problematic; all except for biomass require large up-front investments followed by low operating costs later on. Raising the required capital for investments can make financing their construction impossible, especially in countries where such markets are less well developed. These difficulties, and especially the first two, are the reason that many observers for many years thought it impossible to build a power system based on renewables. This view is now changing and the view that very high shares of renewables are indeed possible is spreading. For example, Scotland recently increased its 2020 renewable power target from 50 % to 80 % – “with little change to the current policy” – as compared to the 20 % in place in 2007 (Scottish Government, 2009; 2010). In recent years, there have been a number of reports published showing how very high shares of renewables are possible also in the larger perspective, but the success of this transformation largely depends on government intervention to correct for current and past market failures support markets to overcome existing hurdles (Czisch, 2005; ECF, 2010; Schellekens et al., 2010; SRU, 2010). As a background to describing that intervention, we discuss each barrier in turn.

3.1 Intermittency

The first major hurdle is the variability of renewable electricity flows, which makes it challenging to deliver a steady, reliable supply of electricity. Sun, wind, rainfall, and even plant harvests fluctuate. This is the central technical challenge of continuing to expand renewables. Efficient integration of large shares of renewable electricity (generally above 20 %) into an existing electricity system requires a different design and management of that system. These changes to operation are necessary in order to successfully effect a transition from the conventional electricity system – with limited variable generation and often inflexible power demand – to an electricity system that includes high levels of non-dispatchable generation flanked by highly flexible generation and demand. Maintaining a reliable system is at its most challenging during this transition. Once it is achieved, the operation of the electricity system creates new and different, but not necessarily greater, concerns for system security.

There are a number of ways to address this difficulty. One is to simply accept that the electricity supply is variable. This solution is often used in off-grid solutions in developing countries: variable power is a great step from not having any power at all. Thus, off-grid solutions are likely to be the first step to give electricity to the 1.5 billion people without electricity access today (see section 4). Still, intermittent power supply is unlikely to fulfil all aspirations for economic development, and may require the construction of expensive off-grid back-up units, such as diesel generators or batteries (Franz and v. Mitzlaff, 2009; Leonhard et al., 2008).

The more usual aspirational approach is to interconnect a large number of renewable generation units via the grid. This can be within distribution networks that can be utilised locally through 'smart grids,' which then link into national, and potentially, trans-national 'supergrids'. Interconnecting vast areas of land and sea will greatly reduce the fluctuations in the grid by stochastically smoothing both the supply and demand curves. Combined with additional load management measures, the state-of-the-art in electricity system research suggests that these two measures may be sufficient to solve the variability problem completely (Czisch, 2005; ECF, 2010; Mackensen et al., 2008; Patt et al., in review; SRU, 2010).

Furthermore, most good renewable generation sites are not located near load centres, but in remote and sparsely populated areas. For instance, some of the best wind resources in the United States are in North Dakota – sufficient for up to 35 % of the US electricity needs – but the nearest major population centre is Chicago, over 1,400 km away (Elliott and Schwartz, 1991). Utilising such resources implies the need to build the infrastructure to transmit the electricity to the load centres. Although transmission investments are bulky, they do not add very much to the cost of electricity; this cost addition will in most cases be more than cancelled by the decrease in cost from utilising good instead of mediocre production sites (Battaglini et al., 2009; Battaglini et al., 2010; DLR, 2006; May, 2005; SRU, 2010). It is a consequence of the current market structures, which divide investments in generation capacity from investments in the grid, that grid investment is seen as an unfortunate additional cost burden associated with renewables. In fact, grid investments need to go hand-in-hand with capacity expansion, and the two together can enable the use of the most cost-effective renewable options.

3.2 Levelised costs of electricity

On a company's balance sheets, the LCOE represents the sum of capital amortisation, interest payments to creditors and dividends to investors, and operation and maintenance over the entire life-cycle of an electricity installation. There have been major LCOE reductions over the past few years for many renewable energy technologies, but with the exception of large hydro and optimally located onshore wind, LCOEs are still higher than conventional power sources. The costs of most renewable technologies can be expected to continue decreasing (Neij, 2008), and most may be able to reach cost parity with current costs for new conventional power within 10-20 years (Schellekens et al., 2010). But until that gap completely closes, private investment still depends on some sort of subsidy to cover the difference.

There have been some attempts to measure how large this difference is. Williges et al. (2010), for example, did so for the case of CSP. Using a scenario of a fixed 25 % capacity growth rate per year, and a number of additional assumptions, they calculated that European subsidies of 65 € billion, committed to over the next fifteen years, would be sufficient to lower the LCOE to below that of fossil fuels, at which point no more subsidies would be required. They also investigated the sensitivity of the model to most of their assumptions, many of which are contingent on future policy such as public R&D spending, with estimated subsidies ranging from less than 15 € billion to more than 200 € billion (Williges et al., 2010).

