MAKING THE MOST OF WIND: A BUSINESS PERSPECTIVE ON SUBSIDY SYSTEMS IN FRANCE, GERMANY, SPAIN AND SWEDEN.

A Thesis

by

ANDREW BARNEY

Submitted to the Office of Graduate Studies of Gotland University
in partial fulfillment of the requirements for the degree of
WIND POWER PROJECT MANAGEMENT

June 2012

Major Subject: "Energy Technology"

Master of Science in Wind Power Project Management

2012 Andrew Barney
MAKING THE MOST OF WIND: A BUSINESS PERSPECTIVE ON SUBSIDY SYSTEMS IN FRANCE, GERMANY, SPAIN AND SWEDEN.

A Thesis

by

ANDREW BARNEY

Submitted to the Office of Graduate Studies of Gotland University in partial fulfillment of the requirements for the degree of WIND POWER PROJECT MANAGEMENT

Approved by:
Supervisor, Liselotte Aldén
Examiner, Bahri Uzunoglu

June 2012
Major Subject: "Energy Technology"
ABSTRACT

Making the Most of Wind: A Business Perspective on the Subsidy Systems in France, Germany, Spain and Sweden. (June 2012)
Andrew Barney, BSA; BA, University of Idaho
Supervisor: Prof. Liselotte Aldén

Determining which countries are the most financially attractive for businesses to build wind projects is a matter of serious discussion that lacks succinct commentary. To fill this void this paper employs an empirical study of the wind subsidy support systems used by Germany, France, Spain and Sweden. This paper is based on the premise that businesses prefer to build where they can find the highest overall remuneration for their production; recognizing also the need for stability in those payments and businesses’ strong preference for larger early returns on their investments. The paper also analyzes the results and gives recommendations on possible improvements to each country’s system and where businesses should invest.

In order to reach their 20-20-20 E.U. goals (European Commission, 2010), countries are encouraging the creation of new green energy projects, and this encouragement is frequently in the form of subsidies. The subsidy types used by the countries reviewed are feed-in tariffs, premiums and a certificate quota system. Each country’s support history is detailed along with the criteria of their respective systems.

The countries systems are then compared using actual income and production data for four criteria at three different production levels – 100 percent, 75 percent and 150 percent of actual – and at two different lengths of time, 7 and 20 years. The first criteria of the comparison is total income, the second for variability of payments, the third for timing of payments and the final is the stability of the system itself.

The results of this research show that the German and French systems are superior at all levels for their low variability in payment prices and in making larger payments to businesses earlier. They are also generally superior at lower and actual production levels for total income amounts. However, the Spanish options are superior at high levels of production for income and have middling variability levels. The Swedish system generally has the highest levels of variability for the lowest levels of income. Only the Spanish system is considered to be unstable in its political support of subsidies. Based upon the preceding findings are given to each country to improve their relative weaknesses. Also recommendations are given to businesses based upon the quality of the locations wind resources.
ACKNOWLEDGEMENTS

I would like to acknowledge my family for their overall support and their review of my paper, especially Rhett Barney Esq. and my wife Maria Nitz. I would also like to acknowledge my classmates and teachers in the program for their assistance and perspectives. With special thanks to Liselotte for her feedback and suggestions on additional facets the paper could cover.

I would also like to thank Siral AB, especially Nina Gynning, for generously providing the actual information I used as the basis for this paper. Göte Niklasson also needs a big thank you for his efforts in connecting me with Siral AB.

A special thank you must also be extended to my daughter Inara for her unerring and tireless efforts to distract me from writing this paper.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iv</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>ix</td>
</tr>
<tr>
<td>CHAPTER I INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>CHAPTER II STUDY OBJECTIVES AND RATIONALE</td>
<td>1</td>
</tr>
<tr>
<td>Study Objectives</td>
<td>1</td>
</tr>
<tr>
<td>Rationale</td>
<td>2</td>
</tr>
<tr>
<td>CHAPTER III SCOPE AND LIMITATIONS</td>
<td>2</td>
</tr>
<tr>
<td>Scope</td>
<td>2</td>
</tr>
<tr>
<td>Limitations</td>
<td>2</td>
</tr>
<tr>
<td>CHAPTER IV LITERATURE REVIEW</td>
<td>3</td>
</tr>
<tr>
<td>Existing Reports and Studies</td>
<td>3</td>
</tr>
<tr>
<td>CHAPTER V METHODOLOGY</td>
<td>4</td>
</tr>
<tr>
<td>Primary Information and Data</td>
<td>4</td>
</tr>
<tr>
<td>CHAPTER VI THEORETICAL FRAMEWORK</td>
<td>5</td>
</tr>
<tr>
<td>Why Do Countries Use Support Policies</td>
<td>5</td>
</tr>
<tr>
<td>Why Use Those Policies for Renewable Energy Production</td>
<td>5</td>
</tr>
<tr>
<td>The Different Types of Subsidies and Methods</td>
<td>6</td>
</tr>
<tr>
<td>Unanalyzed Support Systems</td>
<td>7</td>
</tr>
<tr>
<td>Feed-in Tariffs</td>
<td>7</td>
</tr>
<tr>
<td>Premium</td>
<td>7</td>
</tr>
<tr>
<td>Green Certificates</td>
<td>8</td>
</tr>
<tr>
<td>Methods for Determining Remuneration Amounts</td>
<td>8</td>
</tr>
<tr>
<td>Electricity Markets</td>
<td>9</td>
</tr>
<tr>
<td>Countries Reviewed</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>9</td>
</tr>
<tr>
<td>Germany</td>
<td>10</td>
</tr>
<tr>
<td>Spain</td>
<td>11</td>
</tr>
<tr>
<td>Sweden</td>
<td>12</td>
</tr>
</tbody>
</table>
CHAPTER VII SUBSIDY COMPARISON ........................................................................... 13

Methodology ...................................................................................................................... 13

  German Reference Turbine ............................................................................................ 14

  French Load Hours .......................................................................................................... 15

  Spanish System ................................................................................................................ 15

  Swedish Green Certificate Market ................................................................................. 15

Results of Actual Production ............................................................................................ 16

  Total Income ................................................................................................................... 17

  Price per kWh .................................................................................................................... 17

  Price Variability .............................................................................................................. 18

Results of Actual Production Decreased 25 Percent ....................................................... 19

  Total Income ................................................................................................................... 19

  Price per kWh .................................................................................................................... 20

  Price Variability .............................................................................................................. 21

Results of Actual Production Increased 50 Percent ....................................................... 22

  Total Income ................................................................................................................... 22

  Price per kWh .................................................................................................................... 23

  Price Variability .............................................................................................................. 24

German and French Payment Changes ............................................................................. 25

  Payment Differences between Production Levels ....................................................... 25

  German Extend Introductory Tariff Periods Comparison .............................................. 26

Rates of Return and Net Present Values .......................................................................... 27

Estimated Future Returns for 20 Year Period ................................................................. 28

  Total Income for Project Life of 20 Years Using both Estimated and Actual Data... 28

  Rates of Return and Net Present Values for Project Life of 20 Years Using both Estimated and Actual Data.................................................................................. 29

CHAPTER VIII ANALYSIS AND DISCUSSION OF RESULTS ........................................ 30

  Total Income.................................................................................................................... 30

  Price per kWh .................................................................................................................... 31

  Price Variability .............................................................................................................. 32

  Payment Timing .............................................................................................................. 33

  Other Items...................................................................................................................... 34

CHAPTER IX CONCLUSION AND RECOMMENDATIONS .............................................. 35
CHAPTER X ADDITIONAL RESEARCH........................................................................................................37
BIBLIOGRAPHY........................................................................................................................................38
APPENDICES............................................................................................................................................40
LIST OF FIGURES

Figure 1 Site Production January 2005 – December 2011 .......................................................... 5
Figure 2 Spanish Premium Remuneration Graph ........................................................................ 12
Figure 3 European Spot Markets Graph ..................................................................................... 14
Figure 4 Swedish Green Certificate Surplus ................................................................................ 16
Figure 5 Swedish Green Certificate Prices .................................................................................. 16
Figure 6 Total Income at Actual Production ............................................................................. 17
Figure 7 Price per kWh at Actual Production ............................................................................. 18
Figure 8 Price per kWh Variability at Actual Production ............................................................ 19
Figure 9 Total Income at 75 Percent Production ......................................................................... 20
Figure 10 Price per kWh at 75 Percent Production .................................................................... 21
Figure 11 Price per kWh Variability at 75 Percent Production ..................................................... 22
Figure 12 Total Income at 150 Percent Production .................................................................... 23
Figure 13 Price per kWh at 150 Percent Production .................................................................. 24
Figure 14 Prices per kWh Variability at 150 Percent Production ................................................ 25
Figure 15 German and French Tariff Drop at Actual to 150 Percent Production ......................... 26
Figure 16 German Additional Introductory Tariff Months at Different Production Levels ......... 27
Figure 17 Nord Pool Spot Rates 2004-2011 (Sweden) ................................................................. 31
Figure 18 French 2001 Subsidy Payment Rate Scale for Last 10 Years of Production ............... 32
Figure 19 Annual Electricity System Deficit (Millions of EUR) .................................................. 35
LIST OF TABLES

Table 1 Reviewed Countries RES Goals ................................................................. 6
Table 2 Reviewed Countries Projected Wind Capacity Increases .............................. 6
Table 3 Swedish Green Certificate Purchase Quotas .................................................. 13
Table 4 Total Annual Incomes at Actual Production .................................................. 17
Table 5 Prices per kWh at Actual Production .......................................................... 18
Table 6 Prices per kWh Variability at Actual Production ........................................... 19
Table 7 Total Annual Incomes at 75 Percent Production ........................................... 20
Table 8 Prices per kWh at 75 Percent Production .................................................... 21
Table 9 Prices per kWh Variability at 75 Percent Production .................................... 22
Table 10 Total Annual Incomes at 150 Percent Production ....................................... 23
Table 11 Prices per kWh at 150 Percent Production ................................................. 24
Table 12 Prices per kWh Variability at 150 Percent Production ................................. 25
Table 13 German and French Tariff Drop at Actual to 150 Percent Production .......... 26
Table 14 NPV and IRR at Actual Production ............................................................ 27
Table 15 NPV and IRR at 75 percent Production ...................................................... 28
Table 16 NPV and IRR at 150 Percent Production ..................................................... 28
Table 17 20 Year Annual Income at Actual Production Level ................................... 29
Table 18 20 Year Annual Income at 75 percent Production Level .............................. 29
Table 19 20 Year Annual Income at 150 Percent Production Level ............................ 29
Table 20 20 Year NPV and IRR Actual Production ................................................... 30
Table 21 20 Year NPV and IRR 75 percent Production Level .................................... 30
Table 22 20 Year NPV and IRR 150 Percent Production Level .................................. 30
CHAPTER I
INTRODUCTION

Where are businesses going to invest in green energy projects? With some exceptions, they will build where they are most likely to maximize profits. Presumably, this desire also accounts for the variability of earnings, with time value of money preference to receive the largest payments early in the project. However, in order for wind energy projects to effectively compete with both green and standard projects, with less variability and higher overall income prospects, wind projects must receive incentives beyond those currently offered by the market. As a result, several governments hoping to encourage wind and other green projects have taken numerous steps to provide such incentives.

