Strategies for Promoting & Integrating Renewable Energy Resources in UAE

دراسة حول الاستراتيجيات الممكن تطبيقها لتشجيع الطاقة
المتجددة في دولة الامارات العربية المتحدة

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Abstract

Power is a critical infrastructure input and the lifeblood of the development and growth of the economy of any country. Renewable Energy (RE) supplies are of increasing environmental and economic importance in all countries. Moreover, RE forms an important component in future energy supplies for the electricity supply industry. This research looks into moving energy policy in the UAE in the direction of sustainability to turn the UAE into a leading country in a new environmental field.

The research covers UAE current energy policy especially relevant to RE as well as the current situation and future targets. Furthermore, the research looks into different countries and different case studies that have used RE. Moreover, best practices and applicable strategies to the UAE will be highlighted. A plan for the same was proposed and feedback from concerned authorities and stakeholders in the UAE were be considered to come up with a revised plan that can promote RE in the country.

The findings showed that implementation of RE technologies are possible and can be applied in the UAE through different stages gradually. A draft policy was prepared and was revised based on stakeholder feedback. Moreover, the plan proposed was designed to be implemented in three stages (short, medium and long term). Some of the main components include a deregulation move in the emirate, country and gulf levels through different stages. Other components of the policy include access to the grid which is improved at each stage, as well as financial incentives and implementation of a Feed-In Tariff. Stakeholder Feedback from the Federal Ministry and Dubai Electricity and Water Authority was used to refine the policy.

Key Words:

Renewable Energy (RE)

Renewable Energy Sources (RES)

Greenhouse Gas (GHG)

Carbon Dioxide (CO_2)

Instruments

Mechanism

Deregulation

Avoided Cost

Feed-In-Tariff (FIT)

Policy terms

ملخص

الطاقة هي العمود الأساسي و المحور الرئيسي لتقدم الجانب الاقتصادي وبناء البنية التحتية في اي دولة. تعتبر الطاقة المتجددة من الموارد المهمة للتقدم في المجال البيئي و الاقتصادي الذي يؤثر في نمو و تقدم الدول، وهي من اهم مقومات صناعة الطاقة الكهربائية في المستقبل. يقوم هذا البحث بدراسة امكانية نقل الطاقة الحالية التى تقوم على الوقود و نقلها الى طاقة مستدامة تقوم على الموارد الطبيعية المتجددة لعمل نقلة نوعية لتساهم في تطور دولة الامارات العربية المتحدة و جعلها من الدول المتقدمة و الرائدة في مجال الطاقة و التكنولوجيا.

يتضمن البحث التشريعات القانونية الحالية و المستقبلية الخاصة باستخدام الموارد المتجددة في دولة الامارات العربية المتحدة. حيث يتطرق البحث ليشمل التطورات التي وصلت اليها الدول العالمية المتقدمة في هذا المجال. و تم التعرف على افضل التطبيقات و الممارسات التي تناسب و تتلائم مع قوانين و تشريعات الدولة. و يشمل البحث على مقترح لتشريع استخدام الموارد المتجددة حيث اخذ بعين الاعتبار رأي بعض الهيئات الاتحادية و الفيدرالية المسؤولة عن الطاقة. و بناء على تعديلات و مقترحات الهيئات فقد عدل المقترح ليشجع استخدام الطاقة المتجددة في الدولة.

اوضحت نتائج هذه الدراسة ان دولة الامارات العربية المتحدة قابلة لتطبيق استخدام الطاقة المتجددة بالتدريج و في وجود شروط معينة. حيث تم تصميم هذا

المقترح مع بنوده ليتحقق على ثلاث مراحل (مرحلة قريبة المدى من سنة الى خمس سنوات ،مرحلة متوسطة المدى من خمس الى عشر سنوات، و مرحلة بعيدة المدى من عشرة سنوات و اكثر). و من اهم العناصر الفعاله في المقترح كان نقل قطاع الكهرباء من ان يكون قطاع محتكر على الحكومة، على ان يكون قطاع تتنافس فيه الشركات الخاصة. و تضمن المقترح عناصر فعالة اخرى تشمل السماح للدخول و البيع عبر الشبكة بالاضافة الى التحفيزات المالية و قانون التعرفة.و قد تم تعديل هذا المقترح بناء على توجيهات بعض المسؤولين من وزارة الطاقة و هيئة كهرباء و مياه دبي.

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Chapter 1: Introduction

This section discusses the history of the energy system in the world, and describes climate changes as well as the impact of fossil fuels on the atmosphere. Moreover it covers a discussion about fossil fuel reserves, nuclear power in the world, Green House Gas emissions and (CO_2) emissions. Additionally, the importance of an alternative energy is highlighted as well as the current situation of the Renewable Energy (RE) in the world. Additionally, the obstacles of RE are discussed. This section will also looks at the UAE's current situation; current fuel reserves and future strategies related to renewable energies issues.

1.1 Historical Background

Renewable energy systems are not new. RE was used long time ago and it existed before fossil fuels were discovered. The main expansion in the RE's came as a result of the oil crises of 1973-1980 (Abmann, Laumanns & Dieter 2006). Though RE was known a long time ago, it got an unexpected raise following the 1973 oil shock (Kishore, 2009). Table 1.1 and Figure 1.1 show the energy direction in the twentieth century (Kishore, 2009). From table 1.1 and figure 1.1 we can see that the electricty generation has increased along with the increase of population from 1900-2000. The consumption of oil percentage has reached its highest share from 1970-2000. The dependance on coal as a source of energy was very high in the 1900's and reached to its lowest average in 2000.

In the 21st century, natural gas was considered to be the main source of energy for the economies of the world. In 1900, electricity production was less, where less than 2 % of the world's fossil fuel was converted into electricity. Consumption share increased in 1950 and reached at 10%. Since then, it kept increasing; the expected projection for 2030 is about 45%. This rapid increase in the consumption of fossil fuel to produce electricity is the main concern of this century (Abmann, Laumanns & Dieter 2006).

Table 1.1- Energy direction in the twentieth century (Kishore 2009)

Year	Population (10^9)	PEC (EJ)	Shares of PEC: Coal (%)	Shares of PEC: Oil and gas (%)	Electricity generation (TWh)	Carbon intensity (tC/TJ)	World GDP (1990) (10^{12} USD)	Energy intensity (MJ/USD)
1900	1.6	22	95	5	8	24.3	2.0	11.0
1910	1.7	34	93	7	35	24.1	2.5	13.6
1920	1.8	40	88	11	85	23.3	2.7	14.8
1930	2.1	47	79	20	180	22.2	3.7	12.7
1940	2.3	57	74	25	340	22.6	4.2	13.6
1950	2.5	70	61	37	600	23.0	5.4	13.0
1960	3.0	115	52	46	2300	22.0	8.5	13.5
1970	3.7	189	34	64	5000	21.2	13.8	13.7
1980	4.4	250	31	65	8000	20.6	20.0	12.5
1990	5.3	320	30	61	11 800	18.6	27.4	11.9
2000	6.1	355	26	64	13 500	18.3	32.0	11.1

EJ – exajoules; TWh – terawatt-hour; tC – tonnes of carbon; TJ – terajoule; MJ – megajoule;
PEC – primary energy consumption
Adapted from Smil (2000)

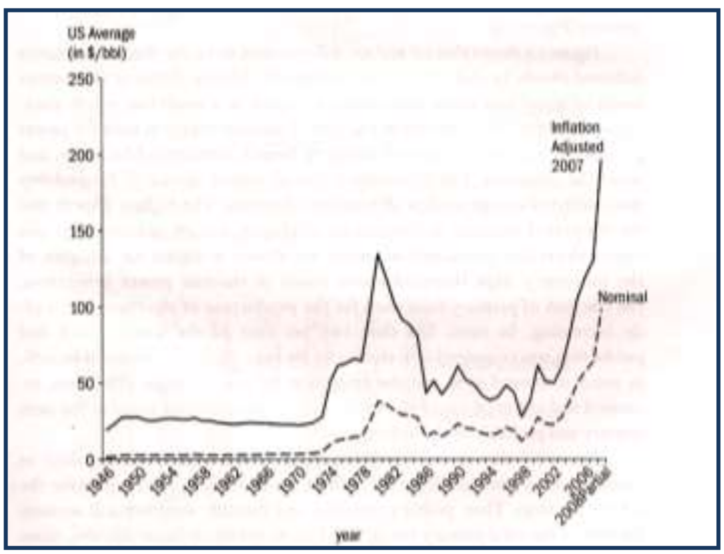

Figure 1.1- Energy direction in the twentieth century (Kishore 2009)

Figure 1.2 shows the evolution of average per capita energy consumption along the time scale of human existence. This graph shows that the average energy consumption has risen from about 200 W per capita to about 2000 W per capita in 100 years. This rapid increase is called an 'energy shock'. Fossil fuels were discovered in that period and were the reason for creating a very high-energy civilization happened in the history (Kishore 2009). Energy consumption can be expressed in different ways; for example EJ/year, W per Capita or MTOE (Million Tons of Oil Equivalent) (Kishore 2009).

The energy consumption differs from country to country. For instance, in Germany, the consumption is 176 million Btu per capita and in the United States (U.S.), it is 340.5 million Btu per capita (Kishore 2009). Nowadays, the total yearly electricity consumption is 15 trillion kWh and because of the high consumption, it is estimated to increase by more than the double in the next 50 years (Liptak 2009). Table 1.2 shows the global and domestic energy sources nowadays, where around 90% of the global power demand is covered by fossil and nuclear sources, although, nuclear is unsafe and fossil is polluting. In early 2008, the whole cost of a million Btus of energy in coal form was about \$6, in natural gas it was about \$ 10, while in oil form it was about \$30 (Liptak 2009).

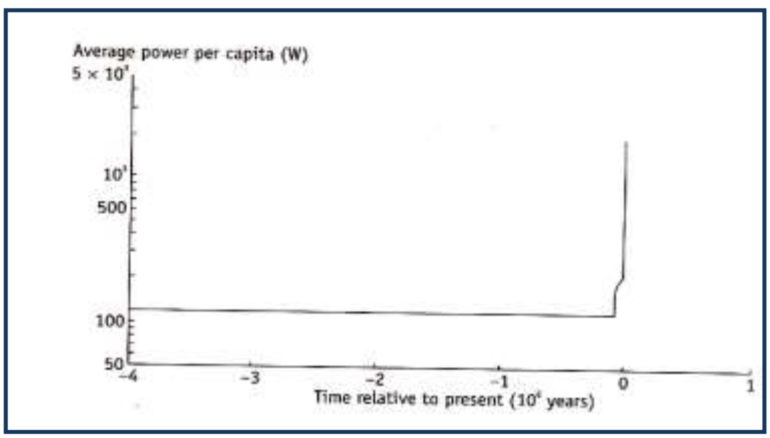

Figure 1.2- Evolution of average per capita energy consumption along the timescale of human existence (Kishore 2009)

Table 1.2- Global and domestic energy sources (Liptak 2009)

Energy Sources	Global (%)	United States (%)
Oil	35–37	39–40
Coal	25–26	23–24
Natural gas	20–25	21–24
Wood and biomass	9–10	*
Nuclear	7.5	8
Hydroelectric	2.4	7
Solar	0.6	a
Geothermal	0.4	a
Wind	0.05	a

1.2 Climate Change

Climate change is defined as a change in the average weather conditions such as an unexpected warming cycle in winter time. This change emerged from the rapid development that causes high emissions of Greenhouse Gases (GHGs) owing to the combustion of fossil fuels. Serious problems emerged from this change are seen in the form of frequent droughts as well as floods. Additionally, this change has resulted in climate change which made the planet warmer and therefore reduced land area due to flooding of coastal regions or due to drought of water sources (Liptak 2009). Consequently it is required to reduce the emission of GHGs, particularly CO_2. This would only be possible with the major shifts towards the use of RE technologies.

Studies to track the effects of global changes were necessary to avoid unwanted results. Global climate change studies have gained importance since 1980, when the importance of GHGs-CH4, N2O, and CFCs- were also recognized. Global warming contains many interacting factors like population growth, energy supply and environment (Letcher 2008). The global temperature has increased by 0.74 C (1.33 F) to date, and in 2007 the UN Panel on Climate Change predicted a rise of 2-6 C (3.5-11 F) in global temperature by 2100 if no action is taken to solve this issue. On the other hand, even if the global temperature was to rise by only 2 C, the consequences would include many effects like wildfires, droughts and rising sea levels causing the collapse of marine ecosystems. Moreover, some climate models are predicting snow- free Arctic summers by 2030. In 2007 the National Snow and Ice Center in Colorado reported that over 40% of the ice on the Arctic Ocean has melted. Some estimates show that the total ice cover of the Arctic would melt by 2040 because melting occurs at a rate of 7.8% per decade (Liptak 2009). In February 2007, the United Nation's Intergovernmental Panel on Climate Change reported that human activity is the main cause of global warming. The 2007, final report of this panel has declared that the GHGs have risen 70% since 1970 and are expected to reach 90% by 2030 (Liptak 2009).

The United Nations Framework Convention on Climate Change (UNFCCC) was drafted and adopted on 9 May 1992 at the UN headquarters in New York. The convention was signed by the Heads of States and senior representatives from 154 countries in June 1992. In 2003, 186 countries committed themselves to the convention terms. The present energy system, which depends heavily on fossil fuels as the main source of energy is causing negative impacts on the atmosphere defined as the 'global warming'(Kishore 2009).

Action is needed and is required to achieve a low-carbon global energy system, because the current CO_2 emission will lead to serious effects to the atmosphere. It is essential to expand the RE supplies and to use the energy in a more efficient way. In 2002, the consumption of the worldwide coal, gas and oil were 78 % of the primary energy consumption; the combustion of fossil fuel has been the main source of CO_2 emissions because this combustion is growing at the rate of 0.5 % per year (Abmann, Laumanns & Dieter 2006).

Although the developing countries form about 80% of the world's population, only 30% of the global energy is consumed by them (Letcher 2008). The differences in the energy systems of OECD countries and the developing countries are shown in Table 1.3. The table shows that the energy consumption in the developing countries is growing 2.3 times more than in OECD countries. In summary, unless immediate actions are taken about today's global energy policy, the use of fossil energy sources and the emitted CO_2 will increase more (Abmann, Laumanns & Dieter 2006).

Figure 1.3 which demonstrates the World-energy-related services (1971-2030) shows that the largest fraction of primary energy is used for power generation, followed by thermal energy in houses, commercial buildings, and industrial processes. Figure 1.4 which describes the per capita electricity consumption, shows that the electricity consumption KWh per capita increased over time from 1971 to 2030, where the OECD has the highest consumption rate compared to the developing countries, and the consumption of electricity has risen more than double during the period mentioned above (Kishore 2009).

Table 1.3 – Energy systems of OECD countries and developing countries (Abmann, Laumanns & Dieter 2006).

	Fossil Fuels (%)	Renewable energy (%)	Nuclear (%)	Growth rate, all sources (%/ year, 1971-2000)
OECD	83.0	5.9	11.1	1.48
Developing countries	78.1	20.0	1.9	2.81

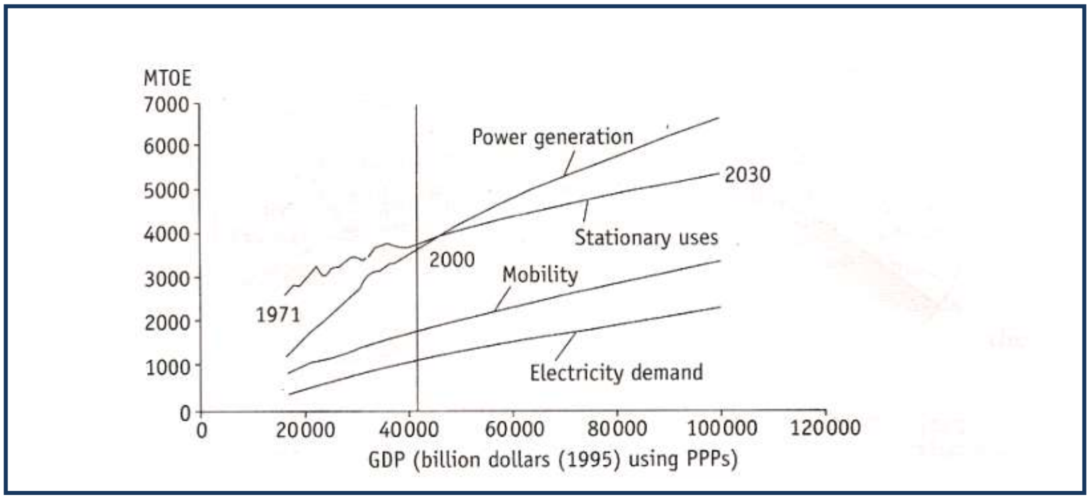

Figure 1.3 - The per electricity consumption graph (Kishore 2009)

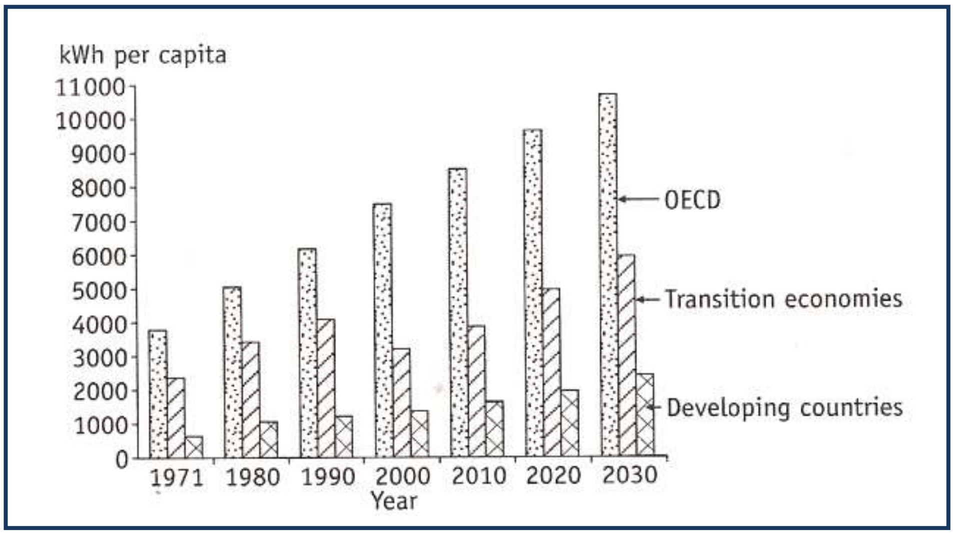

Figure 1.4 - The per electricity consumption chart (Kishore 2009)

<u>1.2.1. Green House Gas (GHG) Effect</u>

The Green House Gas (GHG) is a layer in the atmosphere that absorbs the infrared radiation (Liptak 2009). Some gases in the atmosphere such as CO_2, methane and water vapor reflect amounts of the solar radiation acting like a greenhouse (Figure 1.5). The GHG is a natural layer of different gases that surrounds the earth. Without this layer, life on earth will be impossible because the earth will emit most of its heat into space (Quaschning 2005).

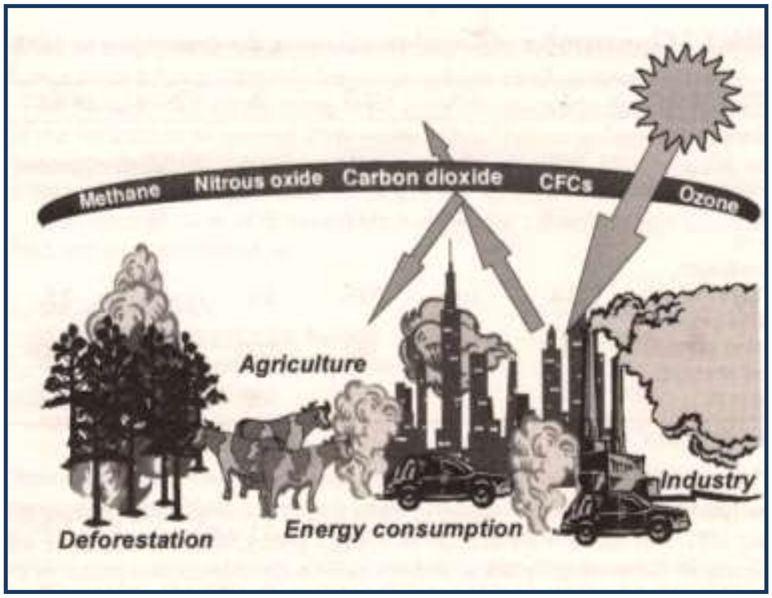

Figure 1.5- The anthropogenic greenhouse effect (Quaschning 2005)

Due to high energy consumption nowadays, more GHGs are being emitted to the atmosphere; these gases are the reason for the anthropogenic green house effect as illustrated in figure 1.5. CO_2 forms around 61% of the total greenhouse contents and is considered to be a serious relevant greenhouse gas (Quaschning 2005). The pulp and paper industry are one of the major sources of GHGs that is because in this process 20% of all GHG emission is released into the atmosphere (Liptak 2009).

Table 1.4 shows the characteristics of the GHGs which are CO_2, CH4, N2O, O3, CFC-11, and HFC-23 and shows the different characteristics of each gas in terms of concentration, lifetime and change in percentage per year (Quaschning 2005). The reduction of GHGs at the global level is one of the most important energy concerns of the millennium. There are many strategies to prevent GHGs for example:

1. Using energy in an efficient manner especially at the point of use especially in buildings, production processes and in transportation.
2. Relying on renewable energy sources for example wind and solar energies.
3. Developing technologies that can produce near almost zero harmful emissions.

The main reason for the anthropogenic greenhouse effect is the increase of fossil fuel consumption. The use of fossil fuels will have to be controlled to lessen the negative impacts of climate warming (Quaschning 2005).

Table1.4 - Characteristics of GHGs (Quaschning 2005)

Greenhouse gas	CO_2	CH_4	N_2O	O_3	CFC-11	HFC-23
Concentration in ppm	365	1.745	0.314	0.03	0.000268	0.000014
Atmospheric lifetime in years	5–200	12	114	0.1	45	260
Rate of concentration change in %/year	0.4	0.4	0.25	0.5	−0.5	3.9
Specific global warming potential	1	32	150	2000	14,000	10,000
Global warming share in %	61	15	4	<9	11 (all fluorocarbons)	

1.2.2 Carbon Dioxide (CO_2)

CO_2 is a gas which is emitted when fossil fuels are burnt. Hence, the process of burning fossil fuels can emit the largest amount of CO_2. It is the main gas that affects the greenhouse layer, whereas the GHG consists of 61 % from the CO_2. The percentage of fossil fuel-related CO_2 emissions is around 75 % in 2002 records, and this amount is increasing. Moreover, the concentration of CO_2 in the atmosphere has boomed from 280 ppmv (parts per million by volume) in 1850 to 372 ppmv in 2002 (parts per million by volume) in 1850 to 372 ppmv in 2002). In 1896, it was estimated that an increase in CO_2 would increase the earth's surface temperature, which will result in minimum warming near the equator, maximum in the polar regions, and less warming in the southern hemisphere. Moreover, deforestation, soil erosion, storms, droughts, and devastation of agriculture would occur as a result because temperatures would exceed the heat tolerance of crops (Liptak 2009).

In order to avoid the disasters mentioned earlier, all national energy plans include important factors to improve and maintain the efficiency of supply and use to reduce the pollution and to maintain a healthy life style (Twidell & Weir 2006). Figure 1.6 prepared by the U.S. Energy Information Administration illustrates the global carbon cycle with a data collected in 2001. The figure shows that from 2001 to 2006 the yearly anthropogenic carbon emissions (measured in carbon equivalent terms) increased from 6.3 to about 9 billion metric tons. In November 2007, the National Academy of Science reported actual emissions of CO_2 in 2006 as 8.4 billion tons. The total quantity of carbon on Earth is around 41,000 billion metric tons (92% in the oceans, 6% on land, and 2% in the atmosphere). Before the Industrial Age, the concentration of CO_2 in the atmosphere was balanced. The balance has been disrupted by different factors including fuel combustion and deforestation. The concentration of CO_2 in the atmospheric has increased from 280 to 380 parts per million (ppm) since the beginning of the Industrial age (Liptak 2009).

It is expected that the world CO_2 emissions will increase by 1.9% annually from 2001 to 2025. Nowadays, an American generates an average of 21 tons of CO_2 a year, whereas in California this value is now reduced to reach 9-13 tones/per capita (Liptak 2009). .

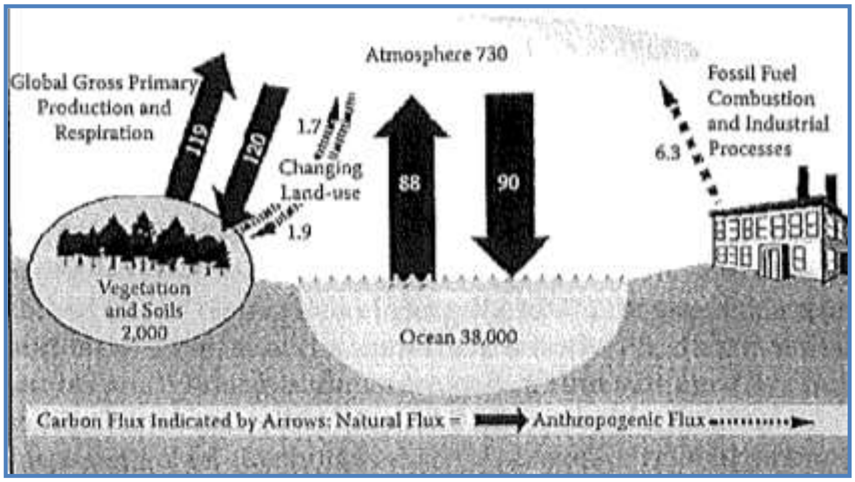

Figure 1.6- Global carbon cycle in billion metric tons of carbon per year (Liptak 2009)

However, the global per capita average is only 4 tons a year. The generation of each kilowatt-hour of electricity from fossil fuels can release from 270 to 1,050 g of CO_2 into the atmosphere. However, a 500 MW coal fired power plant releases 100 tons of CO_2 every hour. In the U.S., GHG emissions come from the following sources: power plants (33%), transportation (28%), industry (20%), agriculture (7%), and households (5%). According to the research results carried out by 2,500 scientists of the UN'S intergovernmental Panel on Climate Change, it is necessary to stabilize GHG emissions by 2015. This carbon emission change would increase gasoline prices by 15% and electricity prices by 35% but would reduce the global economic growth by 10%. Governments can assist in reducing the carbon emissions by the following strategies (Liptak 2009):

- Taxing on the basis of emissions or on the basis of consumption.
- Supporting alternative RE technologies.
- Subsidizing RE technologies.
- Imposing energy and fuel efficiency standards.
- Imposing emission standards.
- Charging a fee for GHG emission.

- Introducing a tariff on imported products.
- By cap-and trade arrangements

Having a direct taxation on the basis of carbon emissions and consumption or use of fossil fuels is one of the effective methods to reduce carbon emissions. And these taxes shall be used to support the development of renewable energy technology. Moreover, the governments shall provide markets for RE systems by installing solar collectors and wind turbines on government and military buildings. Additionally, the government could expand the electric power grid to be an integrated and nationwide grid where in this case all green energy generators could use the grid for storage (Liptak 2009).

Cap-and-Trade is a strategy and a way to commodity the climate change and allows the corporations to deal with it by buying their method of making reductions in their own emissions. The “cap” can be set by allocating the carbon, where it is required to establish a national total target for quantity of carbon allocation and then this can be distributed among the various emitters. It is believed that the carbon allocation can work like taxation with an exception that the emitter can invest in better technology to lower the emissions by purchasing an equal amount of ‘carbon credit’ from other plants that emit less than its allocation (Liptak 2009).

Another method to reduce the carbon emissions is to store the CO_2 emissions underground (sequestering) in the limestone and sandstone cavities from which natural gas and oil has been extracted. Moreover, post-combustion carbon capture equipment can be added to existing power plants, but this method is very expensive. The first European land-based CO_2 sequestration pilot projects were planned in Ketzin, and at Schwarze, Pumpe and southeast of Berlin in Germany. The plants in Ketzin can store 60,000 tons of CO_2 at a depth of 850 m in a salty water aquifer. However, the Schwartze pump plant will store the carbon dioxide in porous stone at 500 atmospheres. The sequestering will add about $ 1 billion to the capital cost of each power plant. Moreover, a new process using chilled ammonia can be used to remove the CO_2 from the flue gas or liquid into the ground at about 9,000 ft below the surface (Liptak 2009).