Caution is advisable in interpreting numbers such as these, as these cost comparisons are oftentimes flawed. LCOE is a measure that is seemingly easy to calculate, but contains a number of caveats. For example, it is difficult to correctly assume fuel and operating costs in the future (de Almeida and Silva, 2009; Patzek and Croft, 2010; Schellekens et al., 2010). Each technology has a different cost and revenue structure, and in the case of renewables location has a large impact. The cost of capital also plays an important role in the calculation and this, in turn, depends on the risk profile of the particular project, the local economic environment, the risk preferences of investors as well as the degree of debt available. The debt/

equity ratio is fundamental to the overall cost of a project, and is highly project specific. Generally, the cost of debt is lower than the cost of equity, as the former are paid first from a company's revenues with the equity holder having a right to the remainder. To calculate the LCOE one has to assume a level of debt and a return for that debt holder. The result is either a point landing, which does not adequately recognise the uncertainties of the cost estimate, or an extremely broad range of LCOE calculations, which is not always very useful in the political discussion.

Furthermore, the world's energy and electricity markets are distorted by a number of direct and indirect subsidies. The size of global fossil-fuel subsidies to consumers in 2008 has been estimated to have been almost $700 billion, which is roughly equivalent to 1 per cent of world GDP (IEA et al., 2010). Of this amount, about $125 billion were used to subsidise fossil power plant fuel (IEA et al., 2010). Russia alone directly subsidises its electricity use with around $20 billion/year. The global direct nuclear power subsidies are $45 billion/year (IEA et al., 2010; Victor, 2009). The indirect subsidies to nuclear power stations – the state acts as accident insurer – have been quantified at $145 billion for the US alone (Goldberg, 2000; Matthes, 2005). As a comparison, the global renewable electricity subsidies amount to $27 billion/year – about 20 % of the direct fossil electricity and electricity consumption subsidies. Nevertheless, these costs are often perceived as highly problematic and damaging to the economy, and the actual reason for reforms or cancellations of support schemes.

Thus, one cannot speak about cost of conventional and renewable power without accounting for these expenditures. Fossil fuel subsidies are especially important in developing countries, as they put significant strain of the public budget and artificially increase energy demand. On the other hand, large parts of the population would not be able to afford to use modern energy at all if the subsidies were removed.

The other element of costs that needs to taken into account when discussing the competitiveness of renewables are environmental externalities, but as they are difficult or impossible, to quantify accurately, they are often not included in the LCOE. The comprehensive EXTERNE-E study of the European Commission concluded that the external environmental costs in Europe[3] are 2–15 €c/kWh for coal/lignite power and 1–4 €c/kWh for gas power, compared to 0.05–0.25 €c/kWh for wind power. The wide ranges come both from uncertainties regarding data and methodologies, and due to the site- and time-specificity of the results (EC, 2003). Attempts to internalise these costs, for example through the European Emission Trading Scheme, have been partly successful, but also with respect to external costs, renewables and conventional power are still far from a level playing field.

3.3 Cost structure

The third hurdle with renewables is their high upfront investment costs, which except for biomass typically account for up to 80 % of the LCOE. Nuclear power has a similar cost structure, but the numbers are quite different for fossil-fuelled power, which typically has high operational and fuel costs and, especially gas power, relatively low capital costs. The effect of these high upfront costs is that the payback period for renewable projects is longer than with conventional power stations. The longer the payback period, the riskier the project is seen from the financier's point of view; the riskier the project is, the higher the cost of capital required to finance those projects. This in turn leads to a higher LCOE. To further complicate issues, the recent financial crisis has also made credit tighter, and despite substantial cuts in central bank lending rates, the cost of capital for many projects has actually risen (IEA, 2009a).

Without a properly functioning capital market, it is very difficult to finance renewable projects. This is particularly difficult for developing countries, as these largely stand well outside the global financial world. The World Bank estimates that sub-Saharan Africa has the potential to add 170 GW (three times current generation capacity) of additional capacity through the United Nation's Clean Development Mechanism (CDM). However, only 53 out of 3,500 CDM projects to date come from the region, as "the lack of investment and financing capacity is a chronic barrier for any capital-intensive infrastructure" in developing regions (de Gouvello et al., 2008). Most CDM projects are in China and India, where capital is far more plentiful.

Thus, although the renewable LCOEs are approaching cost competitiveness with conventional power, the long payback times – up to 20 years for some technologies – are blocking investments. Investment flows instead into other technologies or areas with shorter payback times. This is problematic, especially for developing countries

3 The EXTERN-E project assessed the damage costs of pollutants, but due to the difficulties with assessing the climate damages of European greenhouse gas emissions, the avoidance costs were used to quantify most of the external costs of climate change. It does not assess nuclear safety, proliferation, security of supply and visual intrusion. The EXTERN-E methodology has progressed further with the NEEDS project, which was finished in 2009, but no new direct cost quantifications were published.

but also in the industrialised world, as changing the power system to renewables brings not only environmental benefits, but also economic ones, like reducing electricity price volatility, see section 24.2 (IEA et al., 2010). Gaining some of these benefits would however often require large-scale investments in renewable capacity, and many developing countries do not have access to this – partly due to their energy subsidies – and are thus caught in a vicious circle.

