nccr trade regulation
swiss national centre of competence in research

Working Paper No 2011/63| June 2011

A literature review on subsidies to electricity from renewable energy sources.

Christopher Beaton / Tom Moernhout*

*International Institute for Sustainable Development (IISD); NCCR Trade WP 5 (Trade and Climate Change) affiliates.

NCCR TRADE Working Papers are preliminary documents posted on the NCCR Trade Regulation Website (www.nccr-trade.org) and widely circulated to stimulate discussion and critical comment. First draft: do not cite or quote.

Abstract:

This study reviews a selection of literature on the cost-effectiveness of government support for the research, development, demonstration and the deployment of technologies that generate electricity from renewable energy sources, with an aim of answering three questions: i) what justification is typically given for these subsidies?; ii) how are renewables being subsidized today?; and iii) what have studies concluded about the cost-effectiveness of these subsidies? It finds that subsidies for electricity from renewable energy sources are typically justified by reference to four main policy objectives: environmental gains (in particular, reductions in GHG emissions); stimulating economic development (in particular, creating a national RET industry and related employment); improving energy security; and driving further cost-reductions in renewable energy technologies. It finds that, although there is a broad range of information available about subsidy mechanisms, that there is little consistent data available about subsidy expenditure or recipients. Finally, it also finds that most studies have attempted to analyse cost-effectiveness of subsidies with respect to deployment, as opposed to the ultimate objectives of the subsidies, as identified in this first stage of this review.

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

Die Nationalen Forschungsschwerpunkte (NFS) sind ein Förderinstrument des Schweizerischen Nationalfonds.
Les Pôles de recherche nationaux (PRN) sont un instrument d'encouragement du Fonds national suisse.
The National Centres of Competence in Research (NCCR) are a research instrument of the Swiss National Science Fondation.

Content

DRAFT

1 List of Tables and Figures

2 Acronyms

EC	European Commission
EIA	Energy Information Administration
FIT	Feed-in tariff
FIP	Feed-in premium
GHG	Greenhouse gas
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
RD&D	Research, development and demonstration
RET	Renewable energy technologies
RES-E	Electricity produced from renewable energy sources
RPS	Renewable portfolio standard
Solar PV	Solar photovoltaics
TGC	Tradable green certificate
WEO	World Energy Outlook

DRAFT

3 Introduction

This report reviews a selection of literature on the cost-effectiveness of government support for the research, development, demonstration and the deployment of technologies that generate electricity from renewable energy sources (RES-E). Recognising that any attempt to evaluate a subsidy's cost-effectiveness must be built on an understanding of the rationale for the policy, as well as the specifics of policy itself, it attempts to answer to three basic research questions:

1. **What rationale is typically given for the subsidization of renewable energy technologies?**
   This section identifies the objectives that governments typically claim they want to achieve by subsidizing the development and deployment of renewable energy technologies (RETs),as well as the barriers that might slow or prevent the development and deployment of RETs by market forces. It also summarizes the role that increased generation of RES-E might play in future electricity markets and the mitigation of climate change.

2. **How are renewables being subsidized today?**
   A wide number of countries around the world have developed and implemented support policies for RES-E, particularly over the last ten years. This section defines the major support mechanisms being used, as well as reviewing information sources on policies currently in place in different countries around the world.

3. **What have studies concluded about the cost-effectiveness of renewable energy subsidies?**
   Establishing the 'cost-effectiveness' of support policies for RES-E captures two ideas: first, establishing whether or not the policy achieves its objectives ('effectiveness'), and, if so, whether it does so at a reasonable cost. This section reviews the methodologies that have been used to conduct such evaluations, and summarizes the conclusions of various studies, both those which have looked backward, analysing the performance of existing policies, and those which have looked forward, using econometric modelling to estimate the relative effectiveness of different policies in the future.

By answering these three questions, this review also intends to set out the analytical framework for three studies to follow, focused on the cost-effectiveness of subsidies to particular RETs – wind, solar photovoltaic (solar PV) and biomass technologies – as well as to determine more generally where any consensus and gaps may exist in current knowledge.

The review is modest in its scope. First, the literature that is covered is not comprehensive, focusing only on some of the highest profile studies, which necessarily biases its findings toward developed countries whose renewable support schemes are intended to generate national-level capacity that needs to be integrated into a pre-existing electricity grid. Second, it does not include renewables used to generate heat (RES-H) or those used to substitute fossil transport fuels – it is focused on electricity only. Finally, the world of subsidy policies is a complicated one (see Box 1) and the review only attempts to identify the most high-profile and high-impact policy mechanisms that are in use today.

Box 1. Identifying a subsidy

Although the general definition of a subsidy may sound simple – any form of preferential treatment granted to consumers or producers by a government – identifying and categorizing subsidies can be complicated. Not only do governments tend to support economic actors in many ways, but there is also no clear 'best way' to identify and categorise these different support measures in a sensible order. There are at least three different ways to categorize subsidies:

i. Identifying the effects of support measures – for example, how they affect relative prices in an economy or an international marketplace.
ii. Identifying who receives benefits and how much – for example, the extent to which spending is captured by some actors as private goods and by others as public goods.
iii. Identifying the types of policy instruments ('transfer mechanisms') used to pass on benefits to recipients – for example, listing the various direct financial transfers, tax breaks and other measures used to give preferential treatment.

The GSI recommends that subsidy accounting begin by focusing on the third of these methods. Although other approaches are possible, this allows the analysis of subsidies to be split up into three distinct stages: first, identifying and cataloguing the subsidy mechanisms that exist; second, estimating the financial value of those subsidies; and third, evaluating whether or not the subsidies achieve their stated policy objectives in a cost-effective manner. Importantly, this means that the identification and evaluation of subsidies is split into two distinct stages – simply calling something a subsidy does not necessarily mean it is 'bad'.

In identifying transfer mechanisms, this literature review – and the GSI more generally – follows the World Trade Organisation's (WTO) definition as set out in the Agreement on Subsidies and Countervailing Measures (ASCM). This has support of 153 WTO members, has been tried and tested through a rigorous negotiating process and is supported by extensive legal analysis and jurisprudence from the Dispute Settlement Body and Panels and the Appellate Body. Although the ASCM definition has some limitations – it was developed for trade purposes, so it excludes a number of measures such as subsidy mechanisms that set up an artificial flow of benefits between consumers and producers, an exclusion which is particularly pertinent to a number of subsidies for RES-E – the GSI recommends adoption of the categories set out the ASCM, supplemented by an illustrative list of subsidy types intended to ensure that every variety of subsidy is captured (see Appendix A for more information).

Source:(GSI, 2010)

4 The rationale for subsidizing renewable energy technologies

A number of common arguments are typically made to justify the subsidization of renewable energy technologies (RETs). This section examines these arguments n three steps: first, identifying the policy objectives that governments typically claim they would like to achieve by their subsidization of electricity from renewable energy sources (RES-E); second, identifying the barriers that might slow or prevent market forces from leading to the development and deployment of RETs; and third, setting out the potential contributions that RES-E could make to future electricity generation and the mitigation of climate change.

4.1 Policy objectives behind subsidizing renewable energy technologies

Three varieties of policy objective are generally put forward in support of subsidizing the development and deployment of renewable energy technologies: environmental goals; social and economic goals; and security-related goals.

- **Environmental goals:** the principal objective put forward for promoting RES-E is commonly to help mitigate climate change. This policy objective is particularly prominent in the European Union, whose Directive on renewable energy targets the reduction of GHG emissions by at least 20% compared to 1990 levels by 2020, explicitly requiring that a 20% share of energy consumption come from renewable energy sources(European Commission, 2009). It is also the case, that renewable energy can offer significant benefits by reducing the levels of local pollution, including local air pollution and the environmental impacts of mining activity. (UNEP, forthcoming)

- **Social and economic goals:** although sometimes given a secondary emphasis, the creation of jobs and industries is an increasingly prominent objective behind the promotion of renewable energy technologies, and arguably a politically more powerful motivation than climate change mitigation. Although less developed than analysis regarding climate change mitigation, efforts have recently been made to better quantify the social and economic benefits of renewable energy promotion in the context of the 'green economy' (UNEP, forthcoming), with the International Labour Organisation (ILO, 2008) estimating that the renewable energy sector was responsible for over 2.3 million jobs in 2006 in Europe, the United States, India, China and Brazil. There are also important distinctions to be made on social and economic grounds between developed and developing countries: in the former, electricity generated from renewable energy sources tends to replace components of a large, centralised electricity system, whereas in the latter it can offer new possibilities to extend electricity to households for the first time. In these circumstances, the social objectives behind the promotion of RETs can be considerably broader, given that the UN Millennium Project (2005) identifies electrification as an 'urgent' requirement to meet each of the Millennium Development

Goals. Finally, there are areas where environmental and social goals overlap, such as the Stern report's estimate (UK Office of Climate Change, 2006) that there is a significant net economic benefit to strong, early action against climate change, and preventing local-pollution-related public health problems. It should be noted that claims underlying these social and economic goals are often based on fairly 'soft' analysis – for example, only estimating gross job creation, as opposed to net job creation.

- **Security-related goals:** a third objective behind the promotion of renewable energy technologies is often the improvement of a country's 'energy security' situation–its vulnerability to energy supply disruptions. This might take place by a number of mechanisms. Renewable energy can reduce dependency on energy imports, helping to protect countries from supply disruption resulting from price volatility, scarcity and geopolitical tensions.[1] More generally, it can also diversify a country's energy supply, thus distributing more evenly the risk associated with different energy resources. Historically, energy security has played a bigger role in driving renewable subsidies than climate change or aspirations to stimulate green economic growth, particularly around the oil crises of the 1970s. Although the balance has shifted in recent years, energy security remains a prominent political concern in the energy policies of the United States and the European Union. Ölz et al. (2007) emphasize that the variability of renewable energy supplies must be taken into account if RES-E is to improve energy security. It is argued that this can be done with appropriate grid management and investments in back-up capacity and demand-side management, although this can incur significant additional costs, and many of the more radical solutions to supply variability rely on unproven technologies.

