Az SMART
Arizona's Solar Market Analysis and Research Tool

Market-Based Incentives

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Arizona's Solar Market Analysis and Research Tool (Az SMART)

Arizona's Solar Market Analysis and Research Tool (Az SMART) is a breakthrough analysis environment that will enable stakeholders to examine the complex interaction of economic, security, environmental, and technological issues that impact Arizona's ability to become a global leader in solar power innovation, development and deployment. Multi-disciplinary research efforts and capabilities at Arizona State University and the University of Arizona are being utilized in close collaboration with partners from industry and government in the creation and use of Az SMART.

The goal of the three-year project is to develop a unique analysis tool, tailored to the examination of a successful roll-out of large-scale solar energy infrastructure in Arizona, and the required electric grid technologies to enable that infrastructure.

The principal outputs of the project are Solar Feasibility research, a Solar Scorecard for Arizona, and ultimately, the analytical tool that integrates them into a decision support framework. The end product will be accessible by remote web access (www.Az SMART.org), as well as at Decision Theater, a dynamic, immersive visualization environment facility at Arizona State University

Arizona's Solar Scorecard

Researchers at the L. William Seidman Research Institute of the W. P. Carey School of Business at Arizona State University are developing Arizona's Solar Scorecard. The Solar Scorecard comprises metrics drawn from energy usage forecasts, environmental valuation analyses, economic development analyses, and energy security evaluations. It is assembled from a series of whitepapers which provide the research and analysis to translate commercial and public policy choices into measures of economic, environmental, social and energy security impact on Arizona. The 14 whitepapers are as follows:

1. *Energy Sector Technology;*
2. *The Market-Determined Cost of Inputs to Utility-Scale Electricity Generation;*
3. *Incentives and Taxation;*
4. *Regulations and Standards;*
5. *AZ Energy Demand Analysis;*
6. *Present and Future Cost of New Utility-Scale Electrical Generation;*
7. *Energy Usage/ Supply Forecasts;*
8. *Emissions/Pollution Analysis;*
9. *Solar Export Potential;*
10. *Environmental Valuation Analysis;*
11. *Solar Inter-State Competition;*
12. *Economic Development Analysis;*
13. *Energy Security Issues;*
14. *The Determinants of the Financial Return from Residential Photovoltaic Systems*

About This Paper

This is the third of 14 white papers in the Solar Scorecard. Ultimately, the goal of this paper is to present a feasible set of market-based incentives to encourage the adoption of solar technologies within the state of Arizona. Beginning with a typology of market-based renewable energy incentives, we examine the ways in which variations in the design of each incentive program can alter market outcomes in seven countries. Some of these incentives are targeted at utility scale production; others are simply distributive. Recognizing that solar energy is less abundant in some parts of the world than in others, we include in our survey those mechanisms that have been used to encourage the adoption of wind, biomass, and other renewable energy technologies, in addition to solar. We then conclude with an evaluation of these incentives, drawing from other studies and comparing the timescale of incentive programs with changes in market share, CO_2 *emission levels and net capacity.*

This paper focuses strictly on market-based incentive mechanisms. A separate paper in the Az SMART program examines the regulatory measures that directly or indirectly promote the adoption of renewable energy technologies or energy efficiency measures. The primary distinction is that this paper focuses on mechanisms in which adoption is voluntary, rather than mandatory.

This paper will evolve over time. The objective of the previous version was to identify primary categories of relevant market-based incentive mechanisms and to present a general discussion of some of the results of those programs. In this version we attempt to evaluate these incentives, to provide some guidance and direction for U.S. policy makers and suggest suitable types of incentives for Arizona.

Executive Summary

- The goals of increasing the use of renewable energy and instituting energy efficiency measures face significant obstacles. Without subsidies or offsets, renewable energy technologies are not financially cost-competitive with conventional, non-renewable technologies. Also, it can be difficult to obtain financing for new renewable systems.

- Regulatory requirements can be used to mandate the adoption of renewables and energy efficiency measures, but market-based incentive mechanisms can also achieve the same results by inducing voluntary behavior from stakeholders.

- Several categories of market-based incentives have been introduced. Variations in terms of both design and implementation can have meaningful effects on the outcomes of incentive programs. The six types of incentive examined in this paper are shown in the table below.

Incentive Category	*Characteristics*
Feed-in tariffs (FITs)	A form of pricing law requiring utilities to purchase power that has been generated from renewable sources and fed onto the grid by private system owners or lessees.
Grants/subsidies	Government- or utility-sponsored programs to defray the costs of investment in new systems, technologies, or efficiency measures
Tax incentives	Credits, rebates, or exemptions to offset investment costs for renewable technologies or efficiency measures
Loans	Government- or utility-sponsored programs to improve access to credit for investment in new systems, technologies, or efficiency measures
Reverse auctions	Programs that award power purchase agreements to new projects on the basis of lowest unsubsidized generation cost.
Green marketing	Programs that allow utility customers to pay a premium on their monthly electric bill to contribute to investment in renewable energy.

- We examine seven countries in which renewable energy accounts for a relatively high portion of total net electricity energy consumption, with particular emphasis upon solar and wind. The market-based incentives examined are summarized in the table below:

Country	Summary of Major Incentive Programs Examined
Denmark	Feed-in tariffs (FITs) for on-shore wind were formally adopted in 1993 and remained in place through 1999. Beginning in 2000, the program was phased out and replaced with a renewable portfolio standard (RPS). Installed capacity expanded rapidly when the tariffs were in place, but has leveled off since 2003.
Germany	FITs were originally linked to the spot electricity price, but when the German electricity market was deregulated, tariffs shrank proportionately with retail prices, scaring would-be investors. A fixed tariff was adopted in 2000, and revised in 2004. A grant program also funds a portion of construction costs for new renewable systems. The country has experienced rapid uptake of renewables over the past decade, making it a world leader in wind and solar PV at the end of 2008.
Spain	Premium FITs were introduced in 2007 with no limitations on total installed capacity or eligible size. Installed solar PV capacity grew more than four-fold, year-over-year, in both 2007 and 2008. In 2008, the FITs were revised to include capacity limitations and automatic degression (reduction in rates over time).
Austria	Fixed FITs were introduced in 2002 and later revised to include additional technologies. Although the country is not a large wind or solar market in absolute terms, the growth in installed capacity since the adoption of the FITs has been substantial.
Netherlands	Premium FITs were instituted in 2003 for systems that had been established after 1996. The payments were funded by a levy on grid connection fees. In 2006, tariffs were set to zero because of budgeting problems. The program was briefly funded by the national budget, and then discontinued. A new federal subsidy program, which functions like a FIT, now guarantees a minimum tariff.
Ireland	Fixed, inflation-indexed FITs were adopted in 2005, guaranteeing long-term contracts with renewable energy projects. The program includes a short-term carve-out for developing ocean technologies. The country also has a large grant program to support residential energy efficiency retrofits, and another to defray construction costs for high-efficiency, low-emissions housing. When the FIT was introduced, installed wind capacity began to increase rapidly.
U.S.	At the federal level, a production incentive has been in place since 1992. The American Recovery and Reinvestment Act of 2009 promises large amounts of grant funding for research, development, and commercialization of new technologies from 2009 to 2011. A federal production tax credit, or investment tax credit, which offsets 30 % of construction costs, has been instrumental as a financing tool for large wind and solar installations. At the state level, FITs are a relatively new measure. A municipal FIT was adopted in Florida in early 2009 and the program sold out of planned capacity shortly after it was announced. Other states have subsequently followed.

- We illustrate how the European countries studied generally favor FITs, complemented by a range of other incentives, while the U.S. has traditionally displayed a preference for tax based incentives, grants and loans.

- We note how some U.S. states and cities have started to implement FITs, and compare the magnitude of the 2009 rates offered in the U.S. and Europe, as shown in the table below:

Country	*Solar FIT Range (US$)*[1]	*Average Residential Electricity Prices (US$)*[2]
Austria	$0.418/kWh – $0.641/kWh	$0.2050-$0.2385/kWh
Germany	$0.4603/kWh – $0.5999/kWh	$0.2845-$0.2943/kWh
Netherlands	$0.54/kWh - $0.737/kWh	$0.3348-$0.3361/kWh
Spain	$0.4463/kWh – $0.4742/kWh	$0.1632-$0.1995/kWh
U.S.	$0.25/kWh – $0. 65/kWh	$0.0916-$0.1264/kWh

- An evaluation of the effectiveness of incentives within each country is undertaken via:
  (a) a comparison of the key dates of programs with changes in renewable energy market share, the level of CO_2 emissions and net capacity; and
  (b) A critique of external studies.
- We suggest that the introduction of FITs at state level could add impetus to the market share of electricity generated from renewable sources in the U.S., and discuss the potential implications for Arizona.

[1] All FIT rates converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$
[2] All European country prices converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$

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List of Acronyms

Abbreviation	*Definition*
Entities	
APS	Arizona Public Service Company
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)
CNE	National Energy Committee (Spain)
CPUC	California Public Utilities Commission
DCNER	Department of Communications, Energy & Natural Resources (Ireland)
DOE	Department of Energy (U.S.)
DSIRE	Database of State Incentives for Renewable Energy (U.S.)
ECB	European Central Bank
EIA	Energy Information Administration (U.S.)
FHLMC	Federal Home Loan Mortgage Corporation (U.S.)
GRU	Gainesville Regional Utility
IEA	International Energy Agency
LABC	Los Angeles Business Council
NCU	North Carolina University
NREL	National Renewable Energy Laboratory
OECD	Organisation for Economic Co-operation and Development
PUC	Public Utilities Commision
REN21	Renewable Energy Policy Network for the 21st Century
SEAI	Sustainable Energy Authority of Ireland
SEI	Sustainable Energy Ireland
SEIA	Solar Energy Industries Association (U.S.)
SMUD	Sacramento Municipal Utility Department
USDA	Department of Agriculture (U.S.)
Other Terms	
AER	Alternative Energy Requirement (Ireland)
AET	Average Electricity Tariff (Spain)
ARRA	American Recovery and Reinvestment Act (U.S.)

Abbreviation	*Definition*
BES	Business Expansion Scheme (Ireland)
BIPV	Building-Integrated Photovoltaics
BSE	Decision Subsidies Energy Program (Netherlands)
CREB	Clean Renewable Energy Bonds (U.S.)
CSI	California State Initiative
DCF	Discounted Cash Flow
EEG	Erneuerbare-Energien-Gesetz, Renewable Energy Sources Act (Germany)
EEM	Energy-Efficient Mortgage (U.S.)
EIWOG	Specific Feed-in Tariff (Austria)
EPBB	Expected Performance Based Buydown
ETS	Emissions Trading Scheme (European Union)
FHA	Federal Housing Authority (U.S.)
FIT	Feed-in Tariff
GHG	Greenhouse Gas
HOA	Homeowners' Association
IOU	Investor-Owned Utility
IRR	Internal Rate of Return
ITC	Investment Tax Credit (U.S.)
kW	Kilowatt
kWh	Kilowatt Hour
LCOE	Levelized Cost of Energy
MASH	Multi-Family Affordable Solar Housing (California)
MEP	Environmental Quality of Power Generation Program (Netherlands)
MW	Megawatt
MWe	Megawatts, estimated
MWh	Megawatt Hour
NIPV	Non-integrated Photovoltaic System
NPV	Net Present Value
NSHP	New Solar Homes Partnership (U.S.)
PACE	Property-Assessed Clean Energy Program (U.S.)

Abbreviation	*Definition*
PBI	Production or Performance Based Incentive
PBP	Payback Period
PFER	Plan de Fomento de las Energias Renovables (Spain)
PIER	Promotion Instrument for Electricity from Renewables (Austria)
Pj	Petajoule Unit of Energy
POU	Publically Owned Utilities
PTC	Production Tax Credit (U.S.)
PURPA	Public Utility Regulatory Policies Act (U.S.)
PV	Photovoltaic
REAP	Rural Energy for America Program (U.S.)
REC	Renewable Energy Certificate
REFIT	Renewable Energy Feed-in Tariff (Ireland)
ReHeat	Renewable Heat Deployment Program (Ireland)
REPI	Renewable Energy Production Incentive (U.S.)
RES	Renewable Energy Standard
RES-E	Electricity Produced from Renewable Energy Sources
RPS	Renewable Portfolio Standard
SAM	Solar Advisor Model (U.S.)
SASH	Single-Family Affordable Solar Housing (California)
SDE	Renewable Energy and CHP Production Aid Scheme (Netherlands)
SWHPP	Solar Water Heating Pilot Program (California)
VA	Veterans Affairs (U.S.)

1. Introduction

The goal of increasing the use of renewable energy resources and energy efficiency measures is met with significant barriers. Although there have been rapid technological improvements, existing renewable energy technologies nevertheless remain more costly (in pure financial terms) than their traditional, non-renewable counterparts. Financing can also prove to be a barrier. Investors and potential adopters are challenged to find innovative ways to fund the construction of new plants or systems, or to cover the costs of energy efficiency measures. In Arizona, although solar resources abound, these same barriers persist.

Around the world, a number of policy measures have been adopted to encourage the use of renewable energy resources or energy efficiency measures. Some are regulatory requirements, such as Renewable Portfolio Standards (RPS),[3] which mandate specific outcomes. Others are market-based incentive mechanisms which aim to achieve the same results by inducing voluntary behavior. In this context, market-based incentive mechanisms generally help to defray the cost burden or to assist with financing. In Arizona, where there is interest in encouraging the adoption of solar technologies, the implementation of effective incentive mechanisms is clearly needed- to increase the share of state households participating in solar initiatives and position Arizona as a market leader in the generation of solar energy.

This is the second version of a study of market-based incentive mechanisms.[4] In the previous version, we introduced general categories of incentives and explained the ways in which they vary in design. We then presented a survey of actual incentive mechanisms from select markets around the world, with a high-level assessment of some of the market outcomes of those programs. In this version, we build upon the previous paper by adding a more thorough evaluation of incentive programs, and conclude with proposals for incentive mechanisms for the state of Arizona.

[3] Sometimes referred to as renewable energy standards (RES).

[4] A separate paper in the Az SMART program examines regulatory measures and standards that mandate the adoption of renewable energy technologies and energy efficiency measures.

In Section 2, we present a generic typology of market-based incentive mechanisms, highlighting the unique and shared features of each incentive.

In Section 3, we survey actual market-based incentive mechanisms from seven countries around the globe. These are Denmark, Germany, Portugal, Spain, Austria, Netherlands, Ireland and the U.S. Each country was selected on the basis of total renewable energy consumption as a share of total net electricity energy consumption, with specific emphasis upon solar and wind power. The key characteristics of incentive programs within each country are described, along with market outcomes. Some of the incentives targeted utility scale generation. Other incentives were targeted at low-scale distributed generation schemes. Most of the incentives featured were national in scope, but a few were local/provincial.

In Section 4, we evaluate the effectiveness of incentive programs from two perspectives. First we undertake an empirical evaluation, comparing the key dates of programs in each country with changes in renewable energy market share, the level of CO_2 emissions and net capacity. Then we present the findings of recent studies. This evaluation is to an extent undermined by the insufficiency of cost data available, but nevertheless provides some indicative insight into the effectiveness of incentive programs.

Section 5 summarizes our conclusions and proposes potential incentive programs for Arizona.

Section 6 identifies topics that should be considered for future research.

2. Overview of Market-Based Incentive Mechanisms

We begin with a general typology of six market-based incentives. These are illustrated in Table 1, together with a brief summary of the major characteristics of each incentive. Some of these incentives represent financial intervention by governments to ensure adequate domestic supply, compensate for imperfections in market pricing, or attain economic, environmental and/or social benefits. Others are paid for by utility ratepayers. The remainder of this section will then examine in more detail pertinent features of each market-based incentive, before illustrating practical examples of their implementation in Section 3.

Table 1: Summary of Market-Based Incentives

Incentive Category	*Characteristics*
Feed-in tariffs	Form of pricing law requiring utilities to purchase power that has been generated from renewable sources and fed onto the grid by private system owners or lessees.
Grants/subsidies	Government- or utility-sponsored programs to defray the costs of investment in new systems, technologies, or efficiency measures
Tax incentives	Credits, rebates, or exemptions to offset investment costs for renewable technologies or efficiency measures
Loans	Government- or utility-sponsored programs to improve access to credit for investment in new systems, technologies, or efficiency measures
Reverse auctions	Programs that award power purchase agreements to new projects on the basis of lowest unsubsidized generation cost.
Green marketing	Programs that allow utility customers to pay a premium on their monthly electric bill to contribute to investment in renewable energy.

2.1 Feed-in Tariffs

A feed-in tariff (FIT) is a form of pricing law (Mendonca, 2007a, 2007b) designed to enable homeowners, businesses and public entities to enter the electricity supply market.

LABC (2010a) identify three general qualities of FITs, drawn from panelist comments at the Solar Power International 2009 conference in Anaheim. These are price certainty, simplicity and accessibility. Although other solar incentives can have similar attributes, the LABC argue that the maximization of all three qualities will "… intentionally shape market response" (p.13) – that is, provide the stimulus needed to attract investment in, and ownership of, solar energy systems.

Price certainty refers to the establishment of fixed payments per unit production over a fixed period. Calculated to guarantee profitable operation over a long period of time (e.g. 15-20 years), a FIT can change over time and also differ according to the technology used and size of installation. A FIT does not provide revenue certainty, as that is dependent upon the amount of solar energy generated and fed back into the grid. FIT contracts will, however, establish a market for solar power equivalent to the economic life of the technology, and therefore represent a long term financial asset that can balance the long-term liabilities created by a solar investment. Without this reduction of risk and introduction of greater certainty, the LABC argues owners and capital providers would be less likely to invest in solar technologies.

Simplicity refers to the procurement process. For a FIT to be effective, complex utility procurement processes must be eschewed in favor of simple contracts to encourage widespread participation.

Accessibility is the ease with which producers of renewable energy can interact with the power grid,[5] circumventing any participation in a competitive negotiation process, plus a utility purchase obligation. The price paid for the electricity fed into the grid is called a tariff.

Primarily intended to encourage the adoption of renewable energy technologies by distributing the additional costs of renewable energy among all users across a guaranteed minimum time period, the costs incurred under a FIT are initially paid for by suppliers in proportion to their sales volume, before being passed on to customers by way of a premium on the kilowatt hour (kWh) end-user price. Governments only intervene to the extent that they can mandate the tariff. Hence, FITs can raise the price of electricity for all rate-payers, with variations in the design of FIT laws affecting how the additional cost burden is distributed (Klein, Pluger, Held, Ragwitz, Resch, & Faber, 2008).[6]

[5] Interconnection standards, which affect the ability of private system owners to connect to the power grid, will be discussed in a separate paper in the Az SMART project.
[6] The additional costs of renewable energy may include the explicit generation costs and any avoided external costs, such as costs arising from climate change.

2.1.1 Setting Feed-in Tariff Rates

Cory, Couture and Kreycik (2009) identify two main methodologies for setting a FIT rate. These are the cost-based approach and the value-based approach.

The cost-based methodology focuses on the levelized cost of renewable energy generation. This is an economic assessment of every cost of the energy-generating system throughout its lifetime – i.e. the initial investment, operations and maintenance, cost of fuel and cost of capital. Calculated over long periods of time (20+ years) and stated in units of a currency per kilowatt hour, the cost-based methodology identifies the minimum price at which energy must be sold for an energy project to break even.[7] A small mark-up is then added to ensure a reasonable rate of return for producers and create conditions conducive for market growth.

The value-based methodology sets a FIT payment in accordance with the perceived value of the renewable energy. Potential value measures include the utility's avoided costs, or internalizing the externality costs of conventional generation such as the value of climate mitigation, health and air quality impacts, or effects on energy security. More complex to administer than the cost-based approach, the value-based methodology could potentially provide insufficient payments to stimulate rapid market growth, or conversely provide payments to producers of renewable energy that are significantly higher than their generation costs. Hence, there appears to be greater scope for cost-inefficiency with the value-based methodology and less consensus than the cost method.

2.1.2 Variations in the Design of Feed-in Tariffs

Designing an effective tariff is a complex and dynamic process. By early 2009, FIT programs had been instituted for renewable energy generation in at least 63 countries worldwide (REN21,

[7] To understand this in greater detail, please see two other Az SMART white papers - *The Market-Determined Cost of Inputs to Utility-Scale Electricity Generation* and *Present and Future Cost of New Utility-Scale Electrical Generation*

2009).[8] There is considerable variation in the design of these programs and many of them have evolved over time. Generally, the major differences concern:

(a) The way in which the level of remuneration is determined; and
(b) Whether and how a tariff may change over time (Klein, Held, Ragwitz, Resch, & Faber, 2006).

Table 2 summarizes the ways in which FITs can vary by design, with subsequent sub-sections presenting a more detailed discussion of these variations.

Table 2: Variations in the Design of Feed-in Tariffs

1.	*Characteristics*
Types of feed-in tariffs	
Fixed	Remuneration is a fixed rate per KWh, irrespective of the market price.
Premium	Remuneration is the spot-market price plus either a fixed, non-variable premium, or a variable premium capped in relation to the spot-market price.
Flat	Remuneration formula is the same for all renewable energy sources, or for all plants using the same technology, irrespective of generation costs.
Stepped	Remuneration formulas vary to account for differences in generation costs.
Policy variations	
Degression	Reduction over time in the level of remuneration available to new plants.
Policy review milestone	A pre-determined program threshold, which, when reached, triggers automatic review of the applicable FIT policy.
Capacity limit	A cap on the amount of new installed capacity that is eligible for remuneration from a FIT within a given time period.

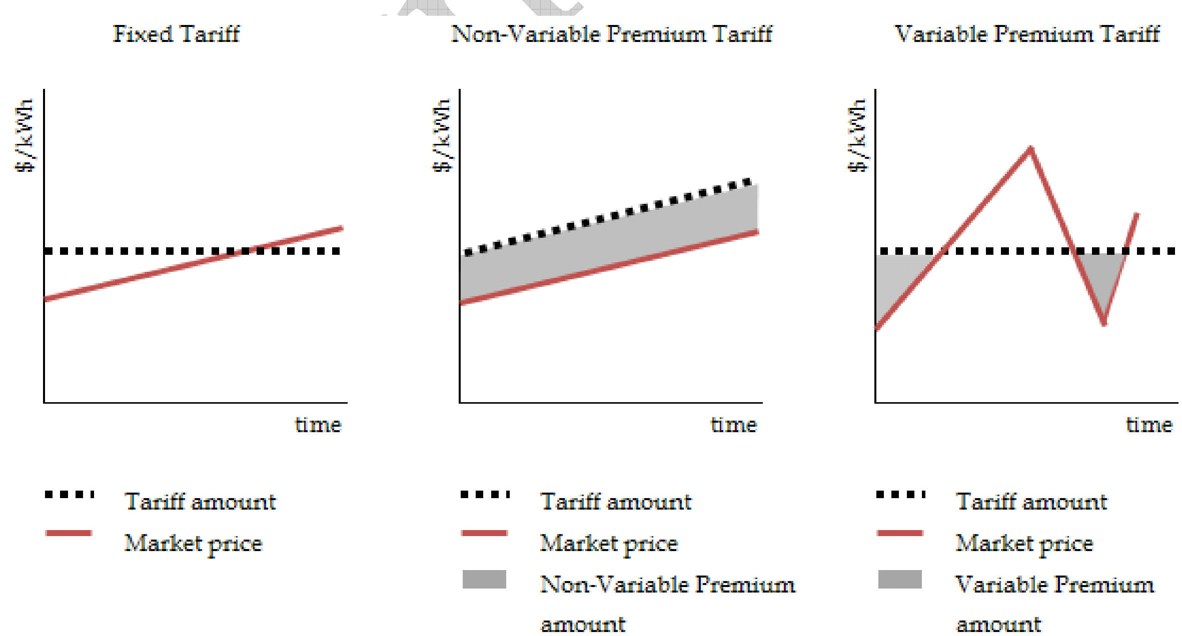
[8] This figure includes some countries that have implemented FIT programs and subsequently ended them or replaced them with other incentive mechanisms.

2.1.3 Fixed versus Premium Tariffs

In a fixed tariff scheme, system owners are paid a fixed rate per kilowatt hour (kWh) of electricity generated, independent of the spot-market price. Rates are usually quoted in nominal terms, but many programs include periodic rate adjustments for inflation. Fixed tariffs are intended to encourage investment by providing investors with some degree of certainty concerning the level of remuneration available per unit of electricity generated and the length of time that benefit will be available (Klein, Pluger, Held, Ragwitz, Resch, & Faber, 2008). This risk reduction can also lead to lower project-financing costs (de Jager and Rathmann, 2008).

By contrast, for a premium tariff, remuneration is the sum of the spot-market price of electricity plus a per-unit premium (sometimes called a 'green bonus'). This premium can be non-variable – that is, a fixed predetermined amount over and above the spot-market price (absolute or percentage). It can also be variable to cover the real time difference between a minimum total payment guarantee and the spot-market price. Figure 1 below illustrates the difference between a fixed and a non-variable premium tariff.

Figure 1: Illustration of Fixed and Premium Tariffs



Source: Cory, Couture and Kreycik (2009)

In Figure 1, the market price in the first two charts increases over time. The fixed tariff remains constant, and the non-variable premium tariff increases at a fixed amount above the market price as the latter increases. Cory, Couture and Kreycik (2009) argue that non-variable premium tariffs can over- or under-compensate producers of renewable energy, resulting in windfall profits whenever spot-market prices increase significantly or placing undue pressure on project-financing costs whenever spot-market prices fall. Hence, the introduction of a variable premium tariff with a price cap and floor in the third chart not only guarantees producers of renewable energy a minimum rate of payment. It also limits the exposure of ratepayers because the premium paid is capped within a spot-market gap model, as shown by the shaded grey area. This is because the FIT is effectively paid to the producer of renewable energy in two ways:

(a) Via the prevailing spot-market price of electricity; and
(b) As a variable payment from the utility company, equating to the real time difference between a minimum total payment guarantee and the spot-market price at any particular time.