Arguably, the most successful attempts to support green industry are the feed-in tariffs and premiums. Depending on the objectives of the government, there are a range of ways that these tariffs and premiums can be setup, but ultimately they are all based on the concept of providing assistance to businesses choosing to pursue green alternatives. In turn these businesses will prefer the countries and systems that best help them reach their objectives.

This paper will compare the subsidy systems of four countries as applied to a specific wind park in Sweden. This comparison will focus on all of the following presumed business preferences: Amount, timing and variability of earnings. Because businesses are faced with substantially more complexity than just the financial payment support system when picking where to build, some additional analysis will be done to determine the historical and future appeal of the subsidy systems reviewed. The other important items businesses should consider, such as the local acceptance levels, wind assessment accuracy, supporting infrastructure, labor costs, administrative complexities, the other economic and non-economic supports offered by the government, among many others, will not be reviewed in this paper. The paper will conclude by recommending those features that attract the most wind power investment.

CHAPTER II
STUDY OBJECTIVES AND RATIONALE

Study Objectives

The primary objective of this study is to determine which of the selected countries’ financial support systems has the highest compensation and stability for wind project development. This compensation will be viewed through the lens of volatility and timing of payment.

The central points are as follows:

- Which countries provide the highest absolute payments over the period with actual data?

- Which countries pay the most over the 20 year lifetime of the park?
Which countries have the lowest volatility in their payments?

What are the political risks of the systems reviewed in regards to their subsidy systems?

Are there any suggestions that can be given to businesses wishing to develop a wind project, in so far as maximizing their short and long term profits?

**Rationale**

While there is commentary and review in existing research discussing the differences between various countries’ subsidy systems (Bökenkamp, et al., 2008) and political risks (Steinhilber, et al., 2011) it generally does not include analysis of specific business conditions. The existing commentary also gives suggestions of preference for wind power developers (Klein, et al., 2008), but again there is little direct comparison of the bottom line financial benefits or shortcomings a individual project would have under a selected system.

**CHAPTER III**

**SCOPE AND LIMITATIONS**

**Scope**

This paper compares the income generated from an actual Swedish wind park under the Green Certificate subsidy system to the systems of three other European countries. Changes in the compared subsidy systems during the review period are reflected in the comparisons. The Swedish electricity spot market rates are used so that final income amounts will be comparable. Additional discussion of the market rates is found in the case study section below.

**Limitations**

The following limitations are found in this review:

- **Scope of Review:** Only four European countries’ subsidy systems have been selected for comparison. A more comprehensive study would include a representative group of countries from around the world, or at least Europe, with a subsidy system in place for wind power development.

- **Size of Review:** Only a single Swedish wind park is being used for comparison in this study. A more comprehensive study would include additional parks from throughout the country and in other countries.

- **Spot Rates:** Monthly average spot rates were used. A more comprehensive study would include daily or hourly rates.

- **Cost Items:** Countries may appear more attractive due to higher payments but may have added costs not addressed in this assessment. A complete review would also include costs incurred relative to the country being assessed.
Wind Assessment: Having an accurate wind assessment for a location can be the basis for determining which subsidy system is most beneficial, and it frequently underlies approval of project financing. This study uses historical production data from an established park making additional commentary as to the importance of the wind assessments beyond the scope of this review. A more complete review of wind assessment may be beneficial in a wider review.

CHAPTER IV
LITERATURE REVIEW

Existing Reports and Studies

a. RE-Shaping (Steinhilber, et al., 2011):

This publication reviews the results of a study launched to evaluate the performance of the European Union member states’ renewable energy support policies. The multinational study attempts to quantitatively rate the successes of the support policies based on their effectiveness in increasing renewable developments, as well as how these increases affected costs to society. The report covers support for all types of renewables, not just wind.

As the scope of this paper is limited to wind power subsidy supports in four of E.U. countries, only data related to these countries was reviewed and analyzed in the comparison of subsidies.

b. Evaluation of Different Feed-In Tariff Design Options (Klein, et al., 2008):

This study broadly describes the feed-in systems in use across the E.U. and does not give any rating of the success of the different policies. However, it does give final general recommendations on how a system should be setup to be effective in encouraging renewable energy development and generation. This report covers all types of renewables and not just wind power, and only very briefly describes the Swedish quota support systems.

As the scope of this paper is limited to wind power subsidy supports in four of E.U. countries only data related to these countries was reviewed and used to analyze in the results of the comparison of subsidies.


This report identifies and then reviews and ranks the effectiveness of the green policy support systems under a number of different criteria. These criteria include effectiveness, cost-efficiency, predictability, etc. which were given a relative weight by a group of stakeholders. The individual policies are further separated into variations within the policy to determine which variation is the most effective. All variations of all support systems are then ranked based on the weights given by stakeholders to determine which is the most effective. The report
concludes with two case studies, the first on German passive house support and the second on Danish onshore wind support.

The scope of the review is limited to the feed-in, premium and quota policy systems. The information from this report was used to analyze results of the comparison of subsidies.

CHAPTER V
METHODOLOGY

This paper is primarily an empirical quantitative study of production and income data provided for a specific wind park in Sweden. The subsidy systems are principally compared based on their absolute numerical financial performances at set production levels. Additional qualitative study is done on each country’s political stability insofar as it relates to continued subsidy payments.

Primary Information and Data

Production and income data was obtained from Siral AB, a Swedish wind power developer and wind park owner, for one of its wind parks in Sweden. The data from Siral refers to a site that has been in operation since before the Swedish green certificate program began. The records provided separate the business’s income into amounts paid by the market and amounts received from sales of green certificates. Additional payments for benefits to the grid were also provided, but have been excluded from this evaluation. Along with the production data, the technical specifications of the turbines were included. All turbines within the data provided had the same make, model and installation period.

When possible the effective payment rates for the German, French and Spanish systems were obtained from each countries’ applicable law. If not possible due to rate adjustments, official documents were sought showing the rate for each year reviewed. When no official documents were found for the Spanish system showing the rate adjustments each year the rates were instead obtained from the Spanish wind energy association, Asociación Empresarial Eólica. In addition the monthly spot electricity market rates were obtained from Nord Pool’s website, nordpoolspot.com.

The remaining periods of the lifetime of the park are estimates based on an average production year, average spot market price and average green certificate price.

Below is a graph of the park’s production from 2005 to 2011 (Siral AB, 2011).
CHAPTER VI
THEORETICAL FRAMEWORK

Why Do Countries Use Support Policies

In general, a subsidy can be any form of economic support to a single business or group of businesses, but it can also include an entire type of activities. These supports are almost exclusively provided by a government to support a specific type of unprofitable or relatively uncompetitive activity or activities. Governmental reasons for doing this vary, but may include a desire to support a historic industry, safeguarding a country’s sovereignty, or providing an initial startup incentive for preferred technologies and industries. Ultimately, no matter the reason for the subsidy, the result is same: A change in either the supply or demand curves of the subsidized goods or services.

Why Use Those Policies for Renewable Energy Production

The European Union has attempted to increase its share of renewable energy production and reduce its environmental impact since the end of the last century with actions like approving the Kyoto Protocol. In furthering this objective, it established a number of goals for its member states to increase renewable energy and decrease emissions. The most recent of these actions is the so called 20-20-20 legislative package. The 20’s mean that the E.U. will increase renewable energy’s share of production to 20 percent of the market, and there will be a 20 percent reduction in energy consumption in the E.U. by 2020 (European Commission, 2010).
The following are considered renewable energy sources by EU Directive 2001/77/EC (Klein, et al., 2008):

- Wind power (onshore and offshore)
- Solar power (photovoltaics and solar thermal electricity)
- Geothermal power
- Hydro power (small scale and large scale)
- Wave power
- Tidal power
- Biomass
- Biogas (including landfill and sewage gas).