1.3 Reserves of Fossil Energy Sources

Fossil fuels such as coal, gas and petroleum have been formed over many millions of years. Organic substances such as animal residues were the main materials. A huge quantity of fossil fuels has been consumed in the 20th century. Today, the energy supply still depends on the fossil energy. Due to heavy use of fossil energy, the extraction of future fossil fuels will be very difficult and more expensive than today. It is obvious that fossil fuels will not be used as a source of energy supply by the future generations. By dividing the proven reserves of fuel by the present yearly demand we can come up with the duration of the reserve (Quaschning 2005).

The present stocks of fossil fuels are ultimately limited. Hence, the reserve lifetime of a resource may be defined as the known available amount divided by the rate of present use. According to this formula, the oil and gas resources will only exist for a few more decades; whereas the coal will be available for few more centuries (Twidell & Weir 2006). The economic price of oil extracted from reservoirs was estimated by the International Energy Agency (IEA) in 2004 and it was observed that utilizing all conventional resources will increase the recoverable hydrocarbon volume by a factor of 5 (Letcher 2008). Table 1.5 shows the fossil fuel reserves (Oil, Natural gas and Coal). The table shows that coal is the only reserves that will be available for a longer period (Quaschning 2005).

Table 1.5 – Fossil Fuel Reserves (Quaschning 2005)

	Crude oil	Natural gas	Coal
Proven reserves[a]	142.7 billion t ≡ 5975 EJ	155.8 billion m^3 ≡ 4944 EJ	984 billion t ≡ 28,852 EJ
Production in 2002	3.56 billion t ≡ 149 EJ	2.53 billion m^3 ≡ 80 EJ	4.82 billion t ≡ 141 EJ
Reserves/production ratio[a]	41 years	61 years	204 years
Unproven additional reserves[b]	84 billion t	217 billion m^3	6668 billion t[c]
Accumulated production[b]	128.2 billion t	69.6 billion m^3	–

Table 1.6 shows the estimated remaining world reserves of oil, coal and natural gas per region. From the data in Table 1.6 it is clear that the coal is more uniformly distributed in the world compare to crude oil. The crude oil reserve in the Middle East countries (Saudi Arabia, Kuwait, Iraq and the United Arab Emirates) account for about 63% of the world's proven crude oil reserves. Whereas, the coal reserves of the U.S., Russia, China and India account for about 68% of the world's proven coal reserves. Moreover, Figure 1.7 shows the estimated future oil consumption per region from 2004-2030 (Letcher 2008).

Table 1.6 – Proven oil, coal and natural gas reserves by region (Letcher 2008)

Table 5.8. Proven oil, coal and natural gas reserves by region.

Region	Oil/ (10^9 barrels)	Coal/ tonnes	Gas/ TCF[1]
Middle East	739.2	0.0	2566
Eurasia	99.9	247.8	2017
Africa	114.1	50.3	484
Asia	33.4	296.4	419
North America	213.3	249.3	277
Central and South America	102.8	19.9	241
Europe	14.8	39.4	179
Other	0.0	2.1	0
Total	1317.5	905.1	6183

[1]Trillion cubic feet (TCF) = 28.31×10^9 (normal cubic meters).

Figure 1.7 – The estimated future oil consumption per region from 2004-2030 (Letcher 2008)

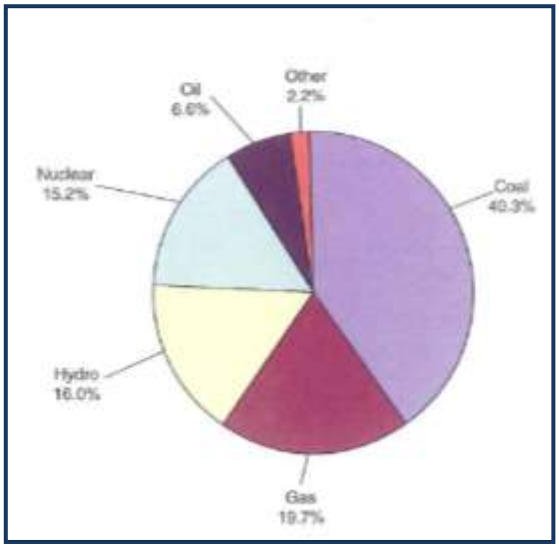

Figure 1.8 shows the fuel shares in electric power generation in 2005. The three major uses of coal are the electricity generation, industrial process heating and cement manufacture. Coal technologies are wide spread worldwide, both in the developing countries and in industrialized countries. In the developing countries, coal covers 53% of electricity generation. In China, coal currently produces 80% of electricity generation. Moreover, in the U.S. most of the electricity is produced by coal which is estimated to be around 51%. However, the percentage of power generation from coal in Russia dropped from 20.7% to 16.7% between1990 and 2005 (Letcher 2008).

Figure 1.9 shows the known fossil fuel reserves. According to the figure, the world's total fossil fuel reserves of the global are estimated to be 75,000 Q, and that the total energy consumption is rising at a higher rate than the growth of the supply of fossil fuels. By 2050, it is expected that the fossil fuel production will reach at 700 Q (Liptak 2009).

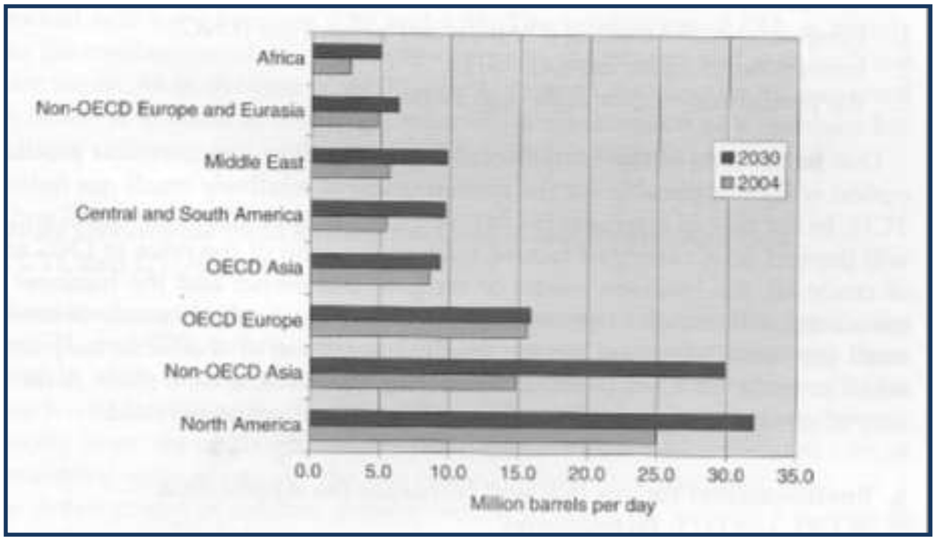

Figure 1.8- Fuel shares in electric power generation in 2005 (Letcher 2008)

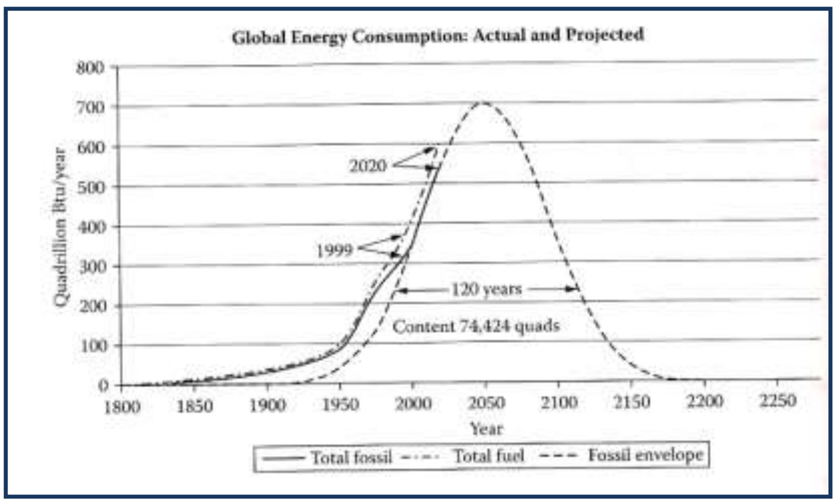

Figure 1.9- Global energy consumption: actual and projected (Liptak 2009)

1.2 trillion from the recoverable global oil suppliers has already been consumed from the original quantities which is estimated to be 3.3 to 4.8 trillion. The U.S. Department of Energy (DOE) estimated that 1.3 trillion barrels of oil remain recoverable. Table 1.7 shows global oil, natural gas and coal reserves which have already been discovered as of January 2007. Moreover, the U.S. consumes about 8 billion barrels of oil a year and imports

5 billion barrels in 2007. The production cost of oil on land was $20 per gallon, $40 in shallow water, $50 from oil shale and $60 from deep waters (Liptak 2009).

The recoverable global natural gas reserve is over 6,000 quadrillion cubic feet. The global demand for oil is estimated to increase up to 40% by 2030. The dependence of the U.S. on imported oil has increased from 35% to 60%, the costs of production reaches about $700 billion yearly. At the same time the cost of discovery of new oil reserves has decreased below the cost of consumption (Figure 1.10) (Liptak 2009).

In June 2008 the wholesale price of a barrel of oil was about $140 and the wholesale price of natural gas was about $10 per 1,000 ft^3. These costs have shown an increase of about 400% during the last five years. The yearly coal consumed by the United States is 1.1 billion tons. In United States, about 2 trillion kWh of electricity is produced from coal today and it is estimated by 2030 that this value will have reached to 3.3 trillion kWh (Liptak 2009).

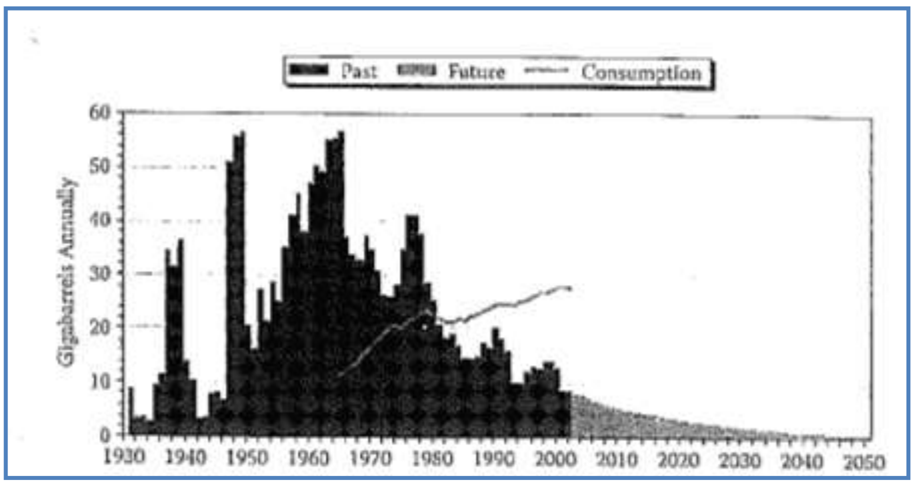

Figure 1.10 – Oil discovery (3-year average-past and projected) 1930-2050 (Liptak 2009)

Table 1.7- Proved global Oil, natural gas, and coal reserves as of January 2007 (Liptak 2009)

By Region and/or by Nation	Oil Reserves in Billion (10^9) Barrels	Percent of Global Oil Reserves	Natural Gas Reserves in Quadrillion (10^{15}) ft^3	Percent of Natural Gas Reserves	Coal Reserves in Billion (10^9) Short Tons	Percent of Global Coal Reserves
GLOBAL TOTAL**	1,317	100	6,182	100	997.7	100
North America	**213**	**16.1**	**276**	**4.5**	**276**	**27.6**
United States**	21	1.6	204	3.3	267	26.7
Canada***	179***	13.7	58	0.9	7	0.7
Mexico	12	0.9	15	<0.5	negligible	<0.5
Latin America	**102**	**7.8**	**240**	**3.9**	**22**	**2**
Venezuela	80	6.1	152	2.5	negligible	<0.5
Brazil	12	0.9	11	<0.5	11	1.1
Equador	4.5	<0.5	3	<0.5	negligible	<0.5
Argentina	2.5	<0.5	16	<0.5	negligible	<0.5
Peru	1	<0.5	9	<0.5	negligible	<0.5
Trinidad	1	<0.5	19	<0.5	negligible	<0.5
Colombia	negligible	<0.5	negligible	<0.5	7	0.7
Europe	**16**	**1.2**	**180**	**2.9**	**65.7**	**6.6**
Norway	8	0.6	82	1.3	negligible	<0.5
Netherlands	0.1	<0.5	50	0.8	negligible	<0.5
UK	4	<0.5	17	<0.5	negligible	<0.5
Denmark	1.3	<0.5	2.5	<0.5	negligible	<0.5
Italy	0.6	<0.5	5.8	<0.5	negligible	<0.5
Poland	0.2	<0.5	5.8	<0.5	15.4	1.5

Table 1.7 (Continued) - Proved global oil, natural gas, and coal reserves as of January 2007 (Liptak 2009)

Romania	0.6	<0.5	2.2	<0.5	negligible	<0.5
Czech Rep.	negligible	<0.5	negligible	<0.5	6.1	0.6
Serbia	negligible	<0.5	negligible	<0.5	18.2	1.8
Germany	negligible	<0.5	negligible	<0.5	7.4	0.7
Turkey	negligible	<0.5	negligible	<0.5	4.6	<0.5
Greece	negligible	<0.5	negligible	<0.5	4.3	<0.5
Hungary	negligible	<0.5	1.5	<0.5	3.7	<0.5
Eurasia	**99**	**7.6**	**2,015**	**32.6**	**250.5**	**25**
Russia	60	4.6	1,680	27.2	173	17.3
Kazakhstan	30	2.3	100	16.2	34.5	3.4
Turkmenistan	0.6	<0.5	100	16.2	negligible	<0.5
Azerbaijan	7	0.5	30	0.5	negligible	<0.5
Uzbekistan	0.6	<0.5	65	1	negligible	<0.5
Ukraine	0.4	<0.5	39	0.6	37.6	3.8
Middle East	**739**	**56.4**	**2,566**	**41.5**	**negligible**	**<0.5**
Saudi Arabia	262	20	240	3.9	negligible	<0.5
Iran	136	10.4	974	15.8	negligible	<0.5
Iraq	115	8.8	112	1.8	negligible	<0.5
Kuwait	102	7.8	55	0.9	negligible	<0.5
Un. Arab Em.	98	7.5	214	3.5	negligible	<0.5
Qatar	15	1.1	910	14.7	negligible	<0.5
Oman	5.5	<0.5	30	<0.5	negligible	<0.5
Yemen	3	<0.5	17	<0.5	negligible	<0.5
Africa	**114**	**8.7**	**484**	**7.8**	**55.5**	**5.5**
Libya	41	3.2	53	0.9	negligible	<0.5

1.4 Uranium Reserves

Uranium is a radioactive element which is used in producing nuclear power. The Earth's Uranium reserves are limited. Currently, only 5% of the global energy demand is provided by nuclear energy. Although the estimated global reserves are less than 20 million tons, 12.52 million tons of the reserves are only speculative. This means that nuclear power cannot be considered as an alternative for fossil fuels. Table 1.8 shows the uranium reserves in 2001 (Quaschning 2005). Although there is an investment in new nuclear capacity which aims to reduce the amount of total gas usage by 2025, the report prepared about the future of nuclear power in Massachusetts Institute of Technology in 2003 concluded that nuclear power is not considered an economically competitive choice for the meantime. Moreover, another report prepared in 2003 for Greenpeace International regarding the economics of nuclear power concluded that over the last two decades there has been a decline in orders for new nuclear reactors globally (Letcher 2008).

Nuclear power is preferred to fossil fuels because it has no carbon emissions and it competes with RE. However, building nuclear power plants takes up to 10 to 20 years, and costs more than building solar power plants. Around 20% of the U.S. electricity is supplied by nuclear energy. Nuclear energy is preferred because of its low operating cost (not low capital cost) and because it does not produce carbon emissions. The main arguments against it include its high capital cost, decommissioning cost and some issues related to safety (Quaschning 2005). Additionally, other concerns include leaks that can be occurred during routine operation, damages that can be occurred to nuclear plants due to earthquakes, aging, and terrorist attacks. Around 443 nuclear power plants are in operation around the world, among them, 103 are located in the United States (Figure 1.11) (Liptak 2009). An example of the nuclear power plant leak is that what had happened in Japan in March 11, 2011.

Table 1.8 – The Uranium reserves in 2001 (Quaschning 2005)

	Resources with production costs US$40/kg U	Resources with production costs US$40-130/kg U	Total
Resources	1.57 Mt[a]	5.67 Mt	7.24 Mt=3620 EJ
Speculative resources	12.52 Mt	NA	12.52 Mt=6260 EJ

Usually, a nuclear plant construction takes over 10 years, and any new orders have not been issued for new construction of nuclear plants for decades. In last 50 years, around 253 nuclear power plants were ordered in the US; of these, 71 were stopped prior to construction, 50 were stopped during the construction process, and 28 were shut down after they started running. However, the Nuclear Energy Institute estimates that 8 new plants will be in operation by 2016, and by 2030 around 16.4 GW capacities will be provided by nuclear plants. France is committed to nuclear power; India is currently building six plants, Russia is building five, China is building four, and the United States and Canada are building one each (Quaschning 2005).One of the main concerns about the use of nuclear energy is the unresolved problem of nuclear waste storage. The benefit of nuclear power plants is that they operate at a 90% capacity factor (loading). Additionally, 1 kg of natural uranium generates about as much as electricity as 20,000 kg of coal. In contrast to fossil fuels, nuclear power does not affect global warming nor does it generate GHGs. The size (generating capacity) of light-water nuclear power plants is usually twice that of their fossil counterparts or about 1,2 GW (1,200 MW) (Liptak 2009).

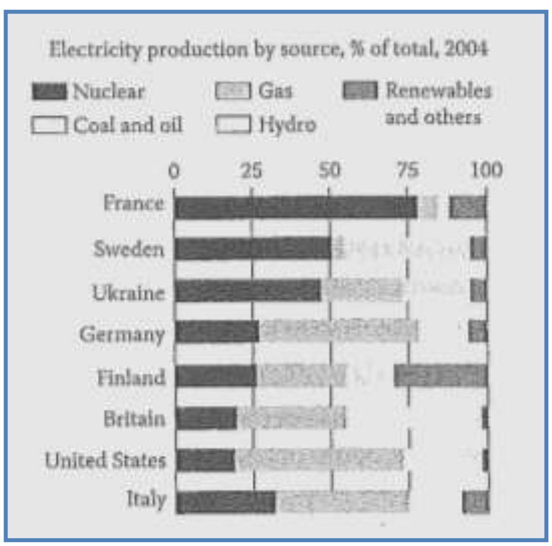

Figure 1.11 – Electricity production by source, % of total, 2004 (Liptak 2009)

The life spans of nuclear plants are in the range of 40 to 60 years and their total cost includes not only construction and operation, but also waste disposal. It is estimated that the initial cost of construction of a 1,000 Mw nuclear power plant is at least $5 billion (Liptak 2009).

Nuclear fusion is a new technology that doesn't require uranium fuel and does not produce radio-active waste. Additionally, it has no risk of explosive radiation-releasing accidents, but it takes place at a temperature of several million degrees. The problem with this technology is that it is very expensive because of required technology for creating very high temperature and therefore it is projected that the first fusion power plant cannot be built until 2050. It is estimated that it will be 50 times more expensive than a regular power plant, and the safety issues cannot be predicted for the time being. In short, the only safe and inexpensive fusion reactor is the sun. Table 1.9 shows a comparison between the main features of nuclear and solar power plants (Liptak 2009).

In my point of view even if solar power plants have no expenses the life time is only 20 years; however, nuclear power plants lasts for 40 to 60 years which is more than double the time. Hence, we cannot compare both plants in terms of decommissioning costs because of the difference in lifetime.

Table 1.9 – Comparison between the main features of nuclear and solar power plants (Liptak 2009)

	Nuclear Power Plant	**Solar Power Plant**
Initial Cost of a 1,000 mW plant	$ 5 billion	$ 3 billion
Construction Time	10-20 years	3-4 years
Fuel Cost	Increased from $10/kg to $75/kg in 10 years	Free
Exhaustibility	Uranium-235 deposits will be exhausted in 60-80 years	inexhaustible
Risk of Accidents	Human error/ Earthquake	None
Decommissioning Cost	After 40 to 60 years life span the decommissioning cost is very expensive	No such expense for solar
Waste Storage	No permanent Solution for waste storage	None required for solar

1.5 Solution

From the above information and considering the discussions and analysis; it is obvious that only few of today's technologies will survive in the 21st century because of the limited quantities of conventional energy reserves. This fact is an alarm to start using RE before the conventional energy reserves run out.

There are serious concerns for humanity related to environmental damage as well as issues related to geopolitical tension due to the continuation of the fossil fuel intensive energy economy. Therefore, reliance on clean renewable energy is very desirable and necessary (James & James 2004). Furthermore, several scenarios have been considered by the Intergovernmental Panel on Climate Change (IPCC) in the fourth assessment report. One of the scenarios is that the concentration of GHGs can be stabilized to limit the temperature increase at equilibrium of 2.0-2.4 C. This can be achieved by a reduction of 50% to 85% in the current level of GHG emission which is required by 2050 (Kishore 2009).

1.6 Constraints and obstacles of RE in the world

It is a fact that about one- third of the people cannot access to RE resources and most of the people who can access the RE services cannot afford to purchase the services even if they are available (Twidell & Weir 2006). Nowadays, RES require expensive processing technologies and advanced systems compare to conventional energy (Kishore 2009).

The first target of the Millennium Development Goals (MDG) which was developed in September 2000 by the UN is to reduce the proportion of people consuming electricity less than one dollar a day by 2015. In April 2001, the importance of energy is recognized in the 9th Session of the Commission on Sustainable Development (CSD-9). However, many developing countries cannot provide the modern energy services to the poorer people at affordable prices for them (Kishore 2009).

1.7 Why RE is important

RE is the energy from natural resources; wind, sunlight, geothermal heat, tides and rain. It is very important to define a new source of energy and be associated with clean energy. Moreover, RE can meet the challenges of future`s energy supplement. The UK RE Advisory Group (REAG) defined RE as the term used to cover ‘those energy flows that occur naturally and repeatedly in the environment, and can be used for human benefit’ (Kishore 2009, pg.15). Renewable Energy Resources (RES) are based on the natural and interconnected flows of energy for our planet. Main RE resources for electrical power generation can be categorized as follows:

- Solar energy.
- Wind, solar, solar PV, small hydro and geothermal.
- Biomass that can be stored and can provide heat and electricity.

RE resources are sustainable resources. They are safe, secure and scalable and moreover can improve the well being of a society. RE offers, clean, safe, local and increasingly cost-effective options for all our energy needs. Moreover, it has the lowest environmental affect of all energy sources; it is also a local and a natural resource. Thus it offers enormous scope for achieving energy security. RE does not cause any environmental hazards such as acid rain and greenhouse warming. RE is called a green supply while the conventional energy is called as a brown supply. Moreover, RE is safe and does not cause any harm to the environment, whereas the conventional energy pollutes air and water. Furthermore, the lifetime of the green energy is infinite but the conventional energy is limited. Table 1.10 shows a comparison between both energies (Kishore 2009).

Figure 1.12 shows an energy-end-use matrix for RE; the possible RE can be highlighted to substitute the existing use of a conventional energy source. From the matrix we can conclude that most of our daily activities can be achieved by the RES (Kishore 2009). Figure 1.13 shows a graph representing the power from RES with a timescale from 1990 to 2002. From the graph we can see that the hydroelectric power started in1990, whereas the photovoltaic power started in 2000 and the energy generated from the photovoltaic power increased after the 2002 (Wengenmay & Buhrke 2008).

Table 1.10- Comparison between conventional energy and RE (Kishore 2009)

	Renewable energy supplies (green)	*Conventional energy supplies (brown)*
Examples	Wind, solar, biomass, tidal	Coal, oil, gas, radioactive ore
Source	Natural local environment	Concentrated stock
Normal state	A current or flow of energy. An income	Static store of energy. Capital
Initial average intensity	Low intensity, dispersed: $\leq 300\,W\,m^{-2}$	Released at $\geq 100\,kW\,m^{-2}$
Lifetime of supply	Infinite	Finite
Cost at source	Free	Increasingly expensive.
Equipment capital cost per kW capacity	Expensive, commonly $\approx$US$1000 kW^{-1}	Moderate, perhaps $500 kW^{-1} without emissions control; yet expensive >US$1000 kW^{-1} with emissions reduction
Variation and control	Fluctuating; best controlled by change of load using positive feedforward control	Steady, best controlled by adjusting source with negative feedback control
Location for use	Site- and society-specific	General and invariant use
Scale	Small and moderate scale often economic, large scale may present difficulties	Increased scale often improves supply costs, large scale frequently favoured
Skills	Interdisciplinary and varied. Wide range of skills. Importance of bioscience and agriculture	Strong links with electrical and mechanical engineering. Narrow range of personal skills
Context	Bias to rural, decentralised industry	Bias to urban, centralised industry
Dependence	Self-sufficient and 'islanded' systems supported	Systems dependent on outside inputs
Safety	Local hazards possible in operation: usually safe when out of action	May be shielded and enclosed to lessen great potential dangers; most dangerous when faulty
Pollution and environmental damage	Usually little environmental harm, especially at moderate scale Hazards from excess biomass burning Soil erosion from excessive biofuel use Large hydro reservoirs disruptive Compatible with natural ecology	Environmental pollution intrinsic and common, especially of air and water Permanent damage common from mining and radioactive elements entering water table. Deforestation and ecological sterilisation from excessive air pollution Climate change emissions
Aesthetics, visual impact	Local perturbations may be unpopular, but usually acceptable if local need perceived	Usually utilitarian, with centralisation and economy of large scale

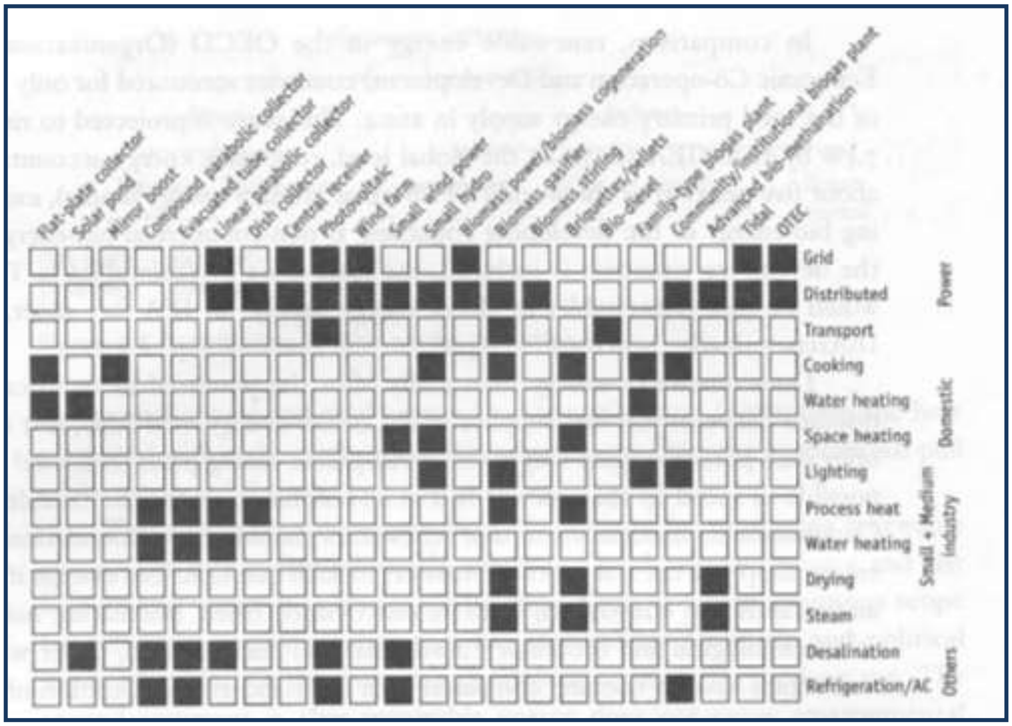

Figure 1.12- Energy-end-use matrix for RE (Kishore 2009)

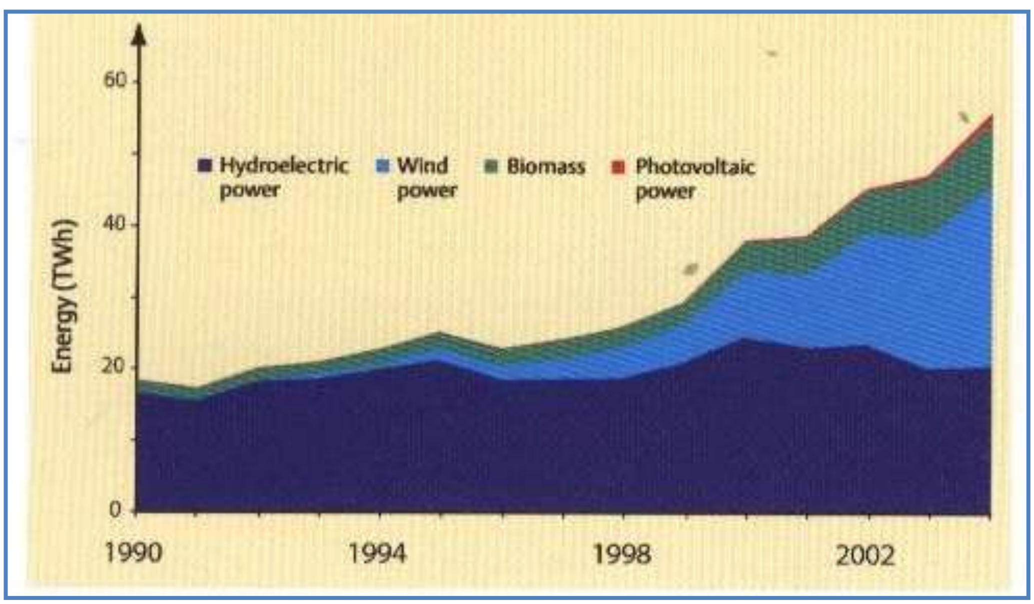

Figure 1.13- Power from RE sources (Wengenmay & Buhrke 2008)

1.8 Promoting RE's in the World

In this section I will give a brief overview of few countries that are promoting RE in the world. This topic will be dealt with in full in chapter 4. "Sustainable development can be defined as living, producing and consuming in a way that meets present needs without affecting the ability of future generations to meet their own needs" (Twidell & Weir 2006, pg. 2). RE Network for the 21st Century (REN21) is a global policy network designed to help utilize the RE in the developing and industrial countries by enhancing the best policies and decision making at the local, national and international levels (Kishore 2009).