Box 3: Southern Africa: challenges and potentials

Due to its varied but complementary resources, combined with the challenges of rural electrification, southern Africa is a particularly interesting region from a renewable power perspective. In addition to several island countries, the region comprises twelve countries, with the Democratic Republic of Congo (DRC) and Tanzania forming the northern frontier. In addition to the Congo River, the Zambezi River has its source in the DRC, before flowing southwards through Zambia, Zimbabwe, and Mozambique, to flow into the Indian Ocean. Further to the south, the continent exhibits a rainfall gradient, from the Namib desert in the west being one of the driest places on earth, across the Kalahari desert, into the semi-arid highlands of Botswana, South Africa, and Zimbabwe, and then to the moist and fertile lowlands of Mozambique on the Indian Ocean coast. Two countries, Mozambique and Botswana, illustrate the issues the region faces and its challenges for renewable energy development.

Mozambique occupies about 800,000 km^2, a little smaller than France and Germany combined, with a population of 23 million. Average per capita GDP is just under $500, and only 6 % of the population has access to electricity (UNDP, 2010). There is a single state owned power company, which is able to supply a peak load of 300 MW, virtually all of which comes from a single dam, Cahora Bassa (HCB), on the Zambezi River in the central part of the country, a large share of which goes to the capital city, Maputo, in the south. HCB has a total capacity of 2.2 GW, with 95 % of the power exported directly, via merchant cables to Zimbabwe and South Africa. Estimates place the total hydro potential of Mozambique at 12.5 GW, far exceeding the total demand in the region outside of South Africa. Because of inadequacies in the Mozambique grid linking HCB with Maputo, the southern region of the country has had to import power from South Africa, as demand has been increasing at 8 % p.a. (ADB, 2007).

Botswana occupies 582,000 km^2 and with a population of 2 million is one of the least densely populated countries on Earth, roughly equivalent to Canada. Average per capita GDP has grown dramatically on account of mineral export revenues, and now stands at about $6,500, or $14,000 in purchasing power parity terms, with 22 % of the population having access to electricity (UNDP, 2010). The country consumes about 2 TWh/a, over half of which is imported from South Africa. There is a single state-owned power company, which generates 80 % of domestic production at the 132 MW air-cooled coal-fired Morupule Power Station. The average daily solar irradiance of 21 MJ/m^2 is among the highest in the world (Mbendi, 2010). Solar power using PV cells, and where necessary batteries, is already a cost-effective option for off-grid energy needs. There is a tremendous potential to develop large scale PV and CSP for domestic consumption and export to South Africa.

The two countries indicate the potential for renewable power in southern Africa. Their resources – hydro in Mozambique and solar in Botswana – which could easily satisfy the entire region's demand, are perfectly complementary from a load management perspective. What is lacking is infrastructure, both in generation and transmission, and the financial means to realise the strong and rapid expansions that are possible. The solution is not only national policies in the specific countries to support renewables, but also an international mechanism to allow the investment of funds from wealthier countries to these countries.

4 EFFICIENCY AND EFFECTIVENESS OF POLICY FRAMEWORKS FOR RENEWABLE ENERGY INVESTMENTS

To make investments in renewables attractive despite their higher LCOE and unique cost structure, many countries and subnational governments (e.g., states, provinces, and cities) have introduced different kinds of support schemes for renewable electricity. Governments' main policy instruments for supporting renewables include feed-in tariffs, quota systems, such as renewable portfolio standards or tradable green certificates, tax incentives, and directed financing programs, such as loan guarantees and low interest rate loans. These policy measures are complex, and each jurisdiction has its own legislation. In addition, there are international support mechanisms like the CDM system as well as international organisations like the World Bank and a number of development banks and development organisations which are involved in financing and promoting renewable projects. There are also different regulations regarding grid access, priority feed-in, and different support schemes for education and capacity building; these issues, going beyond money, have proven to be of high importance for the proper functioning of markets and policies (Ölz et al., 2008). Here, the focus is on the financial policy mechanisms to support capacity expansion.

Presently, 85 countries have some form of renewable energy target in place. In addition, some 83 countries – 41 industrialised and transitional countries and 42 developing countries – have enacted legislation to promote renewable electricity generation. This is nearly double the 48 countries that had legislation in place in 2005 (REN21, 2005; 2010). Tax credits are used in 45 countries and investment support of different kinds has been used in many countries. The vast majority of investments, however, has come from regions with at least one of the three dominant policy tools of stimulating investment in renewable electricity: feed-in tariff, investment or production tax credits, and the quota system (REN21, 2010).

4.1 Feed-in Tariffs

Feed-in tariffs (FITs) impose on electrical utilities the obligation to buy and take renewable energy onto the electricity grid at set prices for agreed periods of time from all eligible producers. The price level is typically technology-specific and is based on costs (used in most countries), the value of the electricity to society or the utility (used in for example California and Portugal), or based on auctioning where the lowest bidder receives the price it offered for a fixed time (used in for example some US legislations, tested in Spain, India and China). The LCOE-based FIT is the most common tool, and the main policy instrument behind the rapid renewables growth in Germany and Spain. FITs are currently being used in over 50 countries (Couture et al., 2010b; REN21, 2010). A variant of the FIT, proposed or in place in parts of the United States, is net metering. This allows individuals and firms that are net consumers of power, but which at times put more power into the grid than they take out, to pay for only the net amount used. This has the effect of setting the price for all the power they produce at the prevailing consumer price, which is usually substantially higher than the average wholesale or producer price.