E.U. member states have each set their own goals for renewable energy sources. Below are the goals of the four countries reviewed in this paper (Teckenburg, et al., 2011) including Sweden's voluntary increase from 49 to 50 percent (Bertilsson, 2011):

<table>
<thead>
<tr>
<th>EU Member State</th>
<th>RES in 2005</th>
<th>2020 RES Target</th>
<th>% increase required</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>10.3%</td>
<td>23%</td>
<td>12.7%</td>
</tr>
<tr>
<td>Germany</td>
<td>5.8%</td>
<td>18%</td>
<td>12.2%</td>
</tr>
<tr>
<td>Spain</td>
<td>8.7%</td>
<td>20%</td>
<td>11.3%</td>
</tr>
<tr>
<td>Sweden</td>
<td>39.8%</td>
<td>50%</td>
<td>9.2%</td>
</tr>
</tbody>
</table>

Table 1 Reviewed Countries RES Goals

Below is the projected wind capacity increases from each reviewed country (including both onshore and offshore projects) (Beurskens & Hekkenberg, 2011):

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>752</td>
<td>5,542</td>
<td>13,445</td>
<td>25,000</td>
<td>451</td>
</tr>
<tr>
<td>Germany</td>
<td>18,415</td>
<td>27,676</td>
<td>36,647</td>
<td>45,750</td>
<td>248</td>
</tr>
<tr>
<td>Spain</td>
<td>9,918</td>
<td>20,155</td>
<td>27,997</td>
<td>38,000</td>
<td>189</td>
</tr>
<tr>
<td>Sweden</td>
<td>536</td>
<td>1,873</td>
<td>3,210</td>
<td>4,547</td>
<td>243</td>
</tr>
</tbody>
</table>

Table 2 Reviewed Countries Projected Wind Capacity Increases

For many E.U. members, achieving these goals will mean significant investment in onshore and offshore wind power (Moccia, et al., 2011). Therefore, many governments have instituted different economic support methods to encourage the growth of wind power in their country.

The Different Types of Subsidies and Methods

Many types of economic supports have been implemented to promote wind and other renewables. The most popular of these are:

- Feed-In tariffs
- Fixed premiums
- Tendering systems
Unanalyzed Support Systems

A tendering support system is a simple option where an auction is held for the installation of wind projects. Bidders can purchase capacity based on set remuneration amounts per the power generated. Many E.U. countries have used this method in the past to support their wind projects and the U.K. is currently using it in conjunction with a certificate system for its offshore wind projects (Steinhilber, et al., 2011).

Investment incentives are another support and are simply a payment from the government to cover a business’s cost. The most basic investment incentive would be a set payment by the government to cover project installation costs. More advanced methods can take into account the production of the project to determine the amount of payment. For example the United States offered a thirty percent payment to cover wind project installation costs for projects started by 2011 (U.S. Department of Treasury, 2011).

Changes in tax laws are another economic support mechanism that can be used to favor renewables. These changes can be as simple as a lower tax rate on income from wind power projects, or an exemption from environmental surcharges. Others include allowing increased depreciation rates on equipment used in wind power. Both investment incentives and favorable tax laws can easily be used in conjunction with other supports.

Feed-in Tariffs

Feed-in tariffs can be broadly defined as regulations which obligate an electricity distribution utility to purchase electricity from an eligible renewable energy seller at specified prices. These tariff rates are normally set in a long term contract with guarantees and with predetermined rate changes. This in turn creates stability that allows the renewable energy producer to sell to the utility or receive amounts directly from the government at those set prices for that duration. However, tariffs are generally paid by grid operators who offset the tariff payments through increased billings to their customers. Currently, the feed-in tariff is the most popular support system in the world and in the E.U. (Hempling, et al., 2010).

A reason for its popularity is because a feed-in tariff is versatile with respect to its adjustability. A country can encourage any range of activities and technologies by adjusting the payment levels. Germany has several examples of this in its system, such as where it pays additional amounts for projects at different wind levels, and incentives are offered for projects to be constructed sooner (Bundestag, 2010).

Premium

Under the fixed premium method, the electricity fed into the grid is paid a premium in addition to the price paid by the electricity market. Generally, fixed premium subsidies also have
guaranteed contract periods in which a project can receive the premium payments and ensure grid access. The premiums, like the feed in tariffs, are frequently paid by grid operators who in turn collect the amount paid from their customers, but can also be paid directly by the government to the producer (Bökenkamp, et al., 2008). Like feed-in tariffs, the fixed premiums can be adjusted to encourage certain types of activities and technologies. For example, the Spanish premium pays a bonus for repowering and different rates for different types of renewables. Additionally, premium price floors and caps can be used to ensure the range of payments is neither too low to adequately subsidize the park for its costs, nor too high so that it results in excessive profits (Real Decreto 661/2007, 2007).

Green Certificates

The certificate system requires that a group in the energy supply chain have a certain quota of renewable electricity in the amounts they sell or buy. In the case of Sweden, the utilities are required to have a certain percentage of renewable energy in the amounts they sell to consumers. Every year the group must show it reached its quota by presenting the certificates it has purchased or traded. A certificate system can either cancel all the certificates produced in a year, or allow certificates to accumulate and be saved. The government can also provide technology banding by offering different payment levels for different technologies types and can provide waivers from the program for energy intensive industries. Like the feed-in tariff or the premium methods the costs of the quotas are generally being paid for by the end consumer. These systems must also have a penalty for failure to meet quota levels that is sufficiently high to encourage the purchase of the certificates (Bökenkamp, et al., 2008).

Methods for Determining Remuneration Amounts

The payment amounts for feed-in tariffs and fixed premiums are calculated a number of different ways. They can be based on the calculated adjusted cost of renewable energy generation as is done in Germany. They can also be calculated using the avoided cost of renewable energy generation. Alternatively, they can be based on a fixed price without relation to either the avoided cost or the adjusted cost. The last option would be to use a cost based on an auction or bidding process. The most common of these methods is to calculate the adjusted cost of wind power, which is used extensively throughout the member states of the European Union (Couture, et al., 2010).

The way the adjusted cost is determined varies from country to country, but it is normally based on a market study and analysis, an auction or an indexed profitability measure. With the market study method, the government generally reviews the costs of wind power projects and determines the amount of feed-in tariff or premium needed to make a profit for a standard, well run project. The auction method uses the free market, rather than analysis, to determine how much the tariff should be. The profitability measure simply establishes an expected profitability for a specific project and bases the tariff or premium on that amount. The market study method is the most widely used of the cost methods (Couture, et al., 2010).
Electricity Markets

The electricity markets are important for most subsidy systems, but are especially important for the fixed premium and green certificate policies which rely on market prices for a portion of their payments. The electricity market allows for the buying, selling and trading of electricity to cover shortages or to sell surpluses. The market also allows businesses to counteract some of the natural risks of purchasing a product with an inherently volatile price through hedging, which is an investment used to offset the risk of another investment. The prices for electricity on these markets normally operate on the principle of supply and demand unless there is government regulation or congestion in the system preventing it.

Within this market exists the spot market. The spot energy market allows producers of surplus energy to quickly find buyers and to negotiate prices while also delivering the actual energy a few minutes later. Depending on its setup the spot markets can allow for buying and selling an hour, half an hour or fifteen minutes before the delivery of electricity.

Countries Reviewed

France

France began using feed-in tariffs for wind in 2001 when their policy paid a set amount for onshore and offshore projects. This set amount, however, only lasted for the first five years of the project. After the first five years, the payment for the remaining ten years was adjusted to the wind resources at the site. This method uses the average full load hours of turbines at the project to determine the tariff amount. If a project has more than 3,600 average full load hours it will receive a minimum tariff amount and if it has 2,000 or less it will continue receiving the full tariff amount. Any load amount between the given payment points uses a linear interpolation to determine the tariff level. The program also has no caps on either capacity or total payments, but does require the project to be in a designated wind development area (Ministère de L’économie, des Finances et de L’industrie, 2001).

France reviewed their tariff law in 2006 and changed the period of set payments to the first 10 years of a projects life. The revised law continued the 3,600 average full load hour minimum payment boundary, but increased the range for the highest tariff rate to 2,400 full load hours for the remaining five years of the lease. The new law also added a separate tariff range for offshore wind projects that both gives higher tariff rates, a longer payment period and a new range with 3,900 full load hours for the minimum payment and 2,800 hours for the maximum payment. Both the on and offshore systems continue to use the linear interpolation between the given tariff levels to determine payments between the max, middle and minimum full load hours. The tariff rates are indexed to inflation for existing projects and the tariff amount is potentially subject to a 60% adjustment for changes in the labor and manufacturing costs of the project (Ministère de L’économie, des Finances et de L’industrie, 2006). The 2006 law was annulled due to a technicality in 2008 because of the legal opposition of a local group. The law was subsequently reinstated by the government, but the same opposition group has recently attempted to again stymie wind power investment based on another technical error that could
potentially temporarily halt the ability of the government to issue new power purchase contracts (Quilter, 2012).

The method used for determining the full load hours of a park will be further explained in the case study below.

**Germany**

Germany began its support of renewables in the early 1980’s by providing funding for research and development projects. In 1990 and 1991 Germany passed acts first calling for 250 MW of wind power development and then creating a national feed-in tariff. The feed-in tariff law required utilities to buy renewably generated electricity from other non-utility generators. The law set payments to a fixed 90 percent of the retail electricity price for wind power production. The utilities were also required to purchase a fixed percentage of their electricity from renewable sources and were also required to provide renewable generators access to the grid (Couture, et al., 2010). The act later capped the utilities requirement to pay the fixed prices when their renewables share reached five percent (Held, et al., 2007).

In 2000, in part due to a number of pressures on renewables from falling retail prices, Germany passed the Renewable Energy Sources Act (EEG) which unlinked the feed-in subsidy amounts from the retail prices and instead set a fixed price for a fixed period. The act also permitted utilities to participate and removed the caps on the share of renewables for payments by spreading costs to all grid operators. The act also added requirements that the payments for wind energy be differentiated based on wind resource quality after five years for the remaining lease period and added a payment degression for wind installed after 2001 (Bundestag, 2000). The resource quality differentiation was created to encourage a wider area of development in the country without giving larger payments to projects in high wind areas. The degression created was to encourage the use of state of the art technology in both manufacturing and energy production by adjusting the relative tariff amounts over time. The tariff rates were also set to be reviewed on a regular basis. Additionally, German transmission service providers were required to build grid connections to new wind parks (Held, et al., 2007).