In policy implementation, the achievement of these objectives is focused on the achievement of two separate but related targets that apply in two different time periods:

- **in the short-term**, immediately deploying RETs, despite their inability to compete with market prices, in order to ensure that GHGs peak at an acceptable level in the future; to establish renewable energy industries as a source of future growth; and to immediately improve energy security. In most countries, the hard policy target for RET support schemes is for a certain amount or percentage of RES-E to be produced by a certain date.

- **in the medium-term**, ensuring that RETs develop, such that existing technologies can operate cost-competitively and currently immature technologies can contribute to electricity generation.

[1]It should be noted, however, that for some countries the development of renewable energy might equally lead to an increased share of energy imports, if renewable energy resource-rich countries export large quantities of electricity, as envisaged in the DESERTEC plan, which aims to develop large renewable energy plants in the Middle East and North Africa region and supply as much as 15% of Europe's electricity demand by 2050 (DESERTEC Foundation, n.d.).

4.2 Barriers to the development and deployment of RETs

Various studies in the literature identifed barriers that exist regarding the development of RETs, in general distinguishing between two main forms of barriers: financial and market barriers, and non-market barriers (Mendonça, Jacobs, & Sovacool, 2010; IEA, 2008 a.; European Commission, 2008), where non-market barriers include political and regulatory obstacles, cultural and behavioral barriers, and aesthetic and environmental challenges. Beck and Martinot (2004) make a distinction among cost- and pricing-related barriers, legal and regulatory barriers and market performance barriers. Ultimately, the distinction is to a certain extent academic, as all of the barriers ultimately have an effect on market performance. It should be noted that not all of the barriers listed below are uniquely a problem for RETs; nor that the necessary policy response to each one is to subsidize selected renewable energy areas. The purpose of this section is simply to articulate the barriers that are commonly put forward as justifying renewable energy subsidies.

Table 1. Summary of barriers to the development and deployment of RETs

	Barrier	Mechanism by which development and deployment of RES-E is affected
	Financial and market barriers	
1.	**General innovation externalties**.	A standard externality in free markets is that firms are disincentived from investing in RDD&D because other firms, who have not shared in the cost, can share from the benefits. Intellectual property rights try to correct for this problem, but can be two-edged, with Palmer and Burtraw (2005) restricting the flow of knowledge might slow the speed of innovation and retard technology transfer between countries. Firms can also be dissuaded from investments in innovation because it is risky. The OECD (2010) suggests that this problem may be intensified in the context of climate change, where large uncertainty exists over future policy frameworks. As well as reducing the likelihood of investment, risk can also distort investments between technologies, making investors more likely to back a relatively mature technology, such as wind power, despite the social interest in the concurrent development of less mature technologies, such as solar PV.
2.	**‘Positive’ and ‘negative’ pricing externalities.**	Another textbook externality is that neither the benefits of RETs nor the true costs of fossil fuels are included in their prices, making RES-E relatively expensive and fossil fuels relatively cheap from a perspective of net societal good. This is not just restricted to the costs of CO_2 emissions and local environmental pollution. In the case of renewables, time is an important variable in determining societal cost –immediate reductions in CO_2may be highly valuable in the short-term, despite the costs of immature technologies. In the case of fossil-fuels, some sources (Beck & Martinot, 2004; ILO, 2008)argue that inherent costs such as fuel-price volatility are rarely included in risk assessment and *ex-ante* economic

		analysis. Furthermore, in many cases, fossil-fuel consumption and production is also significantly subsidized, distorting the investment landscape even further (GSI, 2009).
3.	**High capital requirements**	Renewable energy plants are often highly capital-intensive, requiring large up-front investment and financing, potentially deterring business if access to capital is expensive (Beck & Martinot, 2004; Martinot, 2004), though with variability among different renewable sectors. On the other hand, input costs are generally very low in comparison to other energy sources. Note that electricity generated from biomass can be an exception to this rule, as it is frequently used to co-fire coal power stations, and input costs can vary significantly depending on supply and demand, as well as the burden of information required to ensure that fee stocks and sustainably produced (IEA, 2007).

	Infrastructural and regulatory barriers	
4.	**Centralised, fossil and nuclear energy infrastructure**	In most developed countries, the existing electricity grid is designed for large, centralized electricity suppliers, and can only handle a limited amount of variability. This can be a problem for RETs which may be small-scale, in remote locations and – en masse – require a grid that can handle large fluctuations in the generation of electricity. The European Commission (2008) notes that, as the grid is a "highly capital intensive natural monopoly", private investors are unlikely to be willing or able to bear this cost alone.
5.	**Regulations regarding planning and transmission**	In most developed countries, government regulations play a significant role in the electricity market, setting out requirements for generation, transmission and distribution. Beck and Martinot (2004) note that, because they are often designed for above-mentioned centralised, fossil and nuclear energy infrastructure, that rules regarding the transparency of network data, transmission access, interconnection requirements and pricing regulationare likely to burden smaller energy sources more than larger ones. In addition, planning regulations for the construction of RETs have become a well-documented problem in some countries, increasing costs and risks for investors through permitting requirements, siting restrictions or liability schemes (Martinot, 2004).

	Information-related barriers	
6.	**A lack of information or incorrect information about RETs**	Beck and Martinot (2004)note that investors, producers and consumers often lack correct information on technical, geographical, commercial and performance issues. This information deficit may exist either with respect with the technologies themselves, their costs and inconveniences or the features of renewable resources. Mendonça et al.(2010) report that in some cases misjudging technology performance risks or discount rates when initial capital is available can dissuade investment in RES-E, even when it is economically viable.
7.	**A lack of social acceptance**	On some project sites, and in some countries more generally, there can be a lack of social acceptance for RETs. This may be due to a lack of information or misinformation but can also derive from: scepticism about

	climate policy and its associated costs; practical concerns regarding issues such as noise and the impact of construction on property values; and subjective judgements, such as the aesthetic impact renewable energy plants might have on local landscapes.

4.3 Contributions renewables could make to the mitigation of climate change

Given that the mitigation of climate change is one of the primary objectives behind the subsidization of RES-E, is useful to summarize the extent to which the development and deployment of RETs is important within the context of wider climate change mitigation strategies.

The International Energy Agency (IEA) has conducted the most authoritative estimates of the contribution that RES-E could make to the mitigation of climate change in its World Energy Outlook (WEO) publications. In 2009, the WEO included a 'Reference Scenario', that predicted trends to 2030, assuming the continuation of policies already adopted in the year of publication; and a scenario that estimated how trends to 2030 might alter if policies were introduced to reduce greenhouse gas concentrations to 450 parts per million (the '450 Scenario'), the level identified by the Intergovernmental Panel on Climate Change (IPCCC) as having a 50% likelihood of preventing a global average temperature rise of 2° above pre-industrial levels.

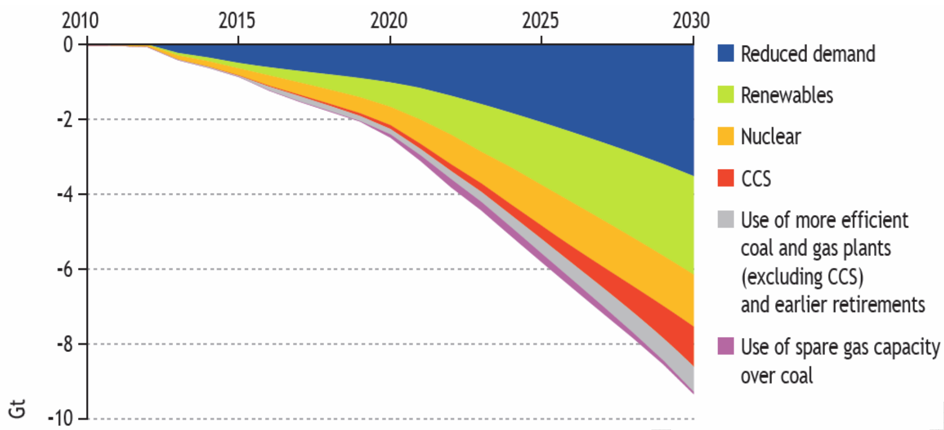
According to the analysis, coal, oil and gas combusted for electricity generation in 2007 was responsible for just over 40% of the world's 28,826 million tonnes (Mt) of energy-related CO_2 emissions, and in the Reference Scenario, the share of emissions derived from the power-generation sector is expected to increase, to 43.3% of total CO_2 emissions by 2020 and 44.3% of emissions by 2030.

In light of this significant carbon footprint, it is commonly observed that there can be no such thing as a low-carbon, sustainable or 'green' economy without a major transformation of the world's power systems (IEA, 2009; UNEP, forthcoming).

Under its business-as-usual Reference Scenario, the World Energy Outlook foresees total electricity generation increasing by 73.6%, from 19,756 TWh in 2007 to 34,292 TWh by 2030, within which non-hydro renewables (biomass and waste, wind, geothermal, solar and tide and wave) are predicted to increase their share of total electricity generation from 2.5% to 8.6%. Under the 450 Scenario, with more ambitious climate policies, electricity generation is predicted to increase by only 52%, from 19,756 TWh in 2007 to 29,939 TWh by 2030, a difference that results from assuming the successful implementation of energy-efficiency measures. The share of total electricity generation attributed to non-hydro renewable energy under this scenario is predicted to increase from 2.5% to 18%.

In the 450 Scenario, the increased deployment of RETs would be the most significant energy-related CO_2abatement measure, accounting for just under 20% of the emissions that could be avoided by 2030 (IEA, 2009, p. 211). While there is considerable room for variation in this estimate, given the emphasis that could be placed on various other policy options used to control emissions (See Figure 1.), it communicates the general principle that increased generation of RES-E is a vital part of any strategy to reduce carbon emissions.

Figure 1. Change in world energy-related CO_2 emissions from the power generation sector in the 450 scenario compared with the reference scenario.