4.2 Tax Credits

Tax credits is the most important policy instrument operating in the United States. They can take two forms. Investment tax credits allow companies or individuals to reduce their total income tax burden based on the amount of investment in new generating capacity. Production tax credits are similar, but are triggered by power production, rather than new investment.

Depending on their size and – in the case of production tax credits – predictable longevity, both may be effective at providing a strong financial incentive to investors at low risk. Unlike a feed-in tariff, however, the extent to which small businesses and families can take advantage of them is limited by their overall tax liability. Hence, a small business not generating substantial profits elsewhere might not be able to use the tax credits

4.3 Quota Systems

Quota systems, or renewable portfolio standards as they are called in North America, compel grid operators to supply a proportion of electricity from renewable sources meeting or exceeding a politically set target. This tool is typically not technology-specific. Quota schemes are used by a number of US states and at the national level in the United Kingdom. Other quota systems are planned at the international level in the power market covering both Sweden and Norway (Swedish Ministry of Enterprise and Energy, 2010). Overall, quota systems are in operation in 56 separate jurisdictions (REN21, 2010).

4.4 Advantages and Disadvantages

The advantages and disadvantages of all three have long been debated, with the quota system being generally favoured by free-market proponents, who prefer leaving prices unregulated, and who are doubtful of the government choosing particular technologies. Their biggest criticism of the FIT is the role of the government in determining the price that is paid to the renewable electricity producer. If the government is involved in fixing the price, it is argued, costs are going to be higher. In recent years, however, empirical evidence has showed that feed-in tariffs are more effective than quota systems in stimulating the rapid deployment of renewable energy technology, as well as being a more cost effective way of doing so (European Commission, 2008; Mitchell et al., 2006; Ölz et al., 2008; Ragwitz et al., 2007).

The quota system fails mainly as it does not provide investment certainty: the future income is determined on a certificate market and, in most cases, on the power market. As these price developments cannot be perfectly predicted, the risk increases. Given that the market for the credits is not very liquid the renewable generator is not able to hedge the risks of future price changes. The result is that the financier both on the debt and equity side regards such projects as higher risk and thus the cost of capital is higher. This in turn increases the cost of the project, makes the investment less attractive and reduces the number of projects completed (DBCCA, 2009).

This can partly be observed in the UK, where the government in 2000 committed to a goal of 10 % of all electricity from renewable electricity by 2010, of which only 5.5 % has been achieved (NAO, 2010). At the same time, it is important not to downplay the effectiveness of well-designed quota systems. Colorado, for example, set in 2004 a 10 % quota for 2015. When it became apparent that it would meet that target easily and below estimated cost, politicians changed it in 2007 to 20 % by 2020. As that target has appeared to be easily reached, politicians have most recently changed it to 30 % by 2020 (Eber and Tucker, 2010).

Well-implemented FITs, on the other hand, have proven very adept at attracting large amounts of equity and debt financing and have led to lower costs than quota systems. FITs have generally had both a higher effectiveness and a higher economic efficiency than other support schemes. There are three main reasons for this. First, FITs are easy to understand, which makes investment evaluation much easier. Second, FITs make it possible for both large and small investors, ranging from banks to private homeowners, to invest in renewable power, which increases the amount of available capital. Third, and most importantly, FITs strongly reduce risk, and this high level of investment security in turn reduces the cost of capital, which is a key determinant of overall cost and likelihood of renewable deployment.

Thus, the stability of a FIT framework leads to the provision of debt financing from traditionally risk adverse investors, further increasing the potentially available capital (Couture et al., 2010b; Ölz et al., 2008). This is examined more closely in section 5. From a macroeconomic perspective, the technology-specificity of FITs lead to lower windfall profits for the producers, thus increasing the efficiency of the support scheme.

Box 4: Iberian Peninsula: Learning from Spain and Portugal

Europe has been very active in supporting renewables over the last decade and countries such as Spain and Portugal have been very successful in not only building up renewable capacity but also demonstrating how renewable policy should be developed and implemented. It is critically important to learn from their experience.

PORTUGAL
For many years, Portugal had a decreasing share of renewables in their power mix (Eurostat, 2010c). With the introduction of feed-in tariffs and a coordinated effort to improve grids, Portugal has increased its installed renewable capacity by 300 % in the last 5 years. Portuguese renewables now provide 45 % of electricity consumed (Rosenthal, 2010). There has also been a growth in jobs in the renewable sector, and the Portuguese renewable utility EDP Renovaveis is one of the world's largest owners of renewable assets. Despite this growth, the price for electricity in Portugal, including the renewable power premium, is about the same as the European average (Eurostat, 2010a).

Portugal's experience may provide a best-practice case for other countries. It's clear ambition to reduce its dependency on imported gas and oil and its stable support scheme coupled with the required grid reinforcements, have created predictable and attractive conditions for investors. Its feed-in tariff is augmented by a tender system for large-scale wind, solar and biomass projects, which brings in an element of competition and has led to bidders accepting prices below the normal feed-in tariff. Auction-based feed-in tariffs maybe the way of the future (EREC, 2009; Heer and Langniss, 2007).