In 2004, Germany reviewed its prior law and gave further incentives for increased power management at wind parks and adjusted the tariff rates for high wind and moderate wind areas. The 2004 Act also created high tariffs for offshore wind parks for the first 12 years of production. The annual degression for wind was also increased to two percent and incentives were given for the repowering of old wind parks (Bundestag, 2004). In 2009 and then in 2011 the law was again reviewed and revised to adjust the tariff rates for both on and offshore wind projects and slightly changed the repowering incentive calculations. The 2009 law also reduced the degression for onshore parks to one percent and increased the offshore degression to five percent after 2015. Unlike the prior laws the latest version of the EEG also gave incentives for both on and offshore parks to come into production by set dates. The program continues to have no caps on payments or capacity and maintains its 20 year maximum on receiving the tariff at any rate (Bundestag, 2010).
The method used for determining the resource quality in different locations will be further explained below in the case study.

Spain

The Spanish feed-in tariff policy began in 1997 with a law that created the Special Scheme rates for production facilities that used renewable energy sources and were less than 50 MW in size. The law also provided for grid access and a premium on payments for the renewable energy. The wind developer was still responsible for their physical connection to the grid. The law also set in place a plan to have 12 percent of Spain’s energy derived from renewable sources by 2010. In 1998 the first law was amended to further identify the renewable producer’s rights and to explain that the payments to the producers were the wholesale price plus a premium determined by the technology type. The first rates for the premiums under the Special Scheme were set in 1998 (Held, et al., 2007).

In 2004 the Spanish issued a new law modifying the Special Scheme again in an attempt to make it more stable. The law also created an option for the energy producer to choose between a fixed tariff rate (regulated tariff) or a premium and incentive amount on top of whatever the market paid. Producers were able to choose between the two methods for one year periods and either continue with that option or switch again. The law also introduced a forecasting penalty of 10 percent of the average tariff on the difference between the predicted and actual production, but only when the difference exceeded 20 percent for wind. The forecasting penalty did not take effect until 2006 (Real Decreto 436/2004, 2004).

The Special Scheme was once again modified in 2007. This scheme still allows a wind project to select either of the two payment methods noted above but introduced a ceiling and floor to the premium option to limit amounts paid out during high electricity prices. The law also added a bonus for repowering and gave an option to those on the fixed tariff option to receive differentiated rates based on peak and off peak times (Real Decreto 661/2007, 2007). In 2010 the Scheme was again modified for the years of 2011-2012. The 2010 modifications reduced the premium amount under the premium option by 35 percent. The ceiling and floor amounts (as indexed to CPI) remain unchanged. The law also limited the payment of the premium to 2,589 full load hours. This load hour cap only goes into effect when the entirety of the Spanish wind sector passes 2,350 full load hours a year (Real Decreto 1614/2010, 2010).

A graph showing an example of the ceiling and floor setup of the premium option is pictured below (Klein, et al., 2008):
Sweden began a carbon dioxide tax in 1991 and has had both investment grants and environmental bonuses for renewable energy sources (Widegren, 2011). In 2003, Sweden created a green certificate program in which renewable energy producers receive certificates for each MWh of electricity they produce. These certificates are then sold to electricity providers to augment the amounts the producer receives from their sales of electricity on the market. These electricity providers are in turn required to have a certain quota of renewable energy evidenced by the number of certificates they have purchased. These certificates have no set lower or upper price and their prices are directly related to the number required to be purchased and the number that have been produced. Electricity intensive businesses are exempted from the need to participate in the quota requirements. Each April certificates that were used in the prior year are cancelled and removed from system. Projects are allowed to receive the certificates for 15 years. Projects in Sweden are responsible for their own connections to the grid (Nilsson, et al., 2011).

The law originally was set to increase renewable generation by 17 TWh from 2002 to 2020. This increase was amended to 25 TWh. The law has also changed to extend the certificate system until 2030 to permit projects coming online in 2016 to receive certificates for the maximum 15 year period (Regeringskansliet, 2006). Additionally, in 2012 the certificate trading market was expanded so they could be bought and sold across a combined Swedish-Norwegian market. Both Sweden and Norway then agreed to jointly increase renewable production to 26.4 TWh (Senneroe & Fouche, 2010).

Sweden instituted the certificate system to create long term predictability for investors by moving the financing from the government to the market. This market financing was expected to help reduce costs of the program by only funding the most cost effective and productive
renewable energies (Widegren, 2011). Meaning the system does not include the technology banding option mentioned above.

The quota percentages per year are pictured below (Nilsson, et al., 2011):

<table>
<thead>
<tr>
<th>Year</th>
<th>Quota</th>
<th>Year</th>
<th>Quota</th>
<th>Year</th>
<th>Quota</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>0.074</td>
<td>2013</td>
<td>0.135</td>
<td>2023</td>
<td>0.17</td>
</tr>
<tr>
<td>2004</td>
<td>0.081</td>
<td>2014</td>
<td>0.142</td>
<td>2024</td>
<td>0.161</td>
</tr>
<tr>
<td>2005</td>
<td>0.104</td>
<td>2015</td>
<td>0.143</td>
<td>2025</td>
<td>0.149</td>
</tr>
<tr>
<td>2006</td>
<td>0.126</td>
<td>2016</td>
<td>0.144</td>
<td>2026</td>
<td>0.137</td>
</tr>
<tr>
<td>2007</td>
<td>0.151</td>
<td>2017</td>
<td>0.152</td>
<td>2027</td>
<td>0.124</td>
</tr>
<tr>
<td>2008</td>
<td>0.163</td>
<td>2018</td>
<td>0.168</td>
<td>2028</td>
<td>0.107</td>
</tr>
<tr>
<td>2009</td>
<td>0.17</td>
<td>2019</td>
<td>0.181</td>
<td>2029</td>
<td>0.092</td>
</tr>
<tr>
<td>2010</td>
<td>0.179</td>
<td>2020</td>
<td>0.195</td>
<td>2030</td>
<td>0.076</td>
</tr>
<tr>
<td>2011</td>
<td>0.179</td>
<td>2021</td>
<td>0.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>0.179</td>
<td>2022</td>
<td>0.18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 Swedish Green Certificate Purchase Quotas

CHAPTER VII
SUBSIDY COMPARISON

The following section will be a comparison of the economic support systems of France, Germany, Spain and Sweden using production data from a Swedish wind park.

Methodology

The time period of the review will be from January 2005 through December 2011 and the park will have been assumed to have been installed in January 2005. An additional review of the project’s final 13 years’ estimated income will also be done. The information will be calculated using whatever system was in effect in all countries at that time. Changes in a country’s subsidy system will result in a change in the calculations only if those changes specify that they will apply to wind parks installed before the change came into effect. This primarily applies to the Spanish system changes.

The actual income information from the Swedish wind park includes income amounts taken from the market rates but also amounts from purchase agreements. From September 2008 through December 2010 an agreement was in place to purchase the power generated from the park at a set rate. As a result, two Swedish calculations will be done, one for the actual park’s income data referred to as “Swedish Actual” and one for income as it would have been if taken from the variable market prices and is referred to as “Swedish Variable.”

The subsidy systems will be evaluated on actual production rates from the Swedish site, which has moderate production, as well as at rates 50 percent above and 25 percent below actual. This will show the difference between the systems at a low, medium and high production site. Additionally, Swedish market rates will be used for the Spanish premium calculations so the
results are consistent and comparable. As shown in the graph below, the Swedish and Spanish market rates, dark blue and red respectively, during this period were not unreasonably different (Ceña, et al., 2011):

Figure 3 European Spot Markets Graph

**German Reference Turbine**

As noted above the German system uses a reference turbine yield to determine the length of its introductory feed-in tariff rate. This reference turbine is of the same type as those installed in the project but its production is based on a set power-wind speed curve. The power yield from this reference turbine and reference site is then used to calculate a reference yield, which is the five year yield of the turbine if it were built on the reference site (Bundestag, 2004).

The reference site is a site determined by means of a Rayleigh distribution with a mean annual wind speed of 5.5 meters per second at a height of 30 meters above ground level, a logarithmic wind shear profile and a roughness length of 0.1 meters (Bundestag, 2004).

A turbine of the type in the Swedish wind park was placed in WindPRO (EMD International A/S, 2012), a wind energy project design and planning software, along with the reference site wind parameters as specified in the law. WindPRO was then used to calculate the reference yield. This reference yield at 150 percent was then used to compare the actual yield of the site to determine the length of the initial tariff rate. The reference yield at 150 percent was also used
to compare the 150 percent and 75 percent production levels to determine the length of the initial tariff rate.

As a result of the project start date, the German system will have a two percent degression applied to its initial and standard tariff amounts.

**French Load Hours**

The French wind subsidy system uses a payment rate based on the full load hours of the site after the end of the introductory period. Full load hours are determined by dividing the annual production of a turbine by its name plate rated power. The average full load hours were determined for each turbine in the park for the first five years to find the effective payment rates for the turbines at actual production and at 150 percent and 75 percent production.

The rates used for the French system will only be the initial rates in the law. No adjustments will be made to apply the inflation rate changes or for installation or operations and maintenance costs.

**Spanish System**

The Spanish system has been calculated on both the feed-in tariff and the fixed premium options as either may be chosen by a company from year to year. No forecasting errors will be assumed under any level of production.

**Swedish Green Certificate Market**

The Swedish system is subject to variations in two markets, the electricity market and the certificate market. As there is no ceiling or floor for the Swedish certificate market, the prices can, and have, varied widely over the review period. In 2010 there was a surplus of 5.5 million certificates which has caused a substantial drop in prices. Below is a graph showing the increasing certificate surplus (Nilsson, et al., 2011):
And below is a graph showing the variability of prices in the system since its creation in 2003 (CESAR Elcertifikat, 2012):

![Swedish Green Certificate Prices](image)

**Figure 4 Swedish Green Certificate Surplus**

**Figure 5 Swedish Green Certificate Prices**

**Results of Actual Production**

The below results are based on the actual production amounts of the nine turbines in the Swedish wind park without adjustment. The graphs and figures used in the remainder of this chapter are based on data from Siral AB (Siral AB, 2011), Nord Pool Spot (Nord Pool Spot, 2012), the German 2004 renewable energy law (Bundestag, 2004), the French 2001 renewable
energy law (Ministère de L’économie, des Finances et de L’industrie, 2001), and the Spanish wind remuneration rates from 2005 through 2011 (Ceña, et al., 2011).