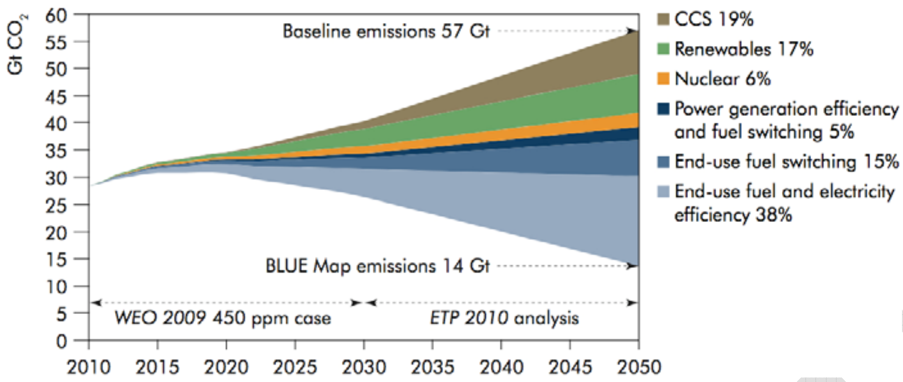


Source: (IEA, 2009, p. 224)[Permission needed for reproduction]

In its Energy Technology Perspectives 2010 (IEA, 2010), the IEA explores how its 450 Scenario might extend forward until 2050, in light of the fact that there are "early signs that… an energy technology revolution is under way." Characterizing its modelling as 'options' as opposed to 'forecasts', the BLUE Scenario argues that significant investments and greater policy intervention will be required if the carbon intensity of electricity generation is to be reduced to 90% of 2007 levels and energy-related CO_2 emissions are to be half their 2007 levels by 2050, regardless of shifts in the balance between renewable energy, nuclear power and carbon-capture sequestration (CCS) in the final electricity mix.

Although the BLUE Scenario is uncertain and could only be achieved at high cost, it illustrates the upper bound of expectations regarding the potential for electricity generated from renewable energy sources: excluding hydropower, 10% of world generation by 2050 in the BLUE Baseline Scenario, and 58.6% of world generation in the BLUE Hi REN Scenario, which assumes that deployment might not only be driven by a CO_2-optimal outcome but also by concerns over energy security and local environment.

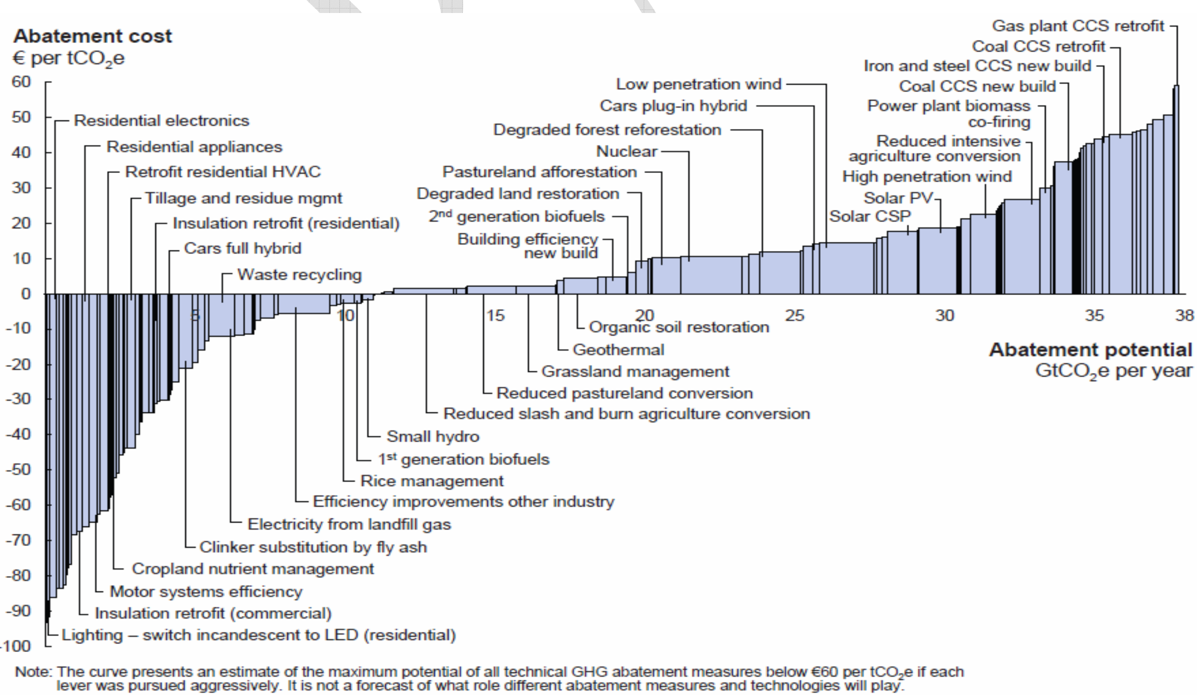
Figure 2. Key Technologies for Reducing CO_2 emissions under the BLUE Map scenario



Source: (IEA, 2010)

As regards costs, analysis by consulting group McKinsey(2009)shows that different renewable energy technologies are represented on both sides of the CO_2 abatement cost curve: with landfill gas electricity generation and small hydropower offering a net cost saving per tonne of CO_2 abated; and geothermal, low-penetration wind, concentrating solar power(CSP), solar PV, high-penetration wind and biomass co-firing incurring net financial costs per tonne of CO_2 abated, with costs ranging from a few euros to just under €40 (See Figure 3). According to the analysis, regardless of their position on the cost scale, all of the above technologies would be required to achieve a scenario in which GHG emissions peak at a CO_2-equivalent of 480 parts per million and ultimately level out at around 400 parts per million in the long-term.

Figure 3. Global GHG abatement cost curve beyond business-as-usual – 2030



Source: (McKinsey & Company, 2009, p. 7)

Finally, it should also be noted that although renewable energy technologies are part of a low-carbon economy, it is generally the case that they involve some carbon emissions in their production. This principal is best known in the case of renewable transport fuels, where life-cycle analysis of biofuel production has shown varying abilities to reduce carbon based on different technologies and feedstocks – according to Doornbosch and Steenblik (2007, p. 18), as high as 100% in some cases, but as low as 13% in the case of ethanol production produced from maize in the United States. Although different carbon footprints vary, life-cycle analysis of technologies that generate RES-E has shown that they are often a significant order of magnitude smaller than their fossil energy counterparts (See Figure 4).

As regards specific technologies:

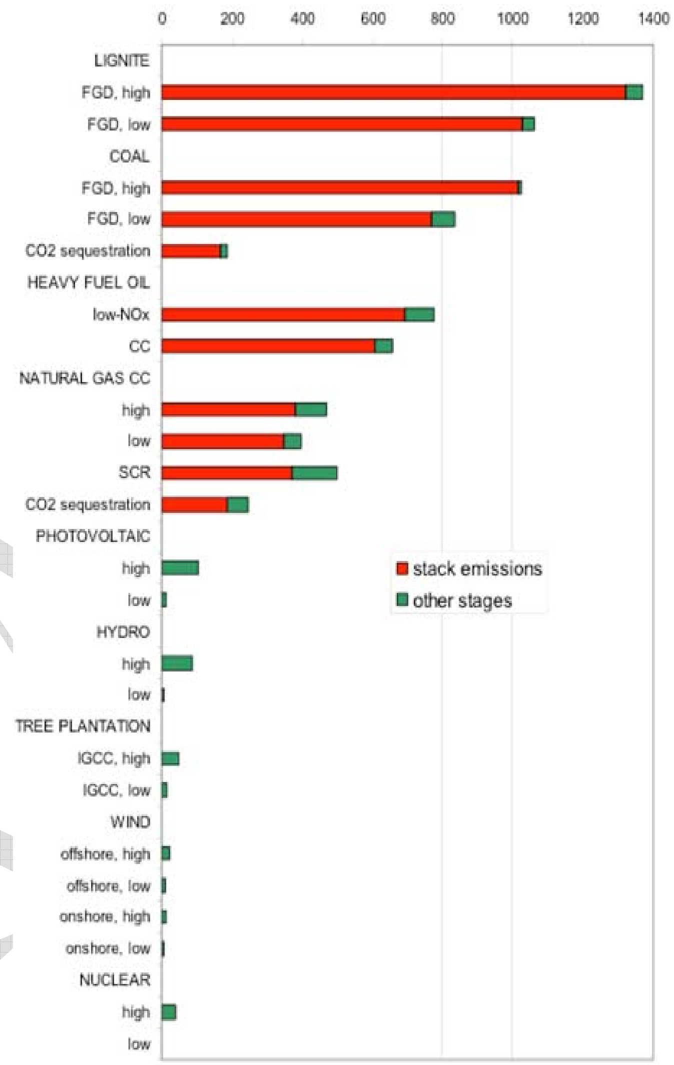
- wind energy has one of the lowest carbon footprints: 98% of its life-cycle carbon emissions come from the production of steel (used for the turbine towers), concrete (used for the foundation) and of epoxy/fibreglass (used for the rotor blades). Studies show that there is only a marginal difference between on-shore and off-shore wind in terms of carbon intensity – around 4.64 gCO_2-eq per kWh compared to 5.25 gCO_2-eq per kWh.(UK Parliamentary Office of Science and Technology, 2006)

- Solar PV has a higher carbon footprint: in the UK, 58 gCO_2-eq per kWh (UK Parliamentary Office of Science and Technology, 2006). This is because the silicon used for PV modules has to be extracted from quartz sand in an energy-intensive process using high temperatures. However, this footprint is lower in areas with higher annual insolation as a greater amount of electricity is produced throughout the lifetime of the solar plant, and new thin-film technologies are made with thinner layers of silicon, allowing for reductions in overall carbon intensity.

DRAFT

- Biomass is often classified as 'carbon neutral' on the basis that the CO_2 in its combustion is equivalent to the CO_2 absorbed by the plants during their lifetime, and that the next generation of plants will absorb the same amount of carbon as those which have been combusted. But as with biofuels there can be additional carbon emissions to take into account from the production process. This means that its CO_2 footprint is variable, depending on what biomass is burned and how it was grown, with fertilizer production, harvesting, drying, transportation and land-use changes being important factors in its ultimate carbon intensity. In the UK, it has been estimated that the carbon footprint of various biomass combustion methods can vary from 25 to 93 gCO_2-eq per kWh. (UK Parliamentary Office of Science and Technology, 2006).