SPAIN
Spain has been especially successful in the wind area. Over the last decade it has developed one of the largest wind fleets in the world with over 20 GW of installed capacity, generating some 13 % of its domestic electricity demand. Spain has also developed a world class wind industry which includes companies like Gamesa and Iberdrola Renovables, the largest owner of wind assets in the world. The Spanish wind expansion was mainly supported by a feed-in tariff system (Ölz et al., 2008).

The Spanish PV expansion was also supported by feed-in tariffs. Falling short of its 400 MW-target for PV, Spain increased its FIT level for PV in 2007, to 57 $c/kWh for 25 years. This level of remuneration enabled developers to construct solar PV projects with IRRs of 12-15 % and equity IRRs in excess of 25 % motivating investors to rush in. Within four months the 400 MW target had been reached and by the end of 2008, 2.6 GW of PV solar was installed in Spain, at a cost of around $20 billion.

Throughout the value chain, participant's made supernormal profits. This, in turn, put significant financial burdens on Spanish state finances, which absorbed the difference between the renewable tariff premium and wholesale electricity. In Spain, 2 % of electricity comes from solar but solar accounts for 16 % of the total cost of electricity in the country (Iberdrola, 2010). Therefore, the government introduced a 500 MW/a cap and a 30 % cut to the feed-in tariff with revisions to the tariff being made on a quarterly basis.

The policy change brought about a dramatic reduction in installations with just 100 MW being installed in 2009. The drop in investment resulted in more than 20,000 job losses and paralysed the maturation of the Spanish PV industry. Today, there are even calls for retroactive cuts in the Spanish feed-in tariffs, a measure that would greatly affect projected returns and has already had the unintended consequence of dislodging investor confidence (Fulton et al., 2009).

The Spanish solar example shows how quickly the financial markets respond to legislative changes. It shows that renewables can be ramped up quickly with appropriate policy, but it also shows the importance of setting the feed-in tariff levels correctly, and then sticking to the remuneration level to maintain market stability and investor confidence.

5 HOW TO SCALE UP INVESTMENTS IN RENEWABLE ELECTRICITY – A GLOBAL RENEWABLES INVESTMENT PLAN (GRIP)

Global annual investment in renewable energy projects, excluding large-scale hydro, has grown seven-fold from $16 billion in 2004 to $101 billion in 2009 (UNEP et al., 2010). While this is only a small fraction of the estimated $178 trillion of assets that are managed by the world's financial markets (Roxburgh et al., 2010), it does suggest that there is substantial room for further investment growth. This section builds upon the analyses made in the last sections which included an analysis of the economic benefits of increasing renewable energy capacity (section 2), an analysis of the specific hurdles to ramping up renewable energy capacity (section 3), and the major policy instruments that are currently being used to support investments in renewable energy (section 4). The Global Renewables Investment Plan (GRIP) is built by using a simple country grouping framework as the basis for a set of strategies to scale up investments in renewable electricity capacity. The section then concludes with an overall consideration of criteria for successful policy implementation of these suggestions. It is recommended that this paper should be used as a starting point for further discussion and research rather than as a definitive and authoritative statement. The set of suggestions presented here for a GRIP stress the need to have a "common vision" to strengthen global efforts to scale up RE investments. Further research to elaborate on the suggestions made here and to quantify various benefits of renewable energy investment would be highly welcomed.

5.1 Country Groupings

A simple country grouping framework is used as the basis for a set of strategies to scale up investments in renewable electricity capacity. It is important to note that the suggestions are in many cases not based on rigorous analysis or peer reviewed scientific results, because to a large extent neither the data to support such analysis or the peer reviewed science exist. These groupings are to be seen as a starting point for further discussion and further research and not as definitive scientific conclusions.

Categorisation		Examples	Comments
1	Industrialised countries, few fossil resources	EU member states, Japan	Economically strong, environmentally active, dependent on energy imports.
2	Industrialised countries, large fossil resources	Norway, US, Australia, Canada	Economically strong, large resource endowments for both renewable and fossil fuel production.
3a	Newly industrialised countries, few fossil resources	Brazil, Mexico, Korea	Rapidly industrialising with growing energy demand, in some cases outstripping domestic fossil fuel production.
3b	Newly industrialised countries, large fossil resources	China, India, South Africa, Russia, UAE	
4	Developing countries, few fossil resources	Morocco, Nicaragua, Cambodia Tajikistan	Developing countries with limited domestic fossil fuel reserves, technical capacity, and available investment capital.
5	Developing countries with fossil resources	Venezuela, Algeria, Kazakhstan	Developing countries economically dependent on fossil fuel exports.

Note: This grouping is far from conclusive. The grouping currently also excludes the major oil producing countries with large renewable resources

To a large extent, a country's willingness to invest in renewables and respective support schemes is a function of the pressure from the main drivers identified in section 2 – electricity access, energy security, balance of trade, price stability, climate protection, and employment – as well as of its economic power and the magnitude of renewable and conventional domestic resources. An analytical tool is useful to help break out countries into bands of activity that highlight the speed at which they might adopt and transition to a greater use of renewable technologies. Table 1 shows how countries have been broken into five groupings. This makes it possible to identify those countries that might be able a play a greater regional or supporting role for other countries at an earlier stage of the transition. At the same time, it allows a discussion to take place on what respective country groups can do to move forward in joint endeavours to scale-up renewable investments.