A number of institutions have been established to solve the problems about climate change. For instance, the United Nations Framework Convention on Climate change (UNFCCC) was set up in 1992 to give a framework for policy making. Almost all nations signed the treaty that set goals to reduce the emission of GHGs, but it achieved little. After five years in 1997, the Kyoto Protocol was formed; it is an international agreement to consider the climate change. The targets set by the Kyoto Protocol are aimed to be met by 2012; hence these targets are set for 37 industrialized countries as well as for the European Community (EC) to reduce GHG emissions mainly CO_2 and how to shift the global to a more sustainable development (Liptak 2009).

The Kyoto Protocol is considered to be one of the most important global agreements of the late twentieth century. More than 170 countries and several non-governmental and intergovernmental organizations were involved in the Kyoto Protocol. It consisted of particular limitations for the period 2008-2012. The aim is to reduce the GHG emissions minimum 5% below 1990 levels. The Kyoto Protocol target was to be met by three market based mechanisms (Liptak 2009).

The Kyoto mechanisms are:

- Emissions trading – known as “the carbon market"
- Clean development mechanism (CDM)
- Joint implementation (JI).

Moreover the Kyoto protocol set the target to reduce GHG emission to 5% by 2012. This treaty was not agreed by China or the United States because these nations refused to limit their domestic emissions. Implementation of the Kyoto Protocol was accepted and agreed by 15 original European Union (EU) countries. A 2% reduction in carbon emissions has been achieved by the Kyoto Protocol by 2005. Additionally, the EU aims to reduce the CO_2 emission 8% by 2012 and 20% by 2020. Moreover, it is required by the EU that by 2010 its members shall increase the RE use in their overall energy consumption from 5.2% to 12% and to generate 22% of their electric energy from RE sources. Another European direction is to regulate the emissions exposed by the airline by charging a carbon tax for emission that exceeds the allowed limit. Denmark, Finland, Norway, and Sweden have been taxing carbon emissions since the 1990s. In 2001 the U.S. withdrew from the Kyoto agreement and refused to accept any carbon emission limits (Liptak 2009).

Germany is considered to be the leader among the individual European states in supporting the RE technology, which already generates 14.2% of its electricity from RE resources. Additionally, Germany aims to reduce GHG emissions to 40% by the year 2020. In Germany, the Feed in Tariff (FIT) program is implemented in which power companies ‘buy back’ the solar-generated electric power at a rate that is secured for 20 years. This program has reflected a reliable income, so many homeowners installed solar collectors in their roofs as well as farmers in their fields. Another policy used to lower GHG emissions was the cap-and-trade policy. In U.S. in February

2008, the House agreed to extend the $17 billion in tax credits to promote RE production and to stop the incentives for the oil and natural gas producers (Liptak 2009).

Currently 25 states in the U.S. support the development of RE and 18 states want to cap industrial carbon emissions. The most appreciated efforts by American States are the Regional Greenhouse Gas Initiative (RGGI) of the 10 northeastern states and the Western Climate Initiative organized by California, Florida, New Jersey, Massachusetts, and California are considered to be the leading states in the RE industry. Moreover, California has set the goal to produce 3,000 megawatts of solar power by 2017 and has set $ 3.2 billion for subsidizing solar installations in order to place solar collectors on one million rooftops. Additionally, Hawaii is planning to get 70% of its energy need from RE resources by 2030. In 2008 Pennsylvania agreed an energy bill that provides $850 million for investments in RE, including $200 million in solar energy installation. California and Florida are planning to reduce their GHG emissions to 25% by 2020 (Liptak 2009).

Different countries met in Copenhagen in December 2009, to draft the Copenhagen Protocol (COP-15). It is the 15th conference (COP 15) within the convention of climate change. The world Meteorological Organization and the United Nations Environment Programme (UNEP) have created the Intergovernmental Panel on Climate Change (IPCC) to study the climate change that is caused from human activities (Letcher 2008). In March 2007, the EU member states announced that the percentage of RE in the total energy consumption of the EU must increase up to 20% and a minimum goal of 10% was specified for the biogenic fuel in the total petrol and diesel consumption for all the EU member states until 2020 (Wengenmay & Buhrke 2008). France also provides a substantial portion from renewable sources such as biomass. The solar thermal usage is spread in Germany, Austria, and Greece. Moreover, Belgium has increased its percentage of RE between 1997 and 2005, from 1.0 to 2.8 %. In Germany, RE sources have increased especially in the electric power sector. Additionally, in 2005 10.2 % of the power for the electrical sockets came from renewable resources, this was because of the increased use of wind power (Wengenmay & Buhrke 2008).

As per Wengenmay and Buhrke's (2008) study, the share of RE in the world's energy consumption is 13.4%. The utilization of RE's differs from region to region. Conventional hydroelectric power has an important energy source in South America, Japan and some European Countries. Around 60% of the RE is used for heating in private homes as well as the public buildings. The Western industrial countries which are the members of the OECD use half of the RE resources for production of electricity; the non-OECD countries use only 14.1% for this purpose (Wengenmay & Buhrke 2008).

Today, most of the RE sources are more expensive than the corresponding fossil-fuel and nuclear sources. The financial subsidies are given to RE's through either pay-as-you-go financing as in the case of electric power or targeted subsidies as in the market launch program of the German Federal government for the area of renewable heating sources. Figure 1.14 shows the world consumption of energy in the world in 1973 and in 2004 (Wengenmay & Buhrke 2008).

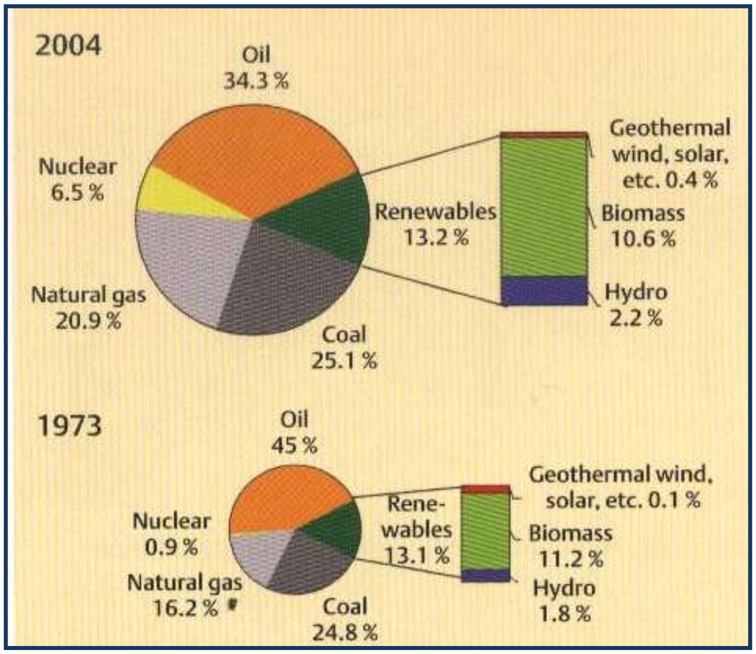

Figure 1.14- World consumption of primary energy (Wengenmay & Buhrke 2008)

1.9 History, Energy, Policies & Strategies of the United Arab Emirates (UAE)

1.9.1. Background of UAE Geography, Energy Resources and Current Status

The United Arab Emirates (UAE) is a federation of seven emirates: Abu Dhabi, Dubai, Sharjah, Ras AlKhaimah, Ajman, Umm AlQuwain and AlFujairah. The UAE has a total geographical area of 83,600 SQ.Km. The country is located in the southern corner of the Arabian Peninsula. It is bordered by the Arabian Gulf to the north, Saudi Arabia to the south and west, Qatar to the northwest, and Oman and the Gulf of Oman to the east. Figure 1.15 shows the UAE Map with the seven emirates locations (Asiarooms 2002).

Figure 1.15- UAE Map (Asiarooms 2002)

UAE relies 100% on the fossil fuels to produce the electricity power required for the country. The capital of the UAE is Abu Dhabi and it has the largest amount of oil resources which is around 92.2 billion barrels. However, Dubai has around 4 billion barrels, whereas Sharjah and Ras AlKjaima have 1.5 billion and 100 million barrels of oil, respectively Embassy of the UAE, (2008). The Annual Statistical Report for electricity and water-United Arab Emirates 2005-2009 is included in Appendix-A.

The UAE is considered to be the world's sixth largest proven oil reserves and the fifth largest natural gas reserve. This makes the UAE a critical supplier in the global energy markets. Additionally, the UAE is considered to be the world's third largest exporter of crude oil. The UAE is an important oil and natural gas producer; moreover, it is a member of the Organization of the Petroleum Exporting Countries (OPEC). More than 40% of UAE crude oil is being exported to Japan, whereas minimal quantities are being exported to the U.S (Embassy of the UAE 2008).

1.9.2. UAE future targets

Although the UAE is still in its developing and growing phase, it has started to locally promote renewable sources of energy; this is being done by setting the green regulations and through the establishment of Masdar which is a sustainable city established in Abu Dhabi. However, the UAE still needs a mechanism to set and reach its future goals. The UAE needs to follow a different promotion strategy to be able to catch the renewable technology train. The promotion of RE can be effective through local municipalities. Besides this, it is necessary to build up a long-term vision to provide people with time for adoption of change. The UAE needs to define its plan, set goals and targets and assigns renewable developers to carry out this work and to promote the efficient use of energy and RE's for now and for the future. It is important to define concepts for a sustainable future energy supply for the UAE including technical and economic feasibility and to provide a positive vision for decisions to be made in the near future. Moreover, the UAE has started establishing a policy on the evaluation and potential development of peaceful nuclear energy. (Details of this study is available in Appendix-B)

Currently the UAE has not officially adopted the use of renewable power, where priority has been focused on traditional ways to generate electricity rather than on renewable directions, although the country has some good RE resources such as solar power which could help in improving sustainability. In the UAE the need for effective RE policy-making is becoming important. It is very important to set a clean development mechanism and to establish a RE industry. There is a need for consistent and stable policies and a true integration of RE resources and energy efficiency into energy system planning. In the meantime, the UAE is taking giant steps forward to RE and energy efficiency programs. In 2005, the UAE gave formal approval to the Kyoto Protocol in the UN Convention on Climate Change. Hence it was considered one of the first main oil-producing countries to sign the agreement Embassy of the UAE, (2008). Abu Dhabi has established very comprehensive clean energy initiative called ‘Masdar’. It is a mini-municipality of 50,000 which will be car free and will be provided by solar panels shades to provide its own electricity. Moreover, its water will be supplied from solar powered desalination plants and the wastes will be recycled. Masdar city is a part of a $15 billion investment in RE technology in Abu Dhabi, it is considered to be the largest RE project in the world (Liptak 2009). ‘Masdar’ was launched in the capital of the UAE, in Abu Dhabi in 2007.

Masdar’s four primary objectives are:

- To enhance the economics of Abu-Dhabi
- To make Abu-Dhabi participate in global energy markets
- To improve Abu-Dhabi technological sector

‘Masdar’ is the first car-free, zero-waste and zero-carbon city in the world. Moreover, electricity will be generated by photovoltaic panels and cooling will be generated from the concentrated solar power. Additionally, grey and treated water will be used for landscaping which is produced by Masdar’s water treatment plant. Moreover, Masdar will focus on solar-Photovoltaic (PV), Wind-Energy, concentrating solar-power (CSP), and the solar-cooling sectors. In 2007, Masdar got the first World Clean Energy award from the Transatlantic 21 Association in Basel, Switzerland. Moreover, it has been voted as the “Sustainable Region/City of the year” in September 2007 at Ernst & Young’s Global Renewable Energy Awards. Masdar provides market incentives to reduce the GHG emissions complying with the Clean Development Mechanism (CDM) framework of the Kyoto Protocol (Embassy of the UAE 2008).

Another improvement in the RE sector has been take by Dubai Electricity and Water Authority (DEWA), which aims to reduce the Carbon emissions to minimize the environmental impact and to reduce the carbon footprint. The Authority along with the collaboration of the United Nations Development Program (UNDP), Dubai Carbon Centre of Excellence (DCCE) offers expertise carbon technical and knowledge support to adopt cleaner technologies to finally reduce the emissions of carbon dioxide (Al Masdar 2010).

The DCCE is the first center in the Middle East specialized in carbon emission reductions. Additionally, the objective is to create a portfolio of environmental credits, investing, structuring, and advising emission reduction projects to achieve ‘Carbon Neutrality’. DEWA aims on providing eco-friendly technologies to increase the efficiency of the produced electricity and water desalination plants (Al Masdar 2010).

1.9.3. UAE Strategy 2011-2013

The UAE Government Strategy 2011-2013 (pg.6-23) was being prepared to lay the foundations of energy strategies to achieve the UAE vision 2021; it consists of seven general principles. Each strategic priority and enabler includes general main directions and specific sub-directions.

The seven general principles set by Government are as follows:

- Devising affective regulations and integrated policies by successful planning and enforcement.
- Enhancing effective coordination among Federal Entities with Local Government.
- Enhancing transparency governance mechanisms
- Pursuing a culture of excellence through strategic thinking

- Promoting efficient resource managements
- Investing in human resource management

The strategic priorities are:

- Cohesive Society and Preserved Identity
- First-Rate Education System
- World-Class Healthcare
- Competitive Knowledge Economy
- Safe Public and Fair Judiciary
- Sustainable Environment and Infrastructure
- Strong Global Standing

(Highlights of the U.A.E. Government Strategy 2011-2013 pg.6-23) Putting Citizens First (An Accountable, Lean, Innovative, and Forward-Looking Government). More details of these strategies are available in Appendix-C (UAE Government Strategy 2011).

1.9.4. DEWA (Dubai Electricity & Water Authority) Strategy 2010-2014

DEWA strategy is based on excellence, which is aligned with Dubai Government strategic plan. DEWA's vision is to be 'A recognized world class utility'. It is the first organization in the Middle East which implemented the Balanced Scorecard (Al Masdar 2010).

1.10. Dissertation Aims and Objectives

The core aim of this dissertation is to define strategies to promote and integrate renewable resources in the UAE and to draw a perspective for further development for the UAE's future green energy policy.

The objectives of the dissertation are as follows:

- To study the main instruments used to promote RE's in the world.
- To study the success and failures of strategies in different countries.
- To study the advantages and the disadvantages of the mechanisms used in different countries.
- To highlight the best mechanism that most matches UAE culture, economics and politics conditions.
- To propose a plan based on the UAE's current situation and conditions and consider stakeholders' feedback.

Chapter 2: Literature Review

As have been discussed in the previous chapter about promoting RE in the world; this section describes the supply and demand equation, deregulation process and types of different mechanisms that have been used as well as the challenges of RE's in the world.

2.1 Challenges of RE in the market

In many countries RE already have a significant market share and have developed along different lines in different countries. Different mechanisms have been applied in different countries to promote and encourage the use of RE. Some countries have used the subsidies; others have used the feed in tariff (FIT) system, whereas others used a free market system; these terms are defined and explained in details in the following section. On the other hand, some utilities were forced by their countries to purchase a specific percentage of RE. The positive and negative impacts of the different mechanisms and strategies being implemented in the world are discussed below. Additionally this section identifies lessons which may be relevant for other developing countries to apply and integrate RE. The development of RE has been supported by the developed countries for the following reasons (Abmann, Laumanns & Dieter 2006):

1. To ensure security of supply and to minimize the usage on fossil fuels.
2. To reduce GHG emissions.
3. To improve industrial capabilities.
4. To increase local benefits through creation of jobs and economic development.

RE could be the key to meet the needs of the energy demand of the Earth. However, for the market to move there has to be a demand for the new product through added extra value in terms of comfort or economics, social and environmental benefits. The product must be affordable in relation to income or investment. Additionally, structure of support for the product is also necessary for example information, awareness, maintenance, quality standards, improvement by research and development. Therefore, the introduction of new technologies depends on three things as follows (Abmann, Laumanns & Dieter 2006):

- The policy framework shall consider future developments.
- A budget for the new technology shall be available
- Supportive environment such as capacities for information and awareness.

It is necessary to provide a market foundation which should be ready for the implementation of RE technologies. The market is affected by many factors such as the country conditions, consumer knowledge, and available service. Moreover, the public has a role to develop these markets based on specific conditions which differs from each country and region. Lots of work is required to develop markets for green energy in the developing countries. The use of RE in the market is for electricity and heat. These exist in all developing countries, for example in having systems for electricity and fuel markets, while others depend on local markets and the use of direct RE (Abmann, Laumanns & Dieter 2006).

Most of the successful energy markets depend on the incentives. In developing countries it is important to consider the end uses and work to improve the RE technology, integrating new methods as well as creating new technologies and industries. Moreover, it is important to mention that direct government support is required for new technologies than for incremental advances (Abmann, Laumanns & Dieter 2006). Policy experts, government, industry, non-government organizations and academia are considered to be interest in RE policies (Lipp 2007). Generally, preconditions and preparations are required in the introduction of new technology in an existing market. The policies need to be very effective so that new technologies can overcome barriers and penetrate the market to a significant extent (Abmann, Laumanns & Dieter 2006). Table 2.1 shows the key barriers and policy options for RE in industrialized countries.

Table 2.1-Key barriers and policy options for RE in industrialized countries (Abmann, Laumanns & Dieter 2006).

	Research and development	*Demonstration*	*Diffusion*	
			Early deployment	*Widespread dissemination*
Key barriers	• Governments consider R&D funding problematic • Private firms cannot appropriate full benefits of their R&D investments	• Governments consider allocating funds for demonstration projects difficult • Difficult for private sector to capture benefits • Technological risks • High capital costs	• Financing for incremental cost reduction (which can be substantial) • Uncertainties relating to potential for cost reduction • Environmental and other social costs not fully internalized	• Weaknesses in investment, savings and legal institutions and processes • Subsidies to conventional technologies and lack of competition • Prices for competing technologies exclude externalities • Weaknesses in retail supply, financing and service • Lack of information for consumers and inertia • Environmental and other social costs not fully internalized
Policy options	• Formulating research priorities • Direct public funding • Tax incentives • Technology forcing standards • Stimulating networks and collaborative R&D partnerships	• Direct support for demonstration projects • Tax incentives • Low-cost or guaranteed loans • Temporary price guarantees for energy products of demonstration projects	• Temporary subsidies • Tax incentives • Government procurement • Voluntary agreements • Favourable payback tariffs • Competitive market transformation initiatives	• Phasing out subsidies to established energy technologies • Measures to promote competition • Full costing of externalities in energy prices • Green labelling and marketing • Concessions and other market-aggregating mechanisms • Innovative retail financing and consumer credit schemes

2.2 Supply and demand

Supply and demand is a principle that says as fossil fuel resources diminish; prices will rise, which will lead to propose other alternatives such as RE. Supply and demand have increased in the last years. Demand can be controlled by reducing electricity consumption; however, supply can be controlled by using another resource and alternatives to fossil fuel such as renewable resources. The following technology options can be used to reduce GHG emissions from power production (Tsoutsos et al. 2007):

1. Improving generation efficiency.
2. Shifting towards a low GHG emission resources.

Both options are affected by factors that have impacts on technological developments, for example cost and efficiency of the technology. Figure 2.1 shows the factors and technological options for reducing GHG emissions (Tsoutsos et al. 2007). Generation efficiency is the balance of capital and operational costs, mainly fuel costs. Efficiency increases when capital cost decreases and it also increases when fuel cost increases. Hence, a policy approach should work along both axes (Wiedman 1998). Moreover, Wiedman (1998) maintains that a balance between supply and demand shall be achieved in real time. The future of RE depends on three factors (Wiedman, 1998):

1) Programs and initiatives developed by the country

2) Improvement in the technical part

3) The prices of fossil fuels, especially natural gas

A logistic curve has been used to describe the S-shaped curve for growth, in the initial stage a rapid jump occurs and when the saturation begins the growth slows and stops at the end (Letcher 2008). Energy demand is increasing rapidly due to the quick growth in the demand of the world. World population is increasing and is expected to double by the end of the 21st century. The developing countries are around 80% of the world's population; however they only consume 30% from the global commercial energy. In addition the consumption of global energy is estimated to increase by 52% between 2006 and 2030 from 10878 x 10^{6} metric tons of oil to 16500x10 6up tons in 2030 (Letcher 2008).

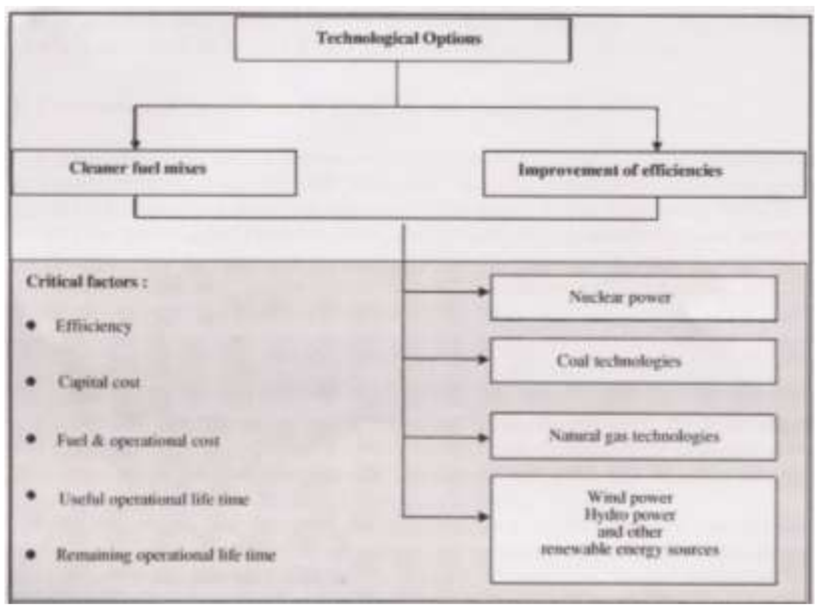

Figure 2.1- The factors and technological options for reducing GHG emissions (Tsoutsos et al. 2007)

2.3 Deregulation

Deregulation is defined as a change and a restructuring in the electricity regulation market in which electricity is purchased from other providers other than the government. In this section different ways of promoting deregulation and RE policies is discussed. Additionally, how deregulation has affected the RE market, and how the Electric Utilities have been regulated. Moreover, the advantages and disadvantages of deregulations are analyzed and the process of deregulation development is highlighted. The discussion below also shows how the removal of government controls helped to create a free market place.

2.3.1. Electric utility deregulation

Regulating of electric utilities exists for close to a century. It started in 1907, when New York and Wisconsin became the first states to regulate their electric utilities (Wiedman 1998). An example of deregulation is the green power marketing which is a program that sells green power not from a single supplier or a project, but from many suppliers and introduced as an option inserted to the final product. As an example, the successful green marketing programs have been used to encourage the promotion of the green energy. Customers paid an extra amount on their electricity bill which has supported the companies that invested in green power projects. These kinds of programs are usually categorized in three categories as follows (Wiedman 1998):

1. Capacity-based programs: allowed customers to purchase blocks from renewable sources.
2. Contribution-based programs: allowed customers to participate in the funds that are used to support RE projects.
3. Energy based programs: allowed customers to purchase fixed or a percentage of electricity from RE resource.

2.3.2. Public Utilities Regulatory Policies Act (PURPA)

After the rise up in the world's energy prices in 1974, it was necessary to develop an alternative energy resource. This program has focused on generating electricity from RES through the development of specific facilities. Utilities were required to pay power rates to two groups of non-utilities, the first group was the small power producers using RES and the second group was the co-generators which is the qualifying facilities (QFs).

The establishment of competition in generation of electric power was being encouraged by PURPA. Additionally, ‘qualifying utilities’ have been required to allow a connection to the grid. Utilities were required to purchase power produced by the qualifying facilities at avoided costs. The development of small-scale electric power plants was encouraged by PURPA; to provide incentives for RE development. It also made contracts procedure simpler and eliminated complicated procedures and planning problems (Zucchet 1995).

2.4. RE support mechanisms

Generally, policies that promote the use of RES can make a difference in the market. RE policies concern the stimulation of markets that aims to improve efficiency and reduce cost. Many mechanisms have been implemented to promote the RE market which will be covered within the scope of this paper such as the fixed tariff mechanism, contract bidding mechanisms, tax credits and the quota or Renewable Portfolio Standards (RPS) mechanism. In the last decades, a number of policy instruments for example the green labeling, target setting and procurement policies have been experimented by developed countries. In General, there are five components that effect the integration of RE (Abmann, Laumanns & Dieter 2006):

- Access
- Price
- Contract
- Policy Deregulations

Temporary subsidies are considered to be a very effective policy option as applied in Germany and Spain; it came with good outcomes for expanding electricity generation from RE. Another option to promote RE’s is the green certificate markets which are used by many countries. As an example, in Sweden the CO_2 tax has helped to move from coal to biomass in the sector of district heating (Abmann, Laumanns & Dieter 2006). In Abmanns study

(2006), it is stated that only 2 % of the world's primary energy is from RE. However, the market situation and condition play an important role in the demand for RE. Moreover, the market stability price may vary according to the technology used to produce the electricity. The RE policies are related to many sectors such as land use, agriculture, buildings and urban planning. It is necessary to set realistic targets and timetables together with policies such as the use of green certificates, favorable prices for renewable electricity (Abmann, Laumanns & Dieter 2006). Many policy mechanisms have been used in the world; the most used mechanism is the fixed tariff mechanism, contract bidding mechanisms and the quota (or RPS) mechanism. The following sections will go through and describe each mechanism separately.

2.4.1. Feed in Tariff (FIT) Mechanism

A tariff is defined as a selling scheme based on a fixed price system to sell the unit; such schemes may focus on quantities or on prices. It guarantees RE generators to be at a fixed price (Lipp 2007). The U.S. Public Regulatory Policies Act (PURPA) was the first to introduce the FIT policies since the 1970s. PURPA declared guaranteed prices depending on the long term cost of fossil energy (estimated $ 100 per barrel of oil in 1998). The second implementation of FIT policies was in Denmark and Germany, which was in the mid of 1990, in which the government determined a price for RE and the utilities were required to purchase at that specific price. The FIT is considered as a political price market model, hence the price is being determined by the government and the market determines the quantity (Komor 2004).

One of the advantages of using the FIT mechanism that it allows the non-traditional developers participate in the RE market, for example the installation of solar panels in households and the owned wind turbines. A disadvantage is that there is no competition in the FIT system; therefore the

RE cannot be achieved at the lowest price (Komor, 2004). It is under the government responsibility to fix a price of the produced electricity from renewable resources. The subsidy can be provided from the government funds or the utility companies may be forced to purchase the electricity produced and sell it to the consumers, thus passing the costs on to the customers (Komor 2004).