Figure 4. Greenhouse gas emissions from alternative electricity production systems (tonnes of CO_2-equivalent of electricity generated)



Source: (World Energy Council, 2004)[permission needed to reprint]

5 Subsidizing renewables

This section reviews the common support mechanisms that are used to subsidize RES-E and briefly discusses how governments determine the extent of the support that they give. It concludes with information sources about support schemes currently in existence.

5.1 Common support mechanisms

This section identifies and defines some of the mechanisms that can be used to subsidize renewables (for more information about defining a subsidy, see 'Introduction' or 'Appendix A.').Three broad types of support mechanisms were found: income or price support; government revenue foregone; and direct and indirect transfer of funds and liabilities.

Table 2. Summary of common subsidy categories, types and mechanisms

Subsidy Category	Subsidy Type	Common Subsidy Mechanism
Income or price support	Market price support and regulation	• Feed-in tariffs(FIPs) or feed-in premiums (FIPs) • Renewable portfolio standards and tradable green certificates (TGCs) • Tendering • Regulatory loopholes
Government Revenue Foregone	Tax breaks and special taxes	• Investment tax credits • Production tax credits • Accelerated depreciation
Direct and indirect transfer of funds and liabilities	Direct spending	• Research, development and demonstration grants • Earmarks
	Credit Support	• Credit support through loan guarantees

As acaution, it should be emphasized that in reality governments are likely to use a suite of policies to promote renewables. It should also be remembered that policies tend to change through time as governments reflect on their performance or as national priorities change. Once one of the mechanisms in this section has been adopted, its design is not necessarily static and it may indeed be scrapped and replaced with another strategy entirely. There is a general consensus in the literature, however, that any policy in support of renewables needs to create long-term stability for investors, so a balance must certainly be struck between achieving this objective and remaining flexibile to adaptation.

Another important category to bear in mind is the difference between subsidies that primarily target research, development and demonstration (RD&D) and subsidies that target deployment.

Although both are intended to incentivize technology development and cost reductions in the generation of RES-E, deployment subsidies are in most cases focused on bringing about cost-reductions through learning-by-doing and the signals they create for private investors. The majority of subsidies that were identified focused on deployment.

Box 2. The significance of common elements of policy design

Although some elements of policy design are common to many or all policies, the specific terms can make two subsidy mechanisms with the same name differ dramatically from one another in effect. These include:

- **Eligibility:** policies usually set out which actors can qualify for the support and what limitations might exist regarding projects, such as technology type, size, location and date of installation.

- **Lifetime**: in order to create certainty for investors, subsidy policies for RETs generally guarantee support for a large number of years. The European Commission (2008) has estimated that schemes in the EU are generally limited to about 10 to 20 years, while Couture et al. (2010) have found FIT policies ranging between 5−25 years, with the majority being 15−20 years. In some cases, such as Spain's feed-in tariff law (IEA, n.d. (a.)), they exist for the lifetime of the qualifying renewable energy plants. The year in which a renewable energy producer first comes online is usually used to determine the rate that they receive (see 'transitional incentives', below), although some policies, such as Spain's, also schedule predetermined tariff decreases a certain points in the lifetime of an RET installation.

- **Differentiation of rates**: it is common for policies to guarantee different amounts of support for different technologies in order to ensure that a range of technologies are developed – giving different payment rates, numbers of certificates or percentages of tax credit, for example, to different technologies. Couture et al. (2010) report that differentiation also commonly takes place according to criteria regarding plant performance, place of installation and scale of installation, although in some countries different subsidy policies are used to target particular sub-groups of RETs, such as the UK's feed-in tariff (Ofgem, 2010) which focuses only on small-scale installations.

- **Transitional incentives**: the IEA (2008 a.) recommends that subsidies to renewable energies decrease over time in order to reflect cost-reductions as technologies mature. Some FITs and FIPs do so via scheduled reductions or 'degressions' in the tariff, such as in Germany (Germany, BMU, 2009). Ideally their design should also include technology improvement factors by which the premium or tariff decreases over time. Tariffs used for new contracts should similarly decrease over time. (Lesser & Su, 2008)

5.1.1 i. Feed-in Tariffs and Feed-in Premiums

Feed-in tariffs (FITs) oblige utilities to purchase RES-E at a certain price, typically per kilowatt-hour (kWh) of electricity produced (Couture, Cory, Kreycik, & Williams, 2010). Feed-in premiums (FIPs) oblige utilities to purchase RES-E at the spot market electricity price plus a certain premium, where the premium can be constant or vary according to the spot market price (Couture, Cory, Kreycik, & Williams, 2010).The distinction is therefore that FITs guarantee renewable energy producers a fixed price, whereas FIPs promise them a price that will fluctuate according to the base market price for electricity. Neither policy involves government spending. Rather, they are subsidies whereby regulation sets up an artifical flow of benefits, such that renewable energy producers are guaranteed an above-market price, which is paid for directly by energy suppliers, usually passed on to consumers in the form of higher electricity bills. FITs and FIPs are policies that focus on the deployment of renewable energy technologies, on the premise that cost-reductions will be achieved because of learning by doing and increased private interest in RD&D activities. According to the Renewables 2010 Global Status Report (REN 21, 2010), FITs and FIPs are currently the most popular mechanism being employed around the world, with at least 50 countries and 25 states or provinces using the policy tool.

5.1.2 ii. Renewable Portfolio Standards

Renewable portfolio standards (RPS) oblige utilities to ensure that a certain amount of the electricity they purchase is RES-E, typically as a share of the total electricity they purchase, with the share being increased at regular intervals (Cory, Couture, & Kreycik, 2009). If operators fail to comply, a financial penalty is incurred. An RPS policy is generally phased in over time. Like FITs and FIPs, it is a regulatory mechanism that sets up an artifical flow of benefits towards producers of RES-E, and focuses on deployment. According to the 2010 Renewables Global Status Report (REN 21, 2010), RPSare in use in six European countries, Australia, some Canadian provinces, Japan and some U.S. states., as well as Chile, China, some Indian states, the Philippines and Uruguay, with most policies obliging utilities to ensure that 5-20% of the electricity they purchase is RES-E by dates up to 2020 and beyond. RPS are often combined with tradable green certificates (TGCs) (see 'iii. tradable green certificates' for more detail).

5.1.3 iii. Tradable Green Certificates

Tradable green certificates (TGC) or renewable energy certificates (REC) can be used as part of an RPS. They allow for the sale of RES-E to be split up into two separate markets. In the first market – the market for kWh of electricity – RES-E is just like electricity from any other source, sold at the market price, with the exception that for each unit sold, producers are given a certificate. In the second market – the market for certificates – the producer can sell the certificates to electricity grid operators, who are required to hold a certain number at the end of a year (or some other, regular period), or face a penalty. The revenue that producers receive from the sale of certificates should, in theory, cover the additional costs that were necessary for the development of RES-E. This mechanism splits up the direct relationship that exists in RPS between purchasing RES-E and achieving a quota, creating equal opportunities for compliance in areas where there is little supply of RES-E. It also allows for the trade of certificates between different actors – for example, one utility with a surplus of certificates might sell to another utility with a deficit. The most important advantage it adds to an RPS is that grid operators have more flexibility to comply with their quota obligations.

DRAFT

5.1.4 iv. Tendering

Tendering is a system in which governments invite companies to submit bids over a long-term contract to supply RES-E. Whoever can provide the lowest price per kWh is offered the contract. Most tenders specify a certain amount of electricity output that has to be reached and in some cases several bidders are offered a contract, until the set amount is reached. The generated renewable electricity is then still sold at market prices, but the government pays the difference between the market price and the agreed upon price per kWh. Tendering focuses on the deployment of renewable energy technologies. According to the Renewables 2010 Global Status Report (REN 21, 2010), competitive bidding schemes have been enacted in eight European countries, Canada, Israel and a range of developing and emerging economies, including Brazil, China, Mexico and South Africa. In theory, tendering should foster competition among providers of RES-Eguarantee a certain output of RES-E at the lowest-cost. However, at least in the context of wind power, Butler and Neuhoff (2004) report that winning bids have not always been realized because of producers under-bidding to win contracts and then failing to deliver.

5.1.5 v. Investment and production tax credits

Taxexemptions or reductions are often used as a supplementary support instrument. Two well-known examples of favourable tax treatments are investment tax credits (ITC) and production tax credits (PTC).

Investment Tax Credits

Investment tax credits (ITCs) give favourable tax treatment to firms and individuals who are investing in RES-E. These credits offer them a partial tax write-off.

Production Tax Credits

Production tax credits (PTCs) provide an annual tax credit to the owner of or investor in an RES property. The tax credit is based on the amount of electricity that has been generated over the whole year.

Like feed-in tariffs, mechanisms involving tax breaks are not recorded as expenditure in government accounts.

5.1.6 vi. Research and development (R&D)

The IEA (2008 a., p. 167)notes, it is “often difficult to get a coherent overview of public RD&D programmes as these may be fragmented and uncoordinated. In most IEA countries, no single organisation has overall responsibility for energy research.” In the United States, for example, Mendonça et al. (2010)find that the federal government subsidizes more than 150 separate R&D programmes, run by 18 federal agencies.

The United States Energy Information Administration (EIA, 2006)notes that renewable energy programs of the Department of Energy are implemented through direct funding for R&D in national laboratories or the allocation of grants to and cooperative agreements with universities. Partnerships with the industry are most of the time cost-shared. This portion of funding provided by the industry partner depends on its size, the technology’s technical risk, nearness to commercial readiness and so on. A U.S. example is the 2010 Funding Opportunity Announcement (FOA). This document served as part of the implementation of the 2007 Energy

Independence and Security Act, which is meant to boost energy efficiency and the use of renewables. The FOA favours small businesses and does not demand any cost-sharing. It utilizes grant mechanisms in which it funds $100,000 for a one year project (phase I awards), extendable for $750,000 for two years (phase II awards).(US Department of Health and Human Services).