2.1.4 Stepped Versus Flat Tariffs

Stepped tariffs vary to account for cost differentials facing different technologies, locations, plant sizes, and/or input fuels. For example, in a stepped tariff, wind, solar, and biomass plants can each receive a different remuneration. Two solar photovoltaic (PV) plants can receive different levels of remuneration if one has significantly larger nameplate capacity. For biomass plants, rates can vary according to the type of fuel used.

However, flat tariffs do not vary to account for cost differences. For example, the same rate may be available for all wind power plants, regardless of the size of each plant. In practice, flat tariffs are relatively uncommon (Pöyry Energy Consulting and Element Energy, 2009).

Fixed and premium tariffs can be stepped or flat. For example, a fixed, stepped tariff could set one fixed rate for wind energy and a separate, fixed rate for solar energy. Neither rate would change in response to changes in the market price of electricity. In the same example, a premium, stepped tariff could also award distinct rates for the two technologies. However, the absolute value of each rate would change as the market price changed.

2.1.5 Degression

Tariff degression is the reduction over time in the level of remuneration available to new plants, based upon the period in which they became operational. Each year, the rate available to a new plant is reduced, but the rate received by a pre-existing plant remains at the level that corresponds to the year in which it became operational. Typically, the reductions are predetermined and range from 1% to 5% per annum. The goal of tariff degression is to encourage innovation to lower costs. It also rewards system owners for building as early as possible (Pöyry Energy Consulting and Element Energy, 2009). Critics argue that degression encourages rapid investment in technologies that are currently available, even if they are not yet efficient or cost-competitive (Frondel, Ritter, & Schmidt, 2008). The predetermination of degression rates is also criticized for being inflexible, failing to take into account global technology cost reductions or technological learning related, for example, to the cumulative amount of installed capacity (Pöyry Energy Consulting and Element Energy, 2009).

2.1.6 Capacity Limitations

Some FIT laws include restrictions on the amount of new installed renewable capacity that may be eligible for program benefits in a given year. Often, changes in these limitations are related to degression rates. In other words, if the capacity limitation for a particular technology is increased by 10% in a given year, the tariff may be lowered by 10% in the same year (IEA, 2009; Global Green USA, 2008).

2.1.7 Policy Review Milestones

Some FIT programs are established with pre-set milestones which, when reached, trigger an automatic policy review. Policymakers then assess the tariff's effectiveness and, if necessary, adjust its parameters. For example, if a large portion of the desired renewable capacity is installed, a program may require revision to curb rapid market growth (IEA, 2009).

2.2 Grants and Subsidies

A second type of in incentive is a grant or subsidy. This refers to the transfer of financial resources to the buyer or seller of a good or service to keep prices below market levels for consumers, above market levels for producers or simply reduce the cost of production of the good or service (OECD, 1998; EEA, 2004).

Grants and subsidies can adopt many different forms. Examples include a direct cash transfer to a producer or consumer, a preferential tax exemption or rebate, or a direct government investment in infrastructure, research and development. They can be oriented towards initial production or consumption, and tied to specific inputs, technologies or outcomes.

The literature is quite loose in its use of the term 'subsidy'. However, for the purpose of this paper, we will use the term 'grants and subsidies' to solely refer to cash transfers paid directly to producers, consumers and other related bodies. That is, on-budget subsidies which directly appear on a balance sheet as expenditure. Other types of indirect support mechanisms such as tax measures, the effects of trade restrictions and price controls, which are also sometimes referred to as subsidies, will be addressed separately within this paper.

Grants and subsidies for renewable energy programs are commonplace throughout the world, but the terms and conditions associated with them can vary significantly. When large amounts of funding are available, awards are commonly made on a competitive basis. For smaller programs, such as those offered to the residential sector, awards are often made on a first-come, first-served basis (NCU and NREL, 2009).

The timing of payments or off-sets from grant and subsidy programs can be one-time, periodic or even received in advance. Some programs that assist with construction cost require a portion of construction to be completed before any payments are made.

Grants and subsidies are funded by a number of entities. Some programs are funded by national, state, or local governments. For these programs, taxpayers are the ultimate cost-bearers and any limits on total program funding are necessarily subject to the budget constraints of the sponsoring entity. Some regulated utilities are required to offer incentive programs to their customers. For these programs, if retail prices increase, ratepayers effectively become the ultimate cost-bearers. Non-profit organizations also offer some grant and subsidy programs (NCU and NREL, 2009).

2.3 Tax Incentives

A third form of market-based incentive is a preferential tax treatment. Offered at a national, state and local level, tax incentives include credits to, exemptions from, and rebates for both personal and corporate income tax to offset the cost of a new system or energy-efficiency measure. Table 3 presents a summary of the three types of renewable energy and energy efficiency tax incentive. Each is described in greater detail in the sub-sections that follow.

Table 3: Summary of Tax Incentives

2.	*Characteristics*
Tax incentive type	
Credit	A one-time or periodic offset to income tax liability to defray the costs of renewable energy generation, technology or energy efficiency purchases, construction, or installation. May be based on investment costs or expected or actual production.
Exemption	Exclusion of certain income items, arising from the sale or use of eligible technologies or resources, from taxable income.
Rebate	Reduction of the taxable basis of an eligible renewable technology asset by means of flat %age reduction in its assessed value. Alternatively, a reduction in taxable income by accelerating the depreciation of an eligible asset.

2.3.1 Credits, Exemptions and Rebates

Tax credits are offered to the residential, commercial, utility and industrial sectors to defray the costs of purchasing or installing renewable energy and energy efficiency systems or equipment. Some credits, exemptions and rebates are determined as a percentage of eligible expenses, up to a maximum dollar amount. Others are based on the production of energy from an eligible renewable technology and are calculated at a rate per kWh sold to others. Some tax schemes also allow for credits to be rolled over into future periods, or to be distributed among several periods.

Tax exemptions exclude from an entity's tax base specific income items related to renewable energy technology or energy efficiency. Exemptions are offered for sales tax on certain items or services, as well as on income from renewable energy generation.

Some tax schemes offer a rebate through the lowering of tax rates on eligible renewable energy or energy efficiency-related items. For example, in some areas, property taxes are assessed on a reduced percentage of the value of eligible taxable property, such as a renewable power plant. Tax reductions also result from accounting functions that are permitted for eligible renewable energy or energy efficiency investments. For instance, in some jurisdictions, businesses can accelerate the depreciation on eligible equipment, thereby reducing their total taxable income and recovering their investment expenses quicker than under normal asset life assumptions.

Preferential tax incentives are a form of off-budget subsidy that will never appear on a balance sheet as expenditure. Johnstone, Haščič and Popp (2010) suggest that tax credits vary across several dimensions, including the rates of both the tax credit and the taxes themselves, and as the technologies eligible for the credit. Energy-specific examples in practice include:

- A Government lowering the sales tax or excise duty of a particular fuel;
- Accelerated amortization of the costs of energy-related equipment during the early years of investment;

- Imposition of carbon dioxide taxes to favor carbon-neutral or zero-carbon sources of energy; and
- Reducing taxation levied on new gas fields where exploration is difficult.

2.4 Subsidized Loans

Subsidized loans are offered to assist with the costs of energy efficiency measures or the purchase or construction of renewable energy systems. These loans usually offer the recipient more favorable financing terms or credit where it would otherwise be denied. In some cases, loan programs are supported and insured by a government entity, to secure lenders against default. Some utilities can also offer low-interest or zero-interest loans to finance energy efficiency projects (NCU and NREL, 2009; IEA, 2009).

2.5 Tender Schemes and Reverse Auctions

A tender scheme or 'reverse auction'[9] awards financial support to projects on the basis of lowest generation cost. Under this scheme, a utility company is required to allocate a set amount of funding to the purchase of energy from new renewable systems within a specific timeframe. Purchase agreements are awarded to bidders in the order of lowest to highest per-unit cost, until all earmarked funds have been awarded for the period. A winning bid then receives a guaranteed price per kWh over some fixed time horizon (Ragwitz, et al., 2007). As described here, a reverse auction has two intended effects. First, it encourages the installation of new renewable generation capacity by requiring utilities to commit funding to the purchase renewable energy from new systems. Second, it encourages innovation to lower the costs of renewable energy, as would-be developers are forced to compete on the basis of per-unit price.

However, Mendonca (2007a) identifies three problems with this form of incentive. First, he argues that the intermittency of tenders can create uncertainty within a renewable energy market. Second, he suggests that the whole process can become too complex and therefore off-putting to the smaller renewal energy producer. His biggest criticism, though, is that reverse

[9] In the U.S., these programs are commonly referred to as ' reverse' auctions because they have the effect of reversing the roles of buyer and seller (i.e. to lower prices, rather than raise them).

auctions can lead to unrealistically low bids from producers, and therefore result in the commitment of funds to renewable projects that have little or no prospect of ever being realized or completed.

Avoiding the traditional FIT pitfall of setting a price that is too high or too low, this market-based, reverse auction approach has been proposed by the California Public Utilities Commission (CPUC) to set the price for small scale, solar FIT contracts, rather than the so-called market price referent set by government (see section 3.2.7.2 for detail).

2.6 Green Power Marketing

Green power marketing generally refers to the promotion of the environmental attributes of power generated from renewable sources. Customers voluntarily elect to pay higher prices to contribute to investment in renewable energy technologies. In this regard, green power marketing is unique as a market-based incentive mechanism.

In competitive retail electricity markets, customers can sometimes choose to switch from their default utility company to an alternative supplier that offers green power. They can also elect to buy some portion of their power from a green power provider, working in conjunction with their utility company (Bird, Kreycik, & Freidman, 2009).

In regulated electricity markets, some utility companies offer 'green pricing' programs, in which customers can elect to pay an additional cost for renewable energy through direct payments on their monthly energy bills. In return, the utility company guarantees that a corresponding amount of electricity provided will be generated from renewable resources. However, this is not necessarily provided direct to the households that pay for it. A percentage of energy from renewable sources is simply made available on the grid, without any guarantees pertaining to the receipients. Utilities can satisfy that requirement directly, by producing the energy from their own renewable power plants, or contractually, by purchasing renewable energy (or the environmental attributes of it) from another supplier (EIA, 2009b) (EIA, 2009b).

2.6.1 Renewable Energy Certificates

Renewable energy certificates (RECs) represent the environmental attributes of the power produced from renewable plants. In some areas, system owners (such as utility companies) use RECs to satisfy regulatory requirements.[10,11] In others, where permitted, they are unbundled and sold separately from commodity electricity (DOE, 2009). Tradable RECs function as a financial incentive. They can generate a new income stream over and above the sale of electricity in the conventional energy market (Bergek & Jacobsson, 2009). Investors can fund the construction of a new renewable plant in return for ownership of the RECs subsequently generated. The RECs can then be sold, either immediately or at a later date, to private retail electricity customers, commercial entities or utilities.

Retail electricity customers can elect to buy RECs on an open market without switching electricity providers. RECs outside Arizona are commonly marketed to individuals as a means of offsetting carbon footprints. Businesses and municipalities can elect to purchase RECs to obtain certain environmental certifications or simply improve their public image. Utility companies are also sometimes allowed to purchase RECs for power they have not generated themselves to satisfy regulatory requirements.

3. Market-Based Incentive Mechanisms around the World

In this section, we will examine market-based incentive mechanisms that have been implemented, are currently in place, or are under consideration in different countries. The rational for this is to identify incentive programs that might be suitable for adoption or adaptation in the U.S. – a strategy used, for example, by Portman (2010) with respect to marine renewable energy policy.

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[10] In the U.S., the Federal climate change bills currently under consideration have special provisions concerning the ways in which RECs could be used to satisfy proposed requirements. We will examine the role of RECs in a regulatory context in a separate, forthcoming paper in the Az SMART program.

[11] A utility, where permitted, will sometimes retain ownership of RECs from its customers' distributed generation systems after the utility has provided incentives to assist with the installation of that system.

3.1 Countries Reviewed

Market-based incentives have been implemented all over the world to encourage the adoption of various renewable energy resources and technologies and energy efficiency measures. Ultimately, our focus is on incentives that are plausible for Arizona, so we have restricted our survey to countries in which wind and solar energy account for a relatively significant portion of total renewable energy consumption, and where total renewable energy consumption accounts for a relatively significant portion of total net electricity energy consumption. Efforts to encourage the adoption of wind technology have been hindered by financing and cost challenges similar to those faced by the solar industry, thereby justifying our examination of market-based incentive mechanisms used to promote the adoption of either technology. However, this is not to say that wind and solar are unique in terms of the financing challenges faced by renewable energy projects. Goldman, McKenna and Murphy (2005), for example, argue that most clean, renewable energy projects face greater challenges securing financing compared to coal or gas plants for at least five reasons:

(a) There is often little or no comparative marketplace information for project financiers to use during their investment deliberations for renewables;
(b) Lower levels of technology testing/verification or marketplace acceptance raise questions about the credit-worthiness of renewable projects;
(c) Higher start-up costs of renewable projects associated with the uncompetitive prices of the relatively new technology necessitates a longer amortization period;
(d) Cash flows and margins can be lowered by the intermittency of renewable sources, thus exerting greater pressure on overhead and maintenance costs; and
(e) The smaller size of distributed generation projects makes them less well-equipped to absorb the due-diligence and transaction costs of financing discussions, compared to larger fossil fuel projects.

We examine market-based incentives in the following seven countries:

- Denmark;
- Germany;

- Spain;
- Austria;
- Netherlands;
- Ireland; and
- United States.

3.1.1 Selection Method

The seven countries were selected on the basis of net electricity consumption from renewable energy, relative to total net electricity energy consumption. We have excluded the consumption of energy from large hydropower plants for this analysis.

Initially, we identified all countries in which total energy consumption from non-large-hydro renewables accounted for at least 5% of total net electricity energy consumption in 2007 (latest available).[12] That list generated 20 countries, illustrated in Table 4. As Arizona is ultimately the focus of our study, we also added the United States to the preliminary list. In 2007, renewable energy accounted for less than 3% of total net electricity energy consumption in the U.S. In 2008, it accounted for 3.5% (EIA, 2009). Table 4 presents historical non-large-hydro renewable energy consumption as a portion of total net electricity energy consumption in 21 countries.

We examined the composition of renewable energy consumption in each of the 21 countries, based on four categories as a percentage of total consumption from non-large-hydro renewable sources. These categories were:

(a) Wind;
(b) Geothermal;
(c) Biomass and waste; and
(d) Solar, tidal, and wave energy.

[12] Consumption data is available for some countries for 2008; however, 2007 was the latest year for which renewable energy consumption data could be obtained for all countries.

We then eliminated those countries in which energy from geothermal, biomass, and waste accounted for the large majority (at least 75 %) of total non-large-hydro renewable energy consumption. Table 5 presents the composition of non-large-hydro renewable energy consumption in 2007 for all 21 countries.

Table 4: Consumption of Non-Hydro Renewable Energy by Country, 2003 - 2007

		Non-Hydro Renewable Energy (% Total Energy Consumption)				
2007 Global Rank	Country	Year				
		2003	2004	2005	2006	2007
1	Iceland	17.0%	17.4%	19.4%	26.9%	30.3%
2	Denmark	25.2%	28.9%	29.6%	27.4%	29.3%
3	El Salvador	25.2%	24.2%	24.1%	24.0%	28.7%
4	Kenya	24.0%	27.5%	26.1%	24.1%	23.3%
5	Nicaragua	20.2%	18.1%	17.6%	17.7%	23.0%
6	Philippines	21.5%	21.3%	20.1%	21.2%	19.9%
7	Guatemala	14.3%	13.7%	13.4%	14.4%	18.3%
8	Costa Rica	20.5%	21.0%	18.4%	19.2%	18.2%
9	Germany	6.0%	7.4%	7.9%	9.4%	12.8%
10	New Zealand	9.2%	9.1%	11.2%	11.5%	12.5%
11	Portugal	5.0%	5.7%	7.9%	10.0%	12.5%
12	Spain	6.7%	7.8%	9.6%	9.9%	11.6%
13	Finland	12.0%	12.2%	11.5%	12.4%	11.5%
14	Austria	4.0%	5.3%	6.2%	8.0%	9.5%
15	Sweden	3.9%	6.3%	6.6%	7.4%	8.5%
16	Netherlands	5.0%	6.0%	8.0%	8.3%	7.9%
17	Ireland	2.3%	3.1%	4.9%	6.7%	7.9%
18	Indonesia	6.8%	6.4%	6.0%	5.7%	5.6%
19	Italy	3.9%	4.4%	4.6%	4.9%	5.3%
20	Chile	3.6%	4.0%	3.4%	2.8%	5.1%
34	United States	2.6%	2.6%	2.6%	2.9%	3.0%

Source: EIA (2009c)

Table 5: Renewable Energy Consumption by Country, 2007[13]

Country	*Non-Hydro Renewable Consumption*	*Share of Non-Hydro Renewables (%)*			
	% of Total Net Electricity Energy Consumption	**Wind**	**Geothermal**	**Biomass & Waste**	**Solar, Tidal & Wave**
Iceland	30.3%	0.0%	99.9%	0.1%	0.0%
Denmark	29.3%	65.0%	0.0%	35.0%	0.0%
El Salvador	28.7%	0.0%	97.8%	2.2%	0.0%
Kenya	23.3%	0.0%	76.1%	23.9%	0.0%
Nicaragua	23.0%	0.0%	39.0%	61.0%	0.0%
Philippines	19.9%	0.6%	99.4%	0.0%	0.0%
Guatemala	18.3%	0.0%	0.0%	100.0%	0.0%
Costa Rica	18.2%	15.5%	79.4%	5.1%	0.0%
Germany	12.8%	54.0%	0.0%	41.8%	4.2%
New Zealand	12.5%	18.1%	66.9%	15.0%	0.0%
Portugal	12.5%	63.0%	3.1%	33.5%	0.4%
Spain	11.6%	86.0%	0.0%	12.4%	1.6%
Finland	11.5%	1.8%	0.0%	98.2%	0.0%
Austria	9.5%	32.6%	0.0%	67.1%	0.3%
Sweden	8.5%	11.8%	0.0%	88.2%	0.0%
Netherlands	7.9%	37.3%	0.0%	62.3%	0.4%
Ireland	7.9%	93.7%	0.0%	6.3%	0.0%
Indonesia	5.6%	0.0%	99.5%	0.5%	0.0%
Italy	5.3%	23.4%	31.4%	45.0%	0.2%
Chile	5.1%	0.3%	0.0%	99.7%	0.0%
United States	2.9%	29.3%	12.5%	57.7%	0.5%

Source: EIA (2009c)

3.2 Geographical Survey

In this next section, we will examine key characteristics that are unique to the incentive programs implemented by our seven chose countries. Where possible, our discussion includes:

[13] This is the latest data currently available.

- The applicable technology;
- Eligible sector(s);
- Restrictions for central or distributed generation;
- System size limitations;
- Timing constraints;
- The incentive amount (per unit or total);
- The ultimate cost-bearer;
- The responsible administrative party; and
- The extent to which competition plays a role in the award process.

3.2.1 Denmark

Denmark is often cited as a renewal energy success story because of its rapid adoption of wind technology in the 1990s and early 2000s. Lipp (2007) describes Denmark as:

> "… one of the few countries in the world that actively, and in a sustained way, supported RE development from the late 1970s, through the 1980s and 1990s to the present." (p.5481)

The reasons for this were twofold. First, Denmark had no known indigenous fossil fuel resources. However, of equal importance was the widespread public opposition that made nuclear power a non-starter from the outset. Table 6 summarizes key milestones in Danish renewable energy activity, classified by incentive type.

Table 6: Key Milestones in Denmark's Renewable Energy Incentives Strategy

Year	*Incentive Type*	*Action*
1979-89	Grant/subsidy	Capital investment subsidy to develop and build new wind installations
1980s – 1996	Tax incentive	Tax exemption on personal income from wind-turbines
1986	-	The Riso Research Centre wind-power test station built to provide quality assurance of turbines sold to the public
1993	Feed-in Tariff	
1993	Tax Incentive	Refund of Danish carbon and energy taxes
1996	Tax Incentive	Reform of exemptions
1998-2003	Feed-in Tariff	Amended to shift the burden of grid connection costs from the utility to the owner, before tariff reduced in 2001
1999	Tradable green certificates	Idea of trading certificates first mooted
2000s	Grant/subsidy	Support cut for research & development
2000s	Tradable green certificates	
2007	-	New Energy Plan proposes reduction of fossil fuel by 15% and doubling of renewables to 30% by 2025
2008	Tradable green certificates	Increased premiums available

Source: Authors

Meyer (2006) identifies three market-based incentives initially contributing to the Danes' renewal energy agenda. These were an investment subsidy, a tax exemption and a FIT.

During the 1980s, the Danish government offered an investment subsidy of 30% of total project costs (Bolinger, 2001) for the installation of wind, solar and biogas digesters. These were scaled down periodically as the industry matured and turbine prices decreased. The biggest benefactor was wind power, with 2,567 wind turbines receiving investment subsidies worth $37.7 Million[14] prior to the abolition of the subsidy in 1989.

At the same time, Danish electricity law dictated direct ownership of wind turbines by electricity consumers. Hence, public ownership was encouraged via a generous tax scheme which exempted personal income from wind turbines. Individuals pooled their savings to invest in a local wind turbine and sold the power wholesale to their utility company at a profit. Such investment opportunities were initially limited to people living within 3km of the turbine,

[14] DKK 275.72 Million - Converted using Antweiler's (2007) 1989 average rate of 7.3102 DKK: 1 US$).

to ensure that those who borne the negative external costs of wind power (i.e. noise and visual intrusion) also benefited from the subsidies available. However, this restriction was repeatedly relaxed during the 1990s to such an extent that any EU citizen could benefit by 2000.

The subsequent introduction of a FIT in 1993, complemented by generous tax refunds, merely served to give greater impetus to the development of wind power as a source of renewable energy. This 1993 FIT obligated utility companies to purchase wind power at 85% of the retail price of electricity (Rickerson, 2008). The FIT also was complemented by a substantial tax refund scheme for carbon and energy taxes, amounting to nearly as much as the payments from the utilities. For each wind partnership received a full refund of the CO_2 tax (1.5 US cents/kWh)[15] and a partial refund of the energy tax (2.6 US cents/kWh).[16]

Tax reforms in 1996 undermined the attractiveness of the tax-free production status whilst retaining some form of incentivization. Individuals who had invested in wind turbines prior to 1996 continued to enjoy exemption for production less than 150% of annual consumption. However, for shares brought during or after 1996, a $517.36 [17] tax-free limit was introduced, with 60% of any income at this level subject to tax. The FIT program was also amended slightly in 1998, shifting the burden of grid connection costs from the utility company to the system owner, and remained in force until 2003 (Farrell, 2009).

However, the most dramatic change to the Danish incentives program for renewable occurred in 1999, when the government proposed replacing the FIT with a green certificate trading mechanism. This led to further modification of the FIT in 2001, which reduced the tariff paid to wind generators to the market price, set by the Nordic Power Exchange, and an environmental premium of 1.2 US cents/kWh[18], which was too low to continue market growth (Lipp, 2007). Wind power producers whose systems came on-line in 2003 were the last producers to receive payments from the FIT program (Farrell, 2009). Support was also cut for certain R&D activities, thereby introducing a period of uncertainty for RE developers and researchers. The change in

[15] 0.10 DKK/kWh – Converted using Antweiler's (2007) 1993 average exchange rate of 6.4839 DKK:1 US$.
[16] 0.17 DKK/kWh – Converted using Antweiler's (2007) 1993 average exchange rate of 6.4839 DKK:1 US$.
[17] 3000 DKK – Converted using Antweiler's (2007) 1996 average exchange rate of 5.7987 DKK:1 US$.
[18] 0.10 DKK/kWh – Converted using Antweiler's (2007) 2001 average exchange rate of 8.3228 DKK:1 US$.

policy reflected a change in political philosophy, prompted in part by an ungrounded fear that feed-in tariffs contravened European law.

Initially, the move towards tradable green certificates was put on hold. However, Jacobsen and Zvingilaite (2010) identify a post-2003 shift from fixed FIT support for renewables to feed-in premiums or tradable green certificates combined with the revenue from power markets. This, they argue, has made renewable generation more dependent upon market prices and the incentives arising from these prices. In 2008, feed-in premiums rose to 4.8 US cents per kWh.[19] Nevertheless, Sovacool et al's (2008) analysis of Danish wind farms still describes the Energy Authority offering a fixed-in tariff for offshore wind parks for the first 12 years, whilst Jacobsen and Zvingilaite also acknowledge the continued existence of mixed schemes. That is, the support for offshore wind expansion today is based on tendering, with the winning bids based on the lowest feed-in tariff. Table 7 presents a summary of cumulative installed wind capacity in Denmark, 1998 to 2008.

Table 7 Cumulative Installed Wind Capacity in Denmark, 1998 - 2008

Cumulative Installed Wind Capacity (MW)										
Year										
1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
1420	1738	2341	2456	2880	3076	3083	3087	3101	3088	3159

Source: BP (2009)

New wind installations expanded quickly until 2003, the same year in which the FIT was phased out. However, since 2003, growth in absolute terms has been relatively flat.

3.2.2 Germany

Germany has implemented a variety of incentives since the late 1980s to become a key player in the growth of renewable energy generally, and current global market leader for solar energy (LABC, 2010a). Table 8 summarizes key milestones in German renewable legislation, classified

[19] 3.3 €cents – Converted using the ECB's average 2008 Reference Exchange Rate of 1 €: 1.4708 US$.

by incentive type, to demonstrate Germany's gradual progression along a renewable energy path.