Group 1

These countries have a strong interest to invest in renewables, and indeed comprise the first-mover countries that have implemented support mechanisms, leading to significant new renewable capacities already installed. National and global environmental concerns initially motivated countries like Denmark and Germany to invest in renewables, but increasingly it is job creation and concerns over energy security that are used by politicians to justify continued policy support for renewables.

Although there are differences between the individual countries in this group, many have all implemented policies to provide investors with low risk opportunities for investing in renewables. Currently, about 50 % of new electricity capacity additions in these countries come from renewables. Nevertheless, there has been substantial variance in the effectiveness of the policies, and most of the growth has happened in only a few countries. It is likely that those countries with less effective policies will learn from their peers, and begin to catch up as they have strong reasons to increase their renewable power generation. The rapid development in some of these countries may cause problems of grid capacity, limiting further growth. Northern Europe stands out as most vulnerable to this. Cooperation between neighbours and within synchronous grids, to reinforce international connections, could be critical for countries in Group 1 to maintain their continued growth in renewables.

As the first-mover group, these countries have played an important role in bringing down the cost of renewables. Creating markets in these economically powerful countries for emerging technologies such as PV, offshore wind, CSP and possibly different marine technologies will continue to allow economies of scale and technological learning to develop, create competition between suppliers and maintain the strong downward price pressure on renewables.

Group 1 has a key role to play in developing best practices for expanding renewables, and triggering renewable investments, and their policy experiences are already important for policy makers in groups 2–5 to learn from. More importantly, Group 1 countries also have a major role in aiding group 4 countries to finance new renewable capacity. The various carbon trading schemes are examples of such support, but they need to be expanded and increasing amounts of this financing needs to be shifted from group 3, which currently receives most of these funds, to group 4 countries.

Group 2

The group 2 countries have incentives to invest in renewable energies on environmental grounds, but also have strong domestic fossil-fuel interests. Two of the Kyoto Annex I countries – Australia and the US – are good examples. In both countries there are ongoing political debates, and changes in government often lead to shifting priorities between renewable investment and fossil fuel expansion. In the US, there is also a great deal of state-to-state heterogeneity, with states such as California and more recently Texas showing renewable growth rates comparable to those in group 1 countries. One of the countries in this group, Norway, satisfies virtually all of its electricity needs with large-scale hydro, but progress in new renewables has been modest.

These countries do not lack technical capacity or available capital, and should concerns over fossil fuel supplies continue to increase, they could move quickly to catch up with group 1 countries, necessitating the same types of new investment in grid capacity. In some countries, such as the US, this already appears to be happening. In such a case, these countries will share with those in group 1 a large part of the future development and cost reduction of renewables. It is expected that they will also share the principle of supporting developing countries' move to clean energy technologies both in terms of financing and technical capacity support.

Group 3

Group 3 consists of emerging global players such as India and China. These countries appear to be highly motivated to invest in renewables, but the major motivation is not environmental concerns. Rather, it appears to be energy access and energy security concerns and the prospects for economic development that are the main drivers. This may change as environmental concerns continue to become stronger.

These countries are watching group 1 countries, and learning fast. They have also been beneficiaries of foreign investments from both Group 1 and 2 countries. Their financial systems are also maturing quickly. This is certainly already the case in China, and in the years to come it will likely be the case in Mexico, Brazil, and India as well. Domestic investment may play an increasing role relative to that from foreign sources.

One of the central roles of these countries is in global manufacturing competition. Today, China plays a key role in pushing down the production costs of PV, and India has played a role in the wind sector. They will increasingly become important for mainstreaming renewables and increasingly international standards will be developed in group 3 countries.

Group 4

These countries comprise the majority of developing countries, with limited fossil fuel resources as well as a rapidly growing need for energy. Their two primary motivations to expand renewable energy investments are improving energy access, and preventing trade deficits, and the resulting currency instability that fossil fuel imports can create. However, these countries lack available capital, partly due to their energy import dependency, and stand largely outside the global financial markets. Thus, this group lacks the economic power to invest themselves in renewables to the extent they would like. It is in these countries that it is most important to obtain the lowest cost electricity, and hence where a drop in the cost of renewables could do the most to stimulate a shift in investment.

Investment that does occur presently relies primarily on development assistance, and secondarily on the Clean Development Mechanism. Both have led to some installed capacity, as with numerous visible cases of off-grid and microgrid electrification of rural villages. Due to the strong benefits of electrification, also with intermittent electricity, it is important to continue these electrification schemes. While investments will likely continue in off-grid solutions, it is important to begin to plan ahead to allow a grid to be developed over time.

Weak economic conditions and lack of access to financial markets are likely to prevail for the near future. These countries will continue to rely on financial assistance and other support from more industrialised regions to increase their capacity. The funds spelled out in the Copenhagen Accord could provide a start for this engagement. Furthermore, emphasis must also be on how these countries can access and be integrated in the financial markets. A reasonable goal could be for all debt and equity to be provided domestically by 2030.

Group 5

This group comprises the developing or emerging countries with large domestic reserves of fossil fuel resources, such as Algeria, Saudi Arabia, and many other OPEC countries, most of which are dependent on fossil fuel exports to sustain their economies. This group has just begun to show interest in renewable energy, climate protection, or resource diversification away from oil and gas. At the same time, many of these countries – especially in the Middle East and North Africa – are sparsely populated, and have large renewable energy potentials, especially for solar and wind. Moreover, many command large sovereign wealth funds, giving them enormous investment capacity.