Another advantage of the Feed-in Tariff mechanism is that it reduces the investors risk; hence the generators guarantee a fixed price with a fixed duration, which reduces the risk to investors. Moreover, this mechanism takes the responsibility that once the plant is in operation there will be a fixed guaranteed price for a known period in the future. Tariff mechanisms have been well used in Europe, and have succeeded in many countries for example Spain, Germany and Denmark. However, this mechanism is considered to be unpredictable because even if the prices are fixed to the RE generators, the market plays a role and decides the level of capacity, which means that the number of investors cannot be predictable (Lewis & Wier 2007).

FIT mechanisms have been shown to be a strong mechanism in promoting RE resources. Moreover, this mechanism can support the future market stability for investors in long-terms. Spain, Denmark and Germany have been the most successful countries in this field and by using the FIT mechanism; these countries have created stable markets for wind power. Furthermore, the feed-in tariff has also supported the US wind industry in the state of California (Lewis & Wier 2007).

2.4.2. Renewable Portfolio Standards (RPS) Mechanism

Renewable Portfolio Standards (RPS) is a quota system that requires electricity suppliers to use a certain share of their electricity from RE. The government place a law on the electricity supply companies that a specified amount of electricity shall be from RES; companies which doesn't meet this law will be forced to pay penalty (Komor, 2004). This mechanism will create a market with competition between generators; which will result in the best lowest price for renewable electricity. An example of implementing the RPS mechanism is as Special Measures Law in Japan, RPS in 21 US States, as a Renewable Obligation in the UK and as the national MRET in Australia (Australian Greenhouse Office, 2004), (Lewis & Wier 2007).

The RPS is affected by free-market conditions which results in an unregulated technology (Komor 2004). In the RPS the price is determined by the market and the quantity established politically. Here the market is the player which decides the source of RE and the price. This means that the RE technology produces power at the lowest cost which is achieved by using advanced technologies and experienced developers. Carbon trading is an example of the RPS policy. Furthermore, in some countries, a cost ceiling is being provided to limit the price of RE is sold (Dinica & Bechberger 2005).

The price in RPS is not predetermined as it is in the UK case, and the uncertainty on the price and period is expected to limit the participants in the market. It is important to level between the RE and the conventional source; this can be achieved by addressing administrative barriers to allow grid access. It has been revealed that the RPS is the more expensive approach to RE deployment. As mentioned earlier that this mechanism will allow competition, which will lead to a reduction in the costs. In practice, generators are liable to risks, which will have impacts on the capital cost and on the total cost of generation, which will result in high cost for the consumer (Lewis & Wier 2007).

2.4.3. Contract Bidding Mechanism

Government places an obligation to take electricity from RE technologies on supply companies, which have been awarded contracts by the government. Generally, the lowest bids are awarded the contract after complying with any criteria set by the government. UK is one of the examples which implemented the contract bidding mechanism through the UK Non-Fossil Fuel Obligation (NFFO); another example is Irelands Alternative Energy Requirement (AER) (Lewis and Wier, 2007). Many contracts in practice which have been awarded under these mechanisms have failed because these companies consider the bids to cover future cost reductions. Ultimately, policy makers found that this mechanism didn't make a manufacturing interest to the country (Lewis &Wier 2007).

2.4.4. Tax Credit Mechanism

Fiscal instruments have been used to promote the generation of electricity from renewable resources for example lowering the rate applied for RES-E systems. Table 2.2 shows the tax incentives in different EC countries (Haas et al. 2004).

Different tax- related Incentives are being provided by many governments to promote the investment in renewable energy. Capital, VAT reductions, tax reductions and property tax incentives are all examples of incentives. In the US federal level the production tax credits was used. Moreover, India's market in the 1990s was also driven by different tax incentives for example 100 percent redemption of wind equipment was used, another incentive is the 5-year tax holiday. Additionally, China uses tax exemption and VAT on electricity generated from wind. However, unstable markets were the results of the countries that have depended on tax strategies (e.g., US and India) (Lewis & Wier 2007).

Table 2.2 –The Tax incentives in different EC countries (Haas et al. 2004)

	Investment-based tax incentives
Austria	Private investors get tax credits for investments in using renewable energies (personal income tax)
Belgium	13,5-14% of RES-investments deductible from company profits, regressive depreciation of investments
Greece	Up to 75% of RES-investment can be deducted
Ireland	Tax relief for certain RES-investments
Italy	Up to 50% of RES-investments can be deducted over a period of two years
Luxembourg	Tax deduction of RES-investments
The Netherlands	VAMIL scheme: RES-investors (specific renewable technologies) are allowed to offset their investments against taxable profits. EIA scheme: RES-investors (same technologies as VAMIL) are eligible for an additional tax deduction against their profits (from 52.5% to 40% depending in sum of the investment) Lower interest rates from Green Funds: RES-investors can obtain lower interest rates (up to 1.5%) for their investments

Chapter 3: Methodology

The following section discusses the different approaches that have used to study, evaluate and implement strategies to promote RE. Moreover, this section also covers the strengths and weaknesses in the different methodologies in order to justify the appropriate methods for the topic. Finally, the best methodology applicable to the research will be selected.

3.1. Outline of the applicable research methods

3.1.1. Literature review approach

Literature review approach contains five stages. The first stage is finding models from previous studies in the same discipline. The next stage is constructing the problem formulation. This is followed by the literature search to identify scope and key issues and then the evaluation of findings. The final stage is concerned with the analysis and interpretation of the reviewed literature.

In the research paper about fostering a RE technology industry, Lewis and Wier (2007) used the literature review methodology to examine the vital roles of national and sub national policies in providing the support to develop a successful wind turbine manufacturing companies. Their intention was to explore the steps that have been used to establish a local wind energy industry. To do that, they compared the employed policy support mechanisms in order to enhance their research. More specifically, they compared between different mechanisms such as feed-in tariff, government tendering and financial and tax incentives to support the integration of RE. They based their argument on the advantages and disadvantages of each mechanism. To support their arguments and to enhance their analysis, they also used graphs. Please see Figure 3.1 and 3.2 below for the examples of graphs used by Lewis and Wier (2007).

Through the adopted methodology, Lewis and Wier (2007) identified that the success in the global wind power market was based on a manufactures' success in a particular country. They argued that policies that support a stable, sizable market for wind power industry is required to manufacture local wind turbine technology. This will create an internationally wind industry and create a competitive market. The analysis of Lewis and Wier (2007) led the conclusion that for countries which are keen to support local wind technology manufacturing are supposed to undertake an assessment of cost reduction advantages as well as assessment of employment. Moreover, they found that the feed-in tariff mechanism was a very successful system to promote wind energy.

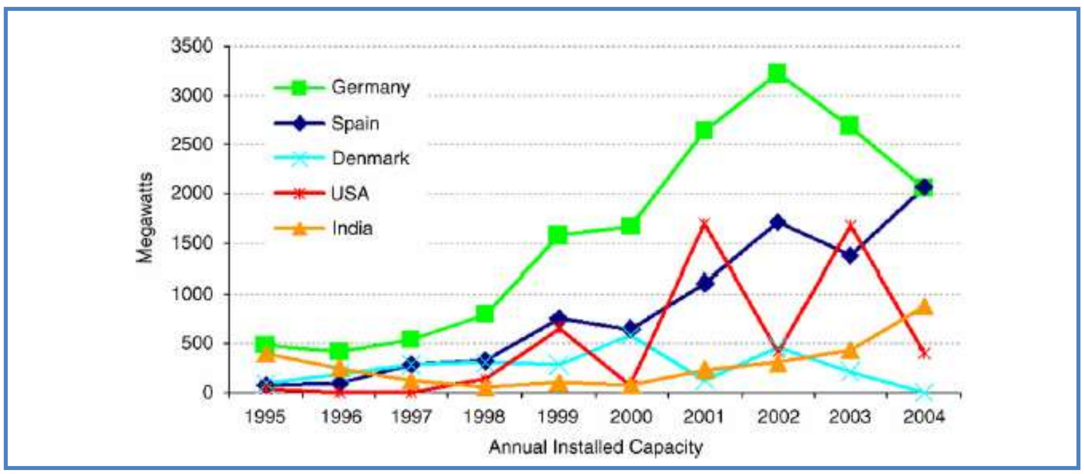

Figure 3.1- Installations of annual wind power capacity in countries with advanced turbine manufacturers, 1995-2004 (Lewis & Wier 2007)

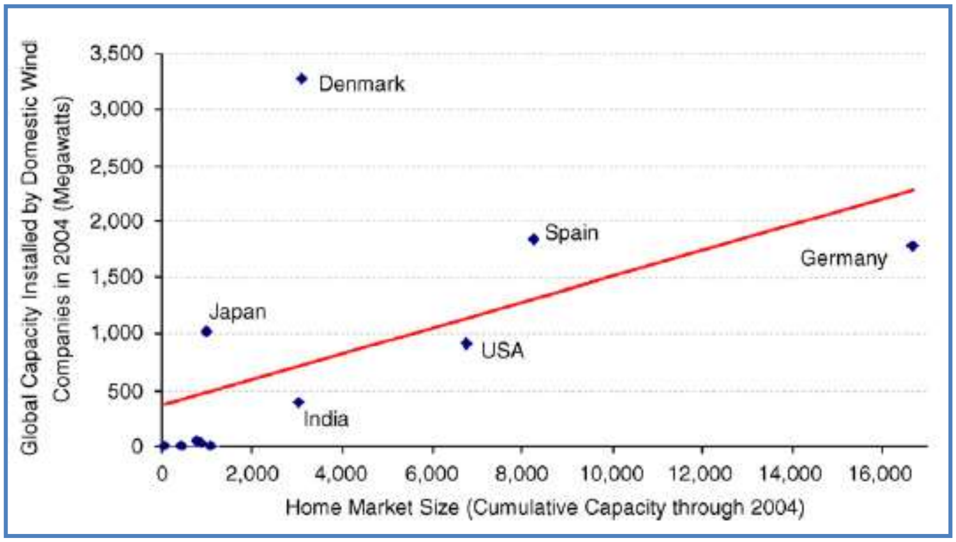

Figure 3.2- Global capacity installed by domestic companies (Wind Industry) (Lewis & Wier 2007)

Cherni and Kentish (2006) examined the effectiveness of the RE policy and legislation implemented in China. Additionally, an investigation has been made on the scope of RE promotion law (2005). The paper discusses two issue related to the electricity sector in China; first issue is the problems that affects the largest power industry in the world, second issue is the potential to use RE technologies. The problems and institutional changes in the electricity changes in China to provide RE technologies have been identified. The aim of the study was to highlight the obstacles against RE in China. Additionally, the RE development in China was examined to identify policy barriers.

Another example where the literature review approach is utilized is the study of Mitchell and Connor (2004). In this study, the scholars examined the RE policy in the UK between 1990 and 2003. The paper started with describing UK RE policy between the selected years as well as the implementation of the wind energy in Europe in the same period. Then, Mitchell and Connor (2004) discussed the possibility of supporting RE's in new ways. In doing this, the scholars, discussed the NFFO mechanism through providing its history as well as drawing the advantages and disadvantages of the NFFO contracts. The NFFO prices were also presented in their paper to enhance their research strategy. Additionally, the scholars examined three cases in details to show the nature of the UK RE policy. In the light of these analyses, Mitchell and Connor (2004) provided an argument on whether RE can become the central supplier of energy in the UK or not.

3.1.2 Examination Approach

The examination approach was used by Tsoutsos (2001) in the investigation of marketing solar thermal technologies. With this approach, Tsoutsos (2001) made an attempt to identify the steps to reduce barriers against marketing of the solar thermal technologies. The major strength, weakness, opportunities and threats (SWOT) was examined of the Solar Thermal Marketing Group (STMG) to identify the major points and actions that should be considered. Based on the experiences of the advanced countries the findings of Tsoutsos (2001) revealed that new subsidy programs based on publications, campaigns, financing schemes and studies are required to overcome barriers. The analysis of Tsoutsos (2001) suggested that a potential marketing strategy can be established for promoting solar thermal technologies.

Additionally Papineau (2004) used the examination approach in his paper which aimed at testing the strength of solar photovoltaic (PV) and wind energy as well as the effect of R&D on cost reduction. Papineau (2004) concentrated on government supports for solar photovoltaic and wind energy particularly on the implemented various policies such as R&D funds and subsidies. The obtained results in the paper show that experience was not a factor to strength the addition of time trend and that R&D in solar and wind technologies does not perform effectively. The cost data of Solar PV has been obtained from the National Renewable Energy Laboratory in the U.S. (1992-2000).

Table 3.1 shows the results of Solar PV at international level between 1992-2000. The examination approach is useful in this kind of studies because it is based on observations under estimation. Panel estimation is useful for examining RE technologies. Moreover, a combination of data in a panel and estimating them jointly will give reasonable results.

Table 3.1 Solar PV international 1992-2000 (Papineau 2004)

Index	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**
1. *CC*	-0.24^{a}		-0.16^{a}		-0.56^{a}	
	(0.02)		(0.03)		(0.06)	
2. *CE*		-0.19^{a}		-0.07^{a}		-0.48^{a}
		(0.01)		(0.01)		(0.03)
PR	0.85	0.88	0.90	0.95	0.68	0.72
LR	0.15	0.12	0.10	0.05	0.32	0.28
Adjusted R^2	0.95	0.96	0.82	0.91	0.93	0.97
Observations	9	9	9	9	9	9

3.1.3 Survey Approach

In his study, Painuly (2000) used the survey methodology to determine the barriers against the integration of RE technologies in India. The study took two years and the scholar employed multi-phase stakeholder approaches for the investigation. As a case study, Maharashtra state was selected. In the research, Painuly (2000) conducted a survey with the households and policy experts as well as to commercial and industry establishments. The involvement of the stakeholders was achieved throughout 80 questionnaires conducted with the households in the residential area. Moreover, several interviews were conducted with different stakeholders like energy developers, policy makers and equipment manufacture. For interviews, 10 companies were selected from the industrial sector; 30 companies from the commercial sector and 10 wind energy developers were selected. The interviews with the stakeholders were used to find out their views on barriers affecting RE technology. The questionnaire with the customers was used to identify the users about their consumption cost, queries to barriers such as high cost and lack of incentives. As a result of the employed methodology, Painuly (2000) concluded that the survey method helped in identifying the barriers to RE technologies in India and led to identification of improvement areas.

Haas et al. (2004) have also used the survey methodology to identify how RE systems can be promoted successfully and effectively. Their objectives were to simulate technological progress, to minimize administration costs and to make RE technologies acceptable to the public. They compared between price-driven system (feed-in tariffs) and capacity driven system (tradable green certificate) and presented their findings with charts to show the difference between these two systems (Figure 3.3 & Figure 3.4) (Haas et al. 2004).

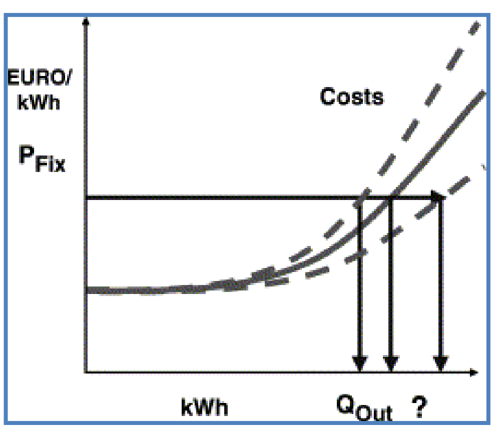

Figure 3.3 – How a FIT works (Haas et al. 2004)

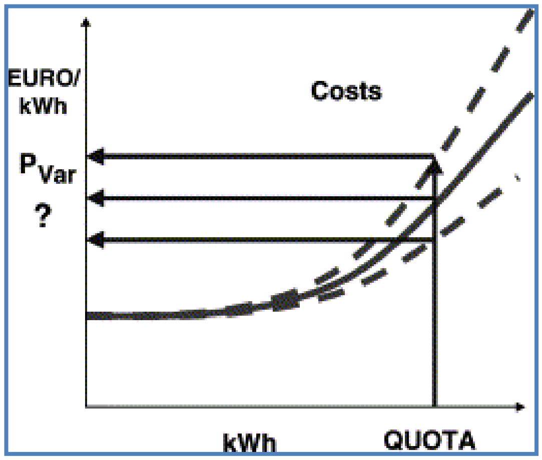

Figure 3.4 How a Tradable Green Certificate-works (Haas, et al, 2004)

An analysis by country was done to reveal the patchwork ongoing changes. Additionally, a dicssuion about the table analysis was carried out later in which each country's current policy was considered as well as their future expectations. In the light of findings from the survey, the scholars drew the following conculsions:

- FIT is the pressfredd mechanism.
- The support mechanism should have a guranteed period.
- To consider the investors risk that is caused by uncertainty regulatory.
- The selected strategy shall consider the current promotion as well as the future changes.
- Training and education programs are required to enhance the incentive-based promotion schemes and support the RES-E market development.
- Transcation costs are caused by issuing certificates, organizing bidding auctions reedming certifactes and including RES regulation.

In another research, Karekezi and Kithyoma (2002) implemented the survey approach to investigate the RE strategies in Sub-Sharan Africa. In their research, the scholars examined the possibility of introducing solar PV. They collected the information about the sources of fuels and fuels used for cooking in rural domestic areas. As a result of the implementation of survey method, Karekezi and Kithyoma (2002) categorized the use of energy into three groups:

- Energy for domestic use
- Energy for agriculture use
- Energy for small companies

Based information collected via survey, Karekezi and Kithyoma (2002) developed the following recommendations:

- Tariff systems can be used for agriculture sector.
- Target women as in rural areas to provide the awareness to use modern energy technologies.
- Target small companies and agriculture sectors.
- Provision of biomass energy technologies.

Surveys are not expensive and can give significant results specially when analyzing large samples. Measurement can become more precise when making the questions standardized. Moreover, it is flexible in terms of deciding how the surveys can be delivered either by telephone, face-to-face interviews or by electronic means. However survey takes very long time in terms of collecting and analyzing data to obtain the results. Additionally sometimes it is difficult for participants to tell the truth about a controversial question. It is the researcher responsibility to ensure that he/she will get a large number answered of the selected sample.

No research papers were found on Simulation approach that answered the same question topic. The following table provides the comparison of reviewed methodological approaches according to three criteria:

Table 3.2 Comparison of reviewed methodological approaches according to three criteria

	Effectiveness	Time	Cost
Literature Review Approach	Effective	Reasonable time	Normal
Experimental Approach	Very Effective	More time required	Very Costly
Survey Approach	Effective	More time required	Normal

3.2 Selection and justification of selected methodology

This section aims to justify the methodological choice made to reach the objective of this dissertation. This is important because it helps in identifying the impact of this research as well as identifying all variables used for the investigations.

The review of the methodological approaches suggests that the literature review approach is the most suitable approach that can be applied in achieving the goal of this dissertation which is to develop the strategies for promoting RE in the UAE. It is believed that the literature review approach will help in finding the ideal way of implementing RE regulations in the UAE.

The methodological process of literature review approach includes collecting information, analyzing data and explaining the findings. With the literature review approach it is possible that the research problem can be delaminated into different levels; a new direction can be found; fruitless approaches can be avoided and recommendations can be developed for further research.

Additionally, in literature review approach it is easy to construct a framework which can be conducted in the future research and can include primary data collection. The steps used for conducting the literature review in chapter 5 are as follows:

- Identification of problem
- Gathering data
- Evaluation of data
- Analysis
- Presentation and final outcomes

Moreover the key components are:

- Research question
- Gathering data plan
- Analyzing data procedure
- Presentation of data procedure

Mainly, major books about RES technologies and policies will be used to get relevant and useful information related to the topic. Additionally, I will rely on UAE and DEWA strategic and future plans in RES's in the proposal of the new policy. Moreover, effective feedback from the stakeholders will be used to refine the proposed policies to match the country's future perspective.

Chapter 4: Lessons Learnt From Global Experiences

In these section different case studies that have implemented RE policies are examined in different countries (developed and developing). Different markets, different strategies, achievements, barriers as well as the promotion systems encouraged are discussed below. Additionally, this section highlights policies that have been implemented in IEA countries in order to increase deployment of RE as well as to increase cost effectiveness of energy supply.

Furthermore, the following lines cover a detailed comparison between different mechanisms used in different countries that have implemented RE electricity strategies, which is analyzed and discussed in terms of achievements, strategies implemented, and barriers faced. Moreover, the following discusses the direction of energy policy in different countries, the barriers faced, success and failures, as well as future targets and plans. Moreover, policies and approaches being used to promote the development of this potential in different countries are included in the scenario set out below. A generic framework for the development of laws and practical policy regarding the country's energy sector is drawn up. The paragraphs below discuss further analysis and comparison of different experiences as well as policy theory and policy outcomes. Finally, the objectives of these policies are highlighted to identify the successful procedures in order to assist governments in policy decisions.

4.1. The case of Spain:

4.1.1. RE policy history in Spain

Spain is considered to be one of the most successful countries in the RE field, particularly electricity from wind energy. Additionally, Spain has establishment the Energy, Environment and Technology Center, whose many activities enhance the RE technology sector. Moreover, Spain is now a leading European PV manufacture; it is considered to be the 2nd largest wind power country in Europe with around 5,000 MW capacity. Also, small power stations were built with mirror modules that concentrated solar radiation to generate electricity in a thermodynamic cycle (Mallon 2006). In 2002 there were already 3337 MW of installed wind capacity, (as compared to 2001) in comparison to 834 MW at the end of 1998 (Bustos 2002). Additionally, three different small solar thermal electric power stations were built in Spain in 2002. Society organization and independent developers enhanced the development of integration of RE resources. In Spain they have independent developers and civil society organization (Mallon 2006). Table 4.1 shows the types of renewable electricity which was sold to the grid on the Spanish mainland in the period from 1990-2002 (Bustos 2002). Table 4.2 shows the accumulative power in Spain between 1995-2003 (Rio & Unruh 2005).

Table 4.1 –The RES technology bands, as differentiated in the 2818/1998 Royal Decree (Bustos 2002)

RES band	Types of renewable energy resources and technologies
b1	only solar energy
b2	only wind energy
b3	geothermal, wave, tidal, hot dry rocks
b4	hydropower < 10 MW
b5	hydropower between 10-50 MW
b6	minimum 90 % primary biomass: naturally occurring or purpose-grown plants younger than 1 years that
b7	minimum 90 % secondary biomass: wastes from a primary use of biomass, especially manure, sludge from residual water treatment, forestry and agricultural wastes, biofuels and biogas.
b8	plants using the b6 and/or b7 resources in a proportion of at least 50 %, together with conventional fuels
b9	plants mixing any of the b1 to b8 groups

Table 4.2- Accumulated power of wind energy in Spain (1995-2003) (Rio & Unruh 2005)

Year	Power installed (MW)	Accumulated power (MW)
1995	46	119
1996	95	214
1997	213	427
1998	407	834
1999	705	1539
2000	795	2334
2001	861	3195
2002	1440	4830
2003	1377	6207
2004	1746	7953

After the oil crisis shot in 1970, the Spanish government started a policy two decades ago aimed energy saving and efficiency (Lopez & Enrique 2000). The move towards renewable direction was to reduce the dependence on imported resources, reduce CO_2, maintain energy security and improve the environmental performance of energy production. In 1998, 6.3% of the total consumption of energy was from renewable resources. Furthermore, a target of 12% of RE to be achieved by 2010 was set by the 54/1997 Law of the Electric sector in Spain. However, the percentage of RE generation dropped from 6.3% in 1999 to 5.6% in 2002. Then, the Spanish RES Agency revised its policies to achieve the 12% goal. After that the 82/1980 Energy conservation Law set the first legal framework for the support of the RE market. The 40/1994 Electricity law came up by 2366/1994 Royal Decree, issued to further specify the new special regime. The Royal Decree 2818/1998 was issued to further specify the terms of the special regime (Bustos 2002).

In Spain the responsibility for energy policies were with the government and the Ministry of Industry and Energy. In 1998, the National Energy

Commission (CNE) was created and attached to the Ministry of Economy in Spain. The goal of the National Energy Commission was to enhance the effectiveness of the energy systems in the country and to protect consumer's interests (Gonzalez 2008). The Institute of Energy Diverstection and Saving (IDAE) was established in 1984 and was the main player in promoting RE technologies in Spain. Its main task was to draft and implement, as well as to oversee, government RE policy. IDAE was effective in investment subsidies and soft loans through the use of the 'third party finance' formula, and through the participation in companies specialized in RE investments. Further, the 1999 policy plan was prepared by the governmental agency to promote and integrate RE systems in order to achieve the targets for 2010 (Mallon 2006).

An association, Renewable Energy Produces (APPA) was formed in 1987; it has improved the investment of RES framework through its media campaigns. The RE development in Spain was enhanced by legal guarantees from 1980 which are the fixed guaranteed price, the purchased contracts and the network connection. This was introduced earlier in the 82/1980 economic attractiveness of RES plants (Stenzel & Frenzel 2007).

Further, an adoption of new electricity law was carried out in 1994 to enhance the regime of RE. On the purchase contracts there was a guarantee of five years. After that, the 12% target of RES contribution by 2010 in the 54/1997 came up. After that, the 2818/1998 Royal Decree came to enhance the investment in the RES. In 1999, a special policy for the promotion of Renewable Energy called (PFER) was approved by parliament (Mallon 2006). Figure 4.1 shows the wind power evolution in Spain from 1990 to 2005 (Stenzel & Frenzel 2007).

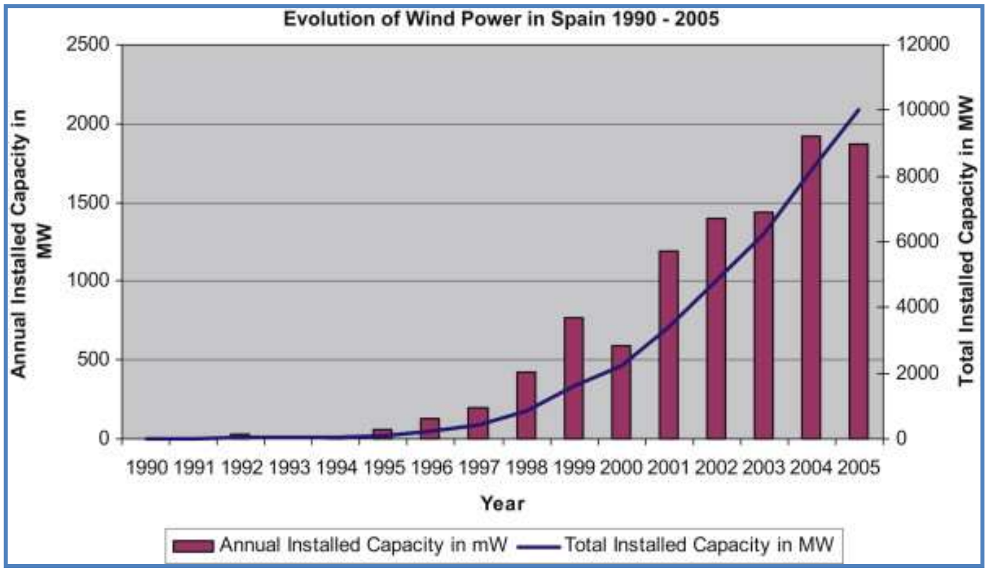

Figure 4.1 - The wind power evolution is Spain from 1990 to 2005 (Stenzel and Frenzel 2007).

The main regulations that enhanced the promotion of RES-E are as follows (Gonzalez 2008):

- The law 82/1980 related to the Conservation of Energy. The main goal of this law was to reduce the dependence on imported energy. The use of RES-E was encouraged through a guaranteed price for RES-E which is being fed into the grid up to 5MW; in addition to that, investment subsidies were also implemented. It was set by the Ministry of Energy and Industry.
- R.D. 2366/1994 which constructed contractual relationships between RES-E and distribution companies. Capacity of plants less than 100 MW had to sell the electricity to distributors. These distributors were forced to buy the electricity at a fixed price which is based on electricity prices and other factors.
- Electricity sector law (law 54/97); this law has guaranteed grid access for RE resources. RES-E plants with less than 10MW will get a

premium which is set by the government. A range of 80-90% of the average electricity price will be paid to the plants.

- Royal Decree on Special Regime (RD 2818/1998). In this regulation RES-E generators have two options; the first option is a fixed feed in and the second option is a fixed premium.
- The promotion of RE (PFER) which emerged in 1999 included a RES-E directive plan for Spain in 2010, which identifies that 29.4% of electricity should be achieved from RE resources.
- Royal Decree 436/2004. This regulation implies that electricity provided from RES-E generators can be sold to distributers or to the market. Here, support is being set to the average electricity tariff (AET). AET value is set annually by government. The regulation encourages RES-E to participate in the wholesale electricity market. Moreover, it included the impact on the stability of the grid affected by the increasing share of RE.
- Royal Decree 661/2007, which started in June 2007. Supports included Floor system for RES-E and Consumer Price Index (CPI).