Table 8: Key Milestones in Germany's Renewable Energy Incentives Strategy

Year	*Incentive Type*	*Action*
1987	-	German Bundestag set targets for reducing green house gases and start to formulate a feed-in-law for generation from renewable energy sources
1991	Feed-in-tariff	First Electricity feed-in-tariff, primarily benefitting hydropower and wind energy
1991-95	Grant/subsidy	Solar Roof Program offering up to 70% subsidy for installation of PV modules
1990-97	Grant/subsidy	Federal and regional research program grants
1990-98	Loans	Reduced interest banking loans for renewable energy supplier installations
1998	-	Deregulation of German electricity market
1999-2003	Loans	100,000 PV roof installation loan program
2000	Feed-in-tariff	New Renewable Energy Law (EEG), replacing percentage-based tariffs with fixed-ones over longer periods
2000 onwards	Grant/subsidy	Construction grants to spur investment in new bioenergy, geothermal, and solar thermal energy
2001	-	Nuclear Energy Phase-Out Act ending all new builds and reviewing existing licences
2004 onwards	Feed-in-tariff	Amendment to the EEG tariff resulting in improved payment conditions

Source: Authors

Renewable energy issues first came to prominence within German political circles in 1987, when Chancellor Kohl expressed concern about climate issues, prompting the Bundestag to set targets for the reduction of greenhouse gases and launch a simple feed-in law for energy generation from renewable sources in 1990. Primarily aimed at hydro station electricity sources, but also extended to wind power, this simple one-page bill was of little value for solar energy because the minimum reimbursement of 10.5 US cents per kWh[20] fed was below the supply cost of solar electricity (Mendonca, 2007a). Nevertheless, this 'Stromeinspeisungsgesetz' or initial Electricity Feed-In Act required utilities to connect renewable energy supplier generators to the grid, purchasing 5% of their total electricity from renewable sources at 65-90% of the average tariff for final customers (Held, Ragwitz, Huber, Resch, Faber, & Vertin, 2007).

[20] 0.17 DEM/kWh – Converted using Antweiler's (2007) 1990 average exchange rate of 1.6157 DEM:1 US$.

During the 1990s, other types of incentive were of greater value promoting a solar energy agenda. For example, a federal and regional grant/subsidy for a solar roof program (1991-95) resulted in 2250 installations, representing approximately 5MW of installed capacity. 50% of the investment costs under this scheme, which had initially targeted only 1000 installations, were funded by federal government, with a further 20% from regional governments. A federal energy research program provided more than $1.06 Billion[21] in grants for all renewal energy technologies, supplemented by $0.91 Billion[22] from the Länder between 1990 and 1997. Reduced interest loans totaling $3.39 Billion[23] were offered to renewal energy supplier installations by the federal government's banking institutions; and loans for a 100,000 PV roof installation program were offered between 1999 and 2003.

As recent as 2000, the German market had only installed 40 mega-watts of solar.[24] However, the catalyst to Germany's rise to prominence within solar power was the replacement of the 1990 FIT by the Renewable Energy Law or 'Erneuerbare-Energien-Gesetz' (EEG) in 2000 (Frondel et al, 2008). The 2000 version of the EEG implemented fixed, stepped tariffs, in which the rates were differentiated according to the renewable producer's costs, market-responsive incentive levels and increased accessibility, rather than longer tied to the spot price of electricity. Administrators therefore set tariffs based on detailed predictions of project costs to cover solar installation plus a reasonable profit. Total participation and the size of eligible systems were also uncapped, creating opportunities for many types of market participants (LABC, 2010a).

The EEG also introduced tariff degression rates, based on theoretical models of technology learning (Held, Ragwitz, Huber, Resch, Faber, & Vertin, 2007). The biggest benefactor of this new FIT was solar energy, with PV electricity receiving $0.47 per kWh fed.[25] This was intended to make the sector more competitive, compensating for the poor, technical efficiencies of PV modules and the unfavorable geographical location of Germany (Frondel et al, 2008).

[21] €1 Billion – Converted using the ECB's average 1999 Reference Exchange Rate of 1 €: 1.0658 US$.
[22] €0.85 Billion – Converted using the ECB's average 1999 Reference Exchange Rate of 1 €: 1.0658 US$.
[23] €3 Billion – Converted using the ECB's average 2003 Reference Exchange Rate of 1 €: 1.1312 US$.
[24] European Photovoltaic Industry Association/Greenpeace, 'Solar Generation V – 2008' p.4
[25] 0.99 DEM/kWh – Converted using Antweiler's (2007) 2000 average exchange rate of 2.1272 DEM:1 US$.

Amendments to the EEG FIT in 2004 offered even greater levels of compensation for solar power, including $0.74/kWh[26] for solar electricity from small façade systems and an increase in annual degression fees for PV energy to 5%. As a result, the number of solar installations in Germany trebled between 2004 and 2006 from 84,870 to 233,557 (Kiesel, 2007). Most utility company objectives to the initial 2000 Act had either been legally quashed or appeased by the 2004 revision.

Mendonca (2007a) describes the increase in tariffs paid for solar PV as "… perhaps the most important of the changes, making PV far more attractive commercially and leading to a solar boom in 2004."(p.35). An LABC (2010a) review also equates Germany's global leadership in solar energy with a clear articulation of "… its national energy goals and … a FIT policy that achieves these goals over the long-term" (p.17).

The EEG has required utilities to purchase renewable energy from anyone willing to supply it, including individuals or entities that do not specialize in energy production. Commercial, industrial, and residential system owners are eligible for payments. Remuneration varies by plant size and energy source, and rates are guaranteed to new system owners for a period of 20 years (IEA, 2009; BMU, 2009).

The solar tariffs were designed to create access to five distinct segments of the solar market:

(a) Residential rooftops;
(b) Medium-sized agriculturally-owned rooftops;
(c) Community rooftops;
(d) Large commercial rooftops; and
(e) Open-space projects.

Each type of owner is allowed to recoup their up-front costs and make a reasonable return on investment of 4-5% after tax (LABC, 2010a). Tariffs decline annually based upon the market's response, with the cost shared equally among all ratepayers.

[26] €0.5953 – Converted using the ECB's average 2004 Reference Exchange Rate of 1 €: 1.2439 US$.

Frondel et al's comparison of the PV tariff with other renewable sources emphasizes the extent to which solar power has benefited from the EEG. For example, the remuneration of $0.65 per kWh[27] solar electricity for PV modules installed in 2006 was almost ten times higher than the market price of conventionally produced electricity, six times the tariff granted for wind power and almost five times the average FIT for electricity from renewable energy technologies of $0.14 per kWh.[28]

Table 9 summarizes the fixed rate FITs for biofuel, geothermal, hydropower, solar PV and wind energy in Germany, categorized by technology used and plant size in 2009.[29]

All tariffs digress over time, with reductions of 1% per annum for new wind installations and up to 10% per annum for new PV installations (BMU, 2009).

Importantly, the operator of an eligible system is responsible for the costs of connecting to the grid. Any upgrades to the grid are the responsibility of the grid operator, but the costs incurred can be passed on to system owners in the form of usage charges. The aim of this requirement is to protect rate-payers (other than the system owner) from paying for the upgrades.

Table 10 presents the change in cumulative installed power capacity from geothermal, solar PV, and wind plants in Germany since the enactment of the EEG in 1990.

Since 1990, installed geothermal, solar PV and wind capacity have cumulatively increased nearly five-fold. Also, since 2004, 117,000 new jobs are estimated to have been created in the renewable energy sector (BMU, 2009).

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[27] €0.518 – Converted using the ECB's average 2006 Reference Exchange Rate of 1 €: 1.2556 US$.
[28] €0.11 – Converted using the ECB's average 2006 Reference Exchange Rate of 1 €: 1.2556 US$.
[29] Policy details adapted from an English edition of the 2009 Amendment of the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz (EEG)).

Table 9: Summary of 2009 Feed-in Tariffs in Germany

Energy Source & System Size	*Program Rates (US$/ kWh)*[30]
Bioenergy	
small systems	0.1627
> 5MW	0.1087
Biogas	
small landfill gas	0.1255
mine gas > 1MW	0.0720
mine gas > 5MW	0.0580
Geothermal	
< 10MW	0.2232
>10MW	0.1465
Hydropower	
new plants, <500 kW	0.1767
modernized, <500 kW	0.1627
>500 kW and < 2MW	0.1207
> 2MW and < 5MW	0.1067
Solar PV	
< 30 kW	0.5999
> 30 kW and < 100 kW	0.6836
> 100 kW and < 1MW	0.5521
> 1MW	0.4603
Wind	
On-shore, first five years of operation	0.1283
On-shore, after first five years	0.0700
Off-shore, until 2015	0.2092
Off-shore after 2015	0.1813[31]

Source: IEA, Renewable Energy Database (2009)

30 All US$ converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.
31 After 2015, tariffs for off-shore wind will decrease by 5 % per year.

Table 10: Cumulative Installed Renewable Capacity in Germany, 1990 - 2008

	Cumulative Installed Capacity (MW)						
	Year						
Renewable Resource	**1990**	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**
Geothermal	–	–	–	0.2	0.2	3.2	6.6
Solar PV	113.7	194.6	278.0	1910.0	2863.0	3998.0	5498.0
Wind	6107	8734	11968	18445	20652	22277	23933

Source: BP (2009)

Although much of this German analysis to date has focused upon FITs, during the first decade of the current century, other forms of market-based incentive have also complemented Germany's EEG. For example, a competitive grant program (or 'Marktanreizprogramm') based on the size of the eligible plant, has encouraged investment in new bioenergy, geothermal, and solar thermal energy plants by assisting with construction costs. This has awarded program funds of $928.1Million[32] since 2000, triggering an estimated investment of $6.97 Billion[33], with a further $557.92 Million[34] allocated for 2009 (IEA, 2009). A 100,000 roof installation grant scheme between 1999 and 2003 also helped to stimulate the market for solar PV. However, the key incentive, particularly since 2004, has been the FIT.

In the absence of any federal subsidies, and a diminishing tariff, Lewis (2010) predicts that Germany's status as a demand driver within solar energy is set to diminish. Nevertheless, during 2009, the FITs ranged from approximately $0.46 to $0.60, equating to a reduction of approximately 10%. Germany's solar industry federation also estimated their 2009 installations to be 3 GW (double the 2008 figure), and the federal government has pledged not to introduce tariff cuts that would damage their world-leading solar-panel makers and project developers.

[32] €665.4 Million - Converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.
[33] €5 Billion - Converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.
[34] €400 Million - Converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.

3.2.3 Spain

Alongside Germany, Spain is often heralded as a successful promoter of electricity from renewable energy sources (e.g. Ragwitz & Huber, 2004; Mendonca, 2007a; Rio & Gaul, 2007; González, 2008; Cory et al, 2009; LABC, 2010a). Table 11 summarizes key milestones in Spanish renewable legislation. This emphasizes an even greater emphasis upon feed in tariffs than Germany. However, González (2008) also suggests that a broad social and political coalition leading to commitment and continuity of feed-in tariffs has also been of importance.

Table 11: Key Milestones in Spain's Renewable Energy Incentives Strategy

Year	*Incentive Type*	*Action*
1980	Prototype Feed-in Tariff	Energy Conservation Law - guaranteed access and price for a feed-in law but not contract length
1994	Prototype Feed-in Tariff	Royal Decree on electricity produced by hydro sources, cogeneration and RES setting basic conditions for the contract between producers and distributors – prices set by royal decree for minimum 5 years
1997	Feed-in Tariff	Law of the Electricity Sector establishing special treatment for renewable, guaranteeing grid access and price-support for producers
1998	Feed-in Tariff	Royal Decree on Special Regime guaranteeing purchase of renewable energy and fixing tariffs for 1999
1999	-	PFER (Plan de Fomento de las Energias Renovables) dictating methods of reaching renewable targets
2004	Feed-in Tariff	Royal Decree: (a) Tying support to the average electricity price (AET), guaranteed but decreasing over the lifetime of an installation; (b) Revision of support levels every 4 years without retroactivity
2005	-	Renewable Energy Plan for 2005-10 supersedes PFER
2007	Feed-in Tariff	Reform of the 2004 tariff to tackle three issues: (a) Security of supply; (b) Encouraging participation; and (c) System costs. Included a move towards a cap & floor variable premium tariff
2008	Feed-in Tariff	Royal Decree cut tariffs by 25%, capped the program at 500MW per year and established a new registration process

Source: Authors

Mendonca suggests that Spain's foray into renewable energy was initially prompted by energy security reasons during the oil crisis of the 1970s, when domestic energy supplies accounted for only 28.6% of the country's needs. Spain's objectives at this time were threefold:

(a) To diversify their primary energy resources;

(b) To develop their energy efficiency; and

(c) To prioritize their promotion of new energy.

The first key milestone along this path was an Energy Conservation Law, passed in 1980, which guaranteed access and prices (set annually by the Ministry of Energy & Industry) for a quasi-FIT without any reference to contract length.

This was followed in 1994 by a Royal Decree on electricity produced from hydro, cogeneration and renewable energy sources. This latter decree established a contractual relationship for producers and distributors, allowing renewable plants with an installed capacity of less than 100MW to sell their surplus electricity to distributors at a prices set for a minimum five years.

LABC (2010a) suggest that 1997 and 1998 were key years in the development of Spanish FITs. For in 1997, the country introduced a tariff-system which differentiated between traditional electricity producers and renewable source producers, and guaranteed both grid-access and price support for renewable producers. By 1998, a legal basis had been established within Spain for the payment of a tariff above market (wholesale) rates for renewable power. Two tariff options were offered to renewable producers. These were a fixed rate on top of the spot-market electricity price, or a fixed total price for investment security which was adjusted annually. The costs of both FIT options were initially paid for by distributors, but passed on to the Comision Nacional de la Energia (CNE) before being shared equally across electricity consumers. Primarily benefiting wind power, Mendonca states that wind capacity increased from 834MW to 6235MW between 1998 and 2003. However, with the overall growth in demand for power simultaneously increasing alongside Spain's renewal energy capacity, any change in the composition of the country energy mix was negligible between 1978 and 2003.

In Spain, the major market-based incentive mechanisms are mandated by the CNE. In 1998, the CNE instituted the Special Regime for the Production of Electricity from Renewable Energy Sources (Royal Decree 436/2004), thereby mandating FITs for a variety of renewable energy resources.

A further Royal Decree in 2004 offered renewable producers the option to sell their electricity to distributors or directly to the open market. The tariffs available from either option were linked to the average electricity tariff (AET) set annually by the Spanish government, and guaranteed for, but decreasing over, the lifetime of an installation. Fixed tariffs were offered to system owners who sold power to distributors. However, for sales on the open market, producers of renewable energy could receive the spot-market price plus a market incentive. The tariffs varied by eligible technology and incentives were guaranteed for 25 years (IEA, 2009). Revisions of the levels of support were guaranteed every four years without any implications for previous investments. Of particular importance from a solar perspective, the capacity threshold below which installations would receive maximum support was also raised from 5KW to 100KW.

González suggests that this new right to participate within the electricity market not only reduced intervention in the setting of electricity prices. It also improved the imputation of system costs, such as the difference between planned and effective generation. The market incentive offered was also in addition to the market price plus tariff amount.

Further tariff reforms in 2007 introduced by the CNE focused upon three key issues.

From a security perspective, priority access was given to the grid for renewable plants producing more than 10MW. Wind and solar PV producers with fluctuating production were also excluded from capacity guarantee payments, and the tolerance thresholds for wind and solar deviations was cut from 20% to 5%.

To help minimize consumer costs, the additional market incentive for producers opting to participate in the market was abolished, and a cap introduced on tariffs payable. To limit the increase in system costs, support levels were delinked from the average electricity price (AET) and a cap on support levels established.

The introduction of a cap and floor price for renewable installations participating in the market was a particularly significant development, providing more stable revenues for developers via a minimum compensation level, but also limiting the exposure of ratepayers by reducing the tariff payment level if electricity prices increased. Under this scheme, whenever the spot-market price plus the tariff premium rose above the cap, renewal energy producers only received the cap floor. When the market price plus tariff premium fell below the floor, they only received the floor price.

LABC (2010a) criticizes Spain's 2007 reforms for failing to differentiate tariffs, which were set by government mandate, in a precise manner, or build in a degression or periodic review. With projects under 10MW receiving $0.64, but larger projects of 10-50MW receiving $0.35, they argue that project developers connected many small solar systems in a series to capture the higher tariffs for smaller projects while simultaneously taking advantage of the economics of scale associated with the larger projects.

As a result, Spain issued another Royal Decree in 2008, cutting tariffs by 25% and capping programs at 500MW per year. Tariffs were differentiated by system (small rooftop, large rooftop or ground-mounted) and an annual degression scheme applied, linked inversely to program cap rates. For example, if a tariff for a particular type of installation is lowered by 10% from one year to the next, the program cap for that type of installation will be raised by 10%. The 2009 laws limit degression to a maximum of 10% per year (Global Green USA, 2008).

A new registration process was also established, requiring applicants to submit administrative authorization, acquire building permits, and post a substantial security deposit. Selected according to strict quarterly cap allowances on a first come, first served basis, successful applicants have been given only one year to connect their projects to the grid.

The 2008 Decree also implemented a policy review milestone. Under the current program, once 85% of the country's Renewable Energy Target has been met for a particular technology, the program must be reviewed to assess the need for design modifications (IEA, 2009).

Today, FITs are offered for solar PV, biomass, geothermal, hydropower, ocean, and wind systems. Tariffs vary by technology and system size, with incentive bonuses offered for high-efficiency systems. Only systems whose installed capacity does not exceed 100MW are eligible. Solar PV systems are exempt from that restriction, but the solar FIT program is capped at an annual limitation of 500MW. Owners of systems with capacity of less than 50MW can opt between a fixed tariff and a premium tariff. Owners of larger systems receive bonuses for electricity produced (IEA, 2009).

Table 12 presents a comparison of the 2007 FIT program with the current one.

Table 12: Comparison of Feed-in Tariffs for Solar PV in Spain, 2007 and 2009

2007	*2009*
Program caps	
None	500MW total 267MW for rooftop installations 233MW for open-space installations
Tariff rates $/kWh[35]	
All types of installations: < 100 kW: 0.6036, then 0.4828 100 kW – 10MW: 0.5722, then 0.4577 10MW – 50MW: 0.3148, then 0.2519	Open space: < 10MW: 0.4463 Rooftop, < 20 kW: 0.4742 Rooftop, 20 kW – 2MW: 0.4463

Source: Global Green USA (2008)

Thanks primarily to its feed-in tariffs, Spain has experienced rapid uptake of certain renewable energy technologies since 1980. Table 13 illustrates the historical change in cumulative installed wind and solar PV capacity in Spain over this period.

Table 13: Cumulative Installed Solar PV and Wind Capacity in Spain, 1980 - 2008

	Cumulative Installed Capacity (MW)							
Renewable Resource	**Year**							
	1980	**1990**	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**
Solar PV	8.0	12.1	15.7	20.5	57.7	118.2	630.2	3291.2
Wind	880	2836	3550	5043	10027	11614	14714	16543

Sources: BP (2009); EIA (2009c)

[35] Converted using the ECB's average 2007 Reference Exchange Rate of 1 €: 1.3705 US$ and the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.

The policy changes enacted in 2007 had a dramatic effect on installed solar PV capacity, with 433% and 422% year-over-year growth in 2007 and 2008, respectively. At the end of 2007, non-large hydro renewable resources accounted for 11.6% of Spain's total net electricity energy consumption. Wind accounted for 86.0% and solar accounted for 1.6% of total energy consumption from non-large hydro renewables (BP, 2009; EIA, 2009).

The new registration process introduced by the 2008 Decree has become a barrier to the owners of rooftop projects, due to the complexity of the procedure, but open floor solar schemes remain heavily over-subscribed. Although 2,661MW of solar were installed in 2008, this fell to 5MW during the first eight months of 2009. Hence, whilst the LABC acknowledges the role feed-in tariffs have played to stimulate renewal energy within Spain, they question the extent to which the tariff in its current guise can create the conditions for solar in particular to continue to contribute to Spain's energy goals.

3.2.4 Austria

Austria has been a primary user of renewable energy sources for many years. Hostile to nuclear power, up to 70% of Austria's electricity was generated by renewables as early as 1997 (DGET, 2008). Table 14 below illustrates key developments in Austria's adoption of renewable energy.

Table 14: Key Milestones in Austria's Renewable Energy Incentives Strategy

Year	*Incentive Type*	*Action*
1976	-	Austrian Energy Research Programme commences
1979ff	Tax Incentive	Cost of energy saving measures deducted from income tax
1980ff	Grants/Subsidies	Provincial investment grants
1994	Grants/Subsidies	
1995	Feed-in Tariff	Provincial feed-in tariffs introduced under August 1995 Ordinance
1997	Feed-in Tariff	Promotion Instrument for Electricity from Renewables (PIER) refinement
1998	Feed-in Tariff	EIWOG amendment
2002	Feed-in Tariff	Ökostromgesetz Act – national feed-in tariffs introduced for small hydro, on-shore wind, biomass, solar PV and geothermal energy
2006, 2008 & 2009	Feed-in Tariff	Amendments to Ökostromgesetz, including the addition of Biogas, reduced contract terms and tariff rates
2007	Tax Incentive	Exemption for Biofuels

Source: Authors

Early emphasis within Austria was placed upon water and biomass as energy sources. Hence, Dell, Egger and Grübel (1996) initially attribute Austria's pursuit of renewables to the country's geographical situation and rich forest resources aligned with national-economic and environmental advantages. However, a key driver since that time has been the FIT.

The first Austrian FITs were introduced in 1995 at a provincial level and usually reflected a province or Länder's specific political climate and natural resources, rather than any desire to optimize renewable energy technology (IEA, 2004). These tariffs established guaranteed minimum prices for electricity traded between provinces and produced from CHP stations and renewable electricity plants. In 1997, the tariffs were amended to include both a capital cost grant, capped at a 7% rate of return for 15 years, plus a guaranteed payment for renewable electricity fed into the grid. A competitive tender procedure was implemented to select projects, awarding grants according to the lowest capital cost for each technology type. In 1998 a further adjustment (EIWOG) obliged system operators to purchase renewable electricity from independent power producers and to pay minimum FITs defined by each Länder. These FITs varied according to technology, type and duration of contract and daily/seasonal demand.

Complementing these provincial FITs, federal grants and incentives of up to 30% were also offered by the Kommunalkredit to renewable energy producers. These grants supported investment in small hydro plants, modern biomass heating systems, biogas, geothermal systems, heat pumps, solar thermal and wind installations, and could be supplemented by an additional 35% grant from the Länder. Personal tax incentives for the purchase of biomass and solar technologies were also introduced in 2001 and 2003.

However, the adoption of the Austrian Green Electricity Act or Ökostromgesetz in 2002, (subsequently amended in 2006, 2007, 2008 and 2009) introduced national FITs to help optimize the development of energy from renewable sources. Under this Act, the purchase and sale of green electricity in Austria is administered by OeMAG, who pay for any electricity fed into the grid and predetermine fixed tariff levels when an agreement is signed. The 2002 Act mandated fixed tariffs for small hydro, on-shore wind, biomass, solar PV, and geothermal energy systems, with remuneration guaranteed for 13 years. A 2006 revision added biogas to the list of eligible technologies and reduced the contract period to 10 years for most technologies, with two additional years at reduced rates.

Table 15 presents a comparison of the programs from 2002 and 2006 (European Renewable Energy Council, 2009).

Table 15: Comparison of the 2002 and 2006 Feed-in Tariffs in Austria

	Remuneration[36]			
	2002		**2006**	
Technology	**Amount ($/kWh)**	**Duration**	**Amount ($/kWh)**	**Duration**
Small hydro	0.036 - 0.060	13 years	0.041-0.075	15 years
On-shore wind	0.074	13 years	0.0961	10 years, + 2 years at reduced rate
Biomass	0.097-0.1603	13 years	0.142-0.197	10 years, + 2 years at reduced rate
Biogas	NA	NA	0.144-0.214	10 years, + 2 years at reduced rate
Solar PV	0.44-0.57	13 years	0.402-0.615	10 years, + 2 years at reduced rate
Geothermal	0.066	13 years	0.093	10 years, + 2 years at reduced rate

Source: European Renewable Energy Council (2009)

Tariffs are paid from two sources. Utility companies pay a yearly defined settlement price paid for the electricity fed into the grid, according to their market share. This is complemented by an annual flat charge for consumers' electricity meters determined by customer grid level connections rather than consumption. For 2007 to 2009, this ranged from $20.92 per year/ per meter for grid level 7 (households) to $20,922 per year per meter for grid levels 1-4.[37] Once a FIT's expired, most installations expect to benefit from a purchase obligation at market prices minus balancing costs for another 12 years. Austria's 2009 FITs are illustrated in Table 16.

To complement the feed-in tariff, tax incentives have also been introduced. These include a biofuel tax exemption from fossil fuel taxes, a tax rebate for biofuel blends introduced in 2007, and income tax rebates for energy saving measures including expenses for heat pumps, solar thermal and bioenergy systems.

[36] Converted using the ECB's average 2002 Reference Exchange Rate of 1 €: 0.9456 US$ and the ECB's average 2006 Reference Exchange Rate of 1 €: 1.2556 US$.
[37] Converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.

Table 16: Austria's 2009 Feed in Tariffs for Electricity from Renewable Energy Sources

Technology	Tariff ($/kWh)[38]
Wind power	0.105
Solid Biomass	0.155-0.218
LiquidBiomass	0.083-0.174
Biogas (agricultural digestion)	0.157-0.236
Biogas (waste)	0.056-0.083
Geothermal	0.102
Photovoltaic	0.418-0.641
Small Hydro	0.046-0.087

Source: IEE (2009)

Lofstedt (2008) suggests that the tariffs have had mixed success. New wind-power plants in Lower Austria and Burgenland helped wind power achieve 2% of the renewable energy mix by January 2005, and there have also been significant advances in small-head hydro power. Biomass has been slower to respond, although Wienstrom opened what was at the time Europe's largest biomass-to-energy plant outside Vienna in 2006, capable of generating 100GWh electricity and 300GWh heat. The first signs of growth in solar PV installations in Austria can be traced to 2002. Table 17 summarizes the historical change in cumulative installed capacity of solar PV in Austria from 1998 to 2008. Installed solar PV capacity increased 68.9%, 63.1%, 25.6%, and 13.7% year-on-year in 2002, 2003, 2004, and 2005 (BP, 2009).

Table 17: Cumulative Installed Solar PV Capacity in Austria, 1998 - 2008

	Cumulative Installed Capacity (MW)										
	Year										
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Solar PV	2.9	3.7	4.9	6.1	10.3	16.8	21.1	24	25.6	27.7	30.2

Source: BP (2009)

[38] Converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.