The EU funds RD&D in renewables through Framework R&D programmes. In its Sixth Framework R&D programme (2002-2006), it spent more than €2 billion to research that directly or indirectly addressed climate change. Funding in the Seventh Programme (2007-2013) has increased to €9 billion, of which €2.34 billion is meant for research and development in energy. The funding goes directly to universities, industry or research centres. (European Commission, 2006) Projects supported include among many, PV Chrystal Clear (€16 million), biofuels RENEW (€10 million) and geological storage of carbon dioxide CO2 SINK (€8.3 million)(European Commission, 2009).

5.1.7 vii. Loans or loan guarantees

In some cases, governments provide developers of RES-E with loans or loan-guarantees that are below-market rates, or they provide below-market credit for things important to the viability and profitability of the industry, such as renewable-friendly infrastructure. The IEA (2008 a.)note that government loans and loan guarantees are used in support of some renewables but do not describe how these mechanisms are structured. Since the financial crisis, the importance of loan guarantees may have increased. In the United States, the *New York Times*(Galbraith, 2009) reported that the RES-E industry had warned that the construction of planned projects would be delayed or cancelled if there was no certainty for loan guarantees, due to status of the capital market. Since this time it has been announced(Cheyney, 2010)that an originally touted US$ 6 billion, a total ofUS$ 2.1 billion of funding has been made available to support up to US$ 20−25 billion of loan guarantees.

5.1.8 viii. Special regulatory treatment

Special regulatory treatment can be considered a subsidy if it transfers significant market advantage and financial return to particular energy market participants. In a report on different support mechanisms for RES-E, the European Commission (2008) found that administrative processes can block rapid RES-E development and advised that one-stop authorization agencies should take charge of processing applications and provide assistance to applicants. It also recommended pre-planning mechanisms in which regions and municipalities are required to assign location for different RE projects, and suggested that procedures for small projects should be lighter.

DRAFT

5.2 Databases on existing support schemes

There are already a significant number of databases which house information about country-specific renewable energy support policies, the most significant of which are listed below. The majority focus on collating information about policies: either helping users identify official policy documents or summarizing the design elements of different policies. Only the IEA *World Energy Outlook 2010* attempts to quantify spending, and the data underlying these estimates is not publically available. None attempt to identify the recipients of expenditure.

IEA: World Energy Outlook 2010

In its 2010 edition, the *World Energy Outlook* estimated the levels of government spending on renewables-based electricity for the first time: approximately US$ 36 billion. The data and calculations underlying this estimate were not made available although the *Outlook* reports that a price gap method is used(taking the difference between prices paid to renewable energy producers and the prevailing market price for electrical energy). Spending is not disaggregated by technology or country. The *Outlook* also estimates global spending on research and development of RETs that produce electricity: approximately US$ 4.8 billion. This is disaggregated by technology type.
http://www.weo2010.org

IEA: Global Renewable Energy: Policies and Measures

This International Energy Agency (IEA) website is a database of information on policies and measures intended to promote renewable energy in all IEA member countries and some others, including Brazil, China, India, Mexico, Russia and South Africa. It is searchable by country, policy type, technology targeted, jurisdiction, year, policy status, plant size and sector. Paper and online sources are indicated. Only data from IEA members is subject to official review and the IEA caution that the database should not be considered exhaustive. Sources (IEA, n.d. (b.))
http://www.iea.org/textbase/pm/?mode=re

REN21: Renewables Interactive Map and Virtual Library of Renewable Energy Policy

The Renewable Energy Policy Network for the 21st Century (REN21) is a 'global policy network' with a goal of strengthening policies that will rapidly expand renewables in developed and developing countries. Its Renewables Interactive Map allows users to search countries according to a range of variables, such as types of policy being used to support renewables, targets for renewables capacity, current levels of renewable energy generation and timelines for policies to be achieved, either across the board or disaggregated by different technologies. Detailed descriptions are available about each country according to variable selected, including paper and online sources. The Virtual Library of Renewable Energy Policy lists over 300 documents published since 1992 about renewable energy, including research reports and political statements. (REN21, n.d. (a.); REN21, n.d. (b.); REN21, n.d. (c.))

http://www.ren21.net/map
http://www.ren21.net/virtuallibrary/default.asp

European Union: Renewable Energy website

This European Commission website brings together a wide variety of material about the EU's renewables support schemes: the EU Directive on renewable energy (which sets out the Union's goal of achieving a 20% share of energy from renewable sources by 2020), each Member State's national renewable energy action plan and information about renewable energy technologies. It also houses a number of studies, including analyses of support schemes, their impacts and best practice recommendations for policy-making. (European Commission, 2010)
http://ec.europa.eu/energy/renewables/index_en.htm

Renewable Development Initiative: Policy and Regulatory database

The European Bank for Reconstruction and Development (EBRD) is a bank, owned by 61 countries, the EU and the European Investment Bank, that invests in central Europe and central Asia with an aim of developing countries' market economies and democracies. The RDI is a project to assess the status of renewable energy in EBRD member countries in order to provide information for developers of renewable energy generation who may qualify for financing. Its website includes a policy and regulatory database that includes policy overviews for 29 countries and a database of information which includes an option to filter results by policy-type. Paper and online sources are indicated. (EBRD, 2010; RDI, n.d.)
http://www.ebrdrenewables.com/sites/renew/default.aspx

United States: Database of State Incentives for Renewables & Efficiency

This government-funded website contains information on over 2,000 United States federal, state, local and utility incentives and policies that promote renewables and energy efficiency. It can be searched by sector, state, technology and policy type. It does not, however, contain information on incentives for research and development, commercialization and demonstration projects, nor one-time grants and RFPs. Paper and online sources are indicated. (United States, n.d.; Vanega, 2010)
http://www.dsireusa.org/

DRAFT

6 3. Cost-effectiveness of support mechanisms

6.1.1

This section summarizes the basic methodologies that have been used to determine the cost-effectiveness of renewables, before reviewing the conclusions that various studies have drawn about the cost-effectiveness of subsidies for RES-E.

6.2 3.1 Methodologies

Studies evaluating the cost-effectiveness of subsidies to RES-E fall into one of two categories: those which analyse policies according to their past performance (*ex-post* analysis) or those that attempt to predict the relative effectiveness and costs of different policies in the future with econometric modelling (*ex ante* analysis).

The methodology underlying *ex-post* analysis can vary in its complexity. At its most basic, it consists of two steps. First, studies establish the effects of a policy –measuring its achievements against its stated policy objectives, as identified in the first part of this literature review. The range of performance criteria that are typically considered are summarized in the table below.

Table 3. Criteria used to measure the effectiveness of subsidies to RES-E

Policy target	**Criteria**
Achieve absolute or percentage target for RET deployment	• Amount of or growth in RES-E deployed; • Size of or growth in share of RES-E as a part of total electricity production
Potential policy objectives	
Environmental goals: mitigation of climate change and reduction of local pollution	• CO_2 emissions offset by deployment of RES-E • RET-related improvements in local pollution
Economic and social goals: job creation, industry creation, regional development	• Amount of or growth in jobs in RET industry (short term and long term)
Increased energy security	• Δ in % of RES-E as a share of total electricity production
Development of RETs	• kWh cost reductions in the final sale of RES-E

Some criteria are more difficult to measure, in particular some aspects of economic and social goals (such as the growth of a renewables industry or the development of a region) and

DRAFT

increased energy security. It should also be noted that, in a number of cases, some effort may be needed to isolate the influence that a subsidy policy has had in comparison to other factors – for example, changes in non-renewable parts of the power sector might have a greater impact on the share of RES-E within total electricity production than subsidy policies; and any cost-reductions in RES-E might have occurred independent of the subsidy.

The second step identifies the costs of the subsidy policy and attempts to evaluate whether the effects that have been identified were achieved at a 'reasonable cost'.

Costs might be measured in the total financial transfers created by the subsidy policy, levels of government expenditure (actual or foregone) or impacts on consumers' electricity bills. This can be more or less difficult depending on the policy in question and the extent of government monitoring and transparency. In its overview of support policies for the deployment of renewables in OECD and BRICS countries, the IEA(2008 a.)highlights that measuring support levels is difficult because information on electricity generation costs is not available for all countries, as uses the remuneration over the lifetime of a renewable energy plant as a proxy for total support levels.

Evaluating the 'reasonableness' of costs is a difficult task. Strategies include:

- questioning the effectiveness of the policy
- holding up the cost of subsidy policies against some pre-defined measure of 'acceptable cost'
- contrasting the cost of the subsidy with alternative policy tools that could achieve the same objective
- comparing the relative effectiveness and costs of policies in different countries

None of these are without problems. Conclusions are easiest to draw where a policy has markedly failed to achieve its policy objectives, in which case its cost-effectiveness is immediately doubtful. In some circumstances, it can be relatively simple for analysts to suggest broad measures for 'reasonable cost' – for example, where total spending on subsidies is very small or very large between one RET and another; or in comparison with budget deficits, spending on social priorities such as health or education, or other initiatives that target similar policy objectives.

Contrasting the cost of a subsidy with alternative policy tools is difficult because it usually relies on a counterfactual which cannot by definition be proven. Alternatively, it is possible to compare a subsidy with data on the performance and costs of policies in other countries but this raises complications due to the large number of inconstant variables between the cases in question. Different countries usually have different policy targets and even where these are broadly compatible, policies may vary with to eligibility, levels of support, lifetimes and so on (see part 2 of this literature review for more information). Over and above this, country-contexts themselves can vary dramatically, including the level of ambition, the maturity of RET markets,

DRAFT

the availability and intensity of renewable energy resources, grid infrastructure and all other relevant policy and market factors relating to financial, infrastructural, regulatory and information-related barriers.

The most sophisticated attempt identified for overcoming these problems was developed by the Fraunhofer Institute, and is used in both the analysis of the IEA and the EC(IEA, 2008 a.; European Commission, 2008).