Amendments on RD 66 with respect to the previous regulation are:

1. The support level will be revised every 4 years from 2010.
2. Reducing technology costs, especially RE technologies costs.
3. Support will vary on the peak and off peak period to feed into the grid.
4. Plants selling to the market will get incentives as well as premium plus.

The success of FIT is the approach of interaction between various stakeholders for example, RES-E generators, policy makers, utilities and the system operator (Gonzalez 2008).

4.1.2. Strategies / policy frameworks /mechanisms and policy design in Spain

The major factors of Spain's success were the strong design elements of support as well as the implemented support scheme (Gonzalez, 2008). In the following lines the main instruments for promoting RE will be outlined discussing types of instruments implemented as well as the success and failure of each in Spain.

From the previous discussions about Spain's RE history, it is revealed that Spain has made efforts and has set targets to define the route for renewable integration; this was done through creating incentives and mechanisms for RE power and to provide a longer term existence for premium payments. Spain required a compulsory law to implement solar energy, saying that all newly built buildings in Spain had to be provided with solar thermal collectors to supply at least 60% of the hot water demand. Moreover, Spain has used the premium payment as a strategy to promote RE generation (Mallon 2006).

Additionally, in 1994, the government forced the electricity companies to fix a minimum price for a period of five years for energy generated from renewable sources. Spain's support system was focused on a feed in tariff (FIT) scheme; the Spain government specified an amount of RE to be generated nationally. Moreover, the installations of RE plants was being regulated by the government in the owner plots. Wind developers pay land owners a rent of 1.5% of the total value of power generated (Mallon 2006). Moreover, incentives were set by the Royal Decree 2818/1998; an amount of 39,668 €cents/kWh was set for PV installation lower than 5kW which is connected to the grid and 21,634 €cents/kWh for installations more than 5kW. This feed-in tariff was less than the tariffs given in most other European countries. Besides, investment subsidies and soft loans were being provided by the National Government. 15% to 50% of the total investment was covered by government subsidies. Table 4.3 shows the wind electricity premiums and fixed prices direction in 1999-2003 (in Euro cents/kWh) (Rio & Unruh 2005).

Table 4.3- Wind electricity premiums and fixed prices direction in 1999-2003 (in Euro cents/kWh) (Rio & Unruh 2005)

WIND	1999	2000	2001	2002	2003	% variation (1999–2003)
Premiums	3.16	2.87	2.87	2.89	2.66	−18.2%
Fixed prices	6.62	6.26	6.26	6.28	6.21	−6.2%

4.1.3. Obstacles for RE in Spain

Although Spain has been a leader in RE technology, it has faced some barriers in the same sector. The main barrier for RES-E development in Spain was that the policies were not integrated. Additionally, the grid connection framework was not clear as well as the different regional procedures which made the global RES-E somewhat difficult (Haas et al 2004). Other obstacles against the RES in Spain were that it had a very small market presence and a lack of policy integration. There was also a lack of an accurate legal framework, as well as insufficient support (Rio & Unruh 2005). Additionally, the Spanish network system was restricted and weak and required the owners to pay from grid connection. Moreover, PV investments are still expensive and have high initial costs (Rio & Unruh 2005). In the following paragraphs the barriers to the PV as well as the barriers to wind energy are highlighted.

Barriers to PV

1. Connection to the grid: Before 2000, there was no such a regulation that allowed connection to the grid, and this made energy firms set exorbitant charges. After that, the Royal Decree 1663/2000 allowed PV systems to connect to the low voltage grid with conditions. The problem that most PV generators have a medium voltage grid connection. Generators claimed that grid access was at unfair fees and directly accused the grid operator and utilities of preventing PV access, which blocks the introduction of a new technology.
2. Administrative Barriers: Administrative procedures are complex, and cause costly delays.
3. Financial barriers: Fund financial conditions are not favorable and generate disincentives.
4. Lack of training and skills of equipment installers.
5. Lack of information: including lack of information of costs of existing subsidies and technologies (Rio & Unruh 2005).

Barriers to wind energy

1. Authorization procedures: Complex procedures created barriers against connection to the grid. These regulations and procedures delayed the granting of permits and increased the risk.
2. Several administrative authorities: the permitting procedures involve many approvals from different authorities (national, municipal and regional). Some time overlap of procedures occurs which leads to slow progress. For example, the implementation of wind farms is done through 60 regulations, 40 procedures which take 4 to 8 years. There procedures should be simplified to overcome this obstacle.

3. Process of grid access: the lack of infrastructure, in addition to the extra costs required for grid connections, complicates the process of grid access.
4. Difficult access to grid: although Law 54/1997 permitted wind energy generator to feed power into the grid, is it still a problem to access the grid.
5. Weakness of the grid: usually wind farms are located in a weak and limited grid infrastructure; the existing grid capacity should be improved which will require additional costs (Rio &Unruh 2005).

4.1.4. Spain's future plans and targets in RE sector

Spain's future target by 2011 is to achieve 13,000 MW of capacity of installed wind energy. Hence, this target is aligned with its RES-E Directive target (Directive 77/2001/EC): which includes that in 2011 29.4% of electricity consumption should come from RE resources (Rio & Unruh 2005). Moreover, the gas discharges are not allowed to go over 15% in 2011. A business plan was set by EUFER to develop 2750 MW of wind energy in Spain by 2011 (Stenzel & Frenzel 2007).

4.2. The case of Germany:

4.2.1. RE policy history in Germany

Renewable energy development in Germany was very successful; Germany achieved 9% of electricity from RE resources in 2002. Moreover, in 2003, it was selected as a world leader in the installation of wind capacity. Furthermore, in the same year, Germany installed the second largest photovoltaic capacity in the world (Bechberger & Reiche 2004).
The installed wind capacity amounted to 13,512 MW in October 2003 (nearly 40 % of the global capacity (Bechberger & Reiche 2004). Germany now has

about 18 years of experience with the fixed minimum payment system for renewable electricity (Feed in Tariff). Additionally, Germany is now recognized as a leader in PV industry development. Also it has increased the generation of RE in the last 5 years to 8% of total electricity using the feed-in tariff for renewable electricity (James & James 2004). Moreover, an increase from 160,000 in 2004 to 250,000 in 2007 in employment was recognized in the renewable industry; the creation of these jobs was by EGG programme (Bechberger & Reiche 2004):

The success of RES development in Germany was based on the following conditions:

1) The instrumental conditions along with the security issues applied for investors in the RES projects.
2) The Cognitive conditions where the strong alliance for RES meant that in the year 2001 more than 100,000 households decided on solar thermal installation.
3) The political conditions which made the private actors deal with RES and the government institutions. Furthermore, a political condition to phase our nuclear energy in Germany is required for the success of RES, this became law of April 26, 2002 which lead to a higher demand for RES. The nuclear power plant that stopped operation in accordance with the decision of nuclear phase-out was the plant in Stadeon, 2003, after 31 years of operation (Bechberger & Reiche 2004).

In Germany generated power from RE has doubled in the last decade. However, it is still to get a sustainable electricity supply because 50% of the energy supply is still generated from coal whereas 28% of the supply is generated from nuclear power (Wustenhagen & Bilharz 2004). Nevertheless, Germany is considered one of the main coals producers in the world.

Additionally, it is considered as a country with good fossil fuel reserves; the proven reserves were 66 billion tonnes at the end of 2002 (Bechberger & Reiche 2004).

Also it has small reserves of oil. Table 4.4 shows the primary energy consumption in Germany and net electricity production in 2002. Moreover, Table 4.5 shows the German available potential of RES in electricity and head generation (Bechberger & Reiche 2004).

Table 4.4 –The primary energy consumption in Germany and net electricity production in 2002 (Bechberger & Reiche 2004)

Energy carrier	Primary energy consumption		Net electricity production	
	PJ	%	TWh	%
Mineral oils	5,370	37.5	20[4]	2
Natural gas	3,107.5	21.7	36	7
Hard coal	1,890.2	13.2	114	22
Brown coal	1,661.1	11.6	143	29
Nuclear energy	1,804.3	12.6	156	31
Renewable energy sources	415.3	2.9	45	9
Others	71.6	0.5[3]	-	-
Total	14,320	100	504	100

From the information provided in Table 4.4 and Table 4.5 as well as the analysis, the technical potential is around 6,000 to 21,000 PJ/year, compared with the German primary energy consumption in 2002 of 14,320 PJ. This means that 40% of the German energy demand can be covered by RES (Bechberger & Reiche, 2004).

Table 4.5 –The available potential of RES in electricity and head generation for Germany (Bechberger & Reiche 2004)

RES technology	RES potential assessment by Enquete-Commission (PJ/yr)		RES potential assessment by UBA (PJ/yr)[1]	
	Electricity	Thermal	Electricity	Thermal
Biomass	140-205	428-695	212	598
Photovoltaics	751	-	302	-
Solar thermal	-	2,112	-	1,541
Hydro power	119	-	90	-
Wind power (onshore)	299-457	-	299	-
Wind power (offshore)	468-853	-	306	-
Geothermal energy	1,620-15,950 ($PJ_e + PJ_{th}$)		237	2520
Total ($PJ_e + PJ_{th}$)	5,937-21,142		6,105	

The beginning of promotion of RES in Germany was through the field of research. Wind energy promotion was started in 1974 by the Federal Ministry of Education and Research (BMBF), which aimed to increase economic efficiency in general. The support of the BMBF has resulted in a wind plant project called (GROWIAN) which was considered a large scale wind plant with a multi mega watt turbine. However, the attempts to build such a plant failed, due to the difficulty of fabricating a large scale wind plant or to combine smaller ones in a centralized electricity supply cluster (Bechberger & Reiche 2004).

The first German feed-in law started in 1991; fixed price was specified for electricity from RE sources. Further, the RE Sources Act was established in 2000 which facilitated the entry of other RE’s, for example, biomass energy and photovoltaic. In the 1990s wind, biomass and the other RE technologies had been operating under a different system of guaranteed payment of production (Bechberger & Reiche 2004).

The Renewable Energy Law (REL) provided a payment on the 1st of April, 2000 for energy generated from PV panels of 50 Euro cents per KWH. This law provided the basic rate for electricity which is provided from solar power and was determined to be 45.7 Euro Cents per KWh. Consequently, if the installations are attached or are built on the top of a building the fees will be 57.0 Euro cents per KWh. This law also determines a manageable price decline on the support tariffs set to 5% per year for new plants which started from 1 Jan 2005 (Bechberger & Reiche 2004).

The EGG has shown itself to be a successful instrument for promoting RE's in Germany when compared to other schemes used in EU countries (Busgen & Durrschmidt 2008). In 1991 the German EFL required utilities to buy renewable energy from power producers at a price specified by the government. Feed-in Tariff schemes are based on the average electricity retail rates for all electricity consumers in Germany. Every two years the German parliament re-evaluates the REL and potentially the rates of tariff (Bechberger & Reiche 2004). Table 4.6 shows the Energy supply by renewable energy resources in Germany in 2002.

Table 4.6 –The Energy Supply by RES in Germany 2002 (Bechberger & Reiche 2004)

Energy carrier	Quantity (GWh)	%
Biomass (heat)	52,500	49.2
Hydro	24,000	22.5
Wind energy	17,200	16.1
Biofuels	5,688	5.3
Biomass (electricity)	4,200	3.9
Solar thermal energy	1,955	1.8
Geothermal energy (heat)	1,050	1.0
Photovoltaic	176	0.2
Total	106,769	100

The most important elements of the EGG are as follows: the reward system was replaced by fixed feed-in-tariffs for the produced amount of renewable energy-electricity generated. The second element is that obligation for RES power should meet the nearest grid. Additionally, the EGG included the provision of connecting and extending existing grid networks (Bechberger 2000).

4.2.2 Strategies / policy frameworks /mechanisms and policy design:

The RE policy mechanism used in Germany was a combination of mechanisms: The first mechanism was the feed in payment which consisted of different tariffs, in which higher prices was given to solar power and this varied between 20 Euros and 1 Euro per KWh for a period from 10 to 20 years, with investment. The second one was investment subsidies which were either a fixed sum or a percentage to a max of 49%of installation price. The third mechanism used was the loan programs and programs to integrate RE resources. In general the approach to promote RES in Germany has been focused on four main mechanisms/instruments as follows (Bechberger & Reiche 2004):

1. Feed In Tariff (FIT)

Germany has adopted a system which provided minimum rates for feed-in of renewable generated electricity. The FIT was set by a federal law called the Renewable Energy Act. This mechanism was successful and made Germany the leading country in wind energy production. In August 2002, it provided a total installed capacity of 100,000 MW (Haas et al. 2004). In North Rhine-Westphalia the electricity supplier has employed an environmental tariff which allowed installing facilities with an output of photovoltaic about one MWp. Feed In Tariff implemented in Germany and was named as 100 MW Mass Testing Programme. The aim of this programme was the creation of incentives to install more wind plants by various companies. A subsidy to run the costs of plant of 8Pf/kWh was provided to the first approved wind projects (Bechberger & Reiche 2004).

Another feed in tariff program in Germany was the Act on Supplying Electricity from Renewable Energies (StrEG). This was one of the most important instruments in promoting RE in Germany during the 1990s. This program has obligated the public utilities to purchase electricity from wind and solar energy based on yearly fixed rates. The reward was double to the average revenues of the public companies for each kWh being sold to the users. The reward for solar and wind power reached 90% of this value, however for other sources of energy the reward was set to around 80% for plants that produce power less than 500kW and 65% for plants that produce from 500kW to 5MW (Bechberger & Reiche 2004).

The StrEG together with the 250 MW wind programme of BMBF helped the wind power sector to reach an important development in the wind energy market. An increase from 48 MW in 1990 to 4,443 MW in 1999 was achieved. Further, wind power was enhanced by soft loans provided by the state-owned *Deutsche* Ausgleichsbank (DtA). These provided loans reached around DM 6 billion (~ 3.1 billion euro) in total between 1990 and 1998 (Bechberger & Reiche 2004).

2. Investment Subsidies

One of the subsidies was that the solar power generators should have a guarantee that they feed into the grid and be paid at rates covering their system costs (Mallon 2004). Loan programs called soft loans are considered to be another method of investment and were available for solar installations at a favorable interest rate. However, they were not widespread and were the least effective method of subsidy. Soft Loans was a mechanism used to encourage and promote the RES projects. It was considered to be a soft loan with a long term, the maximum amount provided was 500,000 euro per system with a very low interest rate and for a term of 20 years. The Combination of schemes made solar installations commercially viable propositions in their own right, meaning that the investment community was stimulated as well as the environmentally motivated consumer (Mallon 2004).

3. The Thousand Roof Program (Programs to integrates renewable resources) (HDTP).

The 100,000 Roofs Programme was established in 1998 after changes occurred in the government. The programme’s goal was to release the installation of 100, 000 photovoltaic plants, with each having a capacity of 3kWp. The programme was funded by 510 million euro and was estimated to provide investments of around 1.3 billion euro. This enhancement made this program one of the biggest promotion programs to promote RE in Germany. (Bechberger & Reiche 2004). The average performance of the PV system in the thousand roof program was about 65%. The program resulted in more than 2100 grid connected solar PV systems which is approximately 7.5 MW of peak capacity. The output of solar generators in the thousand roof program was 2.64 KWP, this output could cover about 50% of the annual electricity need (Mallon 2004).

4. The HTDP programme

This programme has supported the installation of PV plants that produce power of more than kWp. However, this programme was limited in time and was strongly dependant on budgets (Mallon 2004).

5. The Market Intensive Programme (MAP)

The Market Intensive Programme was started in 1st of September 1999. It was an extension of the '100 Million DM Promotion Programme for RES' which was established in 1994. It is considered to be one of the most important programs that supported RE; especially for the production of heat. Photovoltaic installations at schools, solar thermal systems and installations for the combustion of biomass were all supported by financial sectors. This programme was valid for freelancers and for private persons. The support was given by direct subsidies and soft loans (Bechberger &Reiche 2004).

6. The Energy Source Act (EGG)

EGG is a program that came up on the 1st April 2000. The aim of this program was to increase the RES share by 2010. This was achieved through a reward guarantee of RES electricity for 20 years, which provides investors the security to invest in RES projects. EGG started an approach with awarding rates based on the plant size, the technology used and the output power generated from the plant. The Federal government introduced the Ecological Tax Reform (ETR) on April 1999. It included an increase in the taxes of natural gas (0.164 euro ct/kWh), fuel oil (2.05 euro ct/l), motor fuels (3.07 euro ct/l) and electricity tax (1.02 euro ct/kWh) (Bechberger & Reiche 2004).

Germany has been very successful in the integration of RE resources in their markets over the past decade. This achievement was because of the effective public policy which was based on the feed-in tariff system. The following lines discuss the factors that helped in the process of policy in Germany (Wustenhagen & Bilharz 2004):

- A strong government.
- Politicians with expertise in RE.

- Interest groups in RE's.

Moreover, the participation of members of the administration who are aware of RE policy is required in formulating and issuing the effective policies. Based on (Wustenhagen & Bilharz 2004) research, more than 135 marketers provide 1700 GWh of RE power to 490,000 consumers in Germany in 2004, which shows about 1.3% of residential customers share in RE consumption. Moreover, around 95 municipal utilities out of 900 provide RE products. There is an increase in the renewable energy market growth of around 28% in 2001 and 2002 (Figure 4.2) (Wustenhagen & Bilharz 2004).

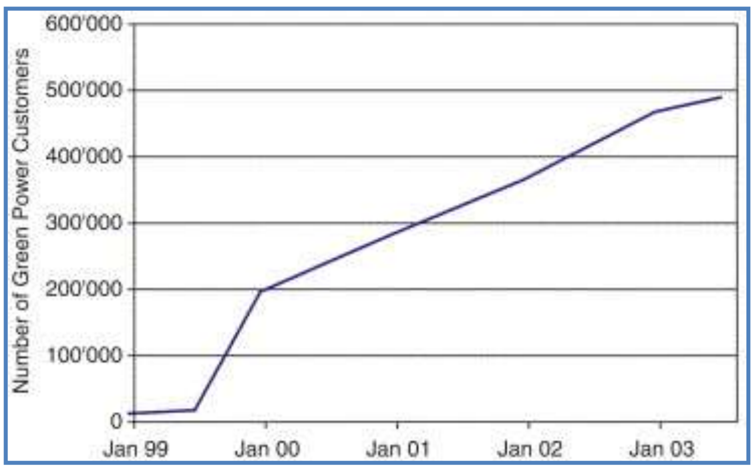

Figure 4.2 – Renewable power demand in Germany (Wustenhagen and Bilharz 2004)

4.2.3. Obstacles for RE in Germany

Although Germany had significant success in the RE market, it was revealed that feed in tariff for PV should have been amended with an extra law. Moreover, local resistance was seen against onshore wind projects in Germany. Feasible locations for building wind power plants should be given by German Municipalities to simplify the processes for investors as well as to avoid local resistances (Bechberger & Reiche 2004).

Another obstacle against the wind turbines is the strong influence of the coal sector which has resulted in a campaign toward wind power in Germany. The procurement policy of natural gas is also considered to be an obstacle against wind power because the supply contracts will expire in 2011 and others are valid until 2030; this might affect the future development of RES in Germany. The energy market should be expanded as per the expected plan and if not the contracted natural gas will be consumed first (Bechberger & Reiche 2004).

4.2.4. Germany's future Plans and targets in RE sector

The Ministry of Environment in Germany has a future target to achieve 1 50% of energy from RES by 2050. A resistance from the Ministry of Economic was against the targets of 2010 and 2020 which was revised to at least 12.5% for 2010 and at least 20% for 2020 (Wustenhagen & Bilharz 2004). Additionally, a 40% CO_2 reduction was set to be achieved by 2020 (Krewitt & Nitsch 2002).

4.3. The case of USA:

4.3.1. RE policy history in the USA

In the USA, the occurrence of RE was at a low rate. On the other hand, drivers promoting RE were expecting to make noticeable expansion in the US RE industry in the future. The main dependence of the US on imported crude oil will enhance the growth of RES industry. The consumption of RES in 1999 was 7.89 EJ, which is around 7.7% of total energy consumption. This percentage was considered as a large consumption between 1990 and 1999 (Klass 2002).

After the deregulation of energy industry in the last decade, the production and marketing of RE electricity has become difficult. Deregulation was permitted in 1996 when the Federal Energy Regulatory Commission (FERC) implemented the legislation to allow deregulation. The Public Utility Regulatory Policies Act of 1978 and the Energy Policy Act of 1992 issued orders to provide access to transmission lines and make it available to all energy producers which increased the competition between electricity suppliers. This made the distribution power generators supply customers and reduce the dependence on large stations (Klass 2002).

There following information highlights the drivers that are related to the usage of RE in the U.S.:

- Global warming and the green house effect

The first report by the United Nations Intergovernmental Panel done on climate change was published in 2001. The report shows that the earth's average surface temperature will rise from 1.4-5.8 C between 1900 and 2100 if no action is taken towards the reduction of GHG emissions. Additionally, rising sea levels are expected to rise between 9 and 88 cm over the same period mentioned. The Kyoto Protocol is one of the drivers that stimulated the RE usage in the USA December 1997 (Klass 2002).

- Government incentives

Different government incentives are being used to promote the use of RES. Federal tax credits, loans and tax subsidies are all examples of incentives that have been used in the USA to encourage RES. Additionally, incentives include solar heating units to be used as heaters for swimming pools for residential use and vehicles operating with non-fossil fuels. Although different incentives were available, many of the tax incentives have been lost because of the provisions incorporated in the legislation. Efforts are being provided to reactivate the RE taxes that were on hold and to give new tax incentives (Klass 2002).

- Technology

Research programs to develop RE technologies have been taking place since the first oil shock. A lot of practical applications have been given during the programs for promoting RES. Moreover, scientific advances for all RE have been discovered, which include lower cost processes, new procedures and higher efficiency. The following are few examples for RE technologies which are applicable for small, medium and large scale utilization of renewable resources (Klass 2002):

- The use of advanced wind turbines for constructing huge systems to generate electricity at competitive costs.
- Architectural designs with lower construction material costs.
- High efficiency photovoltaic devices to produce electricity from solar energy which can be used for small scale buildings.
- New construction materials which are maintenance free.

The commercialization of RE has been expanded through new programs introduced by the Federal Government. The Bio-energy /Bio-products Initiative, are two examples which were provided by the US Congress which started in 2000 as a result of "The Biomass Research and Development Act of 2000" (Klass 2002).

- Other intrinsic drivers

The systems of RES are considered to be flexible, hence the systems can supply local markets without the need for transporting energy. The contribution of RE resources to energy demand is infinite because they are based on renewable resources (solar energy) (Klass 2002).

4.3.2. Strategies / policy frameworks /mechanisms and policy design

The following lines describe the process of introducing the RE regulations in the USA through different kinds of mechanisms and instruments that promote the RE.

1. PURPA

Public Utility Regulatory Policies Act (PURPA) was one of the policies implemented in the early 1980s to regulate renewable resources and to integrate them to the electricity grid. In this mechanism utilities were required to purchase electricity from RES. It was considered to be a successful instrument because the utilities were forced to purchase power at a price specified by the government. The critical components of PURPA were the access and the pricing. As for the access the law required electric utilities to interconnect to “small power producers” which included independent generators relying upon either renewable sources or cogeneration. As for standardized pricing the rules developed for the new law required utilities to purchase power from the independent suppliers (Klass 2002).

2. The National Energy Act

The National Energy Act included two other provisions. The first provision was investment tax credits of 40% for residential wind and solar energy systems and 10% to 15% for business investments in wind, solar and geothermal energy systems (Klass 2002).

3. The Renewable Portfolio Standards

It is a policy that works in a competitive electricity market. In 1993 The American Wind Energy Association (AWEA) began serious efforts to define a new policy mechanism. The RPS in Texas allows wind developers to build larger projects and gain economies of scale. A well designed RPS can provide significant market stimulus to the wind energy industry. RPS has succeeded in Texas for the following reasons (Klass 2002):

- The RPS requirement was placed on all electricity retailer serving competitive markets.
- It was accessible via the internet.
- The electricity retailers were permitted to get up to 5% of their RPS obligations.

4. The Electricity Feed Law (EFL)

It is an approach that requires that RE be purchased at specified fixed tariff rates but with all RE distributed equally among all electricity suppliers. Moreover, the grid operator is required to upgrade the grid when necessary for interconnecting a new wind project. The price paid under the EFL is affected by the percentage of the retail price. The price is a critical factor for the EFL. If the price is too low the market incentive is insufficient and little RE development will take place. However, if the price set too high, political and public support may crumble if costs are perceived as excessive. Wisconsin state provides an incentive for renewable development. The incentive is that the investors who own utilities with qualifying solar thermal, wind or photovoltaic generation will get a payment of 0.75 cents per kilowatt per hour; however other renewable generations get a payment of 0.25 cents per kilowatt per hour (Zucchet 1995). President Carter's target was to achieve a 20% share of RE in the US by the year 2000. Government projections in the late 1980s estimated only a 9.5% contribution from renewable energies by 2000 (Jackson 1993).

5. Loan Programs

The US Federal Governments have many funding programs available to overcome the difficulty of financing RE projects. Loans are being offered by the government to support the business of RE products and it provides subsidies as well as developing insurance programs to provide security for the banks that support RE projects by financial means. Specific large banks, organizations and insurance companies are involved in supporting the financial part of RE projects (Klass 2002).

4.3.3. Obstacles for RE in the US

One of the obstacles faced by the RE regulations in the USA is that the contracts of RE are considered long-term contracts where at least 10 years is required to be signed with RE generators. This caused insecure and risky conditions. Moreover, financing RE products was one of the barriers against RE technologies which should be considered (Klass 2002).

4.3.4. The U.S. future Plans and targets

The future of RE in the USA is projected to have many amendments to increase market share. America's Future Energy (SAFE) Act of 2001 includes incentives to encourage the use of RES-E. It's main goal is to reduce the dependence on imported fossil fuels from 56% to 45% by 2012. Another goal of this legislation is to reduce crude oil imported from Iraq from 700 000 barrels per day to 250 000 barrels per day by 2010 (Klass 2002).

4.4. The case of UK

4.4.1. RE policy history in the UK:

The UK has one of the broadest renewable resources in the world. It has 40 % of the whole wind resource of the EU 15 (before the recent expansion).

However, Britain was not very successful in this field, like its EU partners, in establishing a RE industry. In fact, the UK is one of only two EU countries to meet its climate commitments. The RE policies were established during the first stages of power sector deregulations. In the UK matching of demand and supply is handed by the British Electricity Trading and Transmission Arrangements (BETTA) (Mallon 2006).

4.4.2. Strategies / policy frameworks /mechanisms and policy design:

The UK has implemented different kinds of strategies to integrate the RE resources into the electricity grid. It had implemented two policies the Non-Fossil Fuel Obligation (NFFO) and The Renewable Obligation (RO). The RO is a system which allows electricity suppliers to supply a fixed value of their electricity from renewable electricity (3% 2002-2003 – 10.4% (2010-2011). The RO price will be lower as the renewable output gets closer to the obligation level. A tendering system has been used to promote RES in the UK from early 1900 till 2000. NFFO was considered to be the main promotion based on the tendering system. However, In April 2002, the UK replaced the NFFO with a TGC-based quota system (Mallon 2006). The following lines discuss both schemes briefly.

- Non-Fossil Fuel Obligation (NFFO)

The Non-Fossil Fuel Obligation is a promotion system which is based on tendering. The distribution companies were obliged to take the nuclear output in order to ensure that nuclear could continue to operate and get the money needed to cover decommissioning costs. The cost was covered through charging a tax on all fossil fuels- the Fossil Fuel Levy (FFL); this was the world’s first carbon tax. The levy was imposed on fossil fuel-based power, and set by the independent electricity regulator. Through this mechanism the government made all consumers pays the extra costs for the benefits of nuclear production by applying a broad carbon tax on the rest of the sector.

The government extended the use of money made available by NFFO to technologies other than nuclear that is RE. In 1990s, nuclear received £7.8 bn from the Fossil Fuel Levy, while renewable got £400 m. Nevertheless, NFFO proved to be a powerful incentive to a small industry, in which more money became available for investment because of the expansion of RE. Table 4.7 shows the renewable generating capacity in the period 1992-2003, including former NFFO contracts and capacity outside of NFFO (Mallon 2006).