3.2.5 Netherlands

The 1973 oil crisis first prompted the Netherlands' government to consider renewal energy in the shape of a national research program for the development and application of wind energy. Since that time, the country has introduced a number of market-based incentives to stimulate and develop a renewable energy sector, as illustrated in Table 18.

Tax incentives introduced by the Netherlands include the VAMIL scheme (1996-2002), the Energy Investment Scheme (N-EIA) and Environmental Investment Scheme (MIA) and Green Funds Scheme. The VAMIL scheme offered entrepreneurs a financial advantage by accelerating depreciation for all renewable energy-related technologies equipment, thereby reducing tax payments on company profits (Junginger et al, 2004). The N-EIA and MIA also allowed renewable energy companies to offset investments in technologies against taxable profit, with tax credits ranging from 40 to 52.5%. The Green Funds Scheme enabled private investors to put money into green projects that benefit nature and the environment. Launched in 1995, 200,000 investors have put up five Billion euro, funding 5,000 green projects, by 2007 (Netherlands EEA Plan, 2007).

Examples of grants or subsidies offered included the CO_2 Reduction Plan, EINP, BSE and ZON. The CO_2 Reduction Plan distributed subsidies via a tender system, offering up to 45% of the investment costs for renewable energy projects. EINP was a subsidy scheme for the non-profit sector including private individuals and associations. It provided a subsidy of 14.5–18.5% of investment costs. Decision Subsidies Energy programs (BSE) helped support the development and application of innovative renewable energy projects, whilst ZON was a subsidy scheme for active solar thermal systems.

Table 18: Key Milestones in the Netherlands' Renewable Energy Incentives Strategy

Year	*Incentive Type*	*Action*
1970s	-	National wind energy research program
1980s	Grants/subsidies	Introduction of direct investment subsidies to speed up market growth
Early 1990s	-	Voluntary agreements with energy distributors, setting targets for renewable
1995ff	Tax Incentive	Green Funds Scheme
1996	Tax Incentive	Green electricity consumers exempt from an eco-tax
1996-2002	Tax Incentive	VAMIL scheme
1997ff	Tax Incentive	EIA tax credit introduced to offset investment in renewable technologies against taxable profit
1997-2003	Tax Incentive	MIA tax credit offsetting investment in renewable energy-related technologies against taxable profit
1998	Forerunner of Green certificates	Voluntary Green Label system introduced
2001	Green certificates	Formalization of Green Label system
2003	FIT & Tax Incentive	Implementation of Environmental quality of electricity production (MEP) – feed in tariff and tax exemption
2005	Tax Incentive	Eco-tax phased out
2007	Feed-in Tariff/subsidy	Renewable Energy and CHP Production Aid Scheme (SDE) established

Source: Authors

Between 1990 and 2000, the Netherland's share of renewable energy grew from 0.9% to 2.5% of domestic electricity demand. However, this was less than half the government's target so new policies were introduced at the beginning of the twenty-first century (Junginger et al 2004). For example, an informal green label trading system dating from 1998 to achieve voluntary government targets for electricity generated by wind turbines, solar PV, small-scale hydropower, biogas and woody-biomass, was replaced in 2001 by a national green certificate trading system. Under this scheme, suppliers of green energy were expected to deliver green energy to consumers at a price comparable to, or below that of grey energy thanks to an eco-tax exemption. They were also entitled to trade their green certificates to supplement revenue earned from the sale of renewable source electricity at market-prices (Plumb and Zamfir, 2008).

This was replaced by the Environmental Quality of Power Generation Program (MEP) in 2003. The MEP established a tax exemption for renewable energy projects, as well as premium tariffs for renewable energy installations established after 1996. Premiums varied with each energy source and were paid in excess of the wholesale price of electricity. The highest tariffs were paid for offshore wind and solar PV installations. The Netherlands' EEA Plan 2007 estimated that the subsidy scheme covered approximately 50% of the uneconomic part of the total costs. In the original program design, tariffs were claimed with tradable certificates. The tariffs were guaranteed for 10 years, with annual adjustments. They were also only applicable to electricity produced within the Netherlands (Junginger et al 2004). Funded by a $38.46 annual levy[39] on all household connections to the grid, in 2006 the tariffs were adjusted to zero due to budgetary shortfalls. From 2007, the MEP was financed via the national budget. However, in August 2007, the MEP was suspended for new projects, based on expectations that national renewable energy targets would be met with current obligations (IEA, 2009).

Its replacement in December 2007 was the Renewable Energy and CHP Production Aid Scheme (SDE). This was effectively a variable-premium spot-market gap FIT, including a government subsidy. Described by Cory et al (2009) as a hybrid approach between fixed-price and premium-price FITs, the government guaranteed that SDE projects would receive a pre-determined, minimum total payment to compensate for any difference between the market price and the subsidy floor. However, whenever the market price exceeded the subsidy floor, no subsidy was paid. Generators simply earned more than the standard rate per kWh. The key difference between the SDE and other spot-market gap FITs was the government's willingness to cover the added marginal costs, rather than electricity customers. That is, the gap between the market price and tariff price was paid directly from the taxpayer rather than electricity ratepayer. The program also had annual funding caps for each technology, shown in Table 19:

Table 19: Annual SDE Funding Limits for Eligible Technologies in the Netherlands

Eligible technology	*Annual program funding cap ($ Millions)* [40]
Biogas from sewage and wastewater	1.37
Small-scale solar PV	26.04
Biomass, CHP, co-digestion of food industry waste and manure	93.19
Off-shore wind	163.09
On-shore wind	176.79

Source: IEA (2009)

[39] €34 - Converted using the ECB's average 2003 Reference Exchange Rate of 1 €: 1.1312 US$.

[40] Converted using the ECB's average 2007 Reference Exchange Rate of 1 €: 1.3705 US$.

Market prices exerted a major influence upon the SDE (Van Erck, 2008). For example, whenever the electricity price dropped below two thirds of the expected long-term market price, thereby increasing the required subsidy, the subsidy also dropped with average market price. Hence, this reduced a generator's remuneration until market prices rose again above two thirds of the stated projection. Couture & Gagnon (2009) describe this characteristic as a supplementary risk that Dutch renewable energy developers had to factor into their investment decisions. Although offshore wind power was excluded from the SDE in 2008 and 2009, the 2010 scheme has been extended to include this renewable energy source. The 2009 tariff rates offered for small PV installations up to 15kW $0.737 per kWh and larger projects $0.64 per kWh,[41] with annual budgets for a maximum 15MW small PV projects and 5MW larger solar projects.[42]

Table 20 presents the historical change in installed wind and solar PV capacity in the Netherlands since 1998. Both wind and solar PV installations increased substantially in 2002 and 2003 in year-over-year terms. 2006 and 2008 were also high-growth years for wind.

Table 20: Cumulative Installed Wind and Solar PV Capacity in the Netherlands, 1998 - 2008

	Cumulative Installed Capacity (MW)										
	Year										
Technology	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Wind	379	433	473	523	727	938	1081	1221	1557	1745	2222
Solar PV	6.5	9.2	12.8	20.5	26.3	45.9	49.5	51.2	52.7	54.3	55.9

Source: BP (2009)

3.2.6 Ireland

The energy challenges faced by Ireland are made more acute by the small size of their energy market, the country's peripheral location within Europe, and its limited indigenous fuel resources (DCMNR, 2007). Although oil accounted for 56% of Ireland's total primary energy requirements between 1990 and 2007,[43] the country has no domestic oil production and

[41] €0.526 and €0.459 - Converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.
[42] Tariff rates source: van Ee, M., (2009). *The Netherlands Boosts Its Feed-In Tariff For Renewable Energy*, 18 March 2009
[43] Source: EREC (2010). '*Renewable Energy Policy Review*'.

imported 86% of its electrical, heat and transport energy requirements in 2001.[44] Ireland's principal indigenous fuel resources are natural gas from Kinsale Head, Seven Heads and Corrib plus peat. However, decreased gas production at Kinsale Head since 1993 has prompted increased gas imports from the UK via two undersea gas lines, and the life expectancy of peat could be as low as 15-20 years (Green, 2010). Nuclear energy has also remained off the political agenda since public opposition blocked the development of a reactor at Carnsore in 1971.

Ireland's main renewable sources of power are wind and hydro energy and biomass (EREC 2009). Table 21 illustrates key developments in Ireland's adoption and promotion of renewable energy.

Table 21: Key Milestones in Ireland's Renewable Energy Incentives Strategy

Year	*Incentive Type*	*Action*
1984ff	Tax Incentive	Business Expansion Scheme (BES) – still in existence
1995-2005	Tendering	Alternative Energy Requirement tender schemes to build, own and operate new wind, hydro, biomass and waste-to-energy facilities
2005ff	Tax Incentive	Biofuels Mineral Oil Tax Relief Schemes
2006ff	Feed-in Tariff	REFIT schemes, granting support for up to 15 years for wind, biomass, landfill gas, anaerobic digestion plants, ocean energy and hydro projects
2006	Grants/subsidies	Greener Homes Scheme
2007	Grants/subsidies	Energy Crops Premium Scheme
2007	Grants/subsidies	ReHeat Deployment Program, offering assistance for the deployment of renewable heating systems in industrial, commercial, public and community premises
2008	Grants/susbidies	Low Carbon Homes Program

Source: Authors

One of the first Irish incentives was a tax exemption program called the Business Expansion Scheme (BES). Introduced in 1984, this encouraged developers to invest equity capital in companies within qualifying economic sectors, where raising equity capital might otherwise be difficult. Investments in renewable energy companies were eligible for the offset, which is still in effect. Investors who maintain equity investments in qualifying companies for five years are

[44] Source: Sustainable Energy Ireland (2002) quoted in Carly Green's (2010) unpublished paper '*Current and future perspectives on the energy sector in Ireland*'.

eligible for tax exemption at their marginal tax rate. The exemption is available for investments of up to $44, 285[45] per year, subject to a cap per company of $1,394,800[46] (IEA, 2009).

However, Ireland's main programme to promote electricity from renewable sources at the turn of the century was a tender scheme called the Alternative Energy Requirement (AER). This invited prospective generators to build, own and operate new wind, hydro, biomass and waste-to-energy facilities. Applications were ranked on the basis of bid-price per kilowatt-hour supplied, with power purchase agreements of up to 15 years granted by the Irish Electricity Supply Board. This was an open competitive process conducted in accordance with European Union procurement rules and state aid guidelines. Customer price increases on electricity bills were also supposed to be minimized via a levy that supported power from renewable sources. In total, six AER competitions were held. However, with all bar the first failing to reach the targets set, the Tendering Scheme was abandoned in 2006. Table 22 describes the technologies supported, targets and results of each AER competition.

Given the continual failure of the AER tenders to meet their targets, the Irish Government switched to a FIT in 2006 as the lead incentive for electricity production from renewable energy sources. Wind projects in particular have benefited from this Renewable Energy FIT (REFIT), but it is also applicable for biomass, landfill gas, anaerobic digestion plants, ocean energy and hydro power. Plans are also in place to extend the scheme to co-firing in peat stations.

The REFIT program established long-term fixed tariffs that vary with each eligible technology, adjusted annually for inflation. Table 23 presents a summary of the published tariff rates for each technology with start dates.

[45] €31,750 - Converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.
[46] €1,000,000 - Converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.

Table 22: Ireland's Six AER Incentive Schemes

Scheme	*Technologies Supported*	*Targets*	*Project Results*
AER 1	• Wind • Small Scale Hydro • Biomass (Landfill Gas) • Combined Heat & Power • Waste-to-Energy	• 75MW additional electricity generation capacity	• 34 projects received Power Purchase Agreements • 22 projects commissioned with a total installed capacity of 70.62MW
AER 2	• Waste-to-Energy	• 1 biomass/waste fuelled electricity generating plant (10-30MW)	• Project winner did not proceed with the build
AER 3	• Large Scale Wind (>5MW) • Small Scale Wind (<5MW) • Biomass (Landfill Gas) • Small Scale Hydro • Wave Energy	• 100MW of new electricity generation capacity	• Contracts for 30 projects (158.75MW) offered • Only 11 proceeded (42.11MW)
AER 4	• Combined Heat & Power	• 25MW of newly installed CHP and up to 10MW of additional energy from existing CHP plants	• Contracts offered to 17 new (45MW) and 2 existing (7.6MW) • Only 3 new and 2 existing plants were commissioned (18.35MW)
AER 5	• Large Scale Wind (>3MW) • Small Scale Wind (<3MW) • Biomass (Landfill Gas) • Small Scale Hydro	• 255MW	• Contracts offered for 363MW • 51MW commissioned
AER 6	• Large Scale Wind (>5MW) • Small Scale Wind (<5MW) • Offshore Wind • Small Scale Hydro • Biomass (Landfill Gas) • Biomass (CHP) • Biomass-Anaerobic Digestion	• 500MW by 2005 (Included AER 5 projects) • 2x25MW Offshore Wind projects	• 48 contracts (365MW) offered, plus 2 x 25MW offshore wind projects • 226MW Commissioned

Source: Report on DCNER website, June 2010 - www.dcenr.gov.ie/NR/rdonlyres/2E9CE305-4C9D-4CE2-87E2-2FB8DF13A6AD/0/AERProgramme2005.doc

Table 23: Summary of Published Rates for Feed-in Tariffs in Ireland

Technology	*Start Year*	*Tariff ($/kWh)* [47]
Onshore wind	2006	0.072-0.074
Offshore wind	2006	0.176
Biomass	2006	0.088-0.09
Hydro (<5MW)	2006	0.09
Ocean (wave and tidal)	2008	0.276
CHP	2008	0.151

Source: EREC (2009)

The tariffs for ocean developments are not indexed for inflation. The ocean tariff is intended to be a short-term policy to promote emerging technologies (IEA, 2009).

While the tendering and FIT incentives have provided the primary foundations for Ireland's renewable energy agenda, the country has also implemented a number of grants, subsidies and tax incentives. Three forms of grant or subsidy implemented from 2006 are the Greener Homes Scheme, ReHeat Deployment and Low Carbon Housing Programs plus the Energy Crops Premium.

The Greener Homes Scheme is a grant aid program for domestic households to install renewable heat technologies. Managed by Sustainable Energy Ireland, the initial program rules allowed both new and pre-existing homes to qualify for funding, and targeted 10,000 homes. However, since 2007, only existing homes are eligible. The eligible technologies are solar heating, heat pumps, wood chip or pellet stoves and boilers, and wood gasification boilers. Offering grants of $368-5148[48], phase III of the scheme launched in July 2008, with no end date currently planned.

[47] Tariffs converted using the ECB's average 2006 Reference Exchange Rate of 1 €: 1.2556 US$ and the ECB's average 2008 Reference Exchange Rate of 1 €: 1.4708 US$.
[48] €250-3500 - Converted using the ECB's average 2008 Reference Exchange Rate of 1 €: 1.4708 US$.

Table 24: Level of Funding Available under the Greener Homes Scheme

Renewable Source	*Funding ($)*[49]
Solar Thermal Space and or Hot Water Heating (Evacuated Tube)	$441.2 per m^2(max.6m^2)
Solar Thermal Space and or Hot Water Heating (Flat Plate)	$367.7 per m^2 (max.6m^2)
Heat Pump - Horizontal Ground Collector	$3,677
Heat Pump - Vertical Ground Collector	$5,147.8
Heat Pump - Water (Well) to Water	$3,677
Heat Pump - Air Source	$2,941.6
Wood Chip/Pellet Stove	$1,176.6
Biomass / Wood pellet Stove with Integral Boiler	$2,059.1
Wood Chip/Pellet Boiler	$3,677
Wood Gasification Boiler	$2,941.6

Source: SEAI website – www.seai.ie/Grants/GreenerHomes/Homeowners/Products_and_Grants/

Scheme overview figures published on the SEAI website (June 2010) suggest that 26,352 households have taken advantage of the Green Homes scheme, of which 23% were for heat pump technologies, 23% biomass and 54% for solar.[50]

The Renewable Heat (ReHeat) Deployment Programme, also managed by Sustainable Energy Ireland, has a total grant budget of $35,633,000[51] (2007-2010) to provide assistance for the deployment of solar thermal, geothermal heat pumps and biomass boilers in industrial, commercial, public and community premises. The objective of this program is to reduce 160,000 tonnes of CO_2 emissions per year.

Another SEI grant program encourages energy efficiency and carbon emissions reduction among developers of new multi-family housing units. The Low Carbon Housing Programme provides funding for up to 40% of eligible expenses to developers who meet the high-efficiency and low-carbon requirements, up to a maximum of $20,922[52] per housing unit (IEA, 2009).

The Energy Crops Premium Scheme, piloted in 2007, offered establishment grants to farmers for up to 50% of the costs associated with establishing miscanthus and willow for bioenergy,

[49] Converted using the ECB's average 2008 Reference Exchange Rate of 1 €: 1.4708 US$.
[50] As per June 17, 2010, stated on www.seai.ie/Grants/GreenerHomes/Scheme_Statistics/
[51] €26 Million - Converted using the ECB's average 2007 Reference Exchange Rate of 1 €: 1.3705 US$.
[52] €15,000 - Converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$.

supplemented by premiums per hectare of $61.67 from the EU and $109.64 from the Irish Government.[53]

An example of a tax incentive scheme implemented in Ireland is the Biofuels Mineral Oil Tax Relief Scheme. Initially piloted in August 2005, resulting in the introduction over 5.5M litres of biofuel, a second scheme was launched in 2006, valued at over $251.12 Million [54], granting excise relief for 5 years for defined quantities of biofuels to be placed on the Irish market.

Although still not recognized as a serious player by the leading European wind developers (McBennett, 2010), Ireland already has 3500MW of onshore wind (developed or in planning), and potential offshore wind capacity of 7,100MW. Between 1990 and 2007, renewable energy generally has grown within the country by 182% in absolute terms (equating to 6.3% per annum). Over a third of the current 2.9% renewable energy share of total primary energy requirement is provided by wind. Table 25 illustrates the historical change in cumulative installed wind capacity in Ireland since 2001.

Table 25: Cumulative Installed Wind Capacity in Ireland, 2001-2009

Cumulative Installed Wind Capacity (MW)									
	Year								
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Wind	129	167	230	339	498	748	807	1015	1264

Source: BP (2009) & SEIA (2010)

In 2006, the year in which the REFIT was introduced, the country began to see rapid expansion in wind capacity. This is clear evidence of the value of a FIT as an incentive for electricity generation from renewable sources. In 2007, wind accounted for 93.7% of total non-hydro renewable energy consumption in Ireland. In 2009, the share of Irish electricity generated from renewable energy sources stood at 14.4% - wind energy accounting for over two thirds of that figure (SEIA, 2010). This report also estimated that 0.1% of total residential sector requirements

[53] €45-€80 - Converted using the ECB's average 2007 Reference Exchange Rate of 1 €: 1.3705 US$.
[54] €200 Million - Converted using the ECB's average 2006 Reference Exchange Rate of 1 €: 1.2556 US$.

were met by solar thermal energy in 2008. 15 micro-generation solar PV sites were connected by the end of November 2009 offering a total installed capacity of 33.9kW.

3.2.7 United States

Sections 3.2.1 – 3.2.6 have emphasized the importance of feed-in tariffs to incentivize the development and adoption of renewal energy, albeit complemented by a myriad of grants, subsidies, loans and tax incentives. However, Martin (2009) argues that non-Europeans to date have been less likely to adopt feed-in tariffs, and this is certainly true of the United States. Consider, for example, the emphasis upon tax credits, loans, subsidies and rebate programs in Table 26, illustrating key milestones in U.S. renewal energy incentives since 1978.

Table 26: Key Milestones in U.S. Renewable Energy Incentives Strategy

Year	*Incentive Type*	*Action*
1978	Feed-in Tariff	PURPA
1980	Loan	Energy Efficient Mortgages Introduced
1992	-	Energy Star Homes Initiative
1992	Tax incentives	Energy Policy Act gives rise to the Investment Tax Credit (ITC)
1992	Tax incentives	Energy Policy Act gives rise to the Renewable Energy Production Incentive (REPI)
1992	Tax incentive	Personal income tax exemption for energy conservation subsidies received from utilities
1994-99	Tax incentives	1992 Energy Policy Act gives rise to the Federal Production Tax Credit (PTC)
2002	Grants/Loans	Introduction of the Renewable Energy Systems and Energy Efficiency Improvements Program
2005	Tax incentive	Energy Policy Act introduces Clean Renewable Energy Bond (CREB)
2008	Grants/Loans	Rural Energy for America Program (REAP) replaces the Renewable Energy Systems and Energy Efficiency Improvements Program
2008	Loans	
2009	Tax incentives and grants	American Recovery and Reinvestment Act amends PTC and ITC
2009	Feed-in Tariffs	Introduction of feed-in tariffs at state level

Source: Authors

An EIA (2008b) report estimated that tax expenditures comprise about two-thirds of the total subsidies and support related to U.S. electricity production. 17% of this $4,281 Million tax expenditure ($724 Million) was spent on renewables. Martin proposes at least three reasons for the U.S.'s different approach with respect to renewable energy incentives. These are:

(a) A tax credit is the United States' preferred modus operandi for a variety of other goals, from home ownership to education;
(b) State or local control of utility companies within the U.S. undermines the viability of a national FIT scheme; and
(c) The decentralized structure of the electrical generation and distribution system also hinders a national FIT scheme.

Incentives in the U.S. can emanate from federal government or specific states. The next two sub-sections will address each in turn.

3.2.7.1 U.S. Federal Incentives

The first federal policy was a prototype FIT called the Public Utility Regulatory Policies Act (PURPA). This 1978 statute enabled independent power producers to build and operate electricity generation facilities and sell the resultant electricity to a utility via a fixed-price standard offer contract at the utility's avoided cost of building generation. Komor (2004) suggests that the guaranteed prices were based on the long-term anticipated cost of fossil energy. However, a difficulty with PURPA contracts arose when the spot market price declined and utilities had to honor the agreed fixed-price contracts with independent power producers. Hence PURPA was dismantled, particularly following the introduction of liberalized markets.

Since that time, income tax incentive schemes have become the preferred modus operandi for renewable energy incentives at the federal level. A number of these tax incentives were originally enacted as part of the Energy Policy Act of 1992. These include the Federal Production Tax Credit (PTC), Federal Investment Tax Credit (ITC) and Renewable Energy Production Incentive (REPI).

The Federal Production Tax Credit (PTC)[55] was originally introduced for US-based renewable energy projects installed between 1994 and 1999. It is an inflation-adjusted credit paid per kWh

[55] 26 USC § 45

of generation sold to unrelated third parties for the first 10 years of operation of a qualifying institution. Rather than an outright payment for the production of renewable energy, it can only be used to reduce the amount of taxes a firm owes. For example, if a firm currently produces 1,000,000 kWh of renewable solar energy, the PTC would enable the firm to reduce the amount of federal taxes it owes by $10,000 ($0.01 x 1,000,000). Hence, the PTC provides an economic incentive to develop and deploy technologies that harness renewable resources by reducing the federal income taxes of qualified tax-paying owners of renewable energy projects, based on the electrical output of their renewable energy facilities.

Available to commercial and industrial entities and investor-owned utilities but not to publicly owned electric utilities, eligible recipients today receive $0.021[56] per kWh for electricity generated from qualifying wind, geothermal, and closed-loop biomass systems and sold to another entity. $0.01 per kWh credit is offered for electricity from all other eligible systems. There is no maximum limit for credits claimed through the PTC. Table 27 summarizes the current eligibility requirements and incentive payments available under the PTC for each eligible technology.

Between 1999 and 2004, the PTC was allowed to expire on three separate occasions, before being extended in December 1999, March 2002 and October 2004. Each reinstatement or extension has usually been for 1-2 years. The most recent extension by Congress was ratified by President Obama in February 2009.

Initially, only wind and 'closed loop' biomass were eligible for the PTC. Geothermal and solar energy instead received an investment-based tax credit. However, the PTC was extended to solar, geothermal and other sources of renewable energy as part of the Energy Policy Act 2005. The size of the tax incentive can be reduced by an eligible project receiving other types of incentive such as government grants, tax-exempt bonds, subsidized energy financing, or other federal tax credits. Unused credits earned under this incentive can also be carried forward for up to 20 years following the year of generation, or applied retrospectively for one year upon

[56] In 2009 $US. The original language of the Act establishes an incentive payment of $0.015 per kWh, in 1993 $US, indexed for inflation.

submission of an amended tax return. One limitation, though, is that any credits in excess of a firm's tax liability are lost.

Table 27: Summary of the Current U.S. Federal Production Tax Credit

Federal Production Tax Credit			
Eligible resources[57]	**Eligibility restrictions**	**In-service deadline**	**Credit amount ($/kWh)**
Landfill gas	Facilities placed in service after 10/22/04 are eligible for a five-year period	12/31/2013	0.011
Wind		12/31/2012	0.021
Closed-loop biomass		12/31/2013	0.021
Open-loop biomass	Facilities placed in service after 10/22/04 are eligible for a five-year period. Facilities placed in service before 10/22/04 are eligible for the five-year period beginning 1/1/05	12/31/2013	0.011
Hydroelectric		12/31/2013	0.011
Geothermal electric	Facilities placed in service after 10/22/04 are eligible for a five-year period	12/31/2013	0.021
Municipal solid waste	Facilities placed in service after 10/22/04 are eligible for a five-year period	12/31/2013	0.011
Hydrokinetic	150 kW minimum capacity	12/31/2013	0.011
Anaerobic digestion		12/31/2013	0.021
Small hydro	Facilities placed in service after 10/22/04 are eligible for a five-year period	12/31/2013	0.021
Tidal		12/31/2013	0.021
Wave		12/31/2013	0.021
Ocean		12/31/2013	0.021

Source: EIA (2009a)

Described by Mendonca (2007a) as "…the most effective Federal-level incentive for renewables" (p.61), Wiser, Bolinger and Barbose (2007) propose four reasons for the creation of the PTC. These are:

1. To support the environmental, economic development and energy security benefits accrued via renewable energy generation sources;

[57] New solar systems are not eligible for the PTC. However, solar systems were eligible for a short period, mainly during 2005. Any facilities that were in service during that period can now claim the credit at a rate of $0.021 per kWh for five years.