The approach transforms the data from different countries to make them comparable. This 'levelizing' takes the net present value of the total remuneration throughout the lifetime of a policy and distributes it across a common time-scale, with the IEA(2008 a.)using a discount rate of 6.5% over a common period of 20 years, and the EC (2008) using a 6.6% discount rate over a common period of 15 years. It then measures the annual growth of an RET in a country against an estimate of the 'potential' for annual growth in that RET for that country(see Figure 5).

Figure 5. Overview of alternative indicators of policy effectiveness

Indicator	Formula	Advantage	Disadvantage
Average annual growth rate	$g_n^i = \left(\frac{G_n^i}{G_{n-t}^i}\right)^{\frac{1}{t}} - 1$	Based on empirical values	No consideration of country-specific background
Absolute annual growth	$a_n^i = \frac{G_n^i - G_{n-1}^i}{n}$	Based on empirical values	No consideration of country-specific background
Effectiveness indicator	$E_n^i = \frac{G_n^i - G_{n-1}^i}{ADDPOT_n^i} = \frac{G_n^i - G_{n-1}^i}{POT_{2020}^i - G_{n-1}^i}$	Consideration of country specific background	Difficulties in the identification of additional mid-term potential

a_n^i : Absolute annual growth rate.
g_n^i : Average annual growth rate.
E_n^i : Effectiveness indicator for RES technology i for the year n.
G_n^i : Electricity generation by RES technology i in year n.
$ADDPOT_n^i$: Additional generation potential of RES technology i in year n until 2020.
POT_n^i : Total generation potential of RES technology i until 2020.

Source: Ragwitz & Held (2007b) cited in(IEA, 2008 a., p. 88).

The results of this type of analysis, however, are dependent upon the accurate calculation of the estimated' additional generation potential' for each country. The Fraunhofer Institute indicator as used by the IEA and ECis based upon calculations using the 'Green-X' model for European countries and the 'WorldRes' model for non-European OECD countries the BRICS group. According to the Energy Economics Group(n.d. (b.)), the models take into account historical date, country-specific situations, realization constraints, using dynamic cost-resource curves. These included cost-reduction estimates based on different learning rate estimates for each technology(Energy Economics Group, n.d. (a.)). A detailed description of the calculations for each RET is available inResch et al.'s *Potentials and cost for renewable electricity in Europe – the Green-X database on dynamic cost-resource curves*(2006).

It should also be noted that the act of levelizing differences between policies and countries can exclude variables which have significant explanatory power in the success or failure of a policy. The analysis conducted by both the IEA and the EC focused on identifying the most cost-effective *type* of subsidy mechanism (such as feed-in tariffs (FITs), renewable portfolio standards (PRS), tendering and so on) as opposed to exploring the role played by elements of policy *design,* such as subsidy lifetime or digression rates. It is also the case that important detail may be lost by levelizing country background conditions. For example, a country which has very low renewable energy resources and a relatively undeveloped RET market might find it most cost-effective to invest in policies that would increase the imports of RES-E.

Finally, some words should said about *ex-ante* methodologies. The studies reviewed by this literature review focused on a similar set of variables as *ex-post* studies, and relied upon econometric modeling to estimate effect of various different policies. The models used included the Haiku electricity model in the United States (Palmer & Burtraw, 2005), and GREEN-X in the European Union (Faber, Haas, Huber, Ragwitz, & Resch, 2007). A strength of this method is that it allows for the comparison of a wide range of policies in one context. Potential weaknesses include that a model is only as good as its data and is may fail to take into account important real-world barriers, opportunities and costs that are revealed in an *ex-post* analysis.

6.2.1 Conclusions of cost-effectiveness studies

A review of the studies on the cost-effectiveness of support schemes for RES-E shows a variety of approaches and conclusions. They have been grouped here according to one of three categories: studies that compared subsidy mechanisms with alternative policy tools; studies that compared different subsidy mechanisms with each other; and studies that analysed only the operation of a particular subsidy policy in its national context.

6.2.2 i. Subsidy mechanisms vs. alternative policy tools

Relatively few studies were identified that considered subsidy mechanisms against alternatively policy tools. There could be several reasons for this: there may be a general consensus in the policy-making community that subsidies for RES-E are necessary in order to achieve the policy objectives as set out in this literature review; there may simply be high demand for policy advice on how to subsidize RES-E most cost-effectively, given the number of countries currently employing such subsidies; it may be the case that such analysis is relatively difficult to conduct; or that a wider review of literature is required.

Nonetheless, several such studies were identified. In an *ex-ante* analysis using the Haiku electricity model, Palmer and Burtraw (2005) compared an RPS, tax credits and a carbon trading scheme, concluding that in terms of the installed capacity of RES-E, the best performances were shown by the RPS and carbon trading scheme, especially in cases where emissions allowances in the trading scheme were transferred to producers of RES-E for free (a subsidy mechanisms called 'updating'). They concluded that in terms of CO_2 offset, a carbon trading scheme was the most cost-effective. This was because RES-E was most likely to substitute gas-generated electricity as the producer of electricity at the margin, whereas more carbon-intensive coal-power stations generally produced the base electricity load. By contrast, a carbon trading scheme simultaneously stimulated RES-E and created higher costs for fossil energy plants in accordance with their carbon intensity. In drawing their conclusions, the authors emphasized the importance of how any such tax or equivalent carbon trading scheme is designed. In comparing their results with other evaluations, they summarized the conclusions of another study (Fischer & Newell, 2004), which similarly concluded that an RPS would less cost-effective than a carbon tax in the United States.

6.2.3 ii. Subsidy mechanisms vs. subsidy mechanisms

A relative abundance of studies were identified that compared the cost-effectiveness of different subsidy mechanisms for the deployment of RETs. Few studies were identified that explored the relationship between subsidies to deployment and subsidies to R&D, despite several theoretical discussions that too great an emphasis on one might divert resources from the other (Lesser & Su, 2008).

In an *ex-post* review of policy-making in European countries over a 20-year period, Menanteau, Finon and Lamy (2003) conclude that in terms of controlling the cost of subsidies, quantity-based support schemes such as TGCs and tendering have been the most effective; but that in terms of increasing installed capacity of RES-E, price-based subsidies such as FITs appear to have yielded better results, attributed to the fact that they give a higher level of predictability to investors. The authors concluded that it is unclear which policy would best stimulate technical change, but suggest that FITs might do this well via gains from learning and allowing RET manufacturers to reinvest in R&D. They also note that, while tendering is in theory a powerful support mechanism, its success in driving down the cost of RES-E generation may make investors less willing to accept risk and tend to focus installations on only the most efficient sites, stimulating more powerful public opposition to plant construction.

In their *ex-ante* analysis of the US using the Haiku electricity model, Palmer and Burtraw (2005) concluded that renewable portfolio standards are more cost-effective than tax credits, both in terms of promoting the growth of renewables and reducing carbon. An important factor in this outcome was that tax credits would result in a lower electricity price, thus making the policy less effective at reducing carbon emissions, despite still incurring a cost to taxpayers.

In an *ex-post* analysis of the European Union, the European Wind Energy Association (2005) concluded that past experience showed only FITs and FIPs as effective policies in promoting the generation of RES-E, although cautioning that it was too early to draw conclusions about the full range of policy options available and noting that "[i]t is the design of a mechanism, in common with other measures, that determines its success." (p. 71)It also argued that an additional three areas that affected the financial viability of RES-E were as importance as a good payment mechanism: public acceptance; grid access and strategic development of grids; and appropriate administrative procedures.

In another *ex-post* review of the effectiveness and efficiency of support schemes, the European Commission (2008) found varying performance among member states using the same policies and using different policies. The report drew the general conclusion that FITs had largely outperformed quota systems to date in the effectiveness and efficiency of stimulating the deployment of RES-E, although emphasising the important lesson that FITs be 'well-adapted' if they are to perform well. It also stressed that TGCs are relatively young support systems and might yet prove equally or more efficient as they adapt and age. Notably, the efficiency analysis took into account the difference between support levels and estimated generation costs for different technologies, as well as comparing the expected profit per kWh of support schemes in different countries. This analysis concluded that about two thirds of EU Member States have support schemes which are sufficient to cover generation costs for on-shore wind and biomass and that FITs appeared to be relatively more effective at lower producer profit than other subsidy mechanisms. Despite cost reductions, subsidies for solar PV were considered to be too low in most Member States. The study also commented on the need to improve the competitiveness of the EU's internal electricity market and the "high priority [that] should be given to removing administrative barriers and improving grid access for renewable energy producers" (p. 17).

Similar conclusions were drawn by the IEA in its *ex-post* study *Deploying Renewables* (2008 a.), which used the same methodology as the EC in a broader analysis that covered all OECD countries and the BRICS group. In addition to identifying the above-mentioned performance of FITs and FIPs, and noting the potential for less mature support mechanisms, the report identified "five fundamental principles" (p. 23) of policy design for promoting the deployment of RETs: removing "non-economic barriers" such as regulatory barriers or lack of information; creating a predictable and transparent support network for investors; using incentives that decrease over time to "foster and monitor technological innovation"; differentiating support according to technology; and considering the impact of RETs on the overall energy system. The IEA also noted the importance of an adequate balance between support for deployment and support for R&D. Although reviewing trends in the expenditure on R&D in renewable energy – absolute energy-related spending having remained fairly similar to levels in 1974, but the share to renewables having risen from 2.7% to 10.8% – the analysis focused on country expenditure and which technologies received the largest share of support, as opposed to assessing the cost-effectivness of different support mechanisms at different points of the research, development and demonstration chain. The study did, however, encourage international research as a strategy that reduces overall expenditure, shares expertize and enables technology exchange with developing countries, as well as noting the possible emergence of a shift towards promoting private R&D tax exemptions.

Finally, Haas et al. (2009) concurred with earlier studies FITs have historically yielded more results than quota systems or quota systems combined with TGCs but that their efficiency is strongly correlated with their design. The study also noted that FITs seem to be effective at a relatively low level of producer profit.