Table 4.7 Renewable generating capacity 1992-2003, including former NFFO contracts and capacity outside of NFFO (Mallon 2006)

	Number of projects	*Capacity (MW DNC[1])*
England and Wales		
NFFO1 (1990)	75	152.1
NFFO2 (Late 1991)	122	472.2
NFFO3 (1995)	141	626.9
NFFO4 (1997)	195	842.7
NFFO5 (1998)	261	1177.2
Total NFFO	*794*	*3271.1*
Scotland		
SRO1 (1994)	30	76.4
SRO2 (1997)	26	114.1
SRO3 (1999)	53	145.4
Total SRO	*109*	*335.9*
Northern Ireland		
NI-NFFO1 (1994)	20	15.6
NI-NFFO2 (1996)	10	16.3
Total NI-NFFO	*30*	*31.9*
Total	**933**	**3638.9**

The key aspects of the NFFO concept can be identified as follows:

1. The UK government would secure the largest amount of RE generating capacity for a given cost.
2. By giving developers secure long-term contracts, financing would be relatively easy to come by, and cheap.

The government called for project developers to bid for contracts to select which RE projects were to be supported under NFFO mechanism. The winners were awarded power purchase contracts. The original NFFO applied only to England and Wales, this was implemented in 1994. One of the most successful elements of the scheme is that it did allow some insights into the real pricing of RE's and also did succeed in its stated aim of economic efficiency, providing pressure to keep bid prices as low as possible.

The Non-Fossil Fuel Obligation had the following schemes (Mallon 2004):

1. Simple fix tariff with low risk which has enabled many wind turbines to be cooperatively owned by local residents.
2. Charging a tax in all fossil fuels.
3. The governments made all consumers pay the extra costs for the 'benefits' of nuclear production by applying a broad carbon tax.
4. Retailers who fail to meet their requirements pay a penalty.
5. Requiring retailers to buy renewable obligation certificate, hence a new market for RE was created.

There was a negative impact when the contracts were awarded to the lowest bidders that affected the UK RE industry. Developers were forced to choose the technology that would deliver the lowest price in order to secure NFFO contracts against other projects. Guarantees were also not available for future development direction, which was considered a high risk for investors. The emphasis on the lowest bidder created a highly competitive system, encouraging developers to be optimistic to the extent they bid down prices and filter out those who had been over-optimistic.

- The Renewables Obligation (RO)

The process which leads to the Renewables Obligation (RO) was protracted by constant consultation. The policy on RE was reviewed by the minister

John Battel. It contained the general conclusion that a form of the relatively untried quota-and trade system (known as Renewable Portfolio Standards in the USA) should be implemented through an obligation on suppliers to buy green power. The RO was internationally set up to be technology blind with the cheapest resources. RO development process was that RE policy must result in costs to the consumer that were acceptable. As with NFFO, quantities were defined, although for the RO the quantity was energy generated and not generating capacity. Suppliers achieve compliance with the Obligation by acquiring Renewable Obligation Certificates (ROC's), tradable instruments that are awarded to qualifying generators in propotion to their output, with one ROC equaling 1 megawatt hour (MWh). If a supplier is unable to acquire the required amount of ROCs, it has to pay a buy-out price. By requiring retailers to buy Renewable Obligation Certificates, a new market for RE was created (Mallon 2004).

4.4.3. Obstacles for RE in the UK:

The UK has faced some problems against the issues of transmission network extension. However, it is aiming to build their new plants in which the resources are available, particularly in the case of wind energy. The problem in the UK was in the policy support, which did not work as effectively as was intended. The failure to provide a framework for stakeholders was another obstacle to the success of RE. An additional complication was caused by giving the winning bidders in NFFO a period of five years before the contract offer expired, where some may have falling equipment costs, where if the costs did not fall enough, their projects were not viable. Another disadvantage of the NFFO was that when a tender was announced the risk was on the developers, in which developers spend a lot to calculate the amount of money to devote to their projects when there was no guarantee that they would win the tender. Also it was not clear how many projects the government would award. Another factor that may have affected the relative success of the British industries is the availability of long-term finance at reasonable cost. We conclude from the above discussion that the policy did not give the developers much encouragement (Mallon 2006).

4.4.4. The UK's future plans and targets:

The UK is required to look into the industry and develop its RE policy. Additionally, the policies should be looked at as a whole and not only focus on financial drivers. Other issues should be considered for future policies such as planning, transmission, and grid connection to gain successful RE markets (Mallon 2006).

4.5. The case of India

4.5.1. RE policy history in India:

India relies on fossil fuels as the main source of energy; three fifths of the country's power capacity is based on coal. Moreover, it uses natural gas as a one-twelfth share because it does not need a huge capital amount and because of its shorter construction time. RE technology capacity is around 3% share of the overall generation. The progress of RE technologies for electricity generation in 2000 is shown in Table 4.8(Ghosh et al.,2002).

Table 4.8 – The progress of renewable technologies for electricity generation (Ghosh et al.2002)

Technology	Cumulative installation as on 31st December, 2000	Estimated potential
Small hydro (MW)	1341	15,000
Wind (MW)	1267	45,000
Biomass and cogeneration[a] (MW)	308	19,500
Solar PV[b] (MW)	47 MWp	
Solar thermal (MW)	*	

Note: The potential for solar energy is estimated at 20 MW/km^2

India has taken steps to develop RE technologies that were left behind leaders like PV and wind. According to Mallon, 2006 nearly 20,000 Indian families have solar lighting because they were able to borrow money from innovative loan programmes (Mallon 2006). It is expected that there will be sudden growth in energy demand in the future in India because of shortages and problems. It is essential to start developing and promoting an alternative source to reduce the dependence on fossil fuels and help to integrate a sustainable environment (Mallon 2006).

The Indian RE agency was established in the 1970s. Cash subsidies were provided to promote RE systems. In 1980, Commission on Additional Sources of Energy CASE (CASE) was created. After 2 years, the Department of Non-conventional Energy Sources (DNES) was set up in September, 1982. RE was promoted in India; however, it was not successful because of the lack of experience in this field. In the early nineties, the programme shifted from subsidy-driven dissemination programs to technology promotion. In July 1992, DNES was converted into a fully-trained Ministry (Ministry of Non-conventional Energy Sources, or MNES). This has made India the only country in the world that has specified a ministry to promote RE technologies (Mallon 2004).

The promotion of RE included financial incentives including low tariffs, subsidised interest rates and long repayment programs. By 1998, the largest PV lighting program was developed. Additionally, the RE policies established in the nineties were successful in developing a manufacturing base, and infrastructure to support RE technology. However, commercialization of the technologies has been limited due to insufficient tariffs for RE technologies in addition to lack of consumer participation (Ghosh et al., 2002). Table 4.9 shows the achievements of different new RE sources of energy (NRSE) technologies in India (Mallon 2004).

Table 4.9 – The achievements of different new RE sources of energy (NRSE) technologies in India (Mallon 2004)

Sources/systems	*Potential*	*Achieved*
Biomass power	19,500MW	381 MW
Biomass gasifiers		51 MW
Biogas plants (no.)	12 million	3.26 million
Improved chulhas (no.)	120 million	34.3 million
Solar photovoltaics		85 MW (includes 30MW of exports)
Solar thermal systems (collector area m²)	140 million	0.60 million
Solar power		2.0MW
Wind power	45,000MW	1617MW
Small hydropower	15,000MW	1438MW
Waste to energy	1700 MW	22 MW

4.5.2. Strategies / policy frameworks /mechanisms and policy design:

The shift to RE strategy in India was because of the difference between energy consumption and supply and as a solution to avoid the polluting emissions generated by conventional fossil fuels. RE development in India went through three stages as follows: Stage (1) 1970-1980, which was toward capacity building, especially in educational institutions. Figure 4.3 shows the progress in wind power from 1992 till 2000 (Ghosh et al 2002).

Stage (2) 1980-1990 included activities in improving cooking stones and solar energy. Stage (3) 1990-now included a move from subsidy strategies to commercial activities with technologies for power generation based on wind and small hydro energies. The government agencies made efforts to make RE production occurs. India has an exclusive ministry to deal with new and RE sources. This was because the cost of large-scale resources was high for individual companies to handle.

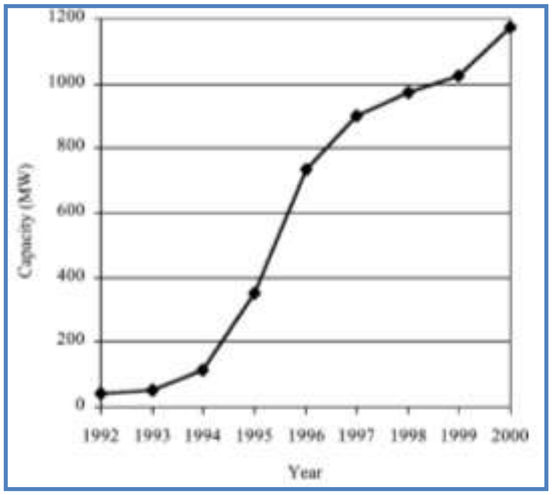

Figure 4.3– The progress in wind power from 1992 till 2000 (Ghosh et al. 2002)

The government of India announced a draft RE policy, where 10% of capacity additions were to be met through RE by 2010. Additionally, the government of India established programs to start policies financing instruments and industrial production. Furthermore, the government is to ensure that markets are not distributed and that consumer confidence in the new technologies is steadily built up. The installations of most solar home systems have been supported by subsidies, where loans and financing schemes have supported the private sector sale. The Indian government has specified different incentives to encourage the use of RE as follows (Mallon 2006):

- The Indian RE Development Agency has provided loans.
- Private investments have been encouraged through incentives, tax holidays.
- Budgetary resources have been provided from government for demonstration projects.

The following are the incentives to promote the wind power plants industry in India (Mallon 2006):

- A five year free tax on income from the sale of generation.
- 100 % depreciation in income tax assessment in capital equipment in the first year.
- Electricity Banking and wheeling facilities.
- Direct sale from third part of power generation in certain states.
- Buy back from power generation at rewarding price.

The government of India imported completed wind electric generators and installed them as demonstration wind power projects through the DNES and MNES. Where this has created awareness, provided experience and established the techno-economic feasibility of wind power generation. MNES is involved in the development of various RE- based technologies including solar thermal, solar photovoltaic's wind power generation. Indians PV market has been promoted by a government programme which included subsidies and financial incentives for two decades (Mallon 2006).

Furthermore, MNES has established a wind turbine test station to focus on standardization to improve the performance levels in manufacturing wind electric generators in India. Additionally, MNES set up two financial institutions as a public limited company and has issued guidelines to all the state governments on policies conductive to power generation from renewable power sources. MNES also issued guidelines in 1995 to all the private sector developers to ensure that the incentives provided by the government were properly utilized by the developer. Additionally, MNES issued guidelines to all states for adopting a uniform policy in relation to non-conventional energy power project. The contribution of renewable total electricity generation reached over 3500 MW in March 2002 (Mallon 2006).

4.5.3. Obstacles for RE in India:

The major obstacles that caused unreliable power supply from RE resources in India can be summarized as (Mallon 2006):

- Improper use of electricity by consumer.
- Skewed tariff structures.
- Unauthorized tapping of power.
- Local power cuts which is caused by inadequate transmission links.
- The capacity of power generation was inadequate.

Additionally, insufficient supporting schemes such as information programmes, training and maintenance of the technologies have resulted as obstacles against the development of RE in India.

4.5.4. India’s future RE plans and targets in RE sector

To improve the RE industry in India, it is necessary to provide a security base for customers, developers, financiers and planners. This can be achieved by improving the competition between developers and by providing a track record. Additionally, it is also important to encourage investment in technologies to achieve optimum performance and cost reduction.

Furthermore, it is necessary to establish a RE portfolio that meets with the overall power sector targets. The Ministry of Non-conventional Energy Sources (MNES) has set a target of 10,000 MW of RE capacity by 2012. Additionally, it has set a target of 10% of the additional power to be provided from RE resources by 2012 (Mallon 2006).

4.6. The case of Greece

4.6.1. RE policy history in Greece

RE in the form of wind energy was utilized in Greece after 1999. Wind turbines are concentrated in specific geographical regions. After the 2244/94 law, the utilization of wind power significantly increased. Figure 4.4 shows the time evolution of Greek wind power from 1987 to 2002 (Kaldellis 2005).

The development of RE program in Greece was activated in 1982. At that time a 520 KW pilot wind park was installed by the State-owned Public Power Corporation (PPC) on Kithons Island. During the last years, Greece provided subsidies to promote private investments in the sector of wind energy applications through the 2601/98-development law or the “Energy Operation” of the Ministry of Development. The grid owner was obliged to buy electricity from the wind industry at 90% of the low voltage tariff on the islands. Additionally, 10 year contracts were being signed between PPC and the private investors in the wind energy industry (Kaldellis 2005).

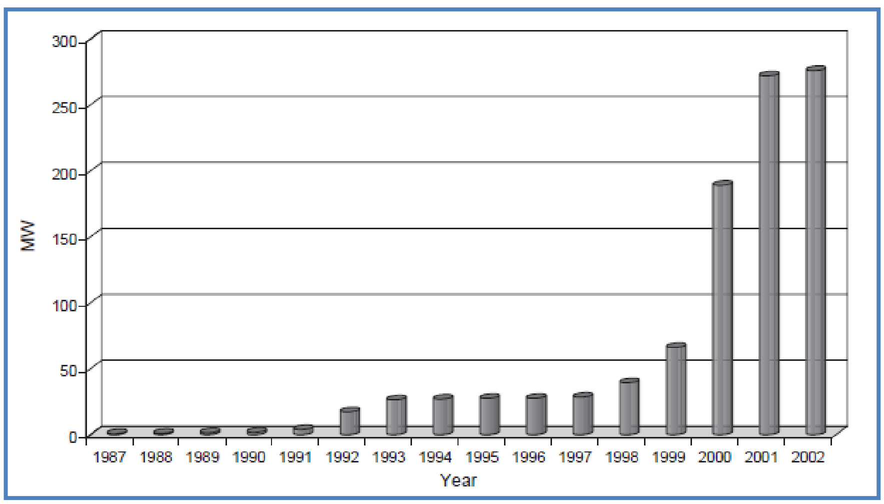

Figure 4.4 – The time evolution of Green wind power (Kaldellis 2005)

4.6.2. Strategies / policy frameworks /mechanisms and policy design:

Greece has worked on an institutional framework to reduce GHG emissions, aiming at policies that are intensively focused on the use and production of energy. The following discusses the policies being implemented in Greece (Tsoutsos 2001):

National Development Law 2601/98

The main core of this policy was to focus on the private sector in Greece to promote RES targets, environmental protection and energy conservation. This law includes amendments on a number of previous laws concerning support and development of the national economy and tax issues (Tsoutsos, 2001). Moreover, the National Action Program has been implemented to reduce GHG emissions until 2010. The following discusses the main actions of the program (Tsoutsos 2001):

- Integration of RES-E to promote the production of electricity.
- Major actions to be taken in the agriculture industry.
- Energy saving in the industrial and domestic sectors.
- Promotion of energy efficient equipment in the domestic sector.

The two axes of action of the National Program are:

- The promotion of RET, on the level of final energy demand as well as electricity production.
- Penetration of natural gas in the future.

The OPS is supported by the European Fund of Regional Development and by the European Social Fund. The OPC has been considered as the means to achieving the Greek RE system, where the monitoring and targeting of the country’s environmental engagements was through the OPC. The OPC actions to promote and integrate the RES are as follows (Tsoutsos 2001):

- Action 2.1.1 Information, support and promotion of CHO, RES and ES.
- Action 2.1.2 Expansion of the technical support infrastructure in CHP, RES, and ES
- Action 2.1.3 Economic incentives of individual private energy investment.

1. Law 2364/95

This law is a tax deduction strategy for RE systems and natural gas. However, in the meantime the available incentive for individuals to install ST systems is the deduction of 75% of the installation cost of RES systems from taxable income (Tsoutsos 2001).

2. Operational Programme for Energy

The operational Programme for Energy was set up in 1996. The program ran for 4 years (1996 till 1999) and supported investment in the area of RES. Public subsidies came from the European Fund for Regional Development and from the Hellenic government (Tsoutsos 2001).

3. Operational Programme for Research and Technology

The aim of this program is to encourage technology and industrial research. The program develops consultation services (Tsoutsos 2001).

4. Regional operational programmes

Greece involves 13 administrative regions, and for each region there is a program covering infrastructure, living conditions and human resources. New financing schemes and developed systems are being established in the market; an example is the third party financing scheme which have been applied in the last few years. The Guaranteed Solar Results (GSR) contracts have supported large installation with financial support. In this scheme the user does not pay money for installation of the system, but pays the manufacturer the energy supplied by the system based on a fixed rate per kWh on a monthly rate.

CRES was acting as a third party which monitored the process. When the consumer pays back the initial payment of the system, it becomes the property of the consumer. It has been decided recently by the Ministries of Development and Environment/Public Works that the General Building and Energy Code shall be considered in the energy design of new buildings. The aim is to save energy and reduce CO_2 emissions (Tsoutsos 2001).

5. Directive 2001/77/EC

This directive promotes the electricity produced from RES in the electricity market and encourages using electricity which is produced from RES to meet the national targets. Additionally, it aims to achieve 22% of the total electricity consumption by 2010 (Tsoutsos 2001).

6. Law 3468/06

This law is the legislative and framework basis for initiation of sustainable PV activities in the country.

The Kyoto protocol framework included a reduction of 8% of the GHG emissions by 8% shall be achieved in the EU countries in the period between 2008-2010. Greece introduced a national program in 2002 for achieving the protocol aim through (law 3017/2002) and through the 6th Action plan. The 6th Action Plan focuses on the management of resources and wastes in a sustainable way, the environment and health and climate change (Tsoutsos, 2001). From the study the projections on existing national EU-15 policies show that only 6% of GHG emissions in 2010 will be achieved which is below base-year levels, however, the Kyoto target is 7.4%. There is potential to reduce this gap by 4% by the MS measures promoting RED power generation, CHP and energy efficiency. The target set by the Kyoto Protocol for Greece expects an increase of GHG emissions by up to 25% for the period 2008-2012 (Tsoutsos 2001).

4.6.3. Obstacles for RE in Greece:

The installed RE power in Greece is low, compared to other European countries. Delays were observed during the first years of implementation RE strategies in Greece. Main causes for the delays are summarized as follows (Tsoutsos 2001):

- The reaction of residents in some regions against the installation of wind turbines (Tsoutsos 2001). In some cases the refusal of the residents led to the termination of the wind power projects (Kaldellis 2005).
- The complex framework and long procedures which made the process of obtaining the installation production and operation licences difficult, long and complex.

4.6.4. Greece future RE plans and targets in RE sector:

There is a target set by the Greek government to achieve a percentage of 40% by 2020, in addition to the 4% which it currently generated from solar and wind power. Additionally, it is expected to raise the PV market in the next 5 years, and to dominate larger size PV systems in the market (EFEF 2011).

4.7. The case of Cambodia

4.7.1 RE policy history in Cambodia:

Cambodia is one of the lease-developed countries in the world. Transport and power production depend on imported fossil fuels, and households rely on energy from wood. However, the country has some good RE resources which could improve energy security and general sustainability. Cambodia has a population of 13.8 million people and covers around an area of 181,035 km^2. War has marred most of the last 30 years of Cambodia's history. Moreover, Cambodia is classified as an undeveloped country and it belongs to the group of 20 poorest nations in the world. Cambodia's economy is based on agriculture (Mallon 2006).

In Cambodia, the generation of electricity is based on imported fossil fuel, diesel and heavy fuel oil, in addition to its conventional energy sources which are available within the country. National consumption uses around 80% of its energy from wood. The country's main energy sources are from fuel wood, conventional energy and from natural forests. Cambodia relies on important fossil fuels, mainly diesel and heavy fuel oil. Moreover, electricity is being provided by various companies using different systems, and qualities. The total installed capacity of electricity is estimated at around 411 MW (Mallon 2006).

The Cambodian consumption rate is about 55kWh per year per person. Cambodia's government electricity system consists of 24 isolated systems with no transmission link between power centers. Moreover, the electricity costs in Cambodia range from US$0.09 per kWh to US$0.53 per kWh. The government-owned Electricite du Cambodge (EDC) is considered to be the largest single supplier in the government. EDC charges a 'social tariff' of 350

Riels per kWh, which provides affordable power to its low-income, low-consumption customers. This tariff has not been changed since 1995. Due to the depreciation of the Riel, the social tariff is now equivalent to about US$0.09 per kWh which is equal to the cost of EDC production. But this tariff does not cover distribution and retailing costs (Mallon 2006).

The social tariff is being cross-subsidized by other customers. This cross-subsidy has undesirable effects. First, it acts as a disincentive to improved energy efficiency by providing power below the real cost of production and distribution. Secondly, it does not assist all Cambodia’s poor people because most of them do not live in places that have access to the EDC grid. Additionally, it creates a barrier against the development of other sources of power that are not subsidized, such as RE technology. It is estimated that about 60,000 GWh per year of energy can be generated from RE. Table 4.9 and figure 4.6 shows a summary of sustainable energy generation status savings in Cambodia (Mallon 2006).

Table 4.9- Summary of sustainable energy generation status savings in Cambodia (Mallon 2006)

	Technical potential (GWh/year)	*Currently installed projects (GWh/year)*	*Theoretical remaining potential (GWh/year)*	*Potential annual greenhouse gas abatement (kilotonne CO_2 equ)*
Hydropower	37,668	55	37,613	26,228
Biomass	18,852	0	18,852	13,146
Solar	65	1	64	44
Wind	3665	0	3665	2556
Industrial energy efficiency	547	0	547	381
Residential energy efficiency	6591	29	6562	4576
Total	67,388	85	67,303	46,931

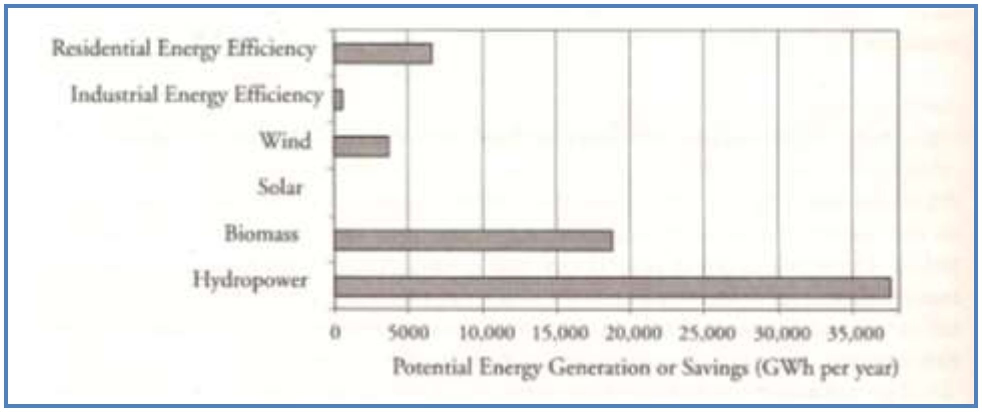

Figure 4.6- Summary of sustainable energy generation status savings in Cambodia (Mallon 2006)

4.7.2. Strategies / policy frameworks /mechanisms and policy design:

In Cambodia there are three Cambodian government institutions which are related to energy as follows: the EDS, the Electricity Authority of Cambodia (EAC), Ministry of Industry and Mines and Energy (MIME). MIME has responsibility for implementing the energy policies given by the government. It consists of three departments: the first is for the planning of general supply and transmission options, the second is for the development of RE and, and the third is for the hydropower projects. EAC was established as a government agency which was responsible for regulating, supplying and distributing electricity. Most of the power is supplied by private companies (Mallon 2006).

There are three large commercial independent power producers (IPPs) that supply power to EDC under medium-term contracts. China Electric Power Technology Import and Export Cooperation operate a 12 MW hydropower plant built in 1968, which was destroyed in 1970 and was re-commissioned in 2002. An estimated 600 rural electricity enterprises (REEs) operate mini-grids that are operated by diesel power. It was estimated to sell power to 60,000 consumers. Tariff value charged by REEs is estimated at US$0.53 per kWh. The Cambodian government does not have any policy to promote the use of RE. The following discussions cover official government policy as well as studies. Table 4.10 and Figure 4.7 show the electricity suppliers in Cambodia (Mallon 2006).

Table 4.10- Electricity Suppliers in Cambodia (Mallon, 2006)

Supplier	*Areas supplied*	*Installed capacity*[3]	*Annual generation*
Electricité du Cambodge (EDC)	Phnom Penh plus 11 provincial towns (MIME, 2004)[4]	114MW	188.4GWh
Independent power producers (IPPs) selling to EDC	Phnom Penh and Kampong Cham (EDC, 2003)	59MW	347.3GWh
Provincial electricity operators (provincial offices of MIME)	Two provincial towns (NEDO, 2002)	3MW	5.1GWh
Rural electricity enterprises (REE) operating mini-grids	Four provincial towns and hundreds of smaller towns and villages (estimated 600 REEs) (Hundley, 2003)	60MW	No data available
Battery-charging services (REEs which do not also operate a mini-grid)	1500 battery-charging services (REEs) in hundreds of towns (Hundley, 2003)[5]	38MW	No data available
Imported power from Thailand and Vietnam (22kV lines)	11 border towns (Hundley, 2003)	21MW	No data available
Private standby diesel generation (large scale only)	All areas, but mainly Phnom Penh and Siem Reap (Hundley, 2003)	116MW	175.0GWh (NEDO, 2002)
Total		**411MW**	

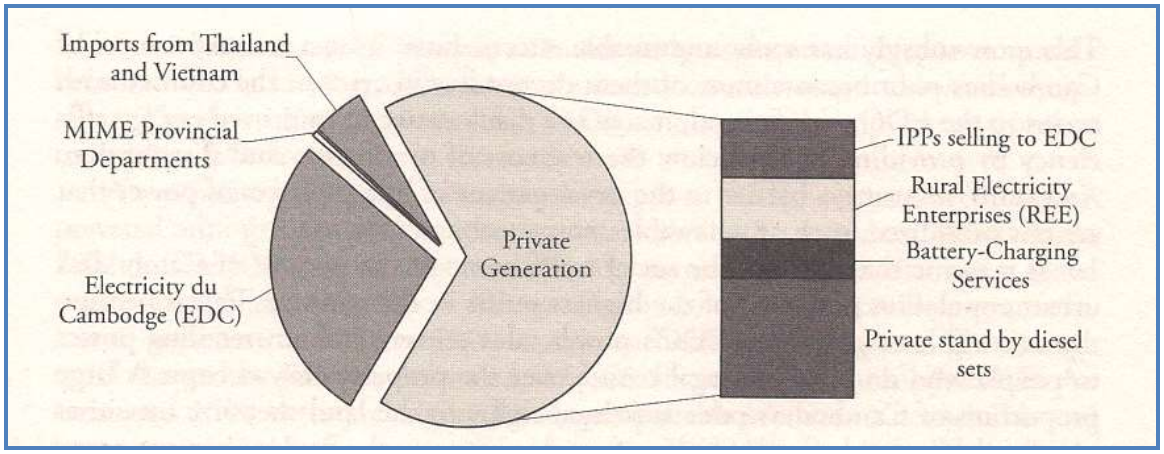

Figure 4.7- Electricity Suppliers in Cambodia (Mallon, 2006)

1. National energy sector development policy

The Cambodian government established a National Energy Sector Development Policy in 1994. This policy sets a generic framework for the development of laws and practical policy regarding the country's energy sector. The following describes the policy intents (Mallon 2006):

- To encourage efficient use of energy and to reduce the environmental effects.
- To encourage the development of environmentally and socially acceptable energy resources.
- To provide a secure electricity supply.
- To ensure suitable, adequate and low cost energy supply for homes.

2. Energy master plans

In 1998 the World Bank commissioned a consultancy firm to develop a transmission master plan strategy for Cambodia. The master plan covers transmission development and power generation options. In brief, the plan encouraged the import of the power from neighboring countries as well as the development of large hydropower schemes involving dams. The government accepted the consultants' recommendations as the Official Cambodia Power Sector Strategy 1999 to 2016 (Mallon 2006).

In 2002 New Energy and Industrial Technology Development Organization (NEDO) embarked on a study to support the creation of an energy master plan specified for Cambodia. NEDO recommends building a national grid network extending to areas of major population. Outside of these areas, NEDO supports renewable energy-based mini grids for rural electrification. In 2004 the Japanese International Cooperation Agency (JICA) sent a team of Japanese engineers to Cambodia for two years to produce a Renewable Energy Master Plan (Mallon 2006).

3. The Electricity Law

The Electricity Law was established in 2001 to control the operations of the electric power industry. The Electricity Law established the EAC to regulate power services. The EAC role includes the issuing, revision, regulating tariff rates and suspension of licenses for the supply of electricity services. In 2004 the ADB provided financial support for a project to establish new regulations, systems, and procedures for tariff setting in Cambodia. Moreover, the EAC process involves analyzing the REE's business and affordable power services (Mallon 2006).