2. To support long-term cost-reduction potential;
3. To compensate for the federal incentives historically offered to conventional fossil fuel energy sources; and
4. To relieve some of the greater tax burden that would otherwise fall on capital-intensive renewable technologies relative to fuel-intensive conventional generation options.

A second federal corporate income tax credit is the Investment Tax Credit (ITC). [58] This reduces federal income taxes for qualified tax-paying renewable energy facility owners based upon their capital investment in renewable energy projects. Investment tax credits, earned when the capital equipment is placed into service, help offset upfront investments in renewable energy projects and provide an economic incentive to develop and deploy more capital-intensive renewable energy technologies, such as solar photovoltaic systems and fuel cells. Available to entities in the commercial and industrial–sectors for renewable energy installations placed in service on or before December 31, 2016, the amount of the credit varies with each technology. After 2016, the amount of credit available for solar installations reverts to 10% (SEIA, 2008). Table 28 summarizes current US federal investment tax credits for renewable energy.

Table 28: Summary of the Current U.S. Federal Investment Tax Credit

Federal Investment Tax Credit			
Renewable resource	**Eligibility restrictions**	**In-service deadline**	**% of expenses eligible for credit**
Solar	Excludes passive solar and solar pool-heating systems		30%
Fuel cells	0.5 kW minimum capacity 30% minimum efficiency		30%
Wind		12/31/2012	30%
Geothermal power	For energy production, applies to equipment used in all stages prior to transmission For geothermal heat pumps, applies to pumps and equipment used to produce, distribute, or use energy derived from a geothermal deposit	12/31/2013 for the 30% credit; none for the 10% credit	10% - 30%
Microturbines	2MW maximum capacity 26% minimum efficiency		10%, up to $200/kW of capacity
CHP	50MW maximum capacity 60% minimum efficiency for systems that use less than 90% biomass	12/31/2013	30%

Source: NREL and NCU

[58] 26 USC § 48

To qualify for an ITC, the owner of a renewable energy facility must be a tax-paying entity who has invested in new equipment, although this latter requirement can be waived subject to the amount of upgrades applied to older, used equipment after the purchase.

There is no maximum ITC limit for solar and geothermal technology investments, but a maximum ITC incentive of $1,000/kW for fuel cell investments and $200/kW for micro-turbine investments does apply. Like the PTC, an ITC can be applied to federal tax liabilities dating from the previous year and carried forward up to 20 years.

From a solar perspective, the latest legislation passed by Congress in 2008 and ratified in 2009 extended the ITC for both commercial and residential solar installations to the end of 2016. It also eliminated a $2,000 cap on the tax credit for the purchase and installation of solar electric on residential properties, and has enabled regulated and public utilities to finally benefit from the credit – something they were prevented from doing under earlier iterations.

Renewable generation facilities are prevented from claiming both PTC and ITC. However, the American Recovery and Reinvestment Act of 2009 modified the PTC and the ITC, extending the in-service deadlines and expanding the lists of eligible technologies for both incentives. Also, and perhaps more importantly, taxpayers eligible for the PTC have now been given an option to receive the ITC instead, or to receive a cash grant in lieu of either of the other options.

As tax credits, both the PTC and ITC are generally more valuable than an equivalent tax deduction because a tax credit reduces tax dollar-for-dollar, while a deduction only removes a percentage of the tax that is owed.

The Renewable Energy Production Incentive (REPI) program was also first introduced in 1992 to provide financial incentives for renewable energy electricity produced and sold by qualified renewable energy generation facilities. The American Public Power Association (2004) suggests that Congress implemented this program to attain two goals:

(a) To help public power utilities overcome economic barriers to greater renewable energy use; and
(b) To ensure equity between investor-owned utilities that received energy tax credits and not-for-profit utilities that were unable to do so.

Available to municipal utilities, state, local and tribal governments, rural electric cooperatives and native corporations for systems placed in use before 2016, REPI is managed by the U.S. Department of Energy. It is an inflation-adjusted cash production incentive for renewable energy projects that do not have federal tax liabilities and are therefore unable to take advantage of a PTC (Bird et al, 2005). The 1992 Act originally established an annual incentive payment to utilities of $0.015 per kWh, indexed for inflation, for the first 10 years of operation, subject to the availability of federal funding appropriations in each fiscal year (NCU and NREL, 2009). In 2009, this was worth $0.021[59] per kWh for electricity generated from qualifying renewable systems and sold to another entity. Qualifying systems include solar PV, solar thermal, landfill gas, wind, biomass[60], geothermal, anaerobic digestion, and ocean systems.

Another incentive open to the individual, which originated in the 1992 Energy Policy Act is a federal tax exemption for energy conservation subsidies received from utilities.[61] Customers of electric utility companies participating in a utility's energy conservation program can receive on their monthly electric bills either a rate reduction in the purchase price of electricity, or a nonrefundable credit against the purchase price of the electricity. Both options are income tax exempt. Although specific technologies are not stated within the Act, it does include solar water heat, solar space heat and PV. The qualifying, non-taxable projects include any measures taken to reduce consumption of electricity or natural gas, or improve the management of energy demand. For 2009 and 2010, individuals can also receive a tax deduction equal to 30% of the total out-of-pocket expenses, net of offsets from utilities, for residential energy efficiency technologies placed in service in either year, subject to a two-year limit of $1,500.[62]

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[59] In 2009 $US. The original language of the Act establishes an incentive payment of $0.015 per kWh, in 1993 $US, indexed for inflation.
[60] Municipal solid waste is excluded.
[61] 26 USC § 136
[62] 26 USC § 25C

In 2002, a different federal type of incentive scheme called the Renewable Energy Systems and Energy Efficiency Improvements Program was introduced. Primarily targeted at agricultural producers and rural small businesses, this scheme offered grants and loan guarantees for energy efficiency improvements and renewable energy systems, as well as for energy audits and renewable energy development assistance. Initially offering up to $23 Million per fiscal year for 2003-2007, this was revised by Congress as the Rural Energy for America Program (REAP) in 2008. Congress allocated $55 Million funding for REAP in FY2009, $60 Million for FY2010 and $70 Million per year for FY2011 and FY2012. Administered by the U.S. Department of Agriculture (USDA), approximately 88% of the funding is dedicated to competitive grants and loan guarantees for energy efficiency improvements and renewable energy systems. 9% of the funding is dedicated to competitive grants for energy technical assistance; 2% for relevant feasibility studies. Eligible renewable energy projects include wind, solar, biomass, geothermal and hydrogen derived from biomass or water using wind, solar or geothermal energy sources. Grants are awarded on a competitive basis and are subject to a maximum 25% of project costs. Loan guarantees cannot exceed $25 Million. The combined total of a grant and a loan guarantee cannot exceed 75% of a project's cost. Up to 20% of the funds available are also set aside for grants of $20,000 or less. The energy audit and technical assistance grants are also available to state, local and tribal government entities, schools, land-grant colleges and universities, rural electric cooperatives and public power entities.

A different tax/loan incentive dates from the 2005 Energy Policy Act. This is the Clean Renewable Energy Bond (CREB), a federal loan program designed to assist public-sector entities finance new electricity generation projects from clean or renewable resources. Eligible renewable technologies listed by DSIRE are solar thermal electric, PV, landfill gas, wind, biomass, hydroelectric, geothermal electric, municipal solid waste, hydrokinetic power, anaerobic digestion, tidal energy, wave energy and ocean thermal.

CREBs are issued by electric cooperatives, government entities (states, cities, counties, territories, Indian tribal governments or any political subdivision thereof). The bonds are meant to be interest-free to the issuer. The borrower must pay back only the principal of the bond (originally in equal, annual payments). The holder receives dollar-for-dollar federal tax credits on a quarterly basis rather than traditional interest payments. However, in practice bond issuers have had to issue the bonds at a discount or make supplemental interest payments in order to find buyers (NCU and NREL, 2009). The IRS treats the credits as taxable income to the holder.

Participation in the program is limited by the volume of bonds allocated by Congress. Eligible entities must apply to the IRS for a CREBs allocation and then issue the bonds upon receipt of IRS approval within 3 years of notification of an approved allocation. Public power providers, governmental bodies, and electric cooperatives are each reserved an equal share (33.3%) of the new CREBs allocation. The tax credit rate is set daily by the U.S. Treasury Department. At first, the credit was taken quarterly on a dollar-for-dollar basis to offset the tax liability of the bondholder. However, under the revised CREB 2009 allocation, the new bonds require the issuer to contribute 30% of the interest payments owed to the bondholder, with the federal government providing a tax credit equivalent to 70% of the interest payment. This modification is intended to offset the increased level of government subsidy for the bond emanating from full repayment at the end of a term rather than level, annual principal repayments (NREC 2009).[63] Two additional changes emanating from the 2009 legislation allow the bond and tax credit to be held by different owners, and the establishment of a reserve fund to invest the money needed on a limited basis to repay the bond at maturity.

The 2005 Energy Policy Act originally allocated $800 Million of tax credit bonds, which was reserved for 610 projects. A further $400 Million plus surrendered volume from the previous allocation was allocated to 312 projects in February 2008. State and local government borrowers were limited to $750 Million of this initial $1.2 Billion tax-credit bond volume cap. The balance was reserved for qualified municipal or cooperative electric companies. A further $800 Million was allocated under the Energy Improvement and Extension Act of 2008, followed by another $1.6 Billion in 2009.

CREBs differ from traditional tax-exempt bonds in that the tax credits issued through CREBs are treated as taxable income for the bondholder. The tax credit may be taken each year the

[63] www.nreca.coop/PublicPolicy/issuespotlight/20090408_IRSOpensApplicationProcess.htm?source=rss

bondholder has a tax liability as long as the credit amount does not exceed the limits established by the Federal Energy Policy Act of 2005.

The American Recovery and Reinvestment Act (ARRA), enacted in February 2009, established short-term funding provisions to support the development, commercialization, and adoption of renewable energy technologies. Generally, projects must be completed within two to three years of the grant award date. Of the $32.7 Billion in grants available through this act,[64] $4.5 Billion has been assigned to lower electricity costs and increase customer choice through electric grid modernization and $3.1 Billion to support State Energy projects. This latter State Energy Program offers financial and technical assistance to states through formula grants ($2.7 Billion) to develop state energy strategies. It also offers annual competitive grants ($454 Million) to adopt energy efficiency/renewable energy products and technologies. States provide a 20% match under SEP annual formula allocations. Grants can be used for energy efficiency and conservation programs and projects communitywide, as well as renewable energy installations on government buildings. Virginia, Maryland, Delaware, Massachusetts, New York, Pennsylvania, Vermont and Wyoming used their SEP allotments to fund existing solar rebate programs and create new ones (SEIA, 2010).

ARRA also includes a further $2 Billion in grants for Scientific Innovation in advanced energy technology research, $2.73 Billion for Energy Efficiency and Conservation Block Grants, and $467 Million to expand and accelerate the development, deployment, and use of geothermal and solar energy throughout the United States. Focusing solely upon the solar aspects of the $467 Million, this consists of $51.5 Million for PV Technology Development, $40.5 Million for Solar Energy Deployment and $25.6 Million for Solar Power Research and Development (EERE, 2009). Most programs established by the Act are set to expire within two or three years of the award of funding.

One final federal incentive that has been around since the 1980s is the Energy-Efficient Mortgage (EEM) loan program. Originally introduced to help existing owners and prospective buyers pay for energy-saving home improvements, it's also now offered for the purchase of

[64] See DOE: http://www.energy.gov/recovery/breakdown.htm

new Energy Star homes. Borrowers who qualify for an EEM need to complete a home inspection by an energy rater working off qualification standards created by the Department of Energy. The results of this energy audit are then used to apply for an EEM. Loans are insured by the U.S. federal government through the Federal Housing Authority (FHA) or Veterans Affairs (VA) programs. In some cases, lenders are permitted to add up to 100% of energy efficiency improvements to existing mortgages, subject to certain program caps (NCU and NREL, 2009).

Tedeschi (2006) estimated that an average Energy Efficient Mortgage loan recipient spent $10,000 on improvements and reduced his annual utility costs by 30% to 50%, although the FHA and VA mortgages usually have lower ceilings for energy improvement expenditure. A potential downside to the program is any investment in energy improvements is not always reflected in the ultimate resale price.

3.2.7.2 State and Local Incentives

The previous sub-section examined federal incentives to drive development of renewable energy generation in the US. However, given the state or local control of electric utilities, plus the decentralized structure of the electrical generation and distribution system, state incentives are also a key driver. These include state tax incentives, grants and subsidies, green pricing programs, and more recently feed-in tariffs.

Sarzynski's (2009) study of the impact of solar incentive programs in ten U.S. states identified a wide range of tax credits and rebates for both corporate and residential sectors, as illustrated in Table 29.

Six of the states examined above all rank in the top 10 U.S. states for solar thermal and PV. These are Arizona, California, Connecticut, Hawaii, New Jersey and Oregon. Sarzynski also used simple bivariate statistical analysis to suggest that states displaying stronger solar deployment had larger populations, higher average incomes, higher electricity or natural gas prices, better solar resources, a need to import more energy, or more liberal-minded citizens.

Table 29: Selection of State Financial Incentive Programs for Renewable Energy, 1994-2009

State	*Incentive Details*	*Technology*
Arizona	**Personal Income Tax Credit – Residential** 25% of installation costs ($1,000 maximum credit)	Solar Electric & Heating
California	**Non-Residential Rebate** $2.50-$3.50/W (max 50 kW in 2008-09; max 30 kW thereafter)	Solar Electric
	Residential Rebate $2.50-$3.50/W for single unit; $3.30-$4 for multi-unit	Solar Electric
Connecticut	**Non-Residential Rebate** $3.50-$5/W (10-200 kW)	Solar Electric
	Residential Rebate $1.75/W for first 5 kW; $1.25 / W thereafter (max $15,000)	Solar Electric
Delaware	**Non-Residential & Residential Rebate** 25% installed cost (max $31,500)	Solar Electric
Hawaii	**Personal Income Tax Credit – All sectors** 35% of installation costs (single unit max $5,000 PV & $2,500 heating; multi-unit maximum $350 per unit)	Solar Electric & Heating
Maine	**Rebate – All sectors** $2/W (max 1kW - $2,000)	Solar Electric
	Rebate – All sectors 25% of installation costs (max $2,000)	Solar Water & Space Heating
Minnesota	**Residential Rebate** $1.75/W (max 5 kW) & $0.25/W for using certified installers	Solar Electric
New Jersey	**Rebate – Commercial, Other & Residential** $1.80-$4.10/W (max 20kW)	Solar Electric
	Residential Rebate (from 2009) $1.55/W (max 10kW) & $0.20/W if perform energy audit	Solar Electric
	Non-Residential Rebate (from 2009) $1/W (max 50kW)	Solar Electric
Oregon	**Personal Income Tax Credit – Residential** $3/W (max $6,000 PV or 50% project cost; $1,500 other solar)	Solar Electric & Heating
	Corporate Income Tax Credit – Commercial 50% of system cost (max $10 Million)	Solar Heating
	Residential Rebate $2-$2.25/W (max $20,000)	Solar Electric
	Commercial & Industrial Rebate $1-$1.25/kW for up to 30kW; $0.50-$1.25/kW for 30-200kW, dependent upon utility company (max $100,000 or $600,000 dependent upon utility company); $0.75 for more than 200kW	Solar Electric
	Residential Rebate $0.07-$0.40/kWh saved & $1.50-$6/therm saved (max $1,500 water heating; $1,000 for pool heating). 1st year only	Solar Heating
Utah	**Income Tax Credit – All** Residential: 25% of installation cost (max $2,000); Commercial: 10% of installation cost (max $50,000)	Solar Electric & Heating

Source: Sarzynski (2009)

In some states, grants support energy efficiency measures in schools and municipalities. In Colorado, the New Energy Economic Development Grant Program appropriates ARRA funds to the residential, commercial, and industrial sectors to assist with the costs of new renewable technologies and energy efficiency measures. In New Jersey, the Edison Clean Energy Fund awards funding of up to $500,000 for the commercialization of new renewable energy technologies or energy efficiency innovations (NCU and NREL, 2009).

IREC (2009) identified a growth in property-assessed clean energy (PACE) financing during 2008-09, with fourteen states enacting legislation to enable local governments to create PACE programs. This is a low-interest loan, repaid over 20 years via an annual assessment on property tax bills, to help commercial and residential property owners meet the initial costs of permanent, renewable energy improvements. PACE loans are issued by municipal financing districts. If the property owner moves or sells the property before the loan is paid back, the remaining balance usually transfers to the buyer. Tying payment to the property solves credit and collateral issues for energy efficiency and renewable energy loans, reduces up-front costs to a minimum payment or zero, and allows for both the payment and the value of the retrofit to be transferred from one owner to the next.

Local governments that offer PACE loans generally secure funds by issuing bonds, partnering with a financial institution, or tapping existing funds. IREC (2009) argues that this policy appeals to state legislators because it can encourage clean energy job growth at the local level without impacting state budgets. During 2008-09, cities and counties in California, Colorado, Illinois, Louisiana, Maryland, Oklahoma, Ohio, Nevada, New Mexico, New York, Texas, Vermont, Virginia and Wisconsin all implemented PACE loans.

Another key local incentive is the green pricing program. This gives customers an opportunity to support a greater level of utility company investment in renewable energy technologies, through the payment of a premium on their electric bills to cover the incremental cost of the additional renewable energy. In return, the local electricity provider guarantees that it will provide either directly, or by contract, a specified amount of renewable-based electricity.

Over 750 utilities in 46 states, including investor-owned, municipal utilities and cooperatives, offer a green pricing option. The exclusions are Arkansas, Louisiana, Tennessee, and West

Virginia, with only the latter having a Renewable Portfolio Standard in place. Information about green pricing programs is collected annually by the Energy Information Administration (EIA). The EIA reports that there were 835,651 electricity customers who participated in green pricing programs in the U.S. in 2007, of which 93% were residential (EIA, 2009b).

A good example of an integrated state incentives program for renewables is 'Go Solar California' – a $3.3 Billion package of incentives striving for 3,000MW of solar energy within 10 years. There are three distinct elements to this integrated campaign, which launched in 2007:

(a) A New Solar Homes Partnership (NSHP) which provides financial incentives to home builders, encouraging the construction of new, energy efficient solar homes that save homeowners money on their electric bills and protect the environment;
(b) A variety of solar programs offered through publicly owned utilities (POU); and
(c) The California Solar Initiative (CSI).

Launched in 2007 with a budget of $2.167 Billion over 10 years, the CSI is overseen by the California Public Utilities Commission (CPUC) and has targeted 1,940MW of installed solar capacity by the end of 2016. It offers upfront cash back incentives for solar systems installed on existing residential homes, as well as existing and new commercial, industrial, government, non-profit, and agricultural properties within the service territories of the state's three investor-owned utilities.

The CSI has five components. The main incentive program is the General Market program. Striving for 1,750MW of capacity, this offers two types of incentive: Expected Performance Based Buydown (EPBB) and Performance Based Incentives (PBI). EPBB incentives are based on verified solar energy system characteristics such as location, system size, shading, and orientation. Paid up front, it is a capacity-based incentive, adjusted according to expected system performance. The PBI incentive is a flat cents-per-kWh payment for all output from a solar energy system, paid during the first five years of operation. This General Market program is supplemented by 4 other programs:

(a) A $50 Million research and development program, providing grants to solar technologies that can advance the overall goals of the CSI;

(b) A $108 Million Single-family Affordable Solar Housing (SASH) program, providing fully or highly subsidized 1 kW solar energy systems to single family low-income housing, determined by the low level of household income;

(c) A $108 Million Multi-family Affordable Solar Housing (MASH) program, providing two types of solar incentive. These are a fixed, up front, capacity-based EPBB incentive and a competitive grant application. The fixed EPBB offers $3.30/watt for a system that offsets common area load and $4/watt for a system that offsets tenant load. Under the competitive grant process, applicants submit a proposed dollar per watt bid for projects that will provide significant benefits to tenants (CPUC, 2010); and

(d) A Solar Water Heating Pilot Program (SWHPP), providing solar hot water incentives to residences and businesses in San Diego.

Perhaps one of the most interesting recent trends at state level, though, has been the emergence of feed-in tariffs. Farrell (2009) argues that California first offered a form of FIT during the 1980s when it instructed utilities to offer a standard 10 year contract with a high fixed price for wind energy. However, this policy was abandoned in the early 1990s as California opted to pursue retail electricity deregulation, only to return to a national agenda in the summer of 2008 when a republican senator proposed a bill to encourage a nationwide FIT scheme. Although the bill wasn't passed, FIT legislation has been successful at state or local levels.

For example, in February 2009 Gainesville Regional Utility (GRU), a municipal utility owned by the City of Gainesville, Florida, implemented a FIT for solar PV systems. GRU offered a flat tariff of $0.26-0.32 over 20 years with incentives for building or pavement mounted solar systems. Shortly after the program was announced, GRU had received enough applications to satisfy its planned annual program caps through 2014, so from March 2009, the utility announced it would only now accept applications for new installations built in 2015 or later.

Vermont and Oregon also enacted FIT legislation in 2009.

Vermont's tariff launched in October 2009, and was quickly oversubscribed. Applications amounting to 208MW were received for a program capped at 50MW. Vermont's FITs are differentiated by technology and size, and set on the cost of generation by profit with a regular program review. With contract terms of up to 20 years, the tariffs are $0.125/kWh for small wind turbines, $0.20/kWh for large wind turbines, $0.16/kWh for landfill and biogas and $0.30/kWh for solar. The Public Utility Board also stipulated that no one technology can occupy more than 25% of the 50MW program cap.

Oregon's pilot tariff rate is based upon the value of the solar generation to the grid, rather than the cost of generation. The Public Utility Commission rates are $0.65 per kilowatt hour for systems up to 10 kilowatts, and $0.55 per kWh for systems between 10 kW and 100 kW. A contract term of 15 years has been proposed with a project cap of 500 kW and program cap of 25MW. Limited to solar PV, three quarters of the capacity is reserved for residential installations and the balance for commercial ones. This equates to approximately 3000 Oregon homes and small business.[65] Portland General Electric and Pacific Power will launch this FIT pilot program for solar PV panels in Oregon in July 2010.[66]

Hawaii's Public Utilities Commission also established a FIT in September 2009. With a program cap of up to 5MW (dependent upon technology and island), eligible technologies for the Hawaiian FIT include solar thermal electric, solar PV, wind, hydroelectric and small hydroelectric. However, as of May 21 2010, the Hawaii PUC had not set the tariffs.[67]

In October 2009, Governor Schwarzenegger also signed into law several feed-in tariffs for California. The bill proposes long term agreements of up to 20 years for systems of 3MW or smaller, increasing the statewide cap to 750MW. It also proposed adjustable market price referent tariffs to account for the time when the power is produced. Renewable power produced during times of peak demand would therefore earn the highest rate. Utilities buying

[65] Hahn, Dan (2010). 'Very Generous Oregon FIT Set to Launch in July', solarpowerrocks.com, June 11, 2010

[66] Daily Journal of Commerce, June 15, 2010 - http://djcoregon.com/news/2010/06/15/oregon-utilities-to-start-feed-in-tariff-programs/

[67] Rate information care of Open Energy Information - http://en.openei.org/wiki/Hawaii_Feed-in_Tariff_(Hawaii)

power under the FIT, which are due to come into effect in January 2011, can also earn credit for the renewable energy under the state's Renewable Portfolio Standard (RPS).

In 2007, California commissioned The Bate White Consultancy to design an economically efficient feed-in tariff. Their recommendation was for a two-part FIT in which a tariff is set via a capacity market auction, but payment was tied to actual power generation, dependent on the spot-market energy price to promote operational efficiency plus a technological progress rate. A pilot FIT in 2008 then directed California's investor-owned utilities to purchase energy from renewable sources at the market price referent up to 1.5MW. However, Niebauer (2010) argues that this pilot had been ineffective because the price was too low to attract solar development. One FIT proposal issued by the CPUC is a market-based approach called the Renewable Auction Mechanism. This allows prospective renewable energy developers to bid the lowest prices at which they would be willing to develop projects. Under the proposed program, utilities would be required to issue solicitations every 6 months for projects to fulfill their needs under the state's Renewable Portfolio Standard (RPS). The CPUC would set limits on the allowable revenue for renewable product categories (i.e. baseload, peaking, and non-peaking) for each round of solicitations. Utilities would also be required to accept bids in order of lowest to highest generation cost, until the commission-defined limits had been met.[68] However, the plan has received jurisdictional objections from Southern California Edison, delaying the announcement of tariff rates until January 2011. This has also resulted in a July 15, 2010 declaration by the Federal Energy Regulatory Commission (FERC) which has ruled that states cannot meet the costs of financing alternative energy via ratepayers. They have to find alternative means of funding, such as tax-based incentives, grants and loans.[69]

Sacramento Municipal Utility District's (SMUD) local renewable energy FIT, though, encountered no objections and was fully subscribed in January 2010. The tariffs paid vary by time of day, season, length of contract and year in which the system is placed in service. For PV projects with 20-year contracts started in 2010, the average weighted production payment is estimated at $0.139 per kWh, and locked in for the duration of the contract. Limited to systems

[68] CPUC Energy Division Staff Proposal: *System-Side Renewable Distributed Generation Pricing Proposal*, August 26, 2009, http://docs.cpuc.ca.gov/efile/RULINGS/106275.pdf.
[69] 132 FERC, (2010). 61,047 – 20100715-3059 (unofficial) published 07/15/2010, retrieved 9 August 2010 from Mondschein, B., (2010) FERC Deals Blow to Above-Market Rates (Feed-In Tariffs)

of 5MW or less, an initial program cap of 100MW was set with applicants charged a refundable cash reservation deposit of $20/kW and a non-refundable interconnection review fee of $1,400.

A June 2010 report by NARUC also identified Consumer Energy MI, Madison WI and San Antonio TX for other U.S. City and utility FIT programs. This report also highlighted Maine for passing feeding tariff legislation. Indiana, Ohio, Washington and Wisconsin were listed as having current and recent proposed FIT legislation. Table 30 compares maximum FIT rates in U.S. cities and states with the average end-use residential price of electricity during the year the FIT is introduced.[70] This illustrates the extent to which producers of electricity generated from solar PV are being paid in excess of the average end-user residential price. The range of surplus payments is $0.0103/kWh in Sacramento CA to $0.5754/kWh in Oregon.