6.2.4 iii. subsidy mechanisms in their national context

A relatively large number of studies also appear to have been conducted looking at the performance of particular subsidy policies by their own merits in their national contexts. Although this literature review gave precedence to studies comparing subsidies with other policies tools or alternative subsidy mechanisms at an international level, one such study in particular, by Frondel et. al (2008), was particularly notable for its attempts to evaluate the social and economic impacts of Germany's FIT for solar PV: arguing that the 17,400 jobs created in the solar PV industry could potentially represent a net loss in employment if crowding-out effects in conventional energy production and the drain of purchasing power from consumers were taken into account; and that 48% of the solar PV modules installed in 2004 were from either Japan or China, suggesting that much of the economic value created by subsidy spending was being captured by other countries.

DRAFT

7 Conclusions

Preliminary conclusions, to be finalized upon internal and external review of existing content and additional research:

- Subsidies for renewable energy are typically justified by reference to four main policy objectives: environmental gains (in particular, reductions in GHG emissions); stimulating economic development (in particular, creating a national RET industry and related employment); improving energy security; and driving further cost-reductions in renewable energy technologies.

- There are a number of organisations tracking deployment subsidies in different countries and summarizing features of their design. Only the IEA's *World Energy Outlook 2010* was found attempting to quantify the size of subsidies, but without publically accessible data or disaggregation by country and technology type. No countries were found trying to systematically identify the recipients of subsidies. No organisations were found attempting to systematically track subsidies to research and development.

- The literature on policy effectiveness was largely focused on establishing the cost-effectiveness of renewable energy subsidies with respect to levels of deployment, as opposed to the cost-effectiveness of achieving the policy objectives outlined above.

- In the literature on the relative efficacy of different subsidy mechanisms, there is growing consensus that FITs and FIPs have performed well historically in terms of relative cost-effectiveness.

- Regardless of the subsidy mechanism employed, it is possible for the policy to be well or badly designed, with attendant impacts on effectiveness and costs.

- Subsidies for the deployment of RETs appear to be relatively ineffective at overcoming a number of barriers commonly referred to as "non-economic", including regulatory obstacles, grid infrastructure and access to information. Failure to attend to these factors may result in ineffective or unnecessarily costly subsidy mechanisms. Little policy advice was identified on how governments can intervene most cost-effectively in these areas.

DRAFT

8 Appendix A. – ASCM subsidy definition and GSI illustrative list of subsidies

According to the World Trade Organisation (WTO) Agreement on Subsidies and Countervailing Measures (ASCM):
A subsidy shall be deemed to exist if:

(a)(1) there is a financial contribution by a government or any public body within the territory of a Member (referred to in this Agreement as "government"), i.e. where:

(i) a government practice involves a direct transfer of funds (e.g. grants, loans, and equity infusion), potential direct transfers of funds or liabilities (e.g. loan guarantees);
(ii) government revenue that is otherwise due is foregone or not collected (e.g. fiscal incentives such as tax credits);
(iii) a government provides goods or services other than general infrastructure, or purchases goods;
(iv) a government makes payments to a funding mechanism, or entrusts or directs a private body to carry out one or more of the type of functions illustrated in (i) to (iii) above which would normally be vested in the government and the practice, in no real sense, differs from practices normally followed by governments;

or

(a)(2) there is any form of income or price support in the sense of Article XVI of GATT 1994;

and

(b) a benefit is thereby conferred.

The GSI has used this definition to create the following illustrative list of subsidy types:

Direct and indirect transfer of funds and liabilities	**Direct spending**	**Earmarks**: Special disbursements targeted at the sector.
		Agency appropriations and contracts: Targets spending on the sector through government budgets.
		Research and Development support: Support provided to industry that is otherwise not provided to other sectors.
	Government ownership of energy-related enterprises	**Security-related enterprises**: Strategic petroleum reserve; some Homeland Security Administration; securing foreign energy shipments or key assets.
		Municipal utilities and public power: Significant public ownership of coal- and natural gas-fired electricity stations; some transmission and distribution systems for both natural gas and electric power
	Credit support	**Government loans and loan guarantees**: market or below-market lending to energy-related enterprises, or to energy-intensive enterprises such as primary metals industries
		Subsidized credit to domestic infrastructure and power plants

		Subsidized credit to oil and gas related exports
	Insurance and indemnification	**Government insurance/indemnification**: market or below-market risk management/risk shifting services
		Statutory caps on commercial liability: can confer substantial subsidies if set well below plausible damage scenarios
	Occupational health & accidents	**Assumption of occupational health and accident liabilities**
	Environmental costs	**Responsibility for closure and post-closure risks**: facility decommissioning and cleanup; long-term monitoring; remediation of contaminated sites; natural resource restoration; litigation
		Waste management: avoidance of fees payable to deal with waste.
		Environmental damages: avoidance of liability and remediation to make the environment whole.
Government revenue foregone	**Tax breaks and special taxes**	**Tax expenditures**: Tax expenditures are foregone tax revenues, due to special exemptions, deductions, rate reductions, rebates, credits and deferrals that reduce the amount of tax that would otherwise be payable.
		Overall tax burden by industry: Marginal tax rates are lower than other industry.
		Excise taxes/special taxes: excise taxes on fuels; special targeted taxes on energy industry (e.g., based on environmental concerns or "windfall" profits)
Provision of goods or services below market value	**Government-owned energy minerals**	**Process for mineral leasing**: auctions for larger sites; sole-source for many smaller sites
		Royalty relief or reductions in other taxes due on extraction: reduced, delayed or eliminated royalties are common at both federal and state levels. Royalties targeted based on type of energy, type of formation, geography or location of reserve (e.g., deep water).
		Process of paying royalties due: allowable methods to estimate and pay public owners for energy minerals extracted from public lands
	Government-owned natural resources or land	**Access to government-owned natural resources land:** at no charge or for below fair market rate
	Government-owned infrastructure	**Use of government-provided infrastructure:** at no charge or below fair market rate
	Government procurement	**Government purchase of goods or services for above market rates**
	Government-provided goods or services	**Government-provided goods or services at below market rates**
Income or price support	**Market price support and regulation**	**Consumption mandates**: fixed consumption shares for total energy use.
		Border protection or restrictions: controls on imports or exports leading to unfair advantages.
		Regulatory loopholes: any legal loopholes, either in the wording of the statute or in its

DRAFT

		enforcement, that transfers significant market advantage and financial return to particular energy market participants
		Regulated prices set at below-market rates: for consumers (including where there is no financial contribution by government)
		Regulated prices set at above-market rates: including government regulations or import barriers

DRAFT

9 References

Decision No 1982/2006/EC of the European Parliament and of the Council of 18 December 2006 concerning the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013) - Statements by the Commission (12 30, 2006).

Beck, F., & Martinot, E. (2004). Renewable Energy Policies and Barriers. In J. C. Cleveland, *Encyclopedia of Energy.* Academic Press / Elsevier Science.

Butler, L., & Neuhoff, K. (2004). *Comparison of feed-in tariff, quota and auction mechanisms to support wind power development.*Cambridge-MIT institute.

Charpin, J.-M., Siné, A., Helleisen, P., Tlili, C., Trink, C., & Stoffaes, C. (2010). *Mission relative à le régulation et au développement de la filière photovoltaïque en France.* Retrieved November 12, 2010, from Ministère de l'écologie, de l'énergie, du developpement durable et da la mer: http://www.developpement-durable.gouv.fr/Photovoltaique-la-France-en-avance.html

Cheyney, T. (2010, August 12). *Another $1.5B removed from DOE renewables loan guarantee program to help und US jobs bill.* Retrieved November 12, 2010, from PV-tech.org Daily News: http://www.pv-tech.org/news/_a/another_1.5b_removed_from_doe_loan_guarantee_program_to_help_fund_u.s._jobs/

Cory, K., Couture, T., & Kreycik, C. (2009, March). *Feed-in Tariff Policy: Design, Implementation, and RPS Policy Interactions.* Retrieved November 12, 2010, from National Renewable Energy Laboratory: http://www.nrel.gov/docs/fy09osti/45549.pdf

Couture, T., Cory, K., Kreycik, C., & Williams, E. (2010, July). *A Policymaker's Guide to Feed-in Tariff Policy Design*. Retrieved November 12, 2010, from National Renewable Energy Laboratory (NREL) website: http://www.nrel.gov/docs/fy10osti/44849.pdf

DESERTEC Foundation. (n.d.). *Red Paper: An overview of the DESERTEC concept.* Retrieved November 10, 2010, from DESERTEC website: http://www.desertec.org/fileadmin/downloads/desertec-foundation_redpaper_3rd-edition_english.pdf

Doornbosch, R., & Steenblik, R. (2007, September). *Biofuels: Is the cure worse than the disease?* Retrieved November 10, 2010, from OECD website: http://www.oecd.org/dataoecd/15/46/39348696.pdf

EBRD. (2010, April). *About the EBRD*. Retrieved August 26, 2010, from European Bank for Reconstruction and Development website: http://www.ebrd.com/downloads/research/factsheets/about.pdf

EIA. (2006). *Policies to promoto non-hydro renewable energyin the United States and elected countries.* Energy Information Administration.