4. Renewable Electricity Action Plan (REAP)

The World Bank hired an expatriate consultant to produce a REAP for Cambodia to promote the production of electricity from RE sources. The REAP sets different targets and activities as follows (Mallon 2006):

- To produce around 6MW installed capacity from RE sources.
- That around 100,000 households should have electricity services.
- To install 10,000 solar homes systems.
- The creation of demand directed markets for electricity generated from RE sources.

The REAP proposes a partnership between public and private sectors in order to facilitate RE project investments. The private sector would develop and supply the projects, while the government would ensure suitable market conditions.

5. National policy and strategy for RE

The World Bank commissioned an international consulting firm in 2003 to prepare strategy and policy documents for RE-based rural electrifications in Cambodia; this was a follow up activity to REAP. This project will be implemented with loan facilities provided from both the ADB and the World Bank. The project includes many activities ranging from building a transmission line from Vietnam to Phnom Penh for importing power to support the development of rural mini-grids, especially those based on renewable energy generations (Mallon 2006).

4.7.3 Obstacles for RE in Cambodia:

The barriers against renewable energy technology in Cambodia are similar to those found in many developing countries. The following discusses some of these barriers (Mallon, 2006).

1. Technology stigma

For most Western countries, RE is still a luxury. There are much cheaper sources of energy available, so the only reason to use RE resources is because of environmental concerns. However, this logic does not work in developing countries where conventional energy fossil fuel-based electricity is very expensive. For example, the average rural tariff in Cambodia of about US$0.05 per kWh would be sufficient to finance almost any RE technology. This tariff is compared to private commercial wind farms being developed in Australia, based on a power price of around US$0.05 per kWh. This means that Western attitudes towards the relative cost of RE technologies are not always applicable in developing countries. So this stigma against the use of RE in Cambodia creates a barrier to sustainable energy policy development (Mallon 2006).

2. Lack of data

The lack of data and information created a barrier to project development. Effective policy requires more data than simply knowledge of the extent of RE resources. Policy-makers need access to current accurate statistics on electricity consumers and suppliers, and business costs for project development, operation, maintenance. None of these data was available in Cambodia; the reason behind this was because the relevant institutions lack sufficient resources and technical capacity to collect the data (Mallon 2006).

3. Short leash syndrome

To make the policies effective, policy-makers must consider the enforcement methods available in the particular sector. Most government agencies in Cambodia tasked with enforcing the government's regulations struggle due to a severe lack of funding and technical capacity. Issuing short-term licences is one pragmatic approach to this problem because it effectively forces licences to approach the regulator for review and approval at regular intervals. This preference for regulators to keep licences on 'short leash' can present a barrier to implementing effective policies for sustainable energy development which generally require long-term conditions to foster investor confidence (Mallon 2006).

4.7.4. Cambodia's future RE plans and targets:

The future target set by the Combodian Government is that all villages should have an access of RES electricity by the year 2030. And that 70% of households should have access to electricity grids (Institute of Technology of Cambodia 2010). Moreover, high level government commitment is required to support, promote and enforce the new policies.

4.8. Cases of other European Countries

Different mechanisms have been implemented in EU countries; the main instruments for promoting RE are feed-in-tariffs, quota obligations, energy tax exemptions and tenders. Additionally, taxes, soft loans, tax allowances, exemptions for RE from energy taxes, information campaigns have been used as well to promote RES (Bechberger & Reiche 2004**.** Table 4.11 shows the production of electricity from RES at the end of 1999.

Table 4.11- The production of electricity from RES at the end of 1999 (& (Bechberger & Reiche 2004)

Country	Hydro[a]	Wind	Biomass	Geothermal	Total
Austria	67.4	0.1	2.6	0.0	70.0
Belgium	0.4	0.0	1.0	0.0	1.4
Denmark	0.1	7.8	4.5	0.0	12.4
Finland	18.4	0.1	12.0	0.0	30.5
France	13.9	0.0	0.5	0.0	14.4
Germany	3.8	1.0	0.8	0.0	5.6
Greece	9.7	0.3	0.0	0.0	10.0
Ireland	3.8	0.8	0.6	0.0	5.3
Italy	17.1	0.2	0.7	1.7	19.6
Luxembourg	9.3	1.7	5.0	0.0	16.1
Netherlands	0.1	0.7	3.3	0.0	4.1
Portugal	16.8	0.3	2.9	0.2	20.1
Spain	10.9	1.3	0.8	0.0	13.1
Sweden	46.2	0.2	2.0	0.0	48.4
United Kingdom	1.5	0.2	1.1	0.0	2.8
EU	∅ 12.1	∅ 0.6	∅ 1.4	∅ 0.2	∅ 14.2

The natural conditions available for RES vary across Europe. Leading countries in the RE field are countries that have good natural conditions. These countries include Austria, Sweden, Portugal, Finland, Spain, Italy and France. EU Member States such as the Netherlands and the UK have available gas and oil reserves; if these resources ran out and RE become cheaper, then the share of RE's would grow. This will apply to the four Member States (Germany, Belgium, the Netherlands and Sweden) (Bechberger & Reiche 2004).

Moreover, Portugal already has already implemented RES-T because of its high dependence on imported fossil fuel resources. Additionally, Portugal has no uranium based energy which might resist RE development. On the other hand, the Austrian paper industry is considered to be one of the largest RES-producers in the country, because it uses its waste to produce energy. Furthermore, solar energy is being utilized more effectively in southern Europe than in Sweden. The countries that have best wind conditions in the EU are UK, France and Ireland. Because of that a wind turbine in Ireland can produce twice as much electricity as the same wind turbine in Germany; however, the installed wind energy capacity in Germany at the end of June 2002 (9841MW) was more than twelve times higher than in Ireland. There are obligations set by the Kyoto Protocol that the EU countries have to reduce its greenhouse gas emissions by 8% of 1990 levels by 2008-2012 (Bechberger & Reiche 2004).

In some countries grid capacity is considered to be a very important obstacle against the development of RE. For example, in France grids were not designed to accept produced electricity rather than to distribute produced electricity from the substations. However, in Sweden, Spain, Greece and the UK local grids are required to be reinforced before deploying higher levels of wind power electricity (Bechberger & Reiche 2004).

4.8.1. The case of Belgium:

The energy sector in Belgium falls under the responsibility of the federal and the regional authorities. For example, the federal authorities are responsible for:

- Tariffs.
- Electricity transmission (high-voltage lines).
- Electricity generation (power stations).

However, the regional authorities are responsible for:

- Promotion of renewable energy sources (RES).
- Distribution of public gas.
- Local transmission and distribution of electricity (under 70kV).

A new green certificate system was established in January, 2002. Moreover, Brussels adopted a new electricity law in July 2001. The main objective of the “quota based system” is to stimulate the integration of RES-E into the electricity market. The national target for RES-E is to achieve 6% of RES by 2010 (Verbrugger, 2004). Feed in Tariff was the implemented strategy in Belgium. RES-E generators benefited from an add-on payment of 4.96 cE/kWh above the low price of about 2.75 average paid by utilities for feed in power till 2002 (Haas et al, 2004).

4.8.2. The case of Austria:

27% of total energy consumption is being supplied by RES; it provides a total of 312 PJ annually. The use of RES has shown an increase from 150 PJ to about 310 PJ over the last 20 years. Fuel wood and wood chips contribute a large share of biomass used for energy in Austria. Moreover, biomass is mainly used for heating. The following types of biomass installations are currently used in Austria:

- 600,000 wood-burning installations.
- 400,000 tiles stoves, found in private residences.
- 150 local district heating plants.
- 25 biogas plants (Dell et al. 1996)

Austria had more than 1,000,000 sq.m of solar collectors in 1994. The use of thermal solar panels began with an organization named “do-it-yourself”. Moreover, new branches developed specialized companies in the installation of solar panels (Dell et al. 1996).

In Austria a mix between different mechanisms are being implemented in promoting RES-E. As an example FIT, rebates, and bidding systems are used. However, no promotional system exists for electricity generated from large hydro power and municipal waste. In September 2008 4% of final electricity consumption was generated from RES. For small hydro power a TGC based quota system was introduced in 2001, which so far has not fulfilled expectations. The major obstacle against RES-E in Austria is that there is an inadequate market (Haas et al. 2004). Efforts were made by the Austrian federal and regional governments to overcome these obstacles against RES-E. A lot of work is required in the fields of demonstration, promotion and applied research to enhance and support the development of RES in Austria (Dell et al. 1996).

4.8.3. The case of Denmark:

Currently, 18% of Denmark’s electricity is being generated from wind power. This industry has created more jobs more than the ones created in the electricity sector itself (James & James 2004). By 2003 Denmark received 27% of its electricity consumption from RE. Danish policies have been effective, which has resulted in the largest wind turbine manufacturing industry in the world. Denmark mechanisms were based on FITs and tax-incentives mechanisms. However, it has not been implemented yet (Haas et al. 2004). Denmark has introduced differentiated RES-E incentives such as guaranteed prices and investment subsidies, including the active promotion of research. Moreover, there have been successive reforms of planning and licensing regulations which focused on reducing administrative barriers and delegating towards regional and local levels. Denmark's centre-right government adopted a new objective of increasing the RE share of primary energy use from 15 to 30 % by 2025 (Jnudsen 2009).

4.8.4. The case of Italy:

Fixed tariff mechanism has been used in Italy with a premium of 8 years to new RES-E projects until 2010. It was mandatory that fossil fuels production should cover 2% of their sales with RE production. This was enhanced by the green certificate market which was established in 2002. However, producers not complying with the requirements will pay a fine equal to 1.5 times the highest price paid in the previous year (Haas et al. 2004).

4.8.5 The case of Netherlands:

FIT was implemented in the Netherlands in 1998. This mechanism was compulsory for all RES except for the large hydropower. Moreover, investment grants were available for bio-fuel fired CHO from the period July 1997 to June 2002. Subsidies were implemented of around (358 e/KW), which was for investment that provided new contributions to electricity generation. Moreover, grants amounting to 15% of the investment for new facilities over 200 kW capacities were available for wind power and for small-scale hydro plants (Haas et al. 2004).

4.8.6. The case of Sweden:

Two new mechanisms have been used in Sweden to support new RE systems. The first mechanism is guaranteed power purchase contracts with local utilities. In this mechanism, it was required that holders of regional power buy electricity from small-scale power projects with capacities up to 1500 KW. The second mechanism used in Sweden to promote RES-E is an environmental bonus, which is paid from the government. Additionally, small RES-E production is enhanced by lower or zero energy tax (Haas et al. 2004).

4.9. Conclusions on the Above Case Studies:

From the preceding discussions and analysis, it is revealed that RES-E technologies have been applied in different ways using different mechanisms and strategies in different countries. The discussion could provide important lessons that could help in improving the process of developing policies to promote RE resources. It was shown that the EU has created a good political framework for REs. Moreover, the EU has provided significant research and developed support to the development of RE technologies. A target value was set by the European Conference of RE that 20% of energy consumption to be provided from RES (James and James, 2004). Moreover, from the experience of the German and Danish cases is clear the importance of a fixed-price mechanism in providing long-term security was highlighted. In addition, the FIT guarantees grid access (Bechberger & Reiche 2004).

Table 4.12 shows the different mechanisms used to promote RE’s in different countries (Reiche and Bechberger, 2003). Furthermore, in the developed countries the basic objective was to reduce CO_2 emissions by 80 %. The EU has already adopted different strategies to promote electricity from RE sources, which will help finally in providing an incentive for the development of the market (James & James 2004).

EU Countries share a wider policy framework and drivers from the international level, in which they have adopted different RES-E policies. Security of supply, climate change, employment and economic targets were the key measures of success in all countries that have made the first step to integrating REs in their regulation. Different kinds of mechanisms have been used to support the development of RE such as tax exemption, FIT and investment subsidy (Mallon 2006).

Table 4.12- Instruments for promoting RE's (Bechberger & Reiche 2004)

Country	Feed-in tariff	Quota obligation	Tenders	Exemption from energy taxes	Parts of the revenue of energy taxes finance RES
Austria	•	•	•*		•
Belgium	•*	•			
Denmark	•	○			
Finland	•				
France	•			•	
Germany	•				•
Greece	•				
Ireland			•		
Italy		•			
Luxembourg	•				
Netherlands				•	•
Portugal	•				
Spain	•				
Sweden	•	○		•	
United Kingdom		•			•

•, present promoting system; *, only in one region; ○, introduction is planned.

In the UK, Denmark and Germany the development of RE does not create a financial burden energy consumers. Moreover, the model of support in Germany and Spain is a simple fixed tariff, which is a low risk profile that enables many wind turbines to be cooperatively owned by local residents (Mallon 2006). In Denmark, utilities are obligated to purchase electricity that is generated from wind power at 85% of the price paid by customers. From the previous discussion it is shown that feed-in tariff is more efficient than the bidding system. Table 4.13 is comparison table between the above case studies showing the different experiences in different countries, the mechanisms used and factors that influence policy decisions.

So far, only Germany and Spain provide long-term security for investors with the promotion of RES-E; this is done through the fixed feed-in tariffs. However, it is required to reduce local resistance against RES projects which occur mainly in Spain. Germany (9841 MW), Spain (3737MW) and Denmark (2571 MW) are the three leading countries in the wind energy sector, and all of them have used the feed-in tariffs systems. However, there are some countries with feed-in tariffs which are not very successful in the wind energy sector, like Finland (39MW) and Greece (311MW), which shows that success depends on specific construction tools.

Table 4.13- Comparison table between different case studies that implemented RE

Country	Policy/Mechanism
Spain	• Feed in Tariff (FIT) Mechanism
Germany	• Investment Subsidies • Feed in Tariff (FIT) Mechanism
USA	• Renewable Portfolio Standard Mechanism • The Electricity Feed Law Feed in Tariff (FIT) Mechanism • Loan Programs
UK	• Non-Fossil Fuel Obligation (NFFO) (Contract Bidding Mechanism) • Simple Fix Tariff (Feed in Tariff (FIT) Mechanism)

India	• Loan Programs • Private Investment (incentives)
Greece	• Tax deduction for renewable and natural gas (Tax Credit Mechanism)
Cambodia	• The Electricity Law (Tariff) • Renewable Electricity Action Plan • (REAP) A loan Program

There are several reasons for the success of countries using feed-in tariffs like Germany and Spain. In the case of Germany, the reason was that the German feed-in law offers investors long-term security through guaranteed and fixed tariffs for a period of 20 years. Additionally, the successes of the German promotion system were because of strong financial subsidy programs such as the 100,000 Roofs Photovoltaic Program. In Spain two tariff options for promoting RES-E is available. One is based on a guaranteed fixed tariff which is updated annually, while the other is a market rated tariff, which makes consumers pay the suppliers an equivalent rate of the electricity market price. Both options are being modified and updated annually by the government. In comparison to the German system, the Spanish provides less investor security. On the other hand, Greece uses a feed in tariff system with guaranteed purchase contracts for a period of 10 years including a renewal option. The Netherlands uses the tax advantage system, however, security and regulations have not been stabilised. Figure 4.8 shows the factors which influence the RE development in EU countries and other countries in general (Bechberger & Reiche 2004).

In 2006, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy prepared a review discussing the "non-technical barriers to renewable energy use". It concluded that the key barriers to the development of RES-E electricity are as follows:

- Lack of regulations and government support in promoting RES-R and the availability of policies that support conventional energy development. For example, fossil-fuel subsidies and the lack of incentives that promote RES-E as well as the long procedures for RE permits.
- Very high capital cost for RES technologies in comparison to fossil fuel energy.
- Lack of customer's awareness.
- Inadequate skills and training as well as a lack of technical knowledge and skills for RE development.
- Lack of stakeholder participation in RE projects

(http://en.wikipedia.org/wiki/Renewable_energy_development#History)

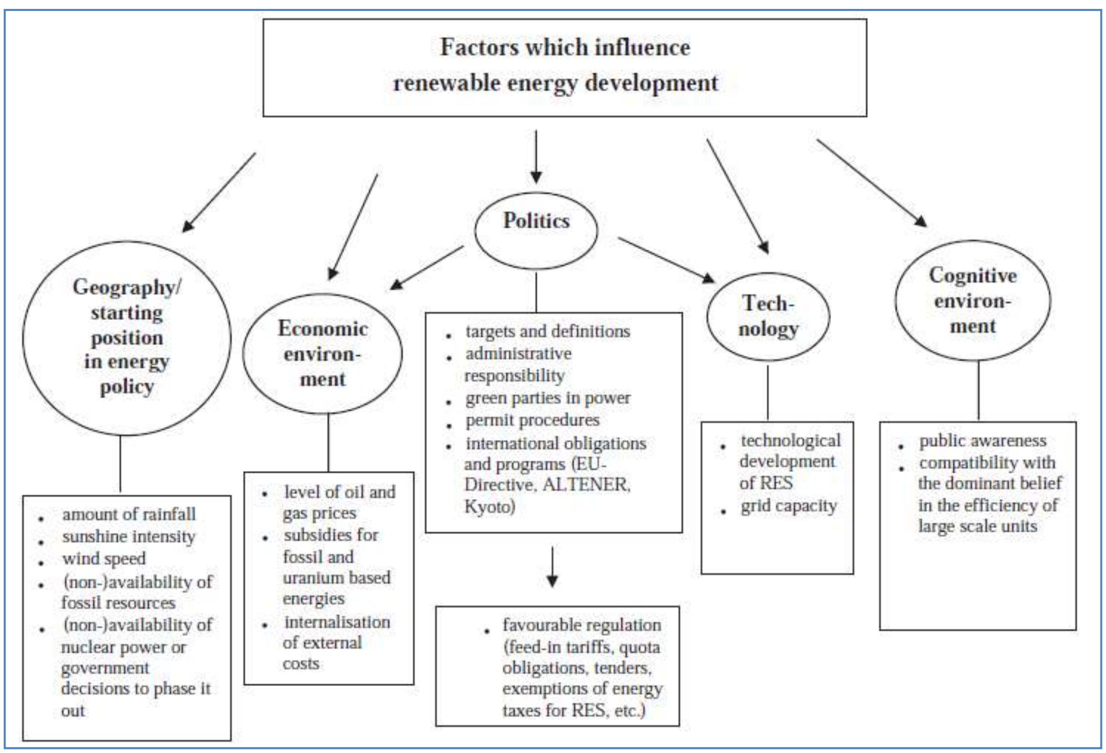

Figure 4.8-Factors which influence the RE development in
in EU countries and other countries in general (Bechberger & Reiche 2004)

Chapter 5: Proposed Policy and Revised Policy Based on Stakeholders' Feedback

This chapter discusses the proposed plan and RE policy recommended for the UAE as well as the criteria required to promote RES. The discussion is based on the research, arguments and studies discussed in the previous chapters. Some steps and conditions are required to introduce the RE strategy to the current market. RE strategy should form a part of energy regulations. Moreover, the public and private roles in RE development should be redefined to have a vital role through encouraging more private participation to speed up the integration of RES in market development (Ghosh et al. 2002).

5.1. RE in UAE market and highlighting the deficiencies and shortfalls of UAE energy strategies and policies

The current RE policy applied does not include main integration of RES. Some policies are available in this regard; however these policies have some weaknesses. Firstly, the policy is not clear and it is unknown to the public. Another issue is that the authority does not allow connection to the main grid, this will cause inconvenience to users of RE resource. The policy needs to be enhanced and supported in order to be effective. In designing and setting the framework of the proposed policy the following shortfalls are considered:

- Policy to be clear and transparent.
- Policy shall include well defined objectives.
- Appropriately applied incentives
- Policy to be stable.

Based on the above discussion we will attempt to propose and revise the policies related to RE sector. The following discusses the steps and the important criteria as well as the stages and elements required to create a draft of directive clean development mechanism. For a successful restructuring of the energy system it is essential to substantially reduce demand for primary energy. By doing so, it will be feasible to meet the remaining demand through RES. It is essential to have a policy as a driver and to prepare an integrated policy framework for creating a RE driver considering technical, economic and environmental parameters. The RES could play more significant roles in the UAE energy balance. Further support action is required in order to enhance the RE system, integrate it into the energy master plan as well as into UAE future strategies and to develop RE markets in the country. The actions below summarize the required steps to be considered to be able to formulate strategies for future energy policies and to confirm the transition from the present situation to the desired future state.

Moreover, this section explores how the future of RE technologies could provide a larger contribution to UAE demand. The RE market requires support and input from government, electricity generation companies and consumers. Additionally, a discussion about policy implications and recommendations will be drawn up. To design a new system properly, it is important to consider the current local RES and to estimate the local RES to create sustainable solutions. Furthermore, continued research is required on local RE technologies. The allocation of the public sector to participate in development of RE is also important. It is necessary to start the movement toward a RE industry and set new regulations, guidelines and procedures to gain experience and to improve technologies.

In the design of RE policies and markets the following recommendations is considered:

- The critical role of parliament in which members of parliament can take the initiative support by the Federal Ministry of the Environment.
- To form inter-party working groups.

- To consider customer demands.

The proposed policy will be implemented in three- stages in terms of short-term (1-5) years, medium-term (5-10) years and long-term (10-20) years. Moreover, the policy will consider mechanisms that have been applied in other countries which match UAE conditions. Additionally, we look into the quality and the availability of renewable resources. Moreover, the pros and cons of various promotion strategies related to the UAE conditions are highlighted.

5.2. Steps for a RE integration plan/proposed design methodology

5.2.1. Framework conditions/ strategy outline political framework

The most critical role of government is to set a policy framework to promote energy and environment security. It is very important to set an energy strategy that includes encouraging future growth. For RE to succeed, convinced government intervention is required; governments have fundamental roles to establish market conditions and focus on policy design to encourage private sector investments into RE projects and industries. Additionally, the government shall provide financial support for the market in order to integrate RE power to help in subsidizing initial capital investment.

Moreover, government action is required to get rapid RE implementation and to define a set of policies that avoid pitfalls and provide a solid frame work for RE. Furthermore, it is important for the government to help to prioritize public and private sector investments in the most viable resources and technologies. Promoting RE will help in educating and activating the public as well as motivating people to adapt methods for sustainable energy consumption and production.

5 .3. Draft Policy

The steps to integrate RE policies in UAE will be through the approach and the implementation of the following stages. The goal is to build up a stable policy framework and to develop supporting policies that are consisted, predictable, specific and long term. Moreover, most of the medium and long term stages are considered to be the advance, upgrade and improved policies of the policies in the short term. Research and technology will be a main and a continued process which will span through the whole life of the integration of RES policies. The following outlines are to be considered along with the following main stages of the policy.

Policy outlines:

1. To have a transparent design making process.
2. Policies and measures to be in line with the country's future targets and strategies.
3. To provide a master plan.
4. To create an environmental tracking system.
5. To create regular monitoring.
6. Devote important efforts and resources to research development and demonstration and to the promotion of new, high quality and cheaper RE technologies.

5.3.1. Stages and policy terms:

Table 5.1 addresses the Short-Term Policies, Table 5.2 addresses the Medium-Term Policies and Table 5.3 addresses the Long-Term Policies.

Table 5.1- Outline of short-term policies (Time Frame 1-5 years)

	Policy Term:	Experience Gained From:	Action to be Taken By:
1.	**Renewable Energy Policy**	All Developed Countries	• Dubai Government • DEWA
2.	**Soft Loans**	Spain/Germany/ USA/ India/Cambodia	• Dubai Government • Local Banks
3.	**Deregulation on Emirate Level(Dubai)**	USA –Example (PURPA), required utilities to buy electricity from renewable resources	• Government • DEWA
4.	**Financial Incentives**	Denmark/ Germany/ The Netherlands/ India	• Government • DEWA
5.	**The Use of Domestic Solar Water Heaters (DSWH):**	Spain/Greece/ Austria	• Federal Government • Dubai Municipality (Building Permit) • JAFZA Building (Building Permit)

Table 5.1- Outline of short-term policies (Time Frame 1-5 years, Cont)

6.	**TAX Deduction ***	Greece	• Federal Government • Dubai Government
7.	**Grid Access (20%)**	Spain/Germany	• Government • DEWA
8.	**Renewable Energy Certificates (REC's)**	USA (Connecticut, Pennsylvania and Nevada)	• Government

*Tax Deduction cannot be applied for the time being because tax is not available but can be applied in future

Following are the details of the proposed items in the Short Term Policies (Time Frame 1-5 years):

1. **Renewable Energy Policy:**

To set a policy dedicated for energy which is supplied from renewable resources. This policy should include strategies/ procedures/ mechanisms which will help in implementing and integrating RES in the energy sector of the country as well as contributing to the main framework of policies set by the government.

2. **Soft Loans**:

Provide Soft Loans Programs to encourage people to invest in renewable power. These loans shall be at a rate below the market rate of interest which is supported by the government and local banks. It shall be a special program offered by local banks and enhanced by government in which consumers can apply for soft loans in order to purchase systems that can produce power from RE's. Moreover, the type of loan shall depend on the type of renewable resource and on the total cost of the project.

3. **Deregulation on Emirate Level (Dubai):**

To reduce the power of government in the energy sector and to encourage the participation of many private companies at emirate level (Dubai); to construct power plants and produce power which will create more competition and will provide a better price for energy.

4. **Financial Incentives:**

An annual budget shall be provided to feed in the financial incentives which are set to support RE projects. Government shall provide financial incentives to help reduce the costs of RE projects through encouraging organizations to install RE generation facilities. Examples of financial incentives include subsidised loans, accelerated depreciation, utility rebate programs and federal incentives for public sector organization. This shall be applied at emirate and federal levels.

5. **The Use of Domestic Solar Water Heaters (DSWH):**

Provide a Compulsory law to implement solar energy (All New Built Buildings in Dubai to be provided with Solar Thermal Collectors to Supply at least 60% of the Hot Water Demand). This policy shall be included as a mandatory term in the building code to use solar water heaters in all new and renovated buildings.

6. **Tax Deduction:**

A tax deduction shall be provided for electricity generated from RE. However this term is not applicable now because tax is not applicable in UAE, but can be applied in the near future.

7. **Grid Access (20%):**

Provide grid access; work on details of grid access for RE projects and to be able to connect to electricity networks. Transmission capacity shall be upgraded and enhanced to enable the grid to transmit energy generated from RE generators. 20% of substation grids shall be upgraded first and increase this value will be increased gradually; however, all new substations shall be able to carry additional power generated from RE generators.

8. **Renewable Energy Certificates (REC’s):**

To sell REC’s on open markets to offset the use of electricity produced from fossil fuels. It shall be under government control and to be assigned by a certifying agency to ensure that it is sold for one time only.

Table 5.2 Medium-Term Policies (Time Frame: 5-10 years):

	Policy Term:	Experience Gained From:	Action to be Taken By:
1.	**Deregulation on Country Level (UAE)**	USA	• Federal Government
2.	**Free Market**	UK	• Federal Government
3.	**Feed-In-Tariff**	Spain/Germany/US/UK/ Cambodia	• Federal Government • DEWA
4.	**Improve the Grid Access for RES (40%)**	Spain/Germany	• Federal Government
5.	**Quota obligations**	USA	• Federal Government • DEWA
6.	**Carbon Tax-Charge Tax on Fossil Fuels**	UK (NFFO) Renewable Obligations (RO)/India	• DEWA (Dubai Electricity & Water Authority) • Government

Following are the details of the proposed items in the Medium Term Policies (Time Frame 5-10 years):

1. **Deregulation on Country Level (UAE):**

To reduce the power of the government in the energy sector and to encourage the participation of many private companies on a country level (UAE) to construct power plants and produce power from many suppliers instead of a single supplier, which will create more competition and will provide a better price of energy at the country level.

2. **Free Market:**

Governments shall allow other competitive organizations to participate in providing electricity pricing. This policy term will provide the lowest cost electricity.

3. **Feed-In-Tariff:**

To sell electricity based on a fixed price system, in which the price of a unit of electricity will be set by the government.

4. **Improve the Grid Access for RES (40%):**

Improve the grid access of RES and reinforce the high voltage grid in areas of prime RE resources to 40% of total grids.

5. **Quota Obligations:**

The government shall place a law on electricity suppliers to produce a certain share electricity from RES. Any companies that do not follow this law shall pay penalties. Government shall provide companies with some facilities, for example, land, to build solar panels.

6. **Carbon Tax-Charge Tax on Fossil Fuels:**

This term shall be under government control; a tax will be set on companies that use fossil fuels to produce electricity.