Table 30: Comparison of FIT Rates with Average End-Use Residential Electricity Price

City/State	*Year FIT Introduced*	*Maximum FIT Rate*	*Average End-Use Residential Electricity Price in Year FIT's Introduced (US$)*	*Difference*
Gainesville FL	2009	$0.32/kWh	$0.1101/kWh	$0.2099/kWh
Vermont	2009	$0.30/kWh	$0.1264/kWh	$0.1736/kWh
Consumer Energy MI	2009	$0.65/kWh	$0.0916/kWh	$55.84/kWh
Wisconsin	2009	$0.25/kWh	$0.0923/kWh	$0.1577/kWh
Oregon	2010	$0.65/kWh	$0.0746/kWh	$0.5754/kWh
Hawaii	2010	Not agreed as at May 31, 2010	$0.3011/kWh	-
Sacramento CA	2010	$0.139/kWh	$0.1287	$0.0103/kWh
San Antonio TX	2010	$0.27/kWh	$0.1133/kWh	$0.1567/kWh

Source: EIA (2010a), (2010b)

[70] State prices are estimated using the EIA's 2008 price per state multiplied by a 2.5% nationwide 2009 average increase, followed (where appropriate) by an additional 0.6% forecasted nationwide 2010 average, as stated in the Short Term Energy Outlook, August 10, 2010

Table 31 compares the average FIT rate for 2009 within the U.S. to the 2009 rates previously discussed for Austria, Germany, The Netherlands and Spain.[71] The average price of electricity stated in this table for the European nations varies according to consumption, is inclusive of tax, and was effective November 2009.[72] The average price of electricity stated in this table for U.S. is drawn from Table 30 and represents the lower and upper range of end-use prices for the residential sector within the four locations offering FITs in 2009. This suggests that the European countries studied offer national FITs at 1.5 to 2.5 times the average residential electricity end-use price, whereas the local U.S. FITs offer approximately 3 to 5 times the average residential electricity end-use price.

Table 31: Comparison of U.S. & European Solar FIT Rates in 2009

Country	*Solar FIT Range (US$)*[73]	*Average Residential Electricity Prices (US$)*[74]
Austria	$0.418/kWh – $0.641/kWh	$0.2050-$0.2385/kWh
Germany	$0.4603/kWh – $0.5999/kWh	$0.2845-$0.2943/kWh
Netherlands	$0.54/kWh - $0.737/kWh	$0.3348-$0.3361/kWh
Spain	$0.4463/kWh – $0.4742/kWh	$0.1632-$0.1995/kWh
U.S.	$0.25/kWh – $0. 65/kWh	$0.0916-$0.1264/kWh

Sources: EIA (2010a), (2010b), Europe's Energy Portal (2010) and analyses presented in Section 3

Table 32 presents a summary of historical cumulative installed renewable capacity in the U.S.

Table 32: Cumulative Installed Wind and Solar PV Capacity in the U.S., 1998 - 2008

Cumulative Installed Capacity (MW)											
	Year										
Technology	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Wind	2141	2445	2610	4245	4674	6361	6750	9181	11635	16879	**25237**
Solar PV	100.1	117.3	138.8	167.8	212.2	275.2	376.0	479.0	624.0	830.5	**1172.5**

Source: BP (2009)

71 Denmark and Ireland are excluded from this Table given their lack of solar incentives.
72 Source: Europe's Energy Portal – http://www.energy.eu/#prices
73 All FIT rates converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$
74 All European country prices converted using the ECB's average 2009 Reference Exchange Rate of 1 €: 1.3948 US$

4. Evaluation of Incentive Programs

Section 3 has illustrated the types of incentive programs implemented by seven leading countries to develop a market for energy generated from renewable sources. Some of these incentives have been national; others more localized. There's also been significant differentiation in terms of the target audience, scope and type of incentives on offer. These variations between incentive programs and their subsequent results emphasize the importance of careful policy design. Hence, we will now attempt to evaluate incentives in two ways. First, we will provide some insight into the effectiveness of programs within the seven countries featured in Section 3, primarily using data drawn from the U.S. Energy Information Administration website and OECD. We will then conclude with a critique of recent studies of the cost-effectiveness of incentives.

4.1 Cost Effectiveness of Incentives – Some Empirical Reflections

Our initial intention was to analyze the cost-effectiveness of the policies implemented by the seven countries featured in our geographical survey in Section 3. Cost-effectiveness analysis compares the relative future economic benefits of actions or strategies to the size of the investment required to generate those benefits. It is a necessary, but not exclusive, criterion for deciding how to allocate resources to promote and develop renewable energy because it directly relates the financial and scientific implications of different interventions.

The principal advantage of a cost-effectiveness assessment, compared to a cost-benefit analysis, is that the researcher does not have to quantify all costs and benefits in comparable terms. The basic calculation divides the cost of an incentive program in financial terms by the expected renewable energy gain measured, for example, by its increased market share of total electricity generation. The problem we face in trying to do this, though, is a lack of access to a definitive set of costs. An EEA (2004) report analyzing energy subsidies within the European Union, for example, wrote:

> "There is no comprehensive official record of historical and ongoing energy subsidies in the EU. … Often, it is practically impossible to assign a monetary value to an individual support mechanism, due either to the nature of the mechanism itself … or to lack of data." (p.13)

Romm (2010) in a submission to the U.S. House of Representatives on green energy tax incentives also refers to the "… fundamental lack of transparency in the tax expenditure system" (p.10), the absence of itemized listings for direct federal spending on energy, and the difficulties analyzing additional Billions of 'under the radar' tax spending on energy, free from congressional and agency overview. Morgan (2007) also argued that the assignment of monetary values to some subsidies was extremely difficult.

4.1.1 Eurelectric's EU Payment & Price Analysis for 2001

Eurelectric (2004) is one exception, quoting both renewable energy source payments and main direct price support schemes implemented by EC countries in 2001, illustrated in Table 33. These totals included quota based systems and fixed price systems, but not capital investment aid, tax measures, R&D support or other forms of indirect support. However, tax incentives were included within the figures for Finland and Sweden.

The countries displayed within this table have been divided into three groups. The first group of eight countries all emphasized a FIT in 2001. The second group of five countries did not have a FIT in 2001. The final two countries state the value of their production of energy from renewable energy sources (excluding large hydro) at market prices plus tax refunds. Notes are also provided below the table to explain some column data and calculations. Eurelectric therefore estimates that $5.55 Billion was paid in total RES payments across all fifteen EU countries in 2001, of which $2.96 Billion was RES direct support. For the group of eight FIT countries, this falls to $2.87 Billion payments, with $1.7 Billion RES direct support.[75]

[75] All figures converted using the ECB's 2001 average Reference Exchange Rate of 1 €: 0.8956 US$.

The FIT group's weighted total RES payment average was higher than the weighted average for all 15. However, the differential was even greater for RES direct support (excluding large hydro) – approximately 16.7% higher

Looking specifically at electricity, there was no difference in terms of a weighted average of US$0.116 (0.13€¢)/kWh. However, if we compared wholesale electricity prices and also considered the cost of emission savings, the weighted average of support for FIT countries was higher at 5.1% and $60/ton avoided CO_2, compared to 4.2% and $52.84/ton avoided CO_2 for all 15 EU countries.[76]

Eurelectric's analysis of 2001 in EU, therefore, lends support to the view that feed-in tariffs can be a more costly incentive from a financial perspective.

[76] All figures converted using the ECB's 2001 average Reference Exchange Rate of 1 €: 0.8956 US$.

Table 33: Estimation of EU Payments & Main Direct Price Support for RES in 2001 *Source: Eurelectric (2004)*

	Avg RES price	*Wholesale-E market price*	*RES Payments*	*RES-E without LH*	*Total-E generation*	*Renewable Energy Sources Direct Support*				
	€¢/kWh	€¢/kWh	Mn €/yr	TWh	TWh	Mn €/yr	Avg €/ton avoided CO_2	€¢/kWh RES (ex LH)	€¢/kWh Total Elec	% wholesale price Total Elec
AUSTRIA	4.69	2.2	229	4.9	62.3	122	36	2.49	0.2	8.9
DENMARK	6.55	2.36	427	6.5	36	273	64	4.19	0.76	32.3
FRANCE	5.45	2.32	196	3.6	526.7	112	83	3.13	0.02	0.9
GERMANY	8.62	2.41	1453	16.8	530	1,047	74	6.21	0.2	8.2
GREECE	6.16	2.3	47	0.8	49.7	29	34	3.86	0.06	2.6
LUXEMBOURG	8.53	2.3	9	0.1	1.3	6	127	6.23	0.52	22.6
PORTUGAL	6.38	4.8	72	1.1	44.9	18	22	1.58	0.04	0.8
SPAIN	6.62	3.85	768	11.6	227.2	323	37	2.78	0.14	3.7
BELGIUM	5	2.3	49	1	76	27	37	2.7	0.03	1.5
IRELAND	5.5	4.2	22	0.4	24.1	96	29	1.73	0.03	0.9
ITALY	12.32	6	2083	16.9	266	5	18	1.3	0.02	0.5
NETHERLANDS	4.28	2.3	127	3	90.4	1,067	100	6.31	0.4	6.7
UK	4.75	3.02	264	5.6	368.5	59	42	1.98	0.06	2.8
FINLAND	2.7	2.28	246	9.1	71.2	38	7	0.42	0.05	2.4
SWEDEN	4.18	2.29	221	5.3	157.7	100	34	1.89	0.06	2.8
Total			6212	86.6	2532	3332				
Weighted Avg	6.66	3.02					58.7	3.64	0.13	4.21
Total Feed-in			3,200	45.4	1478.1	1930				
Weighted Avg Feed-in	6.83	2.63					66.7	4.19	0.13	5.12

TABLE NOTES:

1. *The average renewal energy source price displayed in column 2 is the ratio between columns 4 and column 5. The total RES payments per country (column 4) is the summation of RES electricity (excluding large hydro) in column 5 and guaranteed prices for feed-in tariffs or average green certificate prices for quotas.*
2. *For FIT countries, the RES direct support represents the difference between the RES price (column 7) and the average wholesale electricity market price (column 3). For all others, the RES support data was either provided by members or estimated by Eurelectric from a variety of sources.*
3. *Average renewable energy source direct support (column 9) is the weighted average of column 7 divided by column 5.*
4. *RES direct support in relation to total electricity generation (column 10) is calculated as the ratio between columns 7 and 6.*
5. *Column 11 represents the contribution of RES support to the wholesale electricity market prices, expressed as a percentage.*
6. *Column 8 is the ratio between column 7 and avoided CO_2 emission from RES-E generation. Eurelectric assumes each kWh of RES-E is a substitute for thermal electricity.*

4.1.2 Effectiveness of Incentives – Additional Analysis

Given the difficulties that exist in gathering data addressing costs, our critique will ultimately have to focus upon effectiveness, rather than cost-effectiveness. For the purpose of this paper, we will examine the following dimensions of effectiveness:

(a) The perceived impact of incentives upon the market share of electricity generated from renewable sources (the sole effectiveness criterion adopted by an EU (2008) working paper analyzing the support of electricity from renewable resources);
(b) The perceived impact of incentives upon CO_2 emissions; and
(c) Installation and/or adoption of the technologies illustrated via net capacity data.

Extraneous factors also can clearly impact upon effectiveness, including:

- System owners' access to the power grid;
- System owners' access to financial capital;
- Maturity of the local market for the applicable technology;
- Technology-specific factors, including maturity and generating efficiency;
- Availability of the relevant renewable resource;
- Additive or compounding effects of other incentive mechanisms;
- Interplay of regulatory requirements that alter consumption or generation behavior;
- Effects of concomitant energy efficiency measures; and
- Program administration costs and delays.

A recap summary of the dates of key incentives implemented by the seven countries featured within Section 3's geographical survey is shown in Table 34.

Table 34: Summary of Key Incentives by Date for Seven Countries featured in Section 3

Country	*Grants & Subsidies*	*Feed-in Tariffs*	*Tax Incentives*	*Other*
U.S.	2002 2008	1978 (PURPA) 2009 (Local)	1992ff 2005ff 2009ff	
Austria	1980ff 1994	1995 2006 1997 2008 1998 2009 2002	1979ff 2007	
Denmark	1979-89 2000s	1993 1998 Ends – 2003	1980-96	Green Certificates 2003ff
Germany	1991-97 2000ff	1991 2000 2004		Loans 1990-2003
Ireland	2006 2007 2008	2006	1984ff 2005	Tendering 1995-2005
Netherlands	1980s			
Spain		1980 & 94 – prototypes 1997 2007 1998 2008 2004		

4.1.3 Effectiveness of Incentives - Market Share

To assess the perceived impact of incentives upon the market share of electricity generated from renewable sources, Tables 35 and 36 draw upon data from the EIA website for the seven countries examined in Section 3. These tables present data for 1991-2008. Data for earlier years is available on the EIA website, but not for Germany, due to the country's reunification – hence the chosen start date of 1991 in Table 35 to provide a consistent basis for comparative purposes.

These tables show that in absolute terms, the U.S. produces a larger amount of energy from renewable sources than most other countries, hidden by significant differences in the size of the markets. Percentage wise, the U.S. does not perform so well. Throughout the 1990s, the percentage market share of electricity generated from renewable sources in the U.S. hovered between 10.5% and 12%, apart from 1996-97, before falling below 10% during the 21st century. One possible explanation for the rise in 1996-97 pertains to the delay between the publishing and actual implementation of legislation. For example, the legislation for the PTC, although passed in 1992, did not come into effect until 1994. Hence, it may have taken a year or two to bed in before the impact was truly felt. This would also explain why, in absolute terms, the Billion kWh of electricity generated from renewable energy sources was at its highest during 1995-1999. The fall in market share below 10% throughout the first 8 years of the 21st century can be attributed to the fact that whilst the demand for energy has increased, the absolute amount of kWh generated from renewable energy sources has returned to the pre-1996 levels. Our Regulations & Standards Az SMART paper attributes the fall in part to a reduction in hydropower's contribution to the U.S. electricity generation portfolio. However, it is also possible that the initial positive effects of the 1990s tax incentives has - subsided, with subsequent tax incentives having little obvious effect. The 30% ITC, given time, has the potential to reinvigorate the market, but other new stimuli might be needed, such as new tax incentives, grants, subsidies, a FIT or even a combination of any of the above.

The data for Spain – a country focusing predominantly upon feed-in tariffs – is not so clear. This is because the implementation of feed-in tariffs in the late 1990s actually coincides with a year on year fall in percentage market share for electricity generated from renewables. However, the tables also show that throughout the 18 years, the total electricity generated and share of that market from renewable sources have doubled.

Similarly for Austria, evidence illustrating the importance of feed-in tariffs for increasing the market share of renewable energy is also mixed. For much of the period, over 70% of Austria's total electricity generated came from renewable sources. However, market share fell below 70% in 1996-97, coinciding with the country's first feed-in tariff, and then again in 2003-2006, the Ökostromgesetz tariff.

Stronger support for a potential correlation between the launch or refreshing of FITs (albeit often complemented by other incentives) and the growth in market share for electricity from renewable energy sources can be found in Ireland, the Netherlands, Denmark and Germany.

Table 35: Market Share of Electricity from Renewable Energy Sources within Total Electricity Generated of Seven Countries Studied, 1991-1999 (*Figures quoted in Billion kWh*)

		U.S.	*AUS*	*DEN*	*GER*	*IRE*	*NTH*	*SPA*
1991	Total Elec Gen	3073.80	49.44	34.36	505.17	13.98	70.00	147.10
	Total RES-E	362.51	32.30	1.07	20.39	0.74	1.27	27.69
	%	*11.79%*	*65.33%*	*3.10%*	*4.04%*	*5.28%*	*1.81%*	*18.82%*
1992	Total Elec Gen	3083.88	49.42	28.91	503.30	14.78	72.56	148.09
	Total RES-E	330.58	35.79	1.39	23.40	0.81	1.39	19.47
	%	*10.72%*	*72.41%*	*4.82%*	*4.65%*	*5.51%*	*1.91%*	*13.15%*
1993	Total Elec Gen	3197.19	50.02	31.95	492.80	15.13	72.33	147.39
	Total RES-E	360.19	37.67	1.70	24.23	0.78	1.54	24.93
	%	*11.27%*	*75.31%*	*5.32%*	*4.92%*	*5.18%*	*2.13%*	*16.92%*
1994	Total Elec Gen	3247.52	50.65	37.81	495.17	15.77	74.92	152.84
	Total RES-E	340.33	36.53	1.88	27.96	0.94	1.73	28.86
	%	*10.48%*	*72.13%*	*4.97%*	*5.65%*	*5.97%*	*2.30%*	*18.88%*
1995	Total Elec Gen	3353.49	53.64	34.50	502.50	16.50	76.24	156.79
	Total RES-E	388.90	38.51	2.03	30.51	0.74	2.13	24.41
	%	*11.60%*	*71.80%*	*5.90%*	*6.07%*	*4.46%*	*2.80%*	*15.57%*
1996	Total Elec Gen	3444.19	51.93	50.42	519.64	17.71	80.12	165.09
	Total RES-E	426.53	35.59	2.33	31.30	0.75	2.80	41.20
	%	*12.38%*	*68.54%*	*4.62%*	*6.02%*	*4.26%*	*3.49%*	*24.96%*
1997	Total Elec Gen	3492.17	54.17	41.72	516.61	18.43	80.51	179.61
	Total RES-E	437.25	37.50	3.18	27.94	0.80	3.10	37.13
	%	*12.52%*	*69.24%*	*7.63%*	*5.41%*	*4.32%*	*3.86%*	*20.67%*
1998	Total Elec Gen	3620.30	54.52	38.72	521.50	19.55	84.76	183.36
	Total RES-E	404.00	38.66	4.14	30.69	1.15	3.51	37.02
	%	*11.16%*	*70.90%*	*10.69%*	*5.88%*	*5.87%*	*4.14%*	*20.19%*
1999	Total Elec Gen	3694.81	57.48	36.65	518.59	20.38	80.67	194.20
	Total RES-E	402.98	41.97	4.66	32.57	1.10	3.74	27.60
	%	*10.91%*	*73.02%*	*12.71%*	*6.28%*	*5.41%*	*4.63%*	*14.21%*

Source: EIA (2009c)

Table 36: Market Share of Electricity from Renewable Energy Sources within Total Electricity Generated of Seven Countries Studied, 2000-2008 (*Figures quoted in Billion kWh*)

		U.S.	*AUS*	*DEN*	*GER*	*IRE*	*NTH*	*SPA*
2000	Total Elec Gen	3802.11	58.40	33.95	534.26	22.15	84.34	208.40
	Total RES-E	361.27	43.18	5.86	40.07	1.16	4.25	35.78
	%	*9.50%*	*73.92%*	*17.26%*	*7.50%*	*5.24%*	*5.04%*	*17.17%*
2001	Total Elec Gen	3736.64	58.82	35.53	548.53	23.03	88.25	220.70
	Total RES-E	299.64	41.76	6.13	44.35	1.00	4.55	48.93
	%	*8.02%*	*70.99%*	*17.26%*	*8.09%*	*4.34%*	*5.15%*	*22.17%*
2002	Total Elec Gen	3858.45	58.38	37.00	548.96	23.22	90.40	225.41
	Total RES-E	356.96	41.52	7.06	50.44	1.35	5.18	34.32
	%	*9.25%*	*71.11%*	*19.07%*	*9.19%*	*5.81%*	*5.73%*	*15.23%*
2003	Total Elec Gen	3883.19	55.39	43.50	565.85	23.21	91.06	243.40
	Total RES-E	369.34	34.83	8.33	51.27	1.11	5.29	55.49
	%	*9.51%*	*62.89%*	*19.15%*	*9.06%*	*4.76%*	*5.81%*	*22.80%*
2004	Total Elec Gen	3970.56	59.23	38.11	572.61	23.54	94.84	261.21
	Total RES-E	365.72	39.17	9.68	60.86	1.35	6.54	49.73
	%	*9.21%*	*66.13%*	*25.39%*	*10.63%*	*5.73%*	*6.89%*	*19.04%*
2005	Total Elec Gen	4055.42	60.46	34.18	577.32	23.95	94.34	272.14
	Total RES-E	370.47	39.24	10.10	62.23	1.81	8.72	41.31
	%	*9.14%*	*64.91%*	*29.54%*	*10.78%*	*7.54%*	*9.25%*	*15.18%*
2006	Total Elec Gen	4064.70	58.34	42.98	593.20	25.34	92.63	278.63
	Total RES-E	398.75	39.46	9.51	71.28	2.38	9.18	51.40
	%	*9.81%*	*67.64%*	*22.13%*	*12.02%*	*9.39%*	*9.91%*	*18.45%*
2007	Total Elec Gen	4156.75	58.64	36.92	593.40	26.06	97.19	283.19
	Total RES-E	364.98	41.51	10.51	90.57	2.65	8.86	57.86
	%	*8.78%*	*70.79%*	*28.47%*	*15.26%*	*10.15%*	*9.12%*	*20.43%*
2008	Total Elec Gen	4110.26	62.02	34.34	589.04	26.58	101.36	288.55
	Total RES-E	382.06	44.38	10.28	91.95	3.26	10.54	59.80
	%	*9.30%*	*71.56%*	*29.93%*	*15.61%*	*12.25%*	*10.40%*	*20.73%*

Source: EIA (2009c)

For example, the market share for electricity from renewable sources in Ireland gained real momentum from 2006 onwards, thanks to the launch of a FIT complemented by grants and subsidies. Prior to that, the emphasis on tendering initiatives had failed to attain a market share much higher than 5%, although one could argue that a 2005 tax incentive also kick-started the growth with the increase of an additional 2% market share.

In Germany, single-digit market share growth throughout the 1990s thanks to a combination of grants, loans, subsidies and a FIT were eclipsed by a higher level of growth per annum after the 2000 tariff and 2004 revision. In fact, the tables show that by 2008, the market share of electricity from renewable energy sources had quadrupled at a time when demand for electricity had only increased by approximately 20%. This is consistent with Agnolucci (2006), who argues that renewable electricity policies have been very successful in increasing the generating capacity in Germany, attributing in particular the significant increase in market share post-2004 to the cessation of legal disputes with utility companies and revised terms limiting the burden placed upon such companies.

In Denmark, the market share for electricity generated from renewables started from a very low base in 1991, suggesting the limited impact of grants, subsidies and tax incentives in place at that time. Key growth only started in 1998 – the year of a FIT. However, these particular tables also suggest that the post-2003 shift from fixed FITs to feed-in premiums or tradable green certificates combined with the revenue from power markets has not stopped the momentum continuing. Perhaps, then, FITS are most effective as an initial market stimulant?

Data for the Netherlands, though, suggests otherwise. During 1991-2003, coinciding with a period of grants and subsidies, tax incentives and green certificates, there was continuous, steady growth in the percentage market share of electricity generated from renewable sources. However, real growth has only taken place since 2005, coinciding with a combination of feed-in tariffs (2003 and 2007) and tax incentives (2003 and 2005).

4.1.4 Effectiveness of Incentives – CO_2 Emissions

To assess the perceived impact of incentives upon CO_2 emissions, Table 37 again draws upon data from the EIA website for Section 3's seven countries. It is difficult to identify from this table any type of incentive having a lasting or significant impact upon the reduction of CO_2 emissions – a viewpoint consistent with Frondel et al (2008) who argue that any reduction in emissions gained from renewable energy is usually offset by increased emissions elsewhere. However, there are two possible exceptions. These are Germany post-2004 (revised FIT with improved payment conditions) and to a lesser extent Ireland post-2006 (FIT complemented by grants and subsidies). 2004 was particularly significant year in Germany as most of the utility objections to the EEG had been quashed or appeased by changes in the revised FIT legislation.

Table 37: Total Carbon Dioxide Emissions from the Consumption of Energy within the Seven Countries Studied, 1991-2008 (*Figures quoted in Million Metric Tons*)

	U.S.	*Austria*	*Denmark*	*Germany*	*Ireland*	*Netherlands*	*Spain*
1991	4992.15	60.34	64.46	933.11	26.90	219.40	237.84
1992	5085.88	57.06	61.56	898.83	27.58	213.11	242.60
1993	5192.84	58.49	59.41	896.58	28.23	222.86	231.37
1994	5271.92	57.89	64.98	878.83	29.40	223.07	237.61
1995	5325.90	59.39	69.50	894.27	30.40	223.48	244.05
1996	5511.87	65.04	72.76	893.62	31.81	228.77	237.92
1997	5584.89	64.48	74.99	891.04	34.74	239.74	265.98
1998	5618.85	67.36	60.24	873.16	36.65	241.85	275.62
1999	5679.27	64.87	57.75	841.98	38.60	238.92	299.42
2000	5863.81	64.87	54.65	857.97	40.75	251.49	318.31
2001	5758.96	68.82	56.21	878.88	43.38	278.07	323.03
2002	5800.98	71.81	53.29	858.63	42.44	258.88	340.88
2003	5851.45	75.46	61.92	875.24	41.31	261.14	349.74
2004	5965.32	76.81	56.49	870.82	43.43	270.30	370.68
2005	5988.14	78.90	52.01	850.56	44.43	272.25	383.73
2006	5908.46	74.85	59.52	853.84	45.94	276.31	376.78
2007	6003.26	72.44	57.05	835.15	44.59	281.00	382.82
2008	5832.82	70.48	54.37	828.76	44.51	264.01	358.74

Source: EIA

4.1.5 Effectiveness of Incentives – Net Capacity

The final dimension of effectiveness examined is the impact of specific incentives upon the installation and/or adoption of renewable energy technologies, analyzed with reference to data from pvresources.com (2010) and OECD (2010). Tables 38 and 39 display the world's largest PV power plants and world's largest roof mounted/roof integrated PV systems as at June 2010. The overwhelming dominance of Spanish and German locations within both tables cautiously suggests that their preference for FITs has been more effective for the roll-out of solar PV than the emphasis upon tax incentives implemented within the US. 75% of the top 40 solar PV plants are based in Spain or Germany, compared to just 7.5% in the US. 64% of the top 25 roof mounted PV systems are also currently installed in Spain or Germany, but none in the US.