There are two potential stimuli for renewables in these countries. First, all of them face the choice of using fossil fuels domestically, in what are often highly subsidised markets, or exporting them. Renewable power can free some portion of the fossil fuels used domestically for export, where they can generate higher revenues.

Second, while group 3 countries like the UAE have large fossil fuel resources, others like Algeria, Equatorial Guinea, and Angola, may experience declining oil production in the coming 10 to 20 years (BP, 2010). For these, diversifying both their energy supply and their overall economies will be of crucial importance both to their social and economic development and to their political stability. Many exporting countries may require assistance in doing this; many countries – both their immediate neighbours and wealthy countries further away – may consider such assistance to be a valuable investment in continued energy security.

5.2 Success strategy for the GRIP

Governmental action – strategic public policies implemented through well-crafted legislation and regulation – has driven investment in renewable electricity generation for the last fifteen years, and is likely to drive it until such time as renewables can out-compete fossil fuels on price, reliability, and ease of integration into the power system. That time is drawing near for several technologies, ahead of initial expectations. But to reach the point that renewables can out-compete fossil fuels on price, government policy needs to continue, especially in those countries that are still in an earlier stage of development of renewable energy. A common effort is needed to scale-up renewable investments globally. One major challenge for government policy will also be the need to adapt to changing conditions, most notably the challenges associated with higher market penetration rates of renewables.

For a policy to be successful it has to provide efficient and cost effective ways of increasing renewable electricity capacity. To enable the investments for this, it is crucial that the cost of capital is kept as low as possible by creating a low-risk environment. Experience has shown that to accomplish this, policies should possess TLC: *Transparency, longevity and certainty* (Fulton et al., 2009). To these are added *cooperation* and *competition*. These five attributes are tightly intertwined and are discussed briefly below.

Transparency implies that a policy is easy to understand. From the financial market point of view, the greater the transparency; the more efficient a particular market functions and the more effective the financial market will be in allocating capital. For instance, the US renewables policy framework has been criticised for being too complex and fragmented due to its reliance on a diverse array of state supports and intermittent federal tax incentives (Fulton et al., 2009). Furthermore, understanding how a policy works and why it exists is helpful to understand how the policy will change, which is another important component of reducing risk.

The second key attribute of a successful policy is its lifespan or its *longevity*. This is particularly important to stimulate investments in renewable energy, which have long payback periods. Investors will only put money to work if they can be sure of their returns. The surer they are, the lower the perceived risk, and the more likely they are to invest. For lasting technology transformation, investors require the assurance that policy support will not be withdrawn after a few years.

Uncertainty implies risk and the riskier an investment opportunity is the more expensive it is to finance and the less likelihood that the project will be financed. If a policy withdrawal seems a realistic possibility, the investors will see higher risks, which in turn will either increase the costs of capital or reduce the investment flows into renewables. Knowing that a particular policy will be in place for a long period reduces uncertainty and engenders the *certainty* needed for sustainable investment to take place. Thus, the stability of policy or, at the least, the predictability of future policy change is a key factor to reduce the perceived risks of investment. It is important to note that some policy instruments are inherently more certain than others.

Investment tax credits, for example, provide a certain share of financial return immediately (the rest is dictated by the power market over the lifetime of the investment), and hence reduce uncertainty considerably. Feed-in tariffs provides benefits over a length of time, but these are backed by legally enforceable contracts, and hence quite certain. A project developer does not need to worry that policy-makers in the future may reduce or eliminate the tariff. However, technology producers and operators do. The least certain support policies are those that rely on future expectations of market or political developments to influence current investment. Tradable quota systems can thus create problems, because their success relies on expectations of future market penetration of renewables. Tradable emissions systems, or carbon taxes, are problematic, because they rely on investors expecting future regulators following through on their current pledges, even under conditions of industry opposition.

Transparency, longevity and certainty are clearly the basics of any successful policy but they may not be enough in all situations to guarantee a low-risk and low-cost renewables expansion. Including elements for competition is an important part of successful policy initiatives for supporting renewables. This has been one of the core arguments in the FIT-quota debate (see section 3) – FITs do not allow for *competition* among renewables – but, as mentioned, empirical evidence shows that the risk-reducing attributes of FITs make them both more effective and more efficient; this effect apparently overrides the cost-reducing effects of competition. However, there may be competition in other areas than on the actual electricity market. For example, a FIT with a stable and predictable degression rate puts strong pressure on manufacturers to reduce their costs and prices. Throughout the supply chain, the maximum costs and prices are known for years in advance, as is the knowledge that failing to reach this target may put the company out of business. The certainty about this transparent and long-lived FIT level reduces risks for the manufacturers, which may access cheaper capital, which in turn reduces the total costs for the renewables expansion.