Table 5.3 Long-Term Policies (Time Frame: 10+ years)

	Policy Term:	Experience Gained From:	Action to be Taken By:
1.	**Deregulation at Gulf Level**	USA	• Gulf Countries Members
2.	**Feed-In-Tariff**	Spain/Germany US/UK/Cambodia	• DEWA • Federal Ministry of Energy
3.	**Mandatory use of RES**	EU Countries	• Government • DEW
4.	**Quota Obligation**	USA	• Government • DEWA

Following are the details of the proposed items in the Long Term Policies (Time Frame 10+ years):

1. **Deregulation at Gulf Level:**

   To reduce the power of government in the energy sector and to encourage the participation of private companies at Gulf level to construct power plants and produce power which will create more competition and will provide better price for energy at the country level.

2. **Feed-In-Tariff:**

To sell electricity based on a fixed price system, in which the price of a unit of electricity unit will be set by the government.

3. **Mandatory use of RES:**

To set a percentage of RES as compulsory roles to achieve a specific percentage set by the government.

4. **Quota Obligations:**

The government shall place a law on electricity suppliers to produce a certain share of electricity from RES. Companies that do not follow this law shall pay a penalty. Government shall provide companies with some facilities for example, lands on which to construct solar panels.

Research & Technology

Research and technology practice shall continue to run through the whole life of the project in order to have up-to-date information and the latest technological information and discoveries. New studies shall include solar geothermal carbon capture, carbon storage techniques, grid connection, fusion energy, fuel cells, materials...etc. Additionally, experiments and simulations shall be considered to develop the best RE technologies. Moreover, international conferences shall be attended on a regular basis to ensure the adoption of recent technologies. Research and technology programs will be supported and carried out by the Supreme Council of Energy and Universities.

5.4. Meeting with stakeholders

This section discusses the feedback and attitudes of different stakeholders which are involved in policy decisions of the energy sector including Dubai Electricity & Water Authority (DEWA) and the Ministry of Energy. Opinions of stakeholders were considered and were updated in the revised policy discussed at the end of this chapter, however, points which were unfeasible were not considered. Different issues were outlined in the discussion and were based on judgment and arguments. The goal of the meeting was to find a policy which will help to encourage RES-E in three term stages, short, medium and long stages. The following illustrates the feedback and discussions.

5.4.1. Meeting with Dubai Electricity and Water Authority (DEWA)

5.4.1.2. Meeting with Mr. Waleed Salman- *Acting VP-Business Development and Regulations & Member of Energy Supreme Council*

Meeting Date: *Tuesday 15th March 2011*
Avenue: *DEWA Head Office, Dubai.*

In this meeting the obstacles toward using RES's such as wind and solar power were highlighted; it is said that they are not applicable for the time being and that they are considered unfeasible based on some studies and experiments done by DEWA. However, the authority is studying the implementation of the Clean Development Mechanism (CDM) as a step to implementing green energy. Additionally, the reduction of CO_2 gas emission is considered to be one of the authority's targets. Moreover, an annual budget is required to support the integration of RES.

5.4.1.4. Meeting with Mrs. Fatima Mohd Alfoora AlShamsi-*Senior Manager-New Business Development & Member of Energy Supreme Council*

Meeting Date: *Monday 11th April 2011*
Avenue: *DEWA Head Office, Dubai.*

The importance of provision of a Regulation and Supervision Office was highlighted and was approved in 2010. Table 5.4 illustrates the feedback from DEWA with (Mrs. Fatima AlShamsi) on Short Term Policies, Table 5.5 illustrates the feedback on Medium Term Policies and Table 5.6 illustrates the feedback on Long Term polices as follows:

Table 5.4 Feedback from DEWA with (Mrs. Fatima AlShamsi) on Short Term Policies (Time Frame 1-5 years, cont)

Policy Term	**Feedback from Ministry of Energy**
1. Establish a RE Policy	▪ Dubai will announce "Dubai Power Strategy" in Dubai Energy Global Forum (DEFG) which is conducted on 17th-19th April 2011. ▪ The policy contains a target of 1% of the total energy from RES by 2020 and 5% of the total energy from RES by 2030. ▪ The policy contains an allowance to connect to grid in addition to technical guidelines. ▪ The policy contains a plan of the proposal of "Solar Park"
2. Soft Loans	▪ Loans are not available in the mean time but shall be as a part of the policy proposed by the specialized consultant.
3. Deregulation on Emirate Level (Dubai)	▪ Already started to make the private sector participate in generation of electricity which will be in Hassyan Power Plants affected by 4th April 2011 in rule no. 6 which contains a policy for private sector participation in production of

	electricity for emirate of Dubai. Table 5.4 Feedback from DEWA with (Mrs. Fatima AlShamsi) on Short Term Policies (Time Frame 1-5 years, cont)
	▪ This was done through invitation of Experts of Interest (EOI) then tendering process.
4. Financial Incentives	▪ Essential term, which will be under the specialized consultant scope to define and study the applicable incentives and pricing mechanism.
5. The Use of Domestic Solar Water Heaters (DSWH)	▪ This term is already available in “Dubai Green Building Regulation” but it is optional and it will be a compulsory term in the near future. Inspection Departments are required if this term becomes a compulsory term.
6. Tax Deduction	▪ Taxes are not valid in UAE for the time being. DEWA tried to provide taxes but was very difficult because UAE Market is related to the Gulf Market. ▪ A deduction of taxes can only be provided customs.
7. Grid Access 20%	▪ This term is included in the new policy as “Smart Grid Strategy” ▪ 20% is a very high percentage as a start, 5% is

	suggested. Table 5.4 Feedback from DEWA with (Mrs. Fatima AlShamsi) on Short Term Policies (Time Frame 1-5 years, cont)
8. Renewable Energy Certificates (REC's) Green	▪ Green Certificate is a good start. ▪ DEWA implies a similar mechanism but it is a vice versa "Clean Development Mechanism (CDM)". In which it sells some projects to countries that have reached the limit of CO^2 emissions as per the Kyoto Protocol. ▪ This term can be under the scope of Dubai Carbon Center and The Supreme Council of Energy.

Table 5.5 Feedback from DEWA (Mrs. Fatima AlShamsi) on Medium Terms Policies (Time Frame 5-10 years, cont)

Policy Term	Feedback from Ministry of Energy
1. Deregulation on Country Level (UAE)	▪ Very Effective. ▪ Abu-Dhabi have already implemented the participation of private sectors, Dubai is in process, and rest of emirates already buy electricity form Abu-Dhabi which means that they benefit from AD strategy.
2. Free Market Tenders	▪ Very risky. ▪ The control of electricity sector shall be under

	government. Table 5.5 Feedback from DEWA (Mrs. Fatima AlShamsi) on Medium Terms Policies (Time Frame 5-10 years, cont)
3. Feed-In-Tariff	▪ Will be provided and under the scope of the specialized consultant.
4. Improve the Grid Access for RES (40%)	▪ This term is already included in the “Smart Grid Strategy” for 2030-2035, ▪ 40% is still a high percentage for the midterm stage and it is suggested to be reduced to 10%
5. Quota Obligation	▪ Cannot be implemented. ▪ In the new policy DEWA specifies the amount of power to be generated from each source including the power generated from conventional fuels.
6. Carbon Tax- Charge Tax on fusel fuels	▪ Cannot be implemented. ▪ DEWA specifies the fuels to be utilized to generate power

Table 5.6 Feedback from DEWA (Mrs. Fatima AlShamsi) on Long Terms Policies (Time Frame 10 + years, cont)

Policy Term	Feedback from Ministry of Energy
1. Deregulation at Gulf Level	▪ All gulf countries have started to make the private sector participate in the generation of power, except Dubai and Kuwait. ▪ Dubai will start to implement this policy starting from 2011 including that generators cannot sell electricity except to DEWA, as a long term contract of 25 years.
2. Feed-In-Tariff	▪ Effective policy for the long term.
3. Mandatory use of RES	▪ As a percentage target.
4. Quota Obligation	▪ A percentage shall be specified.

5.4.1.3. Meeting with Mr. Mohamed AlJariri- *Senior Manager-Business Excellence and Environment*

Meeting Date: *Monday 11th April 20112011*
Avenue: *DEWA Head Office, Dubai.*

<u>Summary Milestones of initial feedback:</u>

- Consider UAE environment in the provision of PV power plants, because the soil is sandy, which will affect the cells that need a clean surface to provide best results.
- Decision making takes a long time.
- Renewable Energy Technologies require high capital investments and operational costs in addition to maintenance costs. At the same time, conventional energy is cheaper and affordable.
- Renewable Energy cannot provide the required demand.
- Provide a deduction in custom tax for products utilized in RE technologies.
- Provide awareness programs for government, the private sectors as well as schools and communities.
- A provision of 1-2% of energy from RES in the future is one of the best achievements of the country.
- Provision of multi sources of energy and not focus on one type.
- Provide strategies and plans to reduce consumption of energy.

Table 5.7 illustrates the feedback from DEWA with (Mrs. Mohamed AlJariri) on Short Term Policies, Table 5.8 illustrates the feedback on Medium Term Policies and Table 5.9 illustrates the feedback on Long Term polices as follows:

Table 5.7 Feedback from DEWA (Mr. Mohamed Al Jariri) on Short Terms Policies (Time Frame 1-5 years, cont)

Policy Term	Feedback from Ministry of Energy
1. Establish a RE Policy	▪ Dubai has established a RE policy which will announced at the Dubai Global Energy Forum (DGEF) 17TH April 2011. ▪ The establishment of "Masdar" in Abu-Dhabi
2. Soft Loans	▪ Applicable term in a condition that the government will be involved and it will be an easy loan.
3. Deregulation at Emirate Level (Dubai)	▪ DEWA has started to provide private participation which will be under the coordination of Dubai Supreme Council. ▪ The aim of this direction is to provide multi sources of energy.
4. Financial Incentives	▪ This term is considered as effective renewable energy policies which will be carried out under the scope of Dubai Global Energy Forum "DGFE" which focuses on alternative sources rather than conventional sources to produce energy.

	Table 5.7 Feedback from DEWA (Mr. Mohamed Al Jariri) on Short Terms Policies (Time Frame 1-5 years, cont)
5. The Use of Domestic Solar Water Heaters (DSWH)	▪ Good Term. ▪ 60% of consumed power is utilized by consumption of AC it is recommended to develop AC systems that use RES to provide a portion of power. ▪ Shall be under the scope of building permit departments.
6. Tax Deduction	▪ Can be applied, currently taxes are levied but as fees.
7. Grid Access 20%	▪ Reduce percentage to 5%
8. Renewable Energy Certificates (RECs) Green	▪ Similar mechanism is available but vice versa, in which a country which had exceeded the limits of CO2 emissions as per Kyoto Protocol agreement can buy from UAE. ▪ Shall be under the scope of Dubai Carbon Center

Table 5.8 Feedback from DEWA (Mr. Mohamed Al Jariri) on Medium Term Policies (Time Frame 5-10 years)

Policy Term	Feedback from Ministry of Energy
1. Deregulation at Country Level (UAE)	▪ Privatization is already implemented in most Gulf countries. ▪ As per Sheikh Mohamad Strategy he recommended private sectors to participate in the power industry.
2. Free Market Tenders	▪ Insecure and uncontrolled mechanism.
3. Feed-In-Tariff	▪ Will be very effective with the RE policy.
4. Improve the Grid Access for RES (40%)	▪ Consider technical and maintenance issues and costs.
5. Quota Obligation	▪ Provide a percentage ▪ To provide facilities for private companies to be able to achieve the target. Start with large scale consumers
6. Carbon Tax-Charge Tax on Fossil Fuels	▪ Can be provided in future.

Table 5.9 Feedback from DEWA (Mr. Mohamed Al Jariri) on Long Terms Policies (Time Frame 10 + years)

Policy Term	Feedback from Ministry of Energy
1. Deregulation at Gulf Level	▪ Excellent term to provide power connection between all Gulf Countries which will provide electricity for areas with shortages. ▪ Effective in terms of considering wind power locations and areas with high solar intensives. ▪ Can be applied on an International Level
2. Feed-In-Tariff	▪ Effective term for a long term policy which provides the Electricity Sector under government control.
3. Mandatory use of RES	▪ This term should be finalized by the Supreme Council of Energy with emphasis on generation.
4. Quota Obligation	▪ Provide a percentage as a target ▪ Provide it for small scale producers

5.4.2. Meeting with Federal Ministry of Energy

1) Meeting with Mr. Abdullah Mohammad AlMutawa- *Director of Electricity and Desalinated Water Department*

   Meeting Date: *Sunday 27th March 2011*
   Avenue: *Ministry of Energy Office, Dubai.*

Summary Milestones of initial feedback from Ministry of Energy:

- An official circular has been issued from the United Arab Emirates The Cabinet to integrate RE in the energy sector from effect from 14th June 2009, and it was announced that RE shall be integrated by utilizing different sources of RES as well as using RE to reduce GHG emissions. (Circular : Appendix – D)
- Abu-Dhabi is constructing a new nuclear power plant which will be in operation by 2017.
- The problem that faces the energy sector in the UAE is that the energy sector includes multiple authorities which make it difficult to control. Mr. Abdullah has recommended that there should be one authority responsible for the sub authorities to arrange and manage the regulations throughout the country.
- There will be a new power plant which will operate on coal (dubai).
- Mr. Abdullah has recommended privatization for Dubai city which has already been applied in Abu Dhabi city.
- The support of government is required to enhance the integration of RE in the UAE.
- A need for a regulatory office similar to Abu Dhabi city.
- The disadvantages of RE systems including (cost, maintenance, damage of cells…etc) shall be considered.

- To apply compulsory RE regulation to big developers such as Nakheel and Emar.
- Financial issues shall be considered in the study and suggestions that to estimate the cost of RE projects by considering an applied example in the market.
- Propose a target to achieve 5% from RE by 2020 and this percentage is based on a percentage specified in Abu Dhabi which is 6%.
- To propose a strategy for using multi-types of RESs.
- To include inspection procedures prior to completion certificate of a building this can be carried by the Municipalities that already carry out inspection processes.
- Renewable Energy procedure shall be applied for only new buildings.
- To provide a policy that is based on procedures that reduce cost, improve quality and provide solutions.
- Mr. AlMutawa has gave a brief outline of Masdar's operation RE projects:

  Operating Solar PV project:
  Masdar City PV Plant (ground mounted) 10MW
  Masdar Institute Roof Top PV 1 MW
  Other Building Roof Top PV 1 MW

  Other major projects (planning or construction phases):
  Shams 1 CSP, in Madinat Zayed (Under Construction) 100 MW
  Sir Baniyas Wind (Bidding Stage) 28 MW
  Nour 1 PV in Al Ain (Bidding Stage) 100 MW

Table 5.10 illustrates the feedback from The Ministry of Energy with (Mr. Abdullah AlMutawa) on Short Term Policies, Table 5.11 illustrates the feedback on Medium Term Policies and Table 5.12 illustrates the feedback on Long Term polices.

Table 5.10 Feedback from Ministry of Energy (Mr. Abdulla AlMutawa) on Short Term Policies (Time Frame 1-5 years, cont)

Policy Term	Feedback from Ministry of Energy
1. Establish a RE Policy	• A Policy of RE is under progress and will be published soon • It should not be only under Dubai government but under UAE government ▪ The start of implementing RE policies shall start with government authorities for example to make it compulsory to provide solar lights, solar water heaters as well as ACs that work partially on solar energy and partially on conventional energy especially for government projects such as schools, hospitals, houses. Before applying for private sector, government shall apply new polices first. ▪ Follow strategies applied in countries that have similar case of UAE such as USA, and India
2. Soft Loans	▪ Soft loan incentives shall be linked to the access of grid which will encourage

	Table 5.10 Feedback from Ministry of Energy (Mr. Abdulla AlMutawa) on Short Term Policies (Time Frame 1-5 years, cont)
	consumers to take loans in which they will be able to sell the electricity produced from their solar panels back to the grid, which works like an investment.
3. Deregulation on Emirate Level (Dubai)	▪ Very effective and is recommended
4. Financial Incentives	▪ A proposal that Sheikh Zayed Housing project support the RE by providing incentives for building local houses in which an amount shall be specified to integrate RE for example, 50,000 DHS shall be provided as incentives for installation of RE technologies . By doing so this will make the city move gradually towards a city which uses RE to provide electricity
5. The Use of Domestic Solar Water Heaters (DSWH)	▪ Very good and effective point
6. Tax Deduction	▪ Currently, the country does not use the tax system, and if in future it plans to use tax system it should be carried out by the government and by the regulation &

	supervision bureau
	Table 5.10 Feedback from Ministry of Energy (Mr. Abdulla AlMutawa) on Short Term Policies (Time Frame 1-5 years, cont)
7. Grid Access 20%	▪ To lower the percentage to 5% and it is a very important term to be considered ▪
8. Renewable Energy Certificates (RECs) Green	▪ Recommended as a start that does not require deregulation

Table 5.11 Feedback from Ministry of Energy (Mr. Abdulla AlMutawa) on Medium Term Policies (Time Frame 5-10 years, cont)

Policy Term	**Feedback from Ministry of Energy**
1. Deregulation at Country Level (UAE)	▪ Very important policy term that should be implemented and taken by the Regulation & Supervision Bureau. However, it was pointed out that DEWA will not accept this term because they will have competition and their income will decrease, but it should be an obligatory term not optional.
2. Free Market	▪ Free market does not give the best price
3. Feed-In-Tariff	▪ Very effective and recommended but should be linked with grid access allowance
4. Improve the Grid	▪ Very high percentage, suggested to be

Access for RES (40%)	20%
	Table 5.11 Feedback from Ministry of Energy (Mr. Abdulla AlMutawa) on Medium Term Policies (Time Frame 5-10 years, cont)
5. Quota Obligation	▪ Give specific percentage 5% and provide areas to build power plants. ▪ Specify on large scale consumers Table 5.11 Feedback from Ministry of Energy (Mr. Abdulla AlMutawa) on Medium Term Policies (Time Frame 5-10 years, cont)
6. Carbon Tax- Charge Tax on fusel fuels	▪ Currently, the country does not use the tax system, and if in future it plans to use tax system it should be carried out by the government and by the regulation & supervision bureau

Table 5.12 Feedback from Ministry of Energy (Mr. Abdulla AlMutawa) on Long-Term Policies (Time Frame 10 + years)

Policy Term	Feedback from Ministry of Energy
1. Deregulation at Gulf Level	▪ Very effective and recommended
2. Feed-In-Tariff	▪ Best Strategy and mechanism and shall be implemented to provide RE policies and regulations from different sources of RE
3. Mandatory use of RES	▪ Provide a target or a percentage for example 5% of electricity should be from RES by 2020. Should be carried out by the regulation and supervision bureau.
4. Quota Obligation	▪ Define a specific percentage 10% and provide facilities ▪ Specify on small scale consumers

5.5. Revised policy based on stakeholders feedback

This section includes the revised policy based on the discussions and feedback from the stakeholders mainly the Ministry of Energy and Dubai Electricity and Water Authority. Moreover, major issues that were highlighted in the discussion are mentioned below.

5.5.1. Major issues

1. Major issues in the short term policies

- Policy no.2 (Soft Loans): this policy shall be linked with access to the grid to make this policy affective.
- Policy no.4 (Financial Incentives): provide in the detail of policy examples.
- Policy no. 6(Tax Deduction): not valid policy but can be set as a deduction of custom tax for RE products.
- Policy no. 7 (Grid Access 20%): to reduce this percentage to be 5%.
- Policy no.8 (Renewable Energy Certificates): To be under the scope of Dubai Carbon Center and the Supreme Council of Energy.

2. Major issues discussed in the medium term policies

- Policy no. 2 (Free Market) is not recommended because it is risky and insecure and shall be not included in the policy terms.
- Policy no.3 (Feed-In-Tariff): an allowance to grid connection shall be considered in applying policy no.3.
- Policy no.4 (Improve the Grid Access for RES 40%): percentage to be revised and reduced to 20%. Mrs. Fatima AlShamsi has said that this is a very high percentage even in the midterm stage and recommended setting the percentage to 10%.
- Policy no.5 (Quota Obligations): 2% of energy shall be provided from RES.
- Policy no.6: (Carbon Tax-Charge tax on fusel fuels): not valid in the UAE and cannot be implemented, but can be provided in future. I suggest providing it for future.

3. Major issues discussed in the long term policies:

- Policy no. 3 (Mandatory use of RES) shall have a percentage and a target year, and is revised as Mandatory use of RES as 5% by 2020, to be set for generation companies and under the supervision of the Supreme Council of Energy.

- Policy no. 4 (Quota Obligation) shall have a percentage and facilities, and is revised as Quota Obligation 10% with facilities.

5.5.2. Revised Policy Terms:

Tables 5.13, 5.14 and Table 5.15 illustrate the revised policies in short, medium and long terms as follows:

Table 5.13 Revised Short-Term Policies (Time Frame 1-5 years, cont)

	Policy Term:	Experience Gained From:	Action to be Taken By:
1.	**Renewable Energy Policy**	All Developed Countries	• Dubai Government • DEWA
2.	**Soft Loan**	Spain/Germany/ USA/ India/Cambodia	• Dubai Government • Local Banks
3.	**Deregulation at Emirate Level(Dubai)**	USA –Example (PURPA), required utilities to buy electricity from renewable resources	• Government
4.	**Financial Incentives**	Denmark/ Germany/ The Netherlands/ India	• Government • DEWA

	Table 5.13 Revised Short-Term Policies (Time Frame 1-5 years, cont)		
5.	**The Use of Domestic Solar Water Heaters (DSWH)**	Spain/Greece/ Austria	• Federal Government • Dubai Municipality (Building Permit) • JAFZA Building (Building Permit)
6.	**TAX Deduction for Custom**	Greece	• Federal Government • Dubai Government
7.	**Grid Access (5%)**	Spain/Germany	• Government • DEWA
8.	**Renewable Energy Certificates (RECs)**	USA (Connecticut, Pennsylvania and Nevada)	• Government • Dubai Carbon Center • The Supreme Council of Energy

*Tax Deduction cannot be applied for the time being because tax is not available but can be applied in the future.

Following are the details of the revised items in the Short Term Policies (Time Frame 1-5 years):

Policy no. 2 (Soft Loans):

Provide Soft Loan Programs to encourage people in to invest in renewable power. These loans shall be at a rate below the market rate of interest which is supported by the government and local banks. It shall be a special program offered by local banks and enhanced by government in which consumers can apply for soft loans in order to purchase systems that can produce power from RE. Moreover, the type of loan shall depend on the type of renewable resource and depending on the total cost of the project.

Policy no.4 (Financial Incentives):

An annual budget shall be provided to feed in the financial incentives which are set to support RE projects. Government shall provide financial incentives to help reduce costs of RE project through encouraging organizations to install RE generation facilities. Examples of financial incentives includes subsidised loan, accelerated depreciation, utility rebate programs and federal incentives for public sector organization. This shall be applied at emirate and federal levels. As an example, this can be enhanced in government programs such as Sheikh Zayed Housing projects where an amount of 50,000 Dirhams is to be set for RE projects.

Policy no.6 (Tax Deduction):

A tax deduction shall be provided for electricity generated from RE. However this term is not applicable now because tax is not applicable in UAE.

Policy no. 7 (Grid Access (20%)):

Provide grid access; work on details of grid access for RE projects and to be able to connect to electricity networks. Transmission capacity shall be upgraded and enhanced to enable the grid to transmit the energy generated from RE generators. 20% of substation grids shall be upgraded first and this value increased gradually; however, all new substations shall be able to carry additional power generated from RE generators.

Policy no.8 (Renewable Energy Certificates (RECs)):

To sell RECs on open markets to offset the use of electricity produced from fossil fuels. It shall be under government control and be assigned by a certifying agency to ensure that it is sold for one time only.

Table 5.14 Revised Medium-Term Policies (Time Frame: 5-10 years, cont)

	Policy Term:	Experience Gained From:	Action to be Taken By:
1.	**Deregulation at Country Level (UAE)**	USA	• Federal Government
2.	**Feed-In-Tariff**	Spain/Germany/US/UK/ Cambodia	• Federal Government • DEWA
3.	**Improve the Grid Access for RES (10%)**	Spain/Germany	• Federal Government
4.	**Quota obligations (2%)**	USA	• Federal Government • DEWA

Table 5.14 Revised Medium-Term Policies (Time Frame: 5-10 years, cont)			
5.	**Carbon Tax-Charge Tax on Fossil Fuels for future**	UK (NFFO) Renewable Obligations (RO)/India	DEWA (Dubai Electricity & Water Authority) GOVERNMENT

Following are the details of the revised items in the Medium Term Policies (Time Frame 5-10 years):

1. **Deregulation at Country Level (UAE):**

To reduce the power of government in energy sector and to encourage the participation of private companies at country level (UAE) to construct power plants and produce power from many suppliers instead of a single supplier, which will create more competition and will provide better price for energy at the country level.

Policy no.3 (Feed-In-Tariff):

To sell electricity based on a fixed price system, in which the price of an electricity unit will be set by the government.

Policy no.4 (Improve the Grid Access for RES (40%)):

Improve the grid access of REs and reinforce the high voltage grid in areas of prime RE resources to 40% of total grids.

Policy no.5 (Quota Obligations 2%):

The government shall place a law on the electricity suppliers to produce a certain share of electricity from RES. If companies do not follow this law, they will pay penalties. Government shall provide the companies with some facilities for example, lands on which to construct solar panels.

Policy no.6 (Carbon Tax-Charge Tax on Fossil Fuels):

This term shall be under the government legislations; in which a tax will be set on companies that use fossil fuels to produce electricity.

Table 5.15 Revised Long-Term Policies (Time Frame: 10+ years)

	Policy Term:	Experience Gained From:	Action to be Taken By:
1.	**Deregulation at Gulf Level**	USA	• Gulf Countries Members • Government
2.	**Feed-In-Tariff**	Spain/Germany US/UK/Cambodia	• DEWA • Federal Ministry of Energy • Government
3.	**Mandatory use of RES 5% target by 2020**	Spain/Germany	• Government • The Supreme Council of Energy
4.	**Quota Obligation 10%**	UK	• Government • The Supreme Council of Energy

Following are the details of the revised items in the Long Term Policies (Time Frame 10+ years):

Policy no. 3 (Mandatory use of RES):

To set a percentage of RES as compulsory to achieve a specific percentage set by the government. 5% of energy shall be produced from RES by 2020. This condition is to be set for generation companies and shall be supervised by the Supreme Council of Energy.

Policy no.4 (Quota Obligations 10%):

The government shall place a law on the electricity suppliers to produce a certain share (10% by 2020) of the electricity to be produced from RES. Companies that do not follow this law shall pay penalties. Government shall provide the companies with some facilities for example, lands on which to construct solar panels.

5.6. Summary of expected Achievements

In my point of view, it is very important to define a clear and a flexible policy as well as to integrate consumers and to consider them as a part of the policy. It is necessary for the UAE to set targets and define frameworks and mechanisms to be able to compete in this field in the future. “Masdar” and the Supreme Council of Energy are considered to be a giant step in the RE sector which will help the UAE to compete in this field in the near future.

5.7. Dubai Global Energy Forum (DGEF) (17^{th}-19^{th} April 2011)

This part has been added to the report as last minute information because of the dissertation submission date was on the same time of the forum. But it was preferred to include these information in the report due to relevant and useful information from the forum. DGEF is the first Dubai Global Energy Forum which was conducted on 17^{th} April to 19^{th} April 2011 at Dubai World Trade Center. It was organized by government of Dubai and by the Supreme Council of Energy; this forum has focused on implementing sustainable energy for sustainable future. The forum included nine tracks as follows:

- Track 1: Energy Policy
- Track 2: Energy & Infrastructure Project Finance
- Track 3: Energy Management Opportunities in Industry
- Track 4: Energy Management Opportunities in Transportation Sector
- Track 5: High Performance Buildings
- Track 6: Opportunities in Alternative Energy and Emerging Technologies
- Track 7: Contribution of Nuclear Energy to Sustainable Development
- Track 8: Role of NGOs in Promoting Sustainable Development
- Track 9: Imperatives and Opportunities in Smart Grid Development

<u>The following discuss the main aspects discussed in the forum and relevant to the report topic:</u>

It was encouraged by the conference (DGFE 2011) to focus on renewable energy and benefit from expert countries in this field. It was insisted to have a policy which is clear and transparent. Additionally, the importance of a regulator has been raised and was considered as a main process of integrating a regulatory body for water & electricity. In Europe a target of 20% of energy consumption shall be from RE resources as well as a target of 20% of efficiency to be achieved by 2020. Moreover it was recommended to develop the RE sector in the UAE and to develop smart grids which will help in integrating RE.

The risk of any new technology has been raised and it was recommended to manage the risk. Moreover, carbon capture and storage issues were discussed and it was recommended to produce clean energy and use hydro carbon to help in capturing CO_2, as well as to develop technologies that captures CO_2 at lower price. Additionally, the importance of using energy mix was highlighted and to provide a competitive energy price as well