Energy Economics Group. (n.d. (a.)). *Dynamic Cost-Resource Curves : methodology for model implementation in Green-X.* Retrieved November 20, 2010, from Green-X website: http://www.green-x.at/GX%20viewer%20-%20data/GXviewer_framework.htm

Energy Economics Group. (n.d. (b.)). *Overview on RES-E Potentials.* Retrieved November 20, 2010, from Green-X website: http://www.green-x.at/GX%20viewer%20-%20data/GXviewer_potentials.htm

European Commission. (2008). *The support of electricity from renewable energy sources. Accompanying document to the Proposal for a Direction of the European Parliament and of the Council on the promotion of the use of energy from renewable sources.* Retrieved November 10, 2010, from European Commission website: http://ec.europa.eu/energy/climate_actions/doc/2008_res_working_document_en.pdf

European Commission. (2009, April 23). *Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.* Retrieved November 10, 2010, from EUR-Lex website: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0028:EN:NOT

European Commission. (2010, July 2). *Renewable energy: What do we want to achieve?* Retrieved August 26, 2010, from European Commission Energy website: http://ec.europa.eu/energy/renewables/index_en.htm

European Wind Energy Association. (2005). *Support schemes for renewable energy: a comparative analysis of payment mechanisms in the EU.* Retrieved November 21, 2010, from European Wind Energy Association website: http://www.ewea.org/fileadmin/ewea_documents/documents/projects/rexpansion/050620_ewea_report.pdf

Faber, T., Haas, R., Huber, C., Ragwitz, M., & Resch, G. (2007). Linking promotion strategies for RES-E and for demand-side conservation in a dynamic European electricity market: Lessons from the EU projects OPTRES, FORRES and GREEN-X. *ECEEE 2007 Summer Study. Saving energy - just do it! Conference proceedings.* (pp. 241-252). Stockholm: ECEEE Secretariat.

Fischer, C., & Newell, R. (2004, April). *Environmental and Technology Policies for Climate Change and Renewable Energy. Discussion Paper 04-05.* Retrieved November 21, 2010, from Resources for the Future: http://www.rff.org/Documents/RFF-DP-04-05.pdf

Frondel, M., Ritter, N., & Schmidt, C. (2008, August). *Germany's solar cell promotion: Dark clouds on the horizon.* Retrieved November 22, 2010, from Energy Policy 36 (2008) 4198–4204: www.elsevier.com/locate/enpol

Galbraith, K. (2009, May 9). *Renewable Energy Industries Ask Obama to Speed Loan Guarantees.* Retrieved November 12, 2010, from The New York Times website: http://green.blogs.nytimes.com/2009/05/20/renewable-industries-ask-obama-to-speed-loan-guarantees/#more-9661

DRAFT

Gan, L., Eskeland, G. S., Kolshus, H. H., Birkeland, H., van Rooijen, S., & van Wees, M. (2005). *Green Electricity Market Development: Lesson from Europe and the U.S. and implication for Norway.* CICERO.

Germany, BMU. (2009, January 1). *Act Revising the Legislation on Renewable Energy Sources in the Electricity Sector and Amending Related Provisions (Translation)*. Retrieved November 12, 2010, from Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit [Federal Ministry for the Environment, Nature Conservation and Nuclear Safety]: http://www.bmu.de/files/pdfs/allgemein/application/pdf/eeg_2009_en.pdf

GSI. (2009, October). *Achieving the G-20 Call to Phase Out Subsidies to Fossil Fuels*. Retrieved November 11, 2010, from Global Subsidies Initiative website: http://www.globalsubsidies.org/files/assets/I_policy_brief_on_G-20_Announcement_Oct_09-1.pdf

GSI. (2010, March). *Defining Fossil-Fuel Subsidies for the G-20: Which Approach is Best, Policy Brief.* Retrieved May 4, 2010, from Global Subsidies Initiative website: www.globalsubsidies.org/files/assets/pb5_defining.pdf

Haas, R., Resch, G., Faber, T., Huber, C., Held, A., & Ragwitz, M. (2009). Lessons Learned from Recent Promotion Strategies for Electricity from Renewables. *Proceedings of the ISES World Conference 2007*, 2833-2837.

IEA. (2007, January). *IEA Energy Technology Essentials: Biomass for Power Generation and CHP.* Retrieved November 22, 2010, from IEA website: www.iea.org/Textbase/techno/essentials.htm

IEA. (2008 a.). *Deploying Renewables: Principles for effective policies.* Paris: IEA.

IEA. (2009). *World Energy Outlook 2009.* Paris: OECD/IEA.

IEA. (2010). *Energy Technology Perspectives.* Paris: OECD/IEA.

IEA. (n.d. (a.)). *Feed-in tariffs for electricity from renewable energy sources (Special regime)*. Retrieved November 12, 2010, from IEA Global Renewable Energy Database of Policies and Measures: http://www.iea.org/textbase/pm/?mode=re&id=3648&action=detail

IEA. (n.d. (b.)). *Policies and Measures Databases*. Retrieved August 26, 2010, from International Energy Agency website: http://www.iea.org/Textbase/pm/index.html

ILO. (2008, September). *Green Jobs: Towards decent work in a sustainable, low-carbon world*. Retrieved November 10, 2010, from International Labour Organisation website: http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_098503.pdf

Lesser, J., & Su, X. (2008). Design of an economically efficient feed-in tariff structure for renewable energy development. *Energy Policy*(36), 981-990.

DRAFT

Martinot, E. (2004). *New Academy Review: Global Renewable Energy Markets and Policies.* Retrieved November 11, 2010, from http://www.cfr.org/publication/17226/new_academy_review.html: http://www.martinot.info/Martinot_NAR.pdf

McKinsey & Company. (2009, January). *Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve.* Retrieved November 5, 2010, from McKinsey & Company website: https://solutions.mckinsey.com/ClimateDesk/default.aspx

Menanteau, P., Finon, D., & Lamy, M.-L. (2003). *Prices versus quantities: Environmental policies for promoting the development of renewable energy.* Retrieved November 21, 2010, from Energy Policy 31 (2003) 799–812: http://zonecours.hec.ca/documents/H2007-1-1050423.Economic_Rationale_Renewing_energy.pdf

Mendonça, M., Jacobs, D., & Sovacool, B. (2010). *Powering the green economy: The feed-in tariff handbook.* London, UK: Earthscan.

Milow, B. (2010, September 30). *Germany: The solar PV industry [PowerPoint presentation].* Retrieved November 12, 2010, from RETD: http://www.iea-retd.org/files/100930_RETD_2_GermanyPV.pdf

OECD. (2010, May). *Interim Report of the Green Growth Strategy: Implementing our Commitment for a Sustainable Future.* Retrieved November 10, 2010, from OECD website: http://www.oecd.org/dataoecd/42/46/45312720.pdf

Ofgem. (2010). *Introducing the Feed-in Tariff Scheme*. Retrieved November 12, 2010, from Ofgem website: http://www.ofgem.gov.uk/Media/FactSheets/Documents1/fitfs_energy%20prices%20update%20FS.pdf

Ölz, S., Sims, R., & Kirchner, N. (2007, April). *Contributions of Renewables to Energy Security.* Retrieved November 22, 2010, from IEA website: http://www.iea.org/papers/2007/so_contribution.pdf

Palmer, K., & Burtraw, D. (2005). Cost-effectiveness of renewable electricity policies. *Energy Economics*(27), 873-894.

RDI. (n.d.). *Policy/Regulatory*. Retrieved August 26, 2010, from Renewable Development Initiative website: http://www.ebrdrenewables.com/sites/renew/policy.aspx

REN 21. (2010, September). *Renewables 2010: Global Status Report.* Retrieved November 12, 2010, from REN21 website: http://www.ren21.net/Portals/97/documents/GSR/REN21_GSR_2010_full_revised%20Sept2010.pdf

REN21. (n.d. (a.)). *About REN21*. Retrieved August 26, 2010, from REN21 Renewable Energy Policy Network for the 21st Century: http://www.ren21.net/ren21/default.asp

DRAFT

REN21. (n.d. (b.)). *Renewables Interactive Map BETA*. Retrieved August 26, 2010, from REN21 Renewable Energy Policy Network for the 21st Century: http://www.ren21.net/map/

REN21. (n.d. (c.)). *Virtual Library*. Retrieved August 26, 2010, from REN21 Renewable Energy Policy Network for the 21st Century: http://www.ren21.net/virtuallibrary/default.asp

Renewable Energy Focus.com. (2010, September 7). *Italy Reduces Solar Subsidy.* Retrieved November 12, 2010, from Renewable Energy Focus.com: http://www.renewableenergyfocus.com/view/12274/italy-reduces-solar-subsidy/

Resch, G., Faber, T., Haas, R., Ragwitz, M., Held, A., & Konstantinaviciute, I. (2006, February). *Potentials and cost for renewable electricity in Europe - The Green-X database on dynamic cost-resource curves.* Retrieved November 21, 2010, from OPTRES website: http://www.optres.fhg.de/results/Potentials%20and%20cost%20for%20RES-E%20in%20Europe%20(OPTRES%20-%20D4).pdf

UK Office of Climate Change. (2006, October). *Stern Review on the Economics of Climate Change.* Retrieved November 10, 2010, from The National Archives: http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/sternreview_index.htm

UK Parliamentary Office of Science and Technology. (2006, October). *Postnote: Carbon footprint of electricity generation.* Retrieved November 10, 2010, from UK Parliamentary Office of Science and Technology website: http://www.parliament.uk/documents/post/postpn268.pdf

UNEP. (forthcoming). Renewable Energy. In UNEP, *The Green Economy Report.* Geneva: UNEP.

United Nations Millennium Project et al. (2005). *Energy Services for the Millennium Development Goals: Achieving the Millennium Development Goals.* Retrieved November 10, 2010, from UN Millennium Project website: http://www.unmillenniumproject.org/documents/MP_Energy_Low_Res.pdf

United States. (n.d.). *Search*. Retrieved August 26, 2010, from DSIRE Database of State Incentives: http://www.dsireusa.org/searchby/index.cfm?ee=0&RE=1

US Department of Health and Human Services. (n.d.). *Energy Efficiency and Renewable Energy System Technology Research and Development*. Retrieved from http://grants.nih.gov/grants/guide/pa-files/PA-09-101.html: http://grants.nih.gov/grants/guide/pa-files/PA-09-101.html

Vanega, A. (2010, May 6). The Database of State Incentives for Renewables and Efficiency. *ASES Small Wind Division Bi-monthly Webinar Series [PowerPoint presentation]*. North Carolina, United States: http://www.dsireusa.org/documents/PolicyPublications/ASES%20Small%20Wind%20May%202010.pptx.

World Energy Council. (2004, July). *Comparison of Energy Systems Using Life Cycle Assessment.* Retrieved November 10, 2010, from World Energy Council website: http://www.worldenergy.org/documents/lca2.pdf

DRAFT