**Total Income**

The below graph shows the comparative income from each of the subsidy methods using the actual production amounts from 2005 through 2011 (Graph and Table by Author):

![Total Income at Actual Production](image1)

**Figure 6 Total Income at Actual Production**

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden Actual Income</td>
<td>874,049</td>
<td>950,735</td>
<td>854,561</td>
<td>1,259,740</td>
<td>1,094,283</td>
<td>1,195,740</td>
<td>1,118,288</td>
<td>7,347,395</td>
</tr>
<tr>
<td>Sweden Variable Income</td>
<td>736,674</td>
<td>868,747</td>
<td>802,702</td>
<td>1,289,966</td>
<td>954,466</td>
<td>1,265,901</td>
<td>1,143,597</td>
<td>7,062,052</td>
</tr>
<tr>
<td>Germany Income</td>
<td>1,181,397</td>
<td>1,147,315</td>
<td>1,339,768</td>
<td>1,392,284</td>
<td>1,164,482</td>
<td>1,137,447</td>
<td>1,427,213</td>
<td>8,789,905</td>
</tr>
<tr>
<td>France Income</td>
<td>1,148,412</td>
<td>1,115,282</td>
<td>1,302,361</td>
<td>1,353,411</td>
<td>1,131,969</td>
<td>1,105,690</td>
<td>1,387,365</td>
<td>8,544,491</td>
</tr>
<tr>
<td>Spain Fixed Income</td>
<td>928,210</td>
<td>937,474</td>
<td>1,167,057</td>
<td>1,252,826</td>
<td>1,085,837</td>
<td>1,060,188</td>
<td>1,335,530</td>
<td>7,767,121</td>
</tr>
<tr>
<td>Spain Premium Income</td>
<td>981,230</td>
<td>1,198,917</td>
<td>1,135,187</td>
<td>1,323,396</td>
<td>1,045,408</td>
<td>1,121,907</td>
<td>1,337,183</td>
<td>8,143,228</td>
</tr>
</tbody>
</table>

**Table 4 Total Annual Incomes at Actual Production**

**Price per kWh**

The below graph shows the comparative price per kWh from each of the subsidy methods using the actual production amounts from 2005 through 2011 (Graph and Table by Author):
Price per kWh at Actual Production

The below graph shows the comparative variability from each of the subsidy methods using the actual production amounts from 2005 through 2011 (Graph and Table by Author):

**Table 5 Prices per kWh at Actual Production**

<table>
<thead>
<tr>
<th>Method</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden Actual Income</td>
<td>0.0629</td>
<td>0.0704</td>
<td>0.0542</td>
<td>0.0769</td>
<td>0.0799</td>
<td>0.0894</td>
<td>0.0666</td>
<td>0.0715 €</td>
</tr>
<tr>
<td>Sweden Variable Income</td>
<td>0.0530</td>
<td>0.0644</td>
<td>0.0509</td>
<td>0.0788</td>
<td>0.0697</td>
<td>0.0846</td>
<td>0.0681</td>
<td>0.0685 €</td>
</tr>
<tr>
<td>Germany Income</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850 €</td>
</tr>
<tr>
<td>France Income</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838 €</td>
</tr>
<tr>
<td>Spain Fixed Income</td>
<td>0.0658</td>
<td>0.0689</td>
<td>0.0732</td>
<td>0.0757</td>
<td>0.0782</td>
<td>0.0775</td>
<td>0.0791</td>
<td>0.0741 €</td>
</tr>
<tr>
<td>Spain Premium Income</td>
<td>0.0706</td>
<td>0.0888</td>
<td>0.0720</td>
<td>0.0808</td>
<td>0.0763</td>
<td>0.0838</td>
<td>0.0796</td>
<td>0.0789 €</td>
</tr>
</tbody>
</table>

**Price Variability**

The below graph shows the comparative variability from each of the subsidy methods using the actual production amounts from 2005 through 2011 (Graph and Table by Author):
The below results are based on the actual production of the Swedish wind park with a 25% reduction.

**Total Income**

The below graph shows the comparative income from each of the subsidy methods using the actual production amounts with a 25 percent reduction from 2005 through 2011 (Graph and Table by Author):
Figure 9 Total Income at 75 Percent Production

Table 7 Total Annual Incomes at 75 Percent Production

Price per kWh

The below graph shows the comparative price per kWh from each of the subsidy methods using the actual production amounts with a 25% reduction from 2005 through 2011 (Graph and Table by Author):
Price Variability

The below graph shows the comparative variability from each of the subsidy methods using the actual production amounts with a 25 percent reduction from 2005 through 2011 (Graph and Table by Author):
Results of Actual Production Increased 50 Percent

The below results are based on the actual production of the Swedish wind park with a 50 percent increase.

Total Income

The below graph shows the comparative income from each of the subsidy methods using the actual production amounts with a 50 percent increase from 2005 through 2011 (Graph and Table by Author):

Figure 11 Price per kWh Variability at 75 Percent Production

Table 9 Prices per kWh Variability at 75 Percent Production
The below graph shows the comparative price per kWh from each of the subsidy methods using the actual production amounts with a 50 percent increase from 2005 through 2011 (Graph and Table by Author):
Price Variability

The below graph shows the comparative variability from each of the subsidy methods using the actual production amounts with a 50 percent increase from 2005 through 2011 (Graph and Table by Author):
German and French Payment Changes

This section examines the changes in payment rates related to the tariff declines in the German and French subsidy systems at the three different levels of production.

**Payment Differences between Production Levels**

The below graph shows the comparative differences in the German and French subsidy methods for the prices per kWh using the actual production as well as the 150 percent production for 2005 through 2011 (Graph and Table by Author):
German Extend Introductory Tariff Periods Comparison

The below graph shows the number of months the introductory tariff period was extended in the German system based on the three production levels (Graph by Author).

![Graph showing the number of months the introductory tariff period was extended in the German system based on three production levels.](image)

**Table 13 German and French Tariff Drop at Actual to 150 Percent Production**

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany Actual Production</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
</tr>
<tr>
<td>Germany 150% Production</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0850</td>
<td>0.0703</td>
<td>0.0546</td>
</tr>
<tr>
<td>German Percent Difference</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>-17%</td>
<td>-36%</td>
</tr>
<tr>
<td>French Actual Production</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
</tr>
<tr>
<td>French 150% Production</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0838</td>
<td>0.0516</td>
<td>0.0516</td>
</tr>
<tr>
<td>French Percent Difference</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>-38%</td>
<td>-38%</td>
</tr>
</tbody>
</table>
The internal rate of return (IRR) formula is used by a business to determine the efficiency of a project's use of a business's money. If the project returns an IRR greater than the company's cost of capital it should be considered, if it does not it should be discarded. The net present value (NPV) on the other hand measures only the amount a project will return to the company at a set cost of capital. If the project returns an amount greater than zero it should be considered, but if it returns a negative value it should not be undertaken. Both of these formulas use the time value of money concept, where future payments are discounted back to the present. More simply put, the amounts received in year one are considered to be more valuable than a payment of an equal amount in following years. The value of one euro paid to the company will decrease every additional year it is separated from the present.

The below tables show the relative internal rates of return and net present values for each country's system under the three different production levels during the first seven years of production using a cost of capital of 10 percent and an initial investment of five million euro. No operations and maintenance costs are included (Tables by Author).

### Table 14 NPV and IRR at Actual Production

<table>
<thead>
<tr>
<th>Country</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>NPV</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden Actual Income</td>
<td>874,049</td>
<td>950,735</td>
<td>854,561</td>
<td>1,259,740</td>
<td>1,094,283</td>
<td>1,195,740</td>
<td>1,118,288</td>
<td>11,071 €</td>
<td>10%</td>
</tr>
<tr>
<td>Sweden Variable Income</td>
<td>736,674</td>
<td>868,747</td>
<td>802,702</td>
<td>1,289,966</td>
<td>954,466</td>
<td>1,265,901</td>
<td>1,143,597</td>
<td>-234,116 €</td>
<td>9%</td>
</tr>
<tr>
<td>Germany Income</td>
<td>1,181,397</td>
<td>1,147,315</td>
<td>1,339,768</td>
<td>1,392,284</td>
<td>1,164,482</td>
<td>1,137,447</td>
<td>1,143,597</td>
<td>1,077,224 €</td>
<td>16%</td>
</tr>
<tr>
<td>France Income</td>
<td>1,148,412</td>
<td>1,115,282</td>
<td>1,302,361</td>
<td>1,353,411</td>
<td>1,131,969</td>
<td>1,105,690</td>
<td>1,387,365</td>
<td>907,547 €</td>
<td>15%</td>
</tr>
<tr>
<td>Spain Fixed Income</td>
<td>928,210</td>
<td>937,474</td>
<td>1,167,057</td>
<td>1,252,826</td>
<td>1,085,837</td>
<td>1,060,188</td>
<td>1,335,530</td>
<td>309,129 €</td>
<td>12%</td>
</tr>
<tr>
<td>Spain Premium Income</td>
<td>981,230</td>
<td>1,198,917</td>
<td>1,135,187</td>
<td>1,323,396</td>
<td>1,045,408</td>
<td>1,121,907</td>
<td>1,337,183</td>
<td>608,238 €</td>
<td>13%</td>
</tr>
</tbody>
</table>
75 Percent Production Levels:

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>NPV</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden Actual Income</td>
<td>655,536</td>
<td>713,051</td>
<td>640,920</td>
<td>944,805</td>
<td>820,713</td>
<td>896,805</td>
<td>838,716</td>
<td>-1,241,697 €</td>
<td>2%</td>
</tr>
<tr>
<td>Sweden Variable Income</td>
<td>552,505</td>
<td>651,560</td>
<td>602,026</td>
<td>967,474</td>
<td>715,850</td>
<td>949,426</td>
<td>857,697</td>
<td>-1,425,587 €</td>
<td>1%</td>
</tr>
<tr>
<td>Germany Income</td>
<td>886,047</td>
<td>860,486</td>
<td>1,004,826</td>
<td>1,044,213</td>
<td>873,361</td>
<td>853,085</td>
<td>1,070,410</td>
<td>-442,082 €</td>
<td>7%</td>
</tr>
<tr>
<td>France Income</td>
<td>873,539</td>
<td>848,338</td>
<td>990,640</td>
<td>1,029,471</td>
<td>861,031</td>
<td>841,042</td>
<td>1,055,298</td>
<td>-506,429 €</td>
<td>7%</td>
</tr>
<tr>
<td>Spain Fixed Income</td>
<td>686,354</td>
<td>697,814</td>
<td>865,663</td>
<td>929,730</td>
<td>803,318</td>
<td>777,522</td>
<td>995,909</td>
<td>-1,065,185 €</td>
<td>3%</td>
</tr>
<tr>
<td>Spain Premium Income</td>
<td>735,922</td>
<td>899,188</td>
<td>851,390</td>
<td>992,547</td>
<td>784,056</td>
<td>841,430</td>
<td>1,002,887</td>
<td>-793,822 €</td>
<td>5%</td>
</tr>
</tbody>
</table>

Table 15 NPV and IRR at 75 percent Production

150 Percent Production Levels:

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>NPV</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden Actual Income</td>
<td>1,311,073</td>
<td>1,426,103</td>
<td>1,281,841</td>
<td>1,889,610</td>
<td>1,793,610</td>
<td>1,677,432</td>
<td>2,516,606 €</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>Sweden Variable Income</td>
<td>1,105,011</td>
<td>1,303,120</td>
<td>1,204,052</td>
<td>1,934,948</td>
<td>1,431,699</td>
<td>1,898,852</td>
<td>1,715,395</td>
<td>2,148,826 €</td>
<td>21%</td>
</tr>
<tr>
<td>Germany Income</td>
<td>1,772,095</td>
<td>1,720,972</td>
<td>2,009,652</td>
<td>2,088,426</td>
<td>1,746,722</td>
<td>1,411,378</td>
<td>1,376,141</td>
<td>3,557,031 €</td>
<td>30%</td>
</tr>
<tr>
<td>France Income</td>
<td>1,747,077</td>
<td>1,696,676</td>
<td>1,981,280</td>
<td>2,058,942</td>
<td>1,722,063</td>
<td>1,035,151</td>
<td>1,298,371</td>
<td>3,205,164 €</td>
<td>29%</td>
</tr>
<tr>
<td>Spain Fixed Income</td>
<td>1,372,709</td>
<td>1,395,627</td>
<td>1,731,327</td>
<td>1,859,460</td>
<td>1,606,635</td>
<td>1,555,044</td>
<td>1,991,819</td>
<td>2,869,630 €</td>
<td>25%</td>
</tr>
<tr>
<td>Spain Premium Income</td>
<td>1,471,845</td>
<td>1,798,376</td>
<td>1,702,781</td>
<td>1,985,094</td>
<td>1,568,112</td>
<td>1,682,860</td>
<td>2,005,774</td>
<td>3,412,356 €</td>
<td>28%</td>
</tr>
</tbody>
</table>

Table 16 NPV and IRR at 150 Percent Production

Estimated Future Returns for 20 Year Period

This section will review the future estimated payments to the park up to year 20 under each subsidy system using a series of averages and estimates. No estimate will be done for the Swedish Actual income as it would follow the Swedish Variable income values as no future purchase agreements will be estimated.

For the systems where support ends after 15 years the park is assumed to have continued to operate and sell its production at the average market price until the end of year 20.

Total Income for Project Life of 20 Years Using both Estimated and Actual Data

The below charts show the total income from each of the subsidy methods using the real and estimated actual production income amounts, the real and estimated 75 percent production income amounts and the real and estimated 150 percent production income amounts from 2005 through 2024 (Tables by Author).

Actual Production Income Estimated for 20 Years:
### Table 17 20 Year Annual Income at Actual Production Level

#### 75 Percent Production Income Estimated for 20 Years:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden Variable Income</td>
<td>7,062,952 €</td>
<td>1,057,862</td>
<td>1,057,862</td>
<td>1,057,862</td>
<td>1,057,862</td>
<td>1,057,862</td>
<td>1,057,862</td>
<td>1,057,862</td>
<td>1,057,862</td>
<td>1,057,862</td>
<td>635,328</td>
<td>635,328</td>
<td>635,328</td>
<td>635,328</td>
<td>18,701,592 €</td>
</tr>
<tr>
<td>Germany Income</td>
<td>8,789,905 €</td>
<td>1,255,701</td>
<td>1,255,701</td>
<td>1,255,701</td>
<td>1,255,701</td>
<td>1,255,701</td>
<td>1,255,701</td>
<td>1,255,701</td>
<td>1,255,701</td>
<td>797,739</td>
<td>797,739</td>
<td>797,739</td>
<td>797,739</td>
<td>18,789,874 €</td>
<td></td>
</tr>
<tr>
<td>France Income</td>
<td>8,544,401 €</td>
<td>1,237,973</td>
<td>1,237,973</td>
<td>1,237,973</td>
<td>1,237,973</td>
<td>1,237,973</td>
<td>1,237,973</td>
<td>1,237,973</td>
<td>1,237,973</td>
<td>1,237,973</td>
<td>635,328</td>
<td>635,328</td>
<td>635,328</td>
<td>635,328</td>
<td>16,624,917 €</td>
</tr>
<tr>
<td>Spain Fixed Income</td>
<td>7,767,121 €</td>
<td>1,144,904</td>
<td>1,144,904</td>
<td>1,144,904</td>
<td>1,144,904</td>
<td>1,144,904</td>
<td>1,144,904</td>
<td>1,144,904</td>
<td>1,144,904</td>
<td>1,144,904</td>
<td>22,550,867 €</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain Premium Income</td>
<td>8,143,228 €</td>
<td>1,137,148</td>
<td>1,137,148</td>
<td>1,137,148</td>
<td>1,137,148</td>
<td>1,137,148</td>
<td>1,137,148</td>
<td>1,137,148</td>
<td>1,137,148</td>
<td>1,137,148</td>
<td>22,926,149 €</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 18 20 Year Annual Income at 75 percent Production Level

#### 150 Percent Production Income Estimated for 20 Years:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden Variable Income</td>
<td>5,206,589 €</td>
<td>793,397</td>
<td>793,397</td>
<td>793,397</td>
<td>793,397</td>
<td>793,397</td>
<td>793,397</td>
<td>793,397</td>
<td>793,397</td>
<td>476,406</td>
<td>476,406</td>
<td>476,406</td>
<td>476,406</td>
<td>14,035,194 €</td>
<td></td>
</tr>
<tr>
<td>Germany Income</td>
<td>6,392,429 €</td>
<td>941,776</td>
<td>941,776</td>
<td>941,776</td>
<td>941,776</td>
<td>941,776</td>
<td>941,776</td>
<td>941,776</td>
<td>941,776</td>
<td>725,389</td>
<td>598,304</td>
<td>598,304</td>
<td>598,304</td>
<td>17,588,701 €</td>
<td></td>
</tr>
<tr>
<td>France Income</td>
<td>6,499,599 €</td>
<td>928,480</td>
<td>928,480</td>
<td>928,480</td>
<td>928,480</td>
<td>928,480</td>
<td>928,480</td>
<td>928,480</td>
<td>928,480</td>
<td>476,406</td>
<td>476,406</td>
<td>476,406</td>
<td>476,406</td>
<td>16,309,679 €</td>
<td></td>
</tr>
<tr>
<td>Spain Fixed Income</td>
<td>5,756,311 €</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>858,678</td>
<td>16,919,120 €</td>
<td></td>
</tr>
</tbody>
</table>

### Table 19 20 Year Annual Income at 150 Percent Production Level

#### Rates of Return and Net Present Values for Project Life of 20 Years Using both Estimated and Actual Data

The below tables show the relative internal rates of return and net present values for each country’s system under the three different production levels during the 20 year life of the project using a cost of capital of 10 percent and an initial investment of five million euro. No operations and maintenance costs are included (Tables by Author).

Actual Production Levels:
CHAPTER VII
ANALYSIS AND DISCUSSION OF RESULTS

This section will discuss the above results and identify any items of particular interest.

Total Income

The total incomes of the different systems show that for the first seven years under two of the three production situations, the German system will result in the highest income and that Spain will have the highest income when production is at 150 percent. At seven years, the French system is second highest under all but the 150 percent production level, where it falls behind both Spain and Germany. For the full life of the project Germany only has the highest income at 75 percent production, while the Spanish Premium option leads both actual and 150 percent production. It should also be noted that using the average production, spot rates and green certificate rates allow the Swedish Variable system to pass both France and Germany’s project lifetime incomes at 150 percent production levels.
The Spanish premium option comes in third for the first seven years at the 75 percent and actual production levels. The Swedish system has the lowest income under all three production levels for the first seven years. The Swedish system does manage in 2010 to have the highest income of all systems. This jump is likely due to the two spikes in the Swedish spot prices in 2010 and high Green Certificate prices in early 2010.

As can be seen above, the park’s production was highest in 2011 and at the actual production level all systems but Sweden’s posted their highest income amounts that year. The Swedish systems had their highest income year in 2010 at all three production levels. The Swedish 2010 total income was over 11 percent higher than 2011 despite 2011’s production being over 23 percent higher.