Table 38: World's Top 40 Largest PV Power Plants, 2010

Power	Country	Location	Built
60 MW	Spain	Olmedilla, Castilla-La Mancha	2008
54 MW	Germany	Straßkirchen	2009
53 MW	Germany	Turnow-Preilack	2009
50 MW	Spain	Puertollano, Castila-La Mancha	2008
46 MW	Portugal	Moura, Alentejo	2008
45 MW	Germany	Köthen	2010
42 MW	Germany	Finsterwalde	2009
40 MW	Germany	Brandis	2007
34.5 MW	Spain	Trujillo, Cáceres	2008
34MW	Spain	Arnedo, La Rioja	2008
31.8MW	Spain	Dulcinea, Cuenca	2009
30MW	Spain	Merida, Extremadura	2008
26MW	Spain	Fuente Álamo, Murcia	2008
25MW	U.S.	Arcadia, FL	2009
24.5MW	Germany	Finow	2010
24MW	Italy	Montalto di Castro, Lazio	2009
24MW	Korea	Sinan	2008
23.4MW	Canada	Sarnia, Ontario (extra 60MW to be added)	2009-10
23.4MW	Canada	Arnprior, Ontario	2009
23.2MW	Spain	Lucainena de las Torres, Almeria	2008
23.1MW	Spain	Abertura, Caceres	2008
23MW	Spain	Hoya de Los Vincentes, Jumilla, Murcia	2008
22.068MW	Spain	Almaraz, Caceres	2008
21.78MW	Germany	Mengkofen	2009
21.47MW	Spain	El Coronil, Andalucia	2008
21.2MW	Spain	Calavéron	2008
21MW	U.S.	Blythe, CA	2009
20MW	China	Xuzhou City, Jiangsu	2010
20MW	Germany	Rothenburg, Sachsen	2009
20MW	Korea	Seoul	2009
20MW	Spain	Calasparra, Murcia	2008
20MW	Spain	Beneixama, Alicante	2007
20MW	Spain	El Bonillo, Albacete	2008
19.4MW	Germany	Helmeringen	2008-09
18MW	Germany	Thüngen	2010
18MW	Spain	Olivenza, Badajoz	2008
18MW	Spain	Las Gabias, Granada	2008
16MW	U.S.	San Antonio, TX	2009
15.8MW	Germany	Moos, Bavaria	2010
15.8MW	Spain	Don Quijote, Toledo	2009

Source: pvresources.com (June 2010)

Table 39: World's Top 25 Largest Roof Mounted/Roof Integrated Solar PV Systems, 2010

Power	Country	Location	Built
11.8MW	Spain	GM facility, Zaragoza	2008
9.1MW	France	St Charles International, Perpignan	2010
5.21MW	Japan	Sharp plant, Kameyama * **	2006
5.2MW	Spain	Actiu Technological Par, Castala	2008
5MW	Germany	Bürstadt PV power plant	2005
4.7MW	Italy	KME Group, Serravale Scrivia	2009
4.64MW	Germany	Hassleben feedstock farm	2008
4.64MW	Germany	Dehner Gartencenter, Rain am Lech	2009
4.2MW	Belgium	Balta facility, Sint-Baafs- Vijve	2010
3.839MW	Germany	Co. Hartmann Logistik, Muggensturm	2006
3.8MW	Germany	Stuttgart Fair	2009
3.7MW	Germany	Fischer family warehouse, Kronwieden	2005
3.5MW	Germany	Michelin Reifenwerke KGaA, Homburg	2004-05
3.36MW	Spain	Barcelona Fair	2008
3.3MW	Germany	VW facility PV plant, Wolfsburg	2008
3.26MW	Germany	Co.Mückenhausen, Dingolfing *	2004
3.12MW	China	Shanghai World Expo 2010	2010
3.04MW	Germany	Geflügelhof Waldeck	2008
3MW	China	PV power plant, Yangcheng City	2010
3MW	Spain	Telefónica Madrid	2006
3MW	Germany	Liebherr corp., Biberach/Riß	2005
2.975MW	Belgium	Waregem PV power plant	2009
2.906MW	Italy	Coop, Prato	2009
2.8MW	Italy	Pontenure PV power plant	2009
2.786MW	Spain	Planta Solar, Abrera	2009

Source: pvresources.com (June 2010) **KEY:** * = Building Integrated PV system
** = Distributed PV system

To drill down further into the effectiveness of renewable incentives by country, consider also OECD's (2010) net capacity data for solar PV and wind installations (1991-2007) for the seven countries featured in our geographical survey. This data is shown in Tables 40 and 41.

The growth in wind power within Denmark, 1998-2003, illustrated in Table 41, appears to correlate with the timing of their FIT scheme. The absence of any significant growth post-2003 also corresponds with the replacement of that FIT by tradable green certificates, which Jacobsen and Zvingilaite (2010) suggest made renewable generation more dependent upon market prices.

Table 40: Net Capacity of Solar PV in MW by Country/Year

	U.S.	Aus	Den	Ger	Ire	Neth	Spain
1991	0	0	0	2	0	1	4
1992	44	1	0	6	0	1	4
1993	50	1	0	9	0	2	5
1994	58	1	0	12	0	2	6
1995	67	1	0	18	0	2	7
1996	77	2	1	28	0	3	7
1997	88	2	1	42	0	4	7
1998	100	3	1	54	0	6	9
1999	117	4	1	70	0	9	9
2000	139	5	1	114	0	13	12
2001	168	7	1	195	0	21	16
2002	212	9	2	260	0	26	20
2003	293	15	2	388	0	46	27
2004	363	19	2	708	0	49	37
2005	493	22	3	1508	0	51	60
2006	698	35	3	2831	0	52	169
2007	974	35	3	3811	0	53	638

Table 41: Net Capacity of Wind Power in MW by Country/Year

	U.S.	Aus	Den	Ger	Ire	Neth	Spain
1991	1975	0	413	110	0	83	3
1992	1823	0	458	183	6	101	33
1993	1813	0	491	334	6	131	34
1994	1745	0	532	643	6	152	41
1995	1731	1	616	1137	6	250	98
1996	1678	10	842	1564	6	296	227
1997	1579	19	1130	1966	57	324	420
1998	1698	27	1443	2672	62	363	848
1999	2251	35	1759	4138	70	410	1613
2000	2377	54	2392	6095	115	447	2206
2001	3918	69	2498	8754	123	485	3397
2002	4531	133	2892	12001	136	670	4891
2003	5995	343	3117	14609	210	906	5945
2004	6456	560	3125	16629	341	1073	8317
2005	8706	827	3129	18428	494	1224	9918
2006	11329	969	3135	20622	746	1558	11722
2007	16515	977	3124	22247	855	1748	15097

Source for both tables: OECD (2010)

In Austria, too, the increases in annual net capacity for wind are more apparent from the time of the first provincial FIT in 1995. This is particularly pertinent for the U.S., where the localized nature of the electricity market suggests that state FITs would be easier to introduce than national ones. Prior to 1995, Austria's emphasis on tax incentives and provincial grants or subsidies appeared to have had limited effect upon the net capacity generation of electricity from solar or wind. Larger increases in net capacity for both forms of renewable energy post-2002 also correspond with the Ökostromgesetz Act, Austria's first national feed-in tariff.

Slow but steady growth during the 1990s, when the Netherlands relied heavily upon tax incentives to stimulate the renewable market, has been succeeded by much larger gains post-2003 when the country implemented the MEP - a FIT premium that was complemented by a tax exemption for renewable energy products.

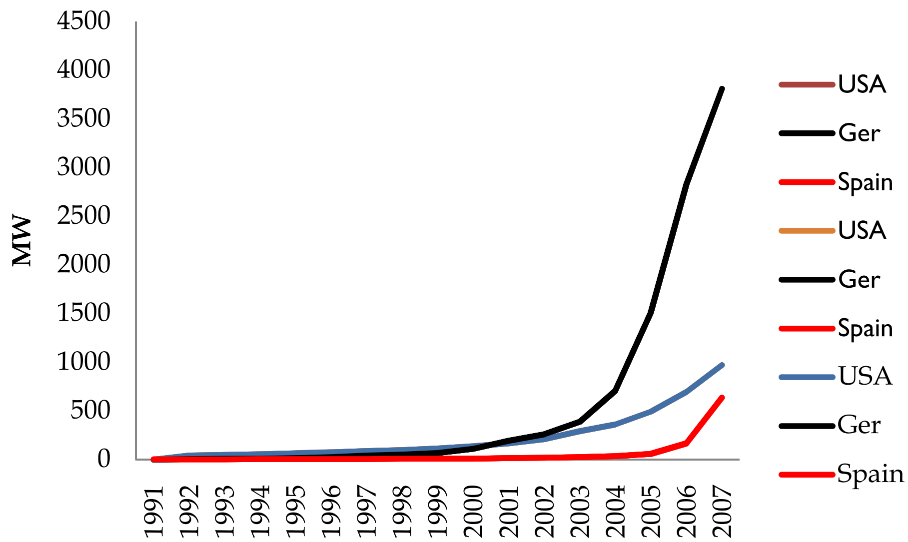
The data for Ireland is inconclusive about the effect of FITs due to the recent timing of its introduction in 2006. Annual net capacity gains in wind power, 1995-2005, though, appear to correlate with the Irish AER tendering scheme.

A closer comparison of wind and solar PV in Germany, Spain and the U.S. also suggests that FITs were more effective at driving net capacity growth than tax incentives up until 2007. This is graphically represented in Figures 2 and 3, but should be reviewed again when the data is available to examine the impact of the current U.S. tax incentives.

Figure 2 illustrates that the pivotal year for solar PV in Germany was 2004, when their EEG FIT of 2000 was revised to offer higher levels of compensation, including $0.74/kWh[77] for solar electricity from small façade systems and an increase in annual degression fees for PV energy to 5%. Also of relevance at this point in time, various legal objections from German utility companies had been quashed or clarified (Agnolucci, 2006).

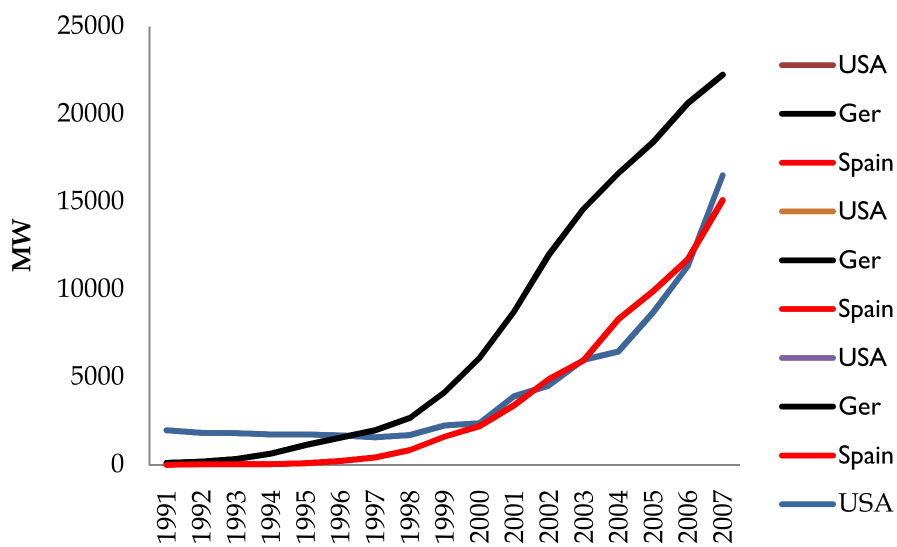
[77] €0.5953 – Converted using the ECB's average 2004 Reference Exchange Rate of 1 €: 1.2439 US$.

Figure 2: Comparison of Solar PV Net Capacity Growth in Germany, Spain and the U.S.



Source: OECD (2010)

Figure 3: Comparison of Wind Net Capacity Growth in Germany, Spain and the U.S.



Source: OECD (2010)

A 2004 FIT in Spain also appears to correspond to the growth in solar PV, although the gains were less dramatic than Germany, possibly reflecting key differences in the types of feed-in tariffs pursued. The German EEG, after all, offered fixed, stepped tariffs based on detailed predictions of project costs to cover solar installation plus a reasonable profit, with total participation and the size of eligible systems left uncapped. However, the Spanish model at this time enabled renewable producers to sell their electricity to distributors or directly to the open market. Fixed tariffs linked to the average electricity tariff set annually by the government were offered for sale to distributors, whereas sales on the open market resulted in a spot-market price plus market incentive. Spanish open market sales, therefore, reduced state intervention in electricity price setting, as well as improving the imputation of system costs, such as the difference between planned and effective generation (González, 2008).

The program of tax incentives in the US, particularly post-2005, appear to have had greater success for solar PV than Spain's FIT, but remain less effective at driving net capacity growth than Germany.

Turning to Figure 3, it's not as easy to match Germany's gains in net capacity electricity generation from wind to any type of incentive. However, the start of an upward curve in Spain in 1997 does appear to correspond with a new FIT establishing special treatment for renewables, guaranteeing grid access and price-support, with sustained growth thereafter. The two key dates for the U.S. – late-90s and 2005 – appear to correspond with tax incentives during the 90s and the launch of the CREB in 2005 (a federal loan program designed to assist public-sector entities for financing new electricity generation projects from clean or renewable resources).

4.1.6 Effectiveness of Incentives – Preliminary Conclusions

Our empirical comparison of published data alongside key incentives policy milestones within seven countries therefore suggests that:

(a) FITs can have greatest impact upon the market share of electricity generated from renewable sources, although they are usually complemented by other forms of incentive such as grants/subsidies, loans or even tax incentives;
(b) Other incentives, such as the combination of grants and subsidies, tax rebates and green certificates in the Netherlands, can have an initial positive effect, but hitting a plateau;
(c) U.S. tax incentives had an initial positive effect upon the percentage of electricity generated from renewable energy sources, but those effects dried up, and no data is currently available to draw comparative conclusions about recent tax incentive changes;
(d) Despite their apparent effectiveness, FITs can be a more costly form of incentive from a financial perspective (Eurelectric, 2004);
(e) The higher adoption rates encouraged by FITs, compared to tax incentives, is probably a reflection of the higher levels of return available to producers and investors. Evidence from Europe certainly suggests that FITs offer higher rates per kWh than the more modest returns usually associated with tax incentives;
(f) It's less easy to identify any type of incentive having a lasting or significant impact upon the reduction of CO_2 emissions because any savings acquired via renewable energy are usually offset by increased emissions elsewhere;
(g) The overwhelming dominance of Spanish and German locations within the world's largest solar PV power plants and roof-mounted systems again hints at feed-in tariffs being more effective for the roll-out of solar PV than an emphasis upon tax incentives;
(h) Increases in net capacity growth for electricity generated from wind or solar PV appear to more closely correspond to FIT legislation than any other forms of incentive;
(i) The specific type of FIT implemented possibly affects the level of net capacity growth, illustrated by German and Spanish result differences;
(j) Although national feed-in tariffs have been the norm, provincial tariffs should not be dismissed – the Austrian renewable energy industry has clearly benefitted from them.

4.2 Recent Cost Effectiveness Studies – A Critique

A number of studies have previously evaluated the impact of renewable energy incentive programs from the perspective of society as a whole, the consumer or the investor.

Evaluations of renewable energy incentives from a societal perspective include Lipp (2007), Lund (2007), Frondel et al (2008) and Alvarez et al (2009).

A recent evaluation of renewable energy incentives which additionally focuses on the consumer perspective is Sarzynski (2009). Consumers need to be given a reason - financial or otherwise - to adopt renewable energy, in preference to conventional fossil-fuel based energy. In the absence of cost-competitiveness, financial incentives are possibly needed to induce consumers to switch to 'greener' sources. Other factors that impact upon consumer choice include income, attitudes towards the environment, the availability of renewable energy, the connection or proximity to power lines and the peak prices of alternative sources of energy. Sarzynski (2009), for example, concluded that U.S states with the greatest degree of citizen liberalism generally have the highest rates of solar deployment, although she also acknowledged that such states often offer the most generous solar incentives Borenstein (2008) argued that although natural gas is relatively inexpensive in California, its high peak electricity prices plus high costs for transmission and distribution possibly explains the high penetration of distributed PV.

Campoccia et al (2009) have evaluated renewable energy incentives from an investor perspective. Investors are usually driven by returns on their investment. Hence financial incentives which offer security and long term rewards for their investment are of paramount importance here.

4.2.1 Frondel et al. (2008)

This study initially suggests that FITs were the primary reason for Germany exceeding its 2010 minimum target for market share of electricity generated from renewable resources three years ahead of schedule. However, Frondel et al's subsequent analysis questions the large feed-in tariffs currently guaranteed for solar energy for at least four reasons:

(a) Solar's percentage share of incentives for renewable does not correlate with the percentage of electricity it actually generates. For example, in 2006, the EEG awarded

$0.65/kWh [78] for solar electricity, nearly ten times the market price of conventional electricity and six times the tariff for wind power. Solar accounted for roughly 20% of the total support offered for renewables, but PV only accounted for 3.2% of electricity production from renewable sources;

(b) Renewable energy's carbon-saving emissions have been offset by increases in other industrial sectors, to a level consistent with the EU Emissions Trading Scheme (ETS);

(c) Whilst the average domestic price effect for electricity due to FIT support in 2006 represented a minor consumer increase of $0.011/kWh[79] or $39.55 per household[80] for the year, the overall loss of consumer purchasing power adds up to $7.04 Billion[81]; and

(d) Any employment benefits are negligible due to the high opportunity cost of FITs, the potential loss of employment elsewhere within the energy sector, and a somewhat dangerous dependence upon a "… robust foreign trade of renewable energies" (p.4201).

To justify their position, Frondel et al estimate the cost of Germany's EEG in two phase out scenarios. In the first scenario, phase out of the program is assumed to commence in 2007; in the second, phase out occurs in 2010. In both scenarios, FIT support would continue for a further 20 years after the phase-out due to the nature of the legislation. To estimate the net cost of subsidizing solar PV, the authors subtract its market value, based on wholesale prices, from the tariffs. This method captures some external costs but ignores some of the administrative costs as well as some external benefits.

The authors estimate that if the EEG had ended in 2007, total real support for PV would have been $42.68 Billion.[82] If it were to end in 2010, total real support for PV would be $88.29 Billion.[83] Both cost estimates, they argue in Germany: "… clearly demonstrate that producing electricity on the basis of PV is among the most expensive greenhouse gas abatement options" (p.4200).

[78] €0.518/kWh - Converted using the ECB's 2006 average Reference Exchange Rate of 1 €: 1.2556 US$.
[79] €0.009/kWh - Converted using the ECB's 2006 average Reference Exchange Rate of 1 €: 1.2556 US$.
[80] €31.50 - Converted using the ECB's 2006 average Reference Exchange Rate of 1 €: 1.2556 US$.
[81] €5.61 Bn - Converted using the ECB's 2006 average Reference Exchange Rate of 1 €: 1.2556 US$.
[82] €30.6 Bn - Converted using the ECB's 2009 average Reference Exchange Rate of 1 €: 1.3948 US$.
[83] €63.3 Bn - Converted using the ECB's 2009 average Reference Exchange Rate of 1 €: 1.3948 US$.

They also argue that the abatement costs of PV displacing conventional electricity generated from a mixture of gas and hard coal are as high as $1041 per tonne at 2007 tariff rates[84] – that's over 25 times higher than the current prices of CO_2 emission certificates established by the EU Emissions Trading Scheme (ETS).[85]

Leaving to one side any doubts about the Federal Ministry for the Environment's (BMU) claim that 17,400 people in 2004 and 35,000 in 2006 found employment within the PV industry thanks to government incentives, Frondel et al also calculate that the required support level far exceeds average wages. In 2006, the per-capita subsidy would have been $257,398.[86]

Frondel et al. conclude that the German FIT is a substantial economic detriment, owing to the "… very high opportunity cost of supporting PV." They argue for greater investment in R&D to bring solar PV to cost-competitiveness with other renewable generating technologies.

This leads the authors to conclude that FITS are a significant detriment to the economy, failing to confer any significant positive benefits on climate or employment. Quoting an International Energy Agency 2007 report recommending policies other than very high FITs to promote solar PV, Frondel et al suggest greater investment in research and development to achieve competitiveness (i.e. grants and loans) would be more cost effective than the FITS' promotion of large-scale production.

4.2.2 Lund (2007)

Lund examines the cost-effectiveness of 20 different policy measures implemented in 8 countries plus the EU to promote renewable energy and energy efficiency. He divides these 20 measures into two distinct categories. The first category is subsidy-based measures, in which government funding generally supports the deployment of new technologies until cost

[84] €760 - Converted using the ECB's 2007 average Reference Exchange Rate of 1 €: 1.3705 US$.
[85] This is significantly higher than the social cost of carbon, as demonstrated in a forthcoming Az SMART white paper looking at the environmental impact of utility based generation.
[86] €205,000 - Converted using the ECB's 2006 average Reference Exchange Rate of 1 €: 1.2556 US$.

competitiveness is reached. Examples here include capital grants and FITs. The second category is catalytic measures in which government support is time-restricted to achieve initial market penetration, before allowing the new technology to grow by itself. Examples here include green certificates or awareness-raising public measures. All 20 case studies were selected for the tangible energy effects they had had on the market. Examples from four of the seven countries examined in Section 3 were included, as shown in the following table:

Table 42: Summary of Programs Examined by Lund (2007)

Country	*Program(s) Examined*
Austria	Investment grants for biomass plants, solar heating and heat pumps
Denmark	Energy labeling for buildings
Germany	Feed-in Tariffs for wind power and photovoltaics
U.S.	Technology procurement programs for efficient lighting

Source: Lund (2007)

Cost-effectiveness is measured in terms of the additional cost incurred (monies spent on support programs) per energy effect (MWh) over a finite lifetime. Lund notes that for this kind of assessment, "… the immediate observed impacts [and] also the future impacts from the measures must be considered in some way." Thus, energy impacts are estimated as the product of installed capacity (or quantity of new installations) and energy production or savings per unit. Table 43 presents Lund's estimates of the cost-effectiveness of incentive programs examined in Austria, Denmark, Germany, and the U.S.

Lund concludes that the policy cost of subsidy-type measures ranged from \$1.37/MWh[87] to \$137/MWh [88] with FITs the most expensive subsidy-type option. There is a potential for this price to drop over time by 30-80%, but it would still remain above \$1.37. In comparison, catalytic instruments cost only \$0.137 to \$1.37 per MWh.[89] This would mean that the policy cost of avoided carbon dioxide emissions was \$3.43 to \$342.63/tCO_2 for subsidy type measures [90] but

[87] 1€/MWh - Converted using the ECB's 2007 average Reference Exchange Rate of 1 €: 1.3705 US$.
[88] 100€/MWh - Converted using the ECB's 2007 average Reference Exchange Rate of 1 €: 1.3705 US$.
[89] 0.1 - 1€/MWh - Converted using the ECB's 2007 average Reference Exchange Rate of 1 €: 1.3705 US$.
[90] 2.5 - 250€/tCO_2 - Converted using the ECB's 2007 average Reference Exchange Rate of 1 €: 1.3705 US$.

only \$0.34to \$3.50/tCO_2 for catalytic ones.[91] Hence, from a cost perspective, Lund appears to be against FITs.

Table 43: Lund's Estimated Energy Impacts and Costs of Public Policy Measures in Austria, Denmark, Germany, and the US

Country	*Program(s) Examined*	*Energy Impact (PJ)*	*Policy Cost-Effectiveness (\$/MWh)* [92]
Austria	Investment grants, Biomass	281	1.75
Austria	Investment grants, Solar	99	27.01
Denmark	Energy labeling for buildings	19	1.52
Germany	FITs, Wind	1840	82.23
Germany	FITs, PV	53	548.2
US	Technology procurement programs for efficient lighting	7	0.22

Source: Lund (2007)

However, he also argues that subsidies are simpler to implement, and will always yield outcomes proportionate to the amount of financial support offered, whereas catalytic instruments require "… a more careful policy design and more profound understanding of the market and its mechanisms" (p.637). This leads Lund to conclude that further study is required to determine whether catalyzing instruments can work as well with large-scale energy production technologies as energy efficiency in consumer products.

4.2.3 Lipp (2007)

Lipp (2007) examines the historical effectiveness of major policy mechanisms in Denmark, Germany and the UK, comparing the German and Danish FIT programs with the UK's preference for a renewables portfolio standard (RPS) quota system. The policies are compared at 4 levels up to 2004. These are:

(a) The bases of the level of renewable energy penetration achieved;[93]

[91] 0.25 – 2.5€/tCO_2 - Converted using the ECB's 2007 average Reference Exchange Rate of 1 €: 1.3705 US\$.
[92] All costs converted into \$ using the ECB's 2007 average Reference Exchange Rate of 1 €: 1.3705 US\$.

(b) The contribution to CO_2 reduction;
(c) The impacts on employment; and
(d) The costs incurred.[94]

Table 44 summarizes her estimated effectiveness indicators for Germany and Denmark's FITs. Lipp identifies a number of factors that contribute to the success of renewable energy policies:

(a) Policies that are framed around specific goals or targets have better results than those that have the more general goal of simply increasing deployment;
(b) Early government commitment to promoting renewables is crucial; and
(c) A 'broad palette' of policies must be chosen, as no single policy, standing alone, is enough to achieve significant results.

Focusing in particular upon her critique of the Danish and German FITs, she suggests that they:

(a) Are more cost-effective than the UK's quota-based system for attaining higher renewable energy targets;
(b) Provide greater investor certainty in terms of pricing and contracts, thus widening the type of participants attracted to the renewables market;
(c) Are flexible enough to enable responses to different stages of a technology's learning curve; but
(d) Must be designed and implemented in such a way that they can interact with other policy incentives if they are to be successful.