Finally, a last and crucial element of a successful policy approach has become apparent when looking at the different country groupings above; international *cooperation* will be required to make investments macro-economically attractive, or at all possible. Countries with low renewables potentials may seek the chance to rely on their neighbours to secure their renewable electricity supply in the future. Likewise, if Northern African countries are to export solar electricity to Europe in the future, such as proposed by Desertec (Club of Rome, 2008) and others, international cooperation is required. Already today, there is the issue of financing renewables in developing countries: Cooperation and financial support from the industrialised countries (groups 1 & 2) is needed to support the developing (group 5) countries to increase their renewable capacity with significant amounts. Strengthening international cooperation can trigger new opportunities for all countries allowing them to gain from mutual benefits. Cooperation may indeed itself create a new momentum towards an on-going scaling-up of renewable electricity.

6 CONCLUSION

As we look at the pressing need for a global change of our energy patterns and a switch to an energy system based on renewable electricity, the world economy finds itself in a unique situation. Most often, the economies of the world are expanding and the trajectory of that expansion offers rational support for investments and assurances for government planning. However at present, due to the financial crisis of 2008 and the subsequent economic downturn, many of the OECD governments' inflows have been shrinking and their costs for social support and job creation are rising. In 2009, the world experienced a decline in total energy demand (IEA 2009), the first since 1981. At the same time, despite the overall economic downturn, the development of the renewable energy sector continued to be promising.

The need for a coordinated Global Renewable Investments Plan (GRIP), has only become greater in the past years to allow for a further expansion of renewable capacities and to support the mainstreaming of renewables.

The current global economic situation offers a window of opportunity to support the change of the global energy system towards a system based on large shares of renewable energy sources. Throughout this paper it has been argued that efforts to scale-up and mainstream renewables investments are to be seen as favourable and long-term investments into the future. The time is right to further emphasize this shift of perception and to use the chance to change our global energy system.

The IEA projects that energy demand will increase by 40 % by 2030. If the bulk of that demand growth was to be supplied by fossil fuels, this business as usual scenario would put the world on track to experience a temperature rise of up to 6 °C by the end of the century (IEA, 2009b). Much still has to be done if the goal to limit the global temperature rise to 2 °C is to be met. Renewables can and will play a key role in this endeavour. Supporting increased renewable energy investment will be the necessary step to move forward towards that goal.

Amid the budget tightening in many countries, trillions of dollars of investment capital are sitting on the sidelines. To trigger these investments, the framework for a Global Renewables Investment Plan (GRIP) has been built up. Having analysed drivers, barriers and policy frameworks, the last chapter laid out the GRIP by showing several pathways for different groups of countries and what their way forward to scale-up renewable electricity investment could look like. Options for interlinking these efforts have been presented as well as overall criteria for the successful design of supporting policy instruments. Using this broad approach, it has become clear that a common approach to global expansion of renewables is advisable, feasible and can provide mutual benefits for all actors. There is still a need for a deeper understanding of the macroeconomic drivers for renewables in a global perspective, and a renewable energy research project analogous to the Stern Review is needed. The DIREC conference 2010 offers a great chance to move forward together in this direction.

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8 APPENDIX

The roadmap above begins to outline suggested steps within and between each of the five country groupings in the period to 2030. At an overall level it proposes two parallel development paths for two overall country groupings:

- Groups 1 and 2: These countries, given their current advanced state of renewable policy and capacity development, have the opportunity to continue to actively drive their transition to renewables such that by 2030 they are in a position where all new generation capacity that is built is renewables based. Existing conventional capacity may still be online but no new conventional generation capacity is added post 2030.

- Group 3: for countries in group 3 there is the opportunity (partly with help from Group 1 and 2 countries) to develop their own capital markets and financing systems. This would allow for more domestic and regional solutions/sources of finance that are more supportive of government targets. Internationally it would also create greater capacity in the world's financial markets for investment in renewables and help to encourage some further development of markets in Group 4 and 5 countries.

- Groups 4 and 5: These countries, given their earlier state of renewable policy and capacity development, need to firstly develop appropriate government policies that support the development of, and investment in, renewables. By 2030 the intention is that they will have caught up with the 2010 state of play in Group 1 and 2 countries. Their infrastructure target is therefore more modest for 2030, but still challenging, since by 2030 investment in renewables should be considered a mainstream investment option for new capacity. This could then be followed, post 2030, with targets similar to those in country groups 1 and 2 for 2030, of having 100 % of new capacity that is added being based on renewables.

Each country, in each group, then has a number of domestic activities that it needs to complete, either on its own or with help from other countries, to arrive at its end targets.

As outlined earlier in the paper, international cooperation will be crucial to the success not only of individual countries' policies but also in relation to renewable technology development and cost reductions. What is perhaps unique about the roadmap proposed above is the level and type of cooperation and interaction that is being proposed between countries at different stages of their renewable capacity development.

The development and delivery of such a roadmap is within the reach of the countries in each of the groups outlined above. What it requires, as outlined in this paper, is a step change in how governments and businesses work together nationally and internationally to facilitate a transition towards greater use of renewable technologies. Early adopters are in the unique position of showing how ambitious targets can be achieved and aiding others at earlier stages in their development for mutual gain. What is needed now is a mechanism, like a Global Renewable Investment Plan, that allows this knowledge and best practices to be disseminated more widely along agreed upon pathways such that the support and investment is available to help less developed countries make rapid progress towards a more renewables based energy system in the years to come.

Figure 8: Stylised summary of the GRIP as described in section 5.