**Figure 17 Nord Pool Spot Rates 2004-2011 (Sweden)**

**Price per kWh**

The price per kWh results are perhaps clearer in showing the actual potential profitability under the different production levels. This is especially true when they are reviewed in concert with German extended initial tariff months and French full load calculations. Looking only at total income amounts at seven years, it may appear that the German system is superior to the others under the 75 percent and actual production levels and will continue to perform well at 150 percent. This is clearly not the case when looking at the price per kWh and the initial tariff months remaining. With the actual production level the German system can be expected to maintain its overall income dominance for another three and half to four and half years. With the 75 percent production the German system will remain the highest producer for the entirety of the project’s contract life of 20 years. At 150 percent production, the project has already used up its initial tariff and has already fallen behind the Spanish premium option and will likely fall behind most of the other systems in both total income and average price per kWh by year 10 of the project’s life.
The French system has a similar experience to the German after the initial five years at the 150 percent production. Rather than going down to the fixed 5.4 euro cents per kWh like Germany the French payment can potentially drop from 8.38 cents to 3.05 cents. However, even at 150 percent production this project’s full load hours did not pass the 3,600 mark which would have caused the drop to that minimum payment level. The location would have had to have been 200 percent more productive than it actually was to receive the lowest amount per kWh. At 150 percent production the park averaged nearly 2,900 full load hours resulting in a payment of 5.16 eurocents per kWh. Under the other two levels of production the park had less than 2,000 full load hours and would continue receiving the maximum payment per kWh for the remaining 10 years of the French contract.

![French 2001 Subsidy Payment Scale for Last 10 Years of Production](image)

**Figure 18 French 2001 Subsidy Payment Rate Scale for Last 10 Years of Production**

**Price Variability**

One component business’s use in making investments is the stability and assurance of payments. The more volatile a project’s payments the higher the return a business will require from the project. From the graphs above it is obvious that under the actual and 75 percent production levels that the German and French systems have no variability for the first seven years. What should also be understood is that this low variability will continue for at least 3 years for the German system and 10 years for the French system at actual production levels. Only at 150 Percent production do those systems gain some variability after the first five years. After this their variability returns to zero for the remaining contract periods. It should also be noted that in both cases the decrease in payment rate should be reasonably easy to anticipate and plan for.

The Spanish options both have some mild variability. The premium option had more variability prior to the institution of the price ceilings and floors in 2007. The fixed option is variable due
to its linkage to the CPI. The overall price variability under both options is limited in the future, at least concerning variations in the market price of electricity.

The Swedish options on the other hand are significantly more variable than any of the other methods and are nearly twice so much as the Spanish premium option. Unlike the French and German systems, these changes are largely unpredictable from year to year and unlike the Spanish premium option there is no cap or floor to control the range of change. From 2010 to 2011 the Swedish system went from having the highest price per kWh to the lowest with a drop in price of nearly 30 percent. Comparing the two Swedish systems it becomes clear that in 2008 through 2010 the purchase agreement helped reduce the variability of the system by stabilizing the electricity price, but the agreement could not reduce the variability in green certificate market.

**Payment Timing**

Payment timing is also heavily weighted in determining if a business should undertake a project. Wind power projects are capital intensive during construction and are relatively cheap to maintain after that point. Projects that are able to pay their initial investment back sooner will be more interesting to businesses because they are more attractive to investors and banks that prefer to get their investment or loan amounts back as soon as possible. Looking at the above systems, the German and French ensure larger payments in the first five years of a project’s life by guaranteeing a minimum rate. The Spanish regulated payment provides a fairly set rate for the entirety of a projects life, but does not have larger early rates. The Spanish premium option is less secure, but does provide a lower range for rates. The Swedish option has no assurance of any rate at any point in the project’s life. An example of the Swedish systems lack of assurance can be seen in year 6 of the project’s life. That year the system has the highest income of the compared countries but the discounted value of that payment is about 62 percent of what it would have been had it been made in year 1.

Looking at the IRR and NPV values for the projects it is unsurprising that the formulas heavily favor the options with the higher upfront payment rates at both the 7 and 20 year periods. What also can be seen is that even heavily discounted future payments can adjust the rankings. On a seven year horizon at 150 percent production all reviewed systems are very profitable and at 75 percent production none should be undertaken. By 20 years even the 75 percent production income results in positive NPVs. It is apparent that in both the 7 and 20 year charts there is some disagreement on the ranking of the subsidy systems between NPV and IRR. This is due to the method in which the formulas work. NPV uses the cost of capital rate to discount cash flows and reinvest them while IRR arbitrarily chooses the rate that causes the NPV to equal zero and uses the same rate to reinvest them. When there are conflicts between the two the NPV should be used.

It should also be noted that using the 10 percent cost of capital rate for all systems is disproportionately favorable to Sweden and to a lesser extent Spain’s market option. The returns in both systems are variable, especially in Sweden where the payment amounts are determined by the two separate markets without a price ceiling or a floor. This means that
investors and banks would require a higher return from projects in Sweden and Spain than under the stable and predictable German system to account for the additional risk.

Other Items

Some items not discussed above still have bearing on the question of which support system is the most attractive to businesses. This includes political risk related to the stability of the payment rates and willingness to support the subsidy long term. In the legal framework section its apparent that countries like Germany have shown they are willing to maintain their support for wind power over a long period of time and follow a relatively unchanging design. Of all the systems reviewed the German is the only that does not have an inflation adjustment, but this can also be seen as a positive from the perspective of the law being simple and clear.

France started later than Germany but continues to use substantially the same design in its programs. Its legislation includes an inflation adjustment for the tariff rates which means the payment rates will increase accordingly, but does add a small level of complexity to the law. As noted before, the tariff increases were not calculated into the French payments so the calculated amounts are less than what the actual payments would have been.

Spain has had its program in place for longer than France and followed a relatively stable progression until 2007. In 2010 the government issued retroactive changes to its photovoltaic rates (Real Decreto 1614/2010, 2010). While this doesn't directly affect the wind power payment rates it does show that the government can, and will, enact retroactive changes in its laws. In addition to numerous legal changes the Spanish government is also experiencing an electrical system deficit in excess of 24 billion euro that, to some extent, was caused by its feed-in tariff and premium options. This deficit has resulted in the Spanish government announcing in 2012 it would, temporarily, not accept any new feed-in tariff and premium contracts starting in 2013 (Couture, 2012). This halt in contracts will essentially stop all new development of wind power in the country for the foreseeable future. A graph of the deficit can be found below (Couture, 2012):
Sweden began its current system in 2003 and has made some small changes to it but overall has remained stable in its support. In 2012, after many years of negotiation, the Swedish green certificate program expanded to include Norway. This merger is hoped to increase the economic efficiency of the certificate market and decrease the certificate surplus, but as with any agreement between two countries, there is increased political risk (Senneroe & Fouche, 2010). How this change will affect the attractiveness of the system to businesses remains to be seen as the certificate prices remain very low and the overall system will likely remain more volatile than many other renewable support systems. The high volatility in payments and subsequent increase in the cost of borrowing may over time result in what would be considered good projects in Sweden not being undertaken by businesses that need to seek financing on the open market. This in turn may result in those same projects instead being developed by larger and more established businesses that are able to self finance or simply not being developed.

Other items that may directly affect a business’s decision to invest in a country could be the local acceptance levels, land leasing costs, amount and quality of supporting infrastructure, local labor costs, general legal and administrative complexities, other economic and non-economic supports offered by the government and home bias among many others. To varying degrees, any of these can make a country’s financial support system more or less relevant to a business’s desire to build a wind project there.

CHAPTER IX
CONCLUSION AND RECOMMENDATIONS

The recent market downturn has placed pressure on almost all businesses trying to get new project financing. As a result, businesses trying to build new wind parks are forced to be even more selective in project siting and more diligent in wind assessments. Whenever possible, businesses will choose sites that have the fewest or most manageable and predictable
challenges. The review of the support systems in these four countries identifies two primary externalities, the political risks and payment risks, which both directly affect a business's ability to maximize profits.

At 75 and 100 percent production the French and German systems remain nearly identical for variability and payment rates for the first 7 years of the project's life. The Spanish options continue to yield reasonable returns with reasonable variability. At 150 percent production, the French and German systems split and the German system comes out slightly ahead. Both France and Germany experience a small amount of variability, but nowhere near the levels of the Swedish system. The Spanish options again produce respectable returns with only mild variability. For the first seven years at all production levels the Swedish system remains unattractive for both its low annual income and high variability.

Expanding the analysis of income to the full 20 year project life, the French and German systems become less attractive at the actual and 150 percent production levels. On the same timeline the Spanish premium system becomes the income leader at both those stages. The Swedish system even becomes more attractive for total income than the German and French systems at high production. These 20 year results are only estimates to show how the systems may look under a very stable set of circumstances. This artificial creation of stability in market prices creates a very attractive environment for the Spanish and Swedish systems. It should also be noted that both the German and French systems were created in ways that reduce windfall payments to highly productive wind parks (Bundestag, 2004), (Ministère de L'économie, des Finances et de L'industrie, 2001). At 150 percent production it becomes apparent the German and French systems are at least partially successful in reducing excessive payments to an already successful park.

Based on the income and variability results alone, it would appear that if a business wanted to build a project with moderate wind resources, it should do so in Germany or France. If it were building in an area with lower wind resources it would again prefer Germany or France. Only if a business was building at a location with high winds would its first choice be the Spanish premium option. However, these choices need to also be tempered by the political risks attributed to each country. This political risk does not change the actual and low level production choices as the German system seems stable. Only at high production does the political risk change the system preference for businesses. This increased risk makes the Swedish system, generally the lowest performer, more attractive than the highest, Spain.

The German system offers stability for both the political and payment rate criteria and even pays higher rates in the beginning. However, Germany does not provide incentives for building in highly productive areas or have adjustments for inflation. The Swedish system is stable politically, but is the least stable in payment amounts, and could easily improve by having technology banding and a price floor like in the Spanish premium system. The need for a floor is made all the more apparent by the Swedish Actual systems 2010 results. After its market price variability was eliminated with a purchase contract, it still had the highest variability in price per kWh when compared to the other countries. The French system, like the German system, offers both political and payment stability but could be made more attractive by increasing its
contract from 15 to 20 years. And finally the Spanish premium system is neither stable politically or completely stable in its payment rates, but through the market has offered incentives to build in highly productive areas. The Spanish system is the most difficult to improve as its largest drawbacks stem from its political risks.