The RPS policy in the UK, though, stalled investment, limiting both the diversity of technologies supported and types of participant to large scale players who could achieve economies of scale. She also argues that the UK quota system resulted in a higher cost for wind, biogas and small-scale hydro plants than the German and Danish FITs, despite comparable generation costs across all three countries. For the UK's quota system was calculated in 2005 to produce wind energy at an average price of $137-213 per MWh, compared to Germany's $100-131 per MWh

[93] Renewable energy penetration includes large hydro, which we have ignored elsewhere in this paper.
[94] Details of cost estimates are not provided.

and Denmark's $71-76 per MWh.[95] Lipp attributes the UK's higher cost of support to the level of price, volume and market risks for developers and high renewable obligation certificate prices. That is, under an RPS, the price is not known beyond the short-term contract and hence subject to fluctuation. There's also greater uncertainty about the sale of the renewable energy power in the future (volume risk) and generation varies according to market rules (market risk). By contrast, FIT generators avoid such risks because they do not negotiate contracts, participate in bidding or obtain complicated permits.

Table 44: Estimated Effectiveness Indicators for Renewable Energy Policy in Germany and Denmark through 2004

	Country	
Indicator	**Denmark**	**Germany**
Installed RE capacity as % of total electricity generation capacity	20%	10.2%
CO_2 reductions (Million tons), 1990 – 2004	-1.2	-215
CO_2 reduction (%), 1990 – 2004	-1.8%	-17.5%
Job creation in RE sector	NR	157,000
Job creation in wind sector only	20,000	70,000
Generation cost ($/MWh) [96]		
Wind	72.15 - 77.12	87.07 - 130.61
Biogas	99.51 - 130.61	118.17 – 143.05
Biomass	93.29 - 118.17	136.83 – 174.15
Hydro	NA	111.95 – 149.27
Solar PV	62.2	684.15 – 870.73

Source: Lipp (2007)

4.2.4 Sarzynksi (2009)

Sarzynski evaluates the extent to which incentives in ten U.S. states in 2008 increase consumer adoption of renewable technologies, reduce consumer demand for conventional energy, and

[95] Currency conversions based upon ECB's 2005 average Reference Exchange Rate of 1 €: 1.2441 US$. All prices courtesy of The European Commission's (2005) Report, 'The Support of Renewable Energy Sources', COM(005) 627.Brussels

[96] Currency conversions based upon ECB's 2004 average Reference Exchange Rate of 1 €: 1.2439 US$

reduce the environmental impacts of conventional energy consumption. All of the incentives are either tax credits or rebates for residential, non-residential and commercial sectors. She uses the U.S. Department of Energy's Solar Advisor Model (SAM) to illustrate how current incentives potentially impact upon the 30-year financial viability of 100% debt-financed PV investments for hypothetical 4 KW residential and 200 KW commercial systems. Her analysis does not account for differences in installation costs, incentive availability, or the unique financing and tax situations of potential customers. However, it is based upon the following assumptions:

(a) Upfront installation costs of $6.5/W for residents and $5/W for commercial are financed entirely rather than paid in cash;[97]
(b) All energy generated is consumed on site - no electricity is sold back into the grid;
(c) No property or sales tax is due;
(d) State cash incentives are personally non-taxable, but reduce the basis for a federal investment tax credit;
(e) State cash incentives are corporately taxable at the state and federal levels, but do not reduce federal investment tax credits; and
(f) State investment tax credits are federally taxable at the personal and corporate level.

Using this framework, Sarzynski describes a state incentive to be as effective if it yields positive net present value (NPV) for the prospective consumer and reduces the levelized cost of electricity (LCOE) below the current electricity price.

[97] Sarzynski acknowledges that these costs are lower than the cost costs for many PV installations supported by incentives in 2009, but states that they reflect the "…informed judgment" (p.23) of her project funder, Zweibel.

Table 45: LCOE & NPV for a Hypothetical Residential System resulting from Federal & State-Level Incentives in Arizona, California, Connecticut and Hawaii

Location	*Avg. Electricity Price ($/kWh)*	*Incentive*	*NPV ($)*	*LCOE ($/kWh)*
AZ	0.1051	None	-14,402	0.2947
AZ	0.1051	Federal ITC	-7,397	0.2144
AZ	0.1051	Federal ITC + State ITC	-6,718	0.2067
CA	0.1491	None	-10,826	0.3200
CA	0.1491	Federal ITC	-3,821	0.2320
CA	0.1491	Federal ITC + rebate	4,377	0.1290
CA	0.1491	Federal ITC + PBI	6,412	0.1068
CT	0.2019	None	-9,930	0.4062
CT	0.2019	Federal ITC	-2,926	0.2954
CT	0.2019	Federal ITC + rebate @33%	1,232	0.2297
CT	0.2019	Federal ITC + rebate @25%	8,952	0.1076
HI	0.2291	None	3,261	0.3271
HI	0.2291	Federal ITC	3,544	0.2372
HI	0.2291	Federal ITC + State ITC	6,938	0.1938

Source: Sarzynski (2009)

Table 45 summarizes some of the key results of Sarzynski's hypothesized model for residential system owners. This suggests that California, Connecticut and Hawaii offer the best incentive programs. In all three states, the LCOE is lowered below the average electricity price and the NPV for the system owner is positive. However, her analysis also suggests that Arizona's smaller package of incentives leaves a larger financial burden on the consumer. Sarzynski's hypothesized negative NPV for Arizona is at odds with other studies such as Huber (2009) which concluded that simple payback for a residential solar investment would occur within 11 years. Huber also argued that a hypothetical Arizona household would earn $28,284 more over a 30-year period from a solar PV investment than a financial instrument yielding an average return of 6% per year. Her analysis is also at odds with Allen, Atwell and Smith (2009) who conclude that the federal tax credit makes an Arizona resident's investment in a solar panel financially worthwhile. This discrepancy is possibly a reflection of Sarzynski's assumptions and key exclusions, such as the omission of non-state incentives offered by utility companies which at the time of her calculations supported approximately 1,500 installations within Arizona, culmulatively representing almost 10 MW PV capacity.

Sarzynski's results for a hypothetical commercial system also suggest the state incentives offered in Arizona are insufficient in and of themselves to make large commercial installation investment a viable alternative. Commercial installation purported to be a good investment even without the state incentive in Hawaii. The other successful incentives listed in Table 45 are paid out of public benefits fund.

Further evaluation of the state incentive programs is made in terms of:

(a) Participation rates among households and businesses;
(b) Program expenditures per participant;
(c) Program-related installed capacity as a proportion of total statewide installed capacity;
(d) Average installation size;
(e) Expenditures per capacity installed;
(f) Energy savings; and
(g) Estimated environmental benefits.

Sarzynski found that participation across all 10 states studied, although increasing, only extended to 80,000, 97% of which is within the residential sector. In fact, only 3 states had more than 10,000 participants overall – California, Arizona and Hawaii. Average expenditure per residential recipient ranged from $449 in Arizona to $36,250 in New Jersey. Participation extended to 5.34% of Hawaiian households, but failed to hit even 1% in any other state (Arizona coming in second at 0.7% share, California third at 0.15%). By contrast the percentage of state federal tax filers claiming the federal residential energy investment tax credit (FRETC) in 2006 and 2007 ranged from 1.52% to 4.47% (Arizona = 2.06%). Sarzynski argues that many claims were for less expensive energy-saving improvements than solar technologies, but might be amenable to future solar technology investment opportunities.

Income tax incentives had higher total participation than cash incentives, despite costing far less per participant.

Residential installations ranged from an average 7.3 kW per recipient to 2.4 kW per recipient; commercial installations from an average 130 kW per recipient to 12 kW per recipient. However, she argues that several factors besides incentives account for the installation trends, including rising real energy prices and recent adoption of RPS policies.

Across all 10 states, $163 solar incentives were spent on average per estimated metric ton of CO_2 avoided. This calls into question the cost-effectiveness of the U.S. incentives, compared to European Exchange prices of $73 per ton of CO_2. However, Sarzynski also identified disparity between states in terms of the amount of investment needed to attain the same level of CO_2 reduction. This was due to differences in the cleanliness of electricity generation. States currently generating cleaner electricity, such as Oregon (via hydropower) and California (via natural gas), therefore need to offer higher incentives.

Acknowledging data inadequacy issues, Sarzynski concludes by recommending states annually track the number of participants, program expenditures and amount of technology supported for tax and cash incentives. She also calls upon DSIRE to consolidate program information from states in an accessible, publicly-available format to enable comparative analysis.

4.2.5 Campoccia et al. (2009)

Campoccia et al. examine the impact of different incentives for the production of electrical energy from solar PV and wind in France, Germany, Italy and Spain. FITs were the preferred incentive for both forms of renewable energy in France and Germany. Italy used a FIT for electric energy produced by PV but a green credits or tags system for wind. Spain used a variable FIT for both forms of renewable energy. Comparisons are made in terms of pay-back period (PBP), net present value (NPV) and internal rate of return (IRR).

The authors estimate the discounted cash flows resulting from representative solar PV and wind systems over a 25-year period. The analysis accounts for kWh produced, monies received from FITs or subsidies, energy savings, installation costs, maintenance and management costs, insurance costs, and others. Table 46 lists the type and peak output of each representative system modeled.

Table 46: Representative Systems Modeled by Campoccia et al. (2009)

Resource	*System Size*	*Technology*
Solar	3 kWp 20 kWp 500 kWp	BIPV[98] BIPV NIPV[99]
Wind	20 kW 20MW 50MW	micro-turbine on-shore farm off-shore farm

Source: Campoccia et al (2009)

Campoccia et al conclude that it is the way in which an incentive is implemented, rather than the type of incentive, that is crucial for renewable energy development, because it can lead to significantly different results. Under the German FIT program, investment in large-scale non-integrated PV systems was most lucrative, as demonstrated by the predominance of such systems within the country. Also, medium-scale systems were better supported than small-scale systems. In Spain, the variable FIT penalized investors in large-scale PV but was advantageous for systems with peak output of less than 100 kWp - results consistent with Hoehner's 2007 report on the role medium sized plants played in the Spanish market.[100]

Complementing Section 3's geographical survey, Table 47 illustrates Campoccia et al's results specifically for Germany and Spain.

98 BIPV = Building Integrated Photovoltaics
99 NIPV = Non-integrated Photovoltaics
100 Hoehner, MAW (2007). *'The Spanish Photovoltaic Market 2006/07 – Growth market with Initial Difficulties'*, EuPD Research:Bonn

Table 47: Investor Outcomes in Germany and Spain

Country	*System Size*	*Results* [101]		
		IRR[102] (%)	NPV[103] ($ 000s)	PBP[104] (years)
Germany				
Solar	3 kWp	0.77	1.69	18.5
	20 kWp	3.86	48.6	13.0
	500 kWp	2.84	896.1	14.5
Wind	20 kW	-	-	-
	20MW	3.19	9,907.48	15.0
	50MW	3.89	60,058.81	13.5
Spain				
Solar	3 kWp	3.52	13.71	16.0
	20 kWp	5.60	128.58	13.0
	500 kWp	-	-	-
Wind	20 kW	-	-	-
	20MW	6.86	28,313.16	12.0
	50MW	2.43	45,681.51	19.0

Source: Campoccia et al. (2009)

4.2.6 Alvarez et al (2009)

Alvarez, Jara, Julian and Bielsa (2009) analyze the impact of wind and solar energy incentives upon Spanish employment via two comparisons:

(a) The renewable subsidies needed to create a green economy job against the average amount of capital that a job requires in the private sector; and

(b) The average annual productivity that green job subsidies would have contributed to the Spanish economy if they had not been consumed in such a way, against the average productivity of the private sector labor worker.

101 Converted from Euros using ECB's 2007 average Reference Exchange Rate of 1 €: 1.3705 US$.
102 IRR = Internal Rate of Return
103 NPV = Net Present Value
104 PBP = Pay Back Period

Their study calculates that since 2000, Spain has spent E571,138 to create each 'green job', but destroyed 2.2 jobs for every 'green job' created. These costs, they argue, are inherent in the schemes adopted to promote renewable energy sources, with the average annuity payable to renewables in 2007 equivalent to 3.45% of household or 5.6% of corporate income tax. Although the solar PV FIT resulted in a mean sale price seven times higher than market prices, Alvarez et al note how solar's market share of Spain's total electricity production in 2008 was less than 1%. This raises questions about the generosity of tariff prices set by the Government, their cost effectiveness, and the consequences of alleged green job creation via renewable energy incentives.

4.2.7 Summary of Findings from External Studies

Independent studies of the cost-effectiveness of renewable energy generation incentives therefore suggest:

(a) Subsidies and feed-in tariffs are more costly than tax incentives and rebates, and cost more per unit of carbon dioxide saved (Frondel et al; Lund);
(b) Questions can also be raised about the employment benefits emanating from tariff-style investment in the renewable sectors (Frondel et al);
(c) Tax incentives have proved more popular and cheaper in the United States than cash incentives (Sarzynski);
(d) However, further research is needed to determine whether catalyzing instruments can work as well with large-scale energy production technologies as energy efficiency in consumer products (Lund);
(e) Feed-in tariffs appear to be a more effective means of increasing the renewable market share of the energy generation mix than the likes of regulatory quota systems (Lipp);
(f) The higher adoption rates encouraged by FITs is due at least in part to the generous, non-market determined tariff rates paid, rather than any notion of cost-effectiveness;
(g) The potential costs of feed-in tariffs, though, can be a serious economic deterrent (Frondel et al) despite their potential for flexibility (Lipp);

(h) The key to the success of any incentives program is the way that it is implemented (Campoccia et al);

(i) A broad palette of incentives are best, in which feed-in tariffs are specifically designed to successfully interact with other types of incentive (Lipp); and

(j) Data collection for all the different types of incentive is at best limited, thereby undermining to an extent the reliability of findings (Sarzynski).

5. Conclusions and Implications for Arizona

There are significant barriers to overcome if we are to successfully increase the use of renewable energy resources and energy efficiency measures. Renewable energy technologies by their very nature are less cost-competitive than traditional, non-renewable technologies. Financing the high costs of new 'greener' installations can also be difficult. Regulatory measures that simply mandate the adoption of renewables can to an extent help overcome these barriers, but market-based incentives can equally achieve those outcomes through voluntary stakeholder participation.

Beginning with a typology of six generic market-based incentives, this paper has attempted to explain the key features of each type from a theoretical and practical perspective. The six types of incentive examined were:

- Feed-in tariffs;
- Grants & subsidies;
- Tax incentives;
- Loans;
- Reverse auctions; and
- Green marketing programs.

Feed-in tariffs were described as forms of pricing law in which homeowners, businesses and public entities can enter the electricity supply market. We suggested that FITs had three general qualities – price certainty, simplicity and accessibility. Price certainty referred to the creation of a predetermined rate, usually set by government mandate, for the purchase of electricity from a renewable energy producer. Simplicity referred to the nature of the procurement process to encourage widespread participation. Accessibility referred to the ease with which producers of renewable energy interact with a power grid. Tariffs are usually set by government mandate. We identified four different types of FIT – fixed, premium, flat and steeped. We also noted key policy variations within FITs such as degression, review milestones and capacity limits.

Grants and subsidies were described as cash transfers to the buyer or seller of a renewable energy good or service to keep prices below market levels for consumers, above market levels for producers or simply reduce the cost of production of the good or service. For the purpose of this paper, we used the term solely to refer to on-budget subsidies which directly appear on a balance sheet as expenditure.

Three types of tax incentive were highlighted - credits, exemptions and rebates. Offered at a national, state and local level, we noted how this type of market incentive can apply to a variety of taxes, including personal income tax, sales and property tax and corporate tax.

Loans were identified as a means of offering individuals and organizations favorable financing terms or credit for renewable energy projects and improvements that would not be available from traditional commercial avenues.

Reverse auctions were the fifth form of market incentive identified. These were programs that award power purchase agreements to new renewable generation projects on the basis of lowest unsubsidized generation cost. As described here, the reverse auction had two intended effects. First, it encouraged the installation of new renewable generation capacity by requiring utilities to commit funding to the purchase renewable energy from new systems. Second, it encouraged innovation to lower the costs of renewable energy because prospective developers were forced to compete on the basis of per-unit price.

The final market incentive identified was green power marketing. This type of incentive encouraged customers to voluntarily elect to pay higher prices to utility system owners to obtain a percentage of their electricity from renewable sources. It also enabled utility system owners to trade renewable energy certificates to satisfy regulatory requirements.

To understand these six types of incentive in practice, we examined the programs and outcomes of seven countries during the past 20-30 years. Six of these countries were from Europe – Austria, Denmark, Germany, Ireland, Netherlands and Spain. The seventh was the U.S. The European countries were selected based upon their high percentage of electricity generated from renewable sources, in particular wind and solar. The U.S. was chosen because it has the largest absolute amount of renewable energy installed and our aim is to explore the renewable energy options within Arizona.

Our geographical survey suggested that the EU countries were more inclined to introduce FITs, albeit as part of a broader palette of incentives, whereas the U.S. had a clear preference for tax incentives.

To evaluate the effectiveness of incentives within each country, we initially compared the key dates of programs with changes in renewable energy market share, the level of CO_2 emissions and net capacity. This suggested that FITs can exert greatest impact upon the market share of electricity generated from renewable sources, particularly when they are complemented by other forms of incentive such as grants/subsidies, loans or even tax incentives. This does not mean that other forms of incentive should be ignored. A combination of grants and subsidies, tax rebates and green certificates in the Netherlands, for example, clearly had an initial positive effect upon renewables' market share. The U.S.'s preference for tax incentives also indicated an initial positive effect upon the percentage of electricity generated from renewable energy sources, and the data is not currently available to examine the impact of more recent tax incentives. However, the Netherlands' subsequent adoption of a FIT has injected new life into their renewables program.

We also argued that Spanish and German dominance of the world's largest solar PV power plants and roof-mounted systems additionally supported the effectiveness of FITs, but acknowledged difficulty in identifying any type of incentive that has a lasting or significant impact upon the reduction of CO_2 emissions.

The key drawback with FITs is that they can prove to be a more costly form of incentive from a financial perspective, as demonstrated by the generous tariff rates set by European governments. However, given the dearth of data available, we had to rely upon external studies to analyze the cost-effectiveness of all market-based incentives.

These studies acknowledged the higher cost of FITs compared to other forms of incentive, in terms of price and cost per unit of carbon dioxide saved. Question marks were also raised about the employment benefits emanating from tariff-style investment in the renewable sectors. However, there was also some acknowledgment of the effectiveness of FITs to increase the renewable market share of the electricity generation mix, albeit at a high financial cost.

Further research was recommended to determine the extent to which cheaper catalyzing instruments such as tax incentives can work well with large-scale energy production technologies. Greater data collection practices were also recommended to enable a more detailed evaluation of the cost-effectiveness of different market-based incentives.

What, then, does this mean for the U.S. and Arizona in particular?

Although tax incentives in the past have proved more popular and actually cheaper to finance than cost incentives within the U.S., the market could benefit from additional stimulants. Total electricity generated from renewable sources in the U.S. has fallen below 10% throughout the first 8 years of the 21st century. Furthermore, while the demand for electricity generally throughout the U.S. has increased, the absolute amount of kWh generated from renewable energy sources has returned to early-1990s levels.

Evidence from Europe suggests that feed-in tariffs could introduce added impetus to the market share of electricity generated from renewable sources in the US, while Kirkegaard et al (2010) argue that multi-year FITs "… provide private industry and investors with the required incentives to rapidly expand the solar PV market." (p.41)

America's tendency to avoid FITs to date has been for political reasons and also due to questions about viability. Politically, the U.S. is opposed to any form of market intervention, preferring tax credits to stimulate a variety of goals from home ownership to education. American critics of FITs have also suggested that the state or local control of utility companies, together with the decentralized structure of electricity generation and distribution systems, undermines the very possibility of a national FIT program for renewable energy.

However, our paper has shown that the design of a FIT is potentially flexible enough to avoid offending traditional U.S. political philosophy, or saddle their citizens with an unacceptable cost-burden. A prime example of this is the variable spot-market gap model, currently implemented by the Netherlands. For this FIT, renewable energy projects are guaranteed a predetermined minimum total payment set by government for the electricity generated. This payment, though, fluctuates over time as it is met from two revenue streams. These are the prevailing spot-market price of electricity, plus a variable FIT payment representing the real-time difference between a minimum total payment guarantee set and the spot-market price.

Cory, Couture and Kreycik (2009) offer three reasons for the political and regulatory suitability of this type of FIT for the US. These are:

(a) Incremental costs are clearly derived from the sum of spot-market gap payments;
(b) The burden upon utility companies is minimized by setting a limit to the tariff paid. That is, FIT payments decline as electricity prices increase; and
(c) Potential legal challenges relating to the right of a state to regulate power costs above federal wholesale rates can be circumvented by designing the spot-market gap to represent the fluctuating REC value, contracted in conjunction with wholesale electricity prices.

One key decision to determine at the outset is who pays for the marginal costs of the FIT – ratepayers or tax payers? In the Netherlands, the gap between the market price and tariff price is met by government subsidy. Couture and Gagnon (2010) argue that government subsidies help curtail the impact on electricity rates and therefore economic competitiveness. However, they are also riskier to develop because of their continued reliance upon government budgetary support; and the longevity of these schemes can be jeopardized by their success, which requires greater budgetary commitment. Hence, any U.S. model might need to pass the marginal costs onto electricity customers/ratepayers.

Sterzinger and Roscheisen (2009) recommend a national feed-in rate for a Renewable Power Marketing Authority to purchase electricity generated from renewable sources, who then offer the energy to investor-owned, municipal and electric co-operative utilities at a price that would attract buyers. Any revenue shortfalls under their proposal would be covered at a federal level. However, a spot-market gap FIT would in all probability need to be introduced at U.S. state as opposed to national level, because the spot-market price of electricity in some states is not transparent.

Our paper has also illustrated that effective FITs do not have to be introduced on a national scale. Austria, for example, successfully implemented provincial feed-in tariffs. Hence, state control of utilities and the decentralized generation and distribution in the U.S. should not be a barrier to the introduction of provincial FITs. Gainesville, Sacramento and Vermont already have FITs for renewable energy in place, at ratios to average residential end-user electricity prices higher than the European countries examined. Oregon and Hawaii are expected to follow. A June 2010 report by NARUC also identified Madison WI, San Antonio TX, Maine, Indiana, Ohio, Washington and Wisconsin as having passed, or considering, FIT legislation.

Sarzynski's (2010) hypothetical model analyzing the use of state incentive packages alone to increase consumer adoption of renewable technologies, reduce consumer demand for conventional energy, and reduce the environmental impacts of conventional energy consumption, calculated that Arizona's incentives currently yield negative net present value (NPV). Her calculations also suggested that the levelized cost of electricity for renewables in

Arizona substantially exceeded the average electricity price. Such findings need to be handled carefully, as her analysis is based upon a number of assumptions, fails to take into account successful non-state incentives offered by utilities, and contradicts other studies (e.g. Huber, 2009; Allen, Atwater & Smith, 2009). Nevertheless a SEIA (2010) report ranking Arizona 5th in the U.S. for the cumulative capacity of grid-tied PV and CSP for 2009 does illustrate that more could be achieved (Table 48). The state's 50MW cumulative capacity falls way short of California's 1102 MW, and is even less than half the New Jersey total of 128 MW – a state with significantly less sunshine hours. Considered as a whole, then, it might be a good time for Arizona to consider new, additional forms of incentive such as a provincial FIT.

Table 48: Top 10 States for New Grid-Tied PV & CSP Solar Electric Cumulative Capacity in 2009

Rank	*State*	*MW*
1	California	1,102
2	New Jersey	128
3	Nevada	100
4	Colorado	59
5	Arizona	50
6	Florida	39
7	New York	34
8	Hawaii	27
9	Connecticut	20
10	Massachusetts	18
	Others	78

Source: SEIA (2010)

Although our paper has advocated the supremacy of a FIT to drive the generation of electricity from renewable resources, we have also illustrated how European countries, including the market leader (Germany) have introduced a broad palette of other incentives to complement their FITs. The decision is not a simple either/or. Campoccia et al (2009), for example, argue that the key to the success of any incentives program is the way that it is implemented; and Lipp (2007) advocates a broad palette of incentives, in which feed-in tariffs are specifically designed to successfully interact with other types of incentive.

Farrell (2009) offers at least three criticisms of the United States' incentives programs as they currently stand. First, he argues that the expiry of federal incentives creates boom and bust cycles in the market. A FIT, though, would introduce stability for a defined period of time. Second, he suggests that the pool of potential renewable energy investors and dollars in the U.S. is reduced by an emphasis on tax incentives that are only valuable to individuals or businesses with a lot of tax liability. The implementation of FITs in Europe, though, has enabled people with little tax liability or even non-taxable entities to pursue renewable energy projects. His third criticism is the amount of administration emanating from the likes of the federal PTC. This requires negotiating with utilities, partnering with tax-credit hungry investors and culminates in an average power purchase agreement of 85 pages. German FIT contracts, by contrast, are usually 2-4 pages.

The City of Phoenix is currently implementing an ambitious sustainability strategy which aims to make it the first carbon-neutral city - and the greenest – throughout the United States. There is no reason why an effective FIT matching both the political philosophy and the unique infrastructure of utility services cannot be designed as part of this 'Green Phoenix' sustainability program. The variable spot-market gap model appears to be a good starting point for such considerations. That particular type of FIT does not equate to the permanent underwriting of unsustainable renewable energy sources that would, under free market conditions, simply collapse. It's a potentially effective way to initially promote or advance new sustainable technologies we could all one day have to rely upon.

6. Recommendations for Future Research

In this study, we have focused strictly on market-based incentives that promote the voluntary adoption of renewable energy sources and efficiency measures. In addition to the incentives discussed here, there are a number of regulatory measures that mandate the same desired outcomes. Regulations and standards are the focus of a separate paper in the Az SMART program.

We have presented a high-level discussion of the effectiveness of various incentive programs in the world's largest energy markets. The insufficiency of cost data has somewhat undermined that effectiveness evaluation, and the incentives should be reviewed again once that type of data becomes available.

Future analysis of the provincial FITs currently in operation or about to be introduced within the U.S. would also be worthwhile, plus a study of the cost effectiveness of FITs for encouraging solar deployment.

Going forward, in conjunction with other research efforts in the Az SMART program, we will examine the potential impacts of some possible incentive programs on the levelized cost of energy in Arizona.

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