This paper’s results can be used to give an idea of what income and political risks businesses can expect to encounter in the four countries reviewed under differing production levels. It can also be used to roughly determine whether two locations in two countries with differing wind resources have the same income potential and risk. Once that basic evaluation has been done the other externalities mentioned above can be added into the business’s calculations to determine its best choice. Ultimately a business’s preference for a subsidy system is based on the productivity of the chosen site. If a business has a lower wind location it should prefer the German or French system to maximize its profits, if it has a higher wind location it would prefer a system similar to the Spanish system but with only a price floor and no ceiling and substantially more political stability to maximize its profits.

Businesses prefer to build under a system that provides the most favorable benefits at all times to their specific set of circumstances. Since no such system exists, and as the EU continues to struggle to regain its economic footing, the days of attractive fixed feed-in tariffs may be limited. This will continue to be the case as long as more countries turn to market based options like the green certificates, as Great Britain has, or simply decide that they are unable to afford to support new renewable development at this time, like Spain.

While the 20-20-20 goals may continue to drive many countries forward in their support of renewables for now, it is far from assured they will continue to do so if the European economy remains weak or worsens.

CHAPTER X
ADDITIONAL RESEARCH

This paper attempts to show which of four countries has the best support system for wind power projects based on a limited number of criteria. These criteria were: Payment amount, payment timing and payment variability, as well as the countries’ political risks related to the subsidy. Additional studies are recommended to expand on this work by either increasing the number of countries’ systems to be reviewed or increase the number of criteria to evaluate them by or both. A study that increases the number of countries and criteria reviewed will give a better understanding of the respective differences for businesses seeking new investment opportunities.

Additionally, a study comparing a number of actual sites with similar wind energy profiles across several countries would provide excellent data on which country has the best system for the largest number of criteria without the need for excessive estimations or guesses.
BIBLIOGRAPHY


Bökenkamp, G. o.a., 2008. Report on policy assessment of instruments to internalise environment related external costs in EU member states, via promotion of renewables, u.o.: University of Flensburg.


Ceña, A. o.a., 2011. Asociación Empresarial Eólica la Referencia del Sector, u.o.: Asociación Empresarial Eólica.


Held, A. o.a., 2007. Feed-In Systems in Germany, Spain and Slovenia, Karlsruhe: u.n.


Steinhilber, S. o.a., 2011. *Indicators assessing the performance of renewable energy support policies in 27 Member States*, u.o.: Intelligent Energy Europe.


APPENDICES

Appendix 1. Sweden Actual Site Income Currency Conversion

Both the market income and certificate income from the actual site was provided in SEK and needed to be converted to euro. The total number of SEK paid for each at the end of year was then multiplied by the below respective average exchange rate to obtain the payment in euro (Oanda, 2012).

<table>
<thead>
<tr>
<th>Year</th>
<th>SEK to Euro Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>0.1077</td>
</tr>
<tr>
<td>2006</td>
<td>0.1080</td>
</tr>
<tr>
<td>2007</td>
<td>0.1081</td>
</tr>
<tr>
<td>2008</td>
<td>0.1041</td>
</tr>
<tr>
<td>2009</td>
<td>0.0942</td>
</tr>
<tr>
<td>2010</td>
<td>0.1048</td>
</tr>
<tr>
<td>2011</td>
<td>0.1107</td>
</tr>
</tbody>
</table>

Appendix 2. Sweden Variable Income

To determine the Swedish variable income first the electricity spot market prices were obtained from Nord Pool’s website, nordpoolspot.com. Once all monthly data from 2005 to 2011 was downloaded, the monthly spot rate was then multiplied by its corresponding actual production to obtain the electricity market payment. The electricity market payment was then added to the certificate payment to arrive at a total monthly payment.

For the 75 percent and 150 percent production levels no changes were made to the above method beyond the production adjustment.

Appendix 3. German System Income

To determine the German system’s income, total production was assigned to its respective turbine on a monthly basis. The sum of the first five years production for each turbine was then determined and subtracted by 5 times the annual reference yield increased 150 percent. The difference between the two was then converted to a percent by dividing the difference by five times the annual reference yield increased 150 percent. The resulting percentage was then divided by .75 percent to find a number that when multiplied by 2 equaled the additional months that the specific turbine would receive the introductory tariff rate. This was repeated for each turbine and the total months for each production level are shown in a graph above.

For the first five years of the projects life, total kWh production was multiplied by the introductory rate of 8.5 eurocents, to get monthly income amounts. After the first five years the introductory rate continued until the point determined in the above paragraph after which
production was multiplied by the standard rate of 5.4 eurocents to get monthly income amounts.

For the 75 percent and 150 percent production levels no changes were made to the above method beyond the production adjustment.

**Appendix 4. French System Income**

To determine the French system’s income total production was again assigned to its respective turbine on a monthly basis. The production of each turbine totaled each year and divided by the turbines rated power to get its annual full load hours. The annual full load hours for the first five years of each turbine’s life were averaged to get an average annual full load hour amount. This average full load hour number was then compared to the 2001 French payment scale to determine the prescribed payment per kWh for each turbine for the remaining 10 years of the payment contract.

For the 75 percent and 150 percent production levels no changes were made to the above method beyond the production adjustment.

**Appendix 5. Spanish Regulated System Income**

To determine the Spanish regulated system’s income the annual production for the park was multiplied by the amount set by the Spanish government per kWh.

For the 75 percent and 150 percent production levels no changes were made to the above method beyond the production adjustment.

**Appendix 6. Spanish Premium System Income**

To determine the Spanish premium option’s income in 2005 and 2006 the monthly park production was multiplied by the sum of the corresponding Nord Pool monthly spot electricity price and the premium amount per kWh set by the Spanish government. To determine the Spanish premium option income after 2006 the monthly park production was multiplied by the sum of the corresponding Nord Pool monthly spot electricity price and the premium amount per kWh set by the Spanish government within the given bands. However, if the market price plus the premium was less than the lower payment band the lower payment band amount would instead be used. Or if the sum of market price plus the premium amount was greater than upper band only the upper band amount would be used. Additionally if the market price itself was greater than the upper band amount only the market price would be used.

Below are the ceiling and floor bands instituted after 2007 along with the corresponding premium amount (Ceña, et al., 2011):
For the 75 percent and 150 percent production levels no changes were made to the above method beyond the production adjustment.

Appendix 7. Total Annual System Incomes for the First 7 Years

Total annual incomes from each system were determined by following the methods outlined above for each year and then adding all seven years together for each system.

Appendix 8. Total Annual System Incomes for 20 Years

The total annual income for each system for the first seven years were determined in Appendix 7. The remaining 13 years incomes were calculated in the following manners.

The average annual production for each level of production was determined from the seven years of actual data. The average spot market price was also determined for the period of 2005 through 2011. The average green certificate price was determined from 2003 through 2011. Average production was used to get the average number of certificates received at each level of production.

In the German system the average annual production was multiplied by either the introductory rate or the standard payment rate per kWh depending on the number of additional introductory period months determined as in Appendix 3 to get find the average annual income.

In the French system the effective payment rate determined Appendix 4 was multiplied by the average annual production to determine the average annual income. After the contract period ended the average annual production amount was multiplied by the average spot market price to get the average market payment which was then used as the average annual income for the remaining five years.

In the Spanish regulated option the average annual production was multiplied by an estimated set rate of 7.75 eurocents per kWh to determine average annual income.

In the Spanish market option the average spot market price was added to the 2011 premium rate and then compared to the 2011 ceiling and floor levels. The amount was less than the floor level so the floor amount of 7.6975 eurocents was multiplied by the average annual production to determine average annual income.

In the Swedish variable system, the average production was multiplied by the average spot market price to get the total average market payment. The average price per green certificate

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>7.1275</td>
<td>7.3663</td>
<td>7.6098</td>
<td>7.5405</td>
<td>7.6975</td>
</tr>
<tr>
<td></td>
<td>2.9291</td>
<td>3.0272</td>
<td>3.1273</td>
<td>3.0988</td>
<td>2.0142</td>
</tr>
</tbody>
</table>
was then multiplied by the average number of certificates received to get total payment for the certificates. The two payment amounts were then added together to get the average annual payment for the remaining eight years of the Swedish contract. After the contract period ended the total average market payment was then used as the average annual income for the remaining five years.

**Appendix 9. Price per kWh**

The price per kWh each year for each system was determined by dividing each systems total annual system income as found in Appendix 7 by the corresponding year’s production amount.

**Appendix 10. Price per kWh Variability**

The variability of the price per kWh of each system was determined by finding the price change from one year to the next and dividing that change by the prior year’s price. The average price deviation was found by averaging the absolute value of each year’s percent change beginning in 2006 and then dividing by the number of years averaged.

**Appendix 11. German and French Tariff Rate Drop**

To determine the percent drop in the German and French systems from their actual production rates to their rates at 150 percent production the actual production payment per kWh each year was divided by the 150 percent production payment per kWh for the same year.

**Appendix 12. Net Present Values and Rates of Return**

To determine each system’s net present value the system’s annual income amounts were placed in the below formula with an initial investment of five million euro and a cost of capital of 10 percent. $N$ below is equal to the number of periods, $Payment$ is equal the total annual payment in a given year and $i$ is equal to the cost of capital:

$$ NPV = \sum_{t=0}^{N} \frac{Payment_t}{(1 + i)^t} $$

To determine each system’s internal rate of return the system’s annual income amounts were placed into Microsoft Excel with an initial payout of five million euro. The Excel Internal Rate of Return formula was then used to determine each system’s rate of return.

For the 7 year and 20 year NPV and IRR calculations levels no changes were made to the above methods beyond the adjustment to the number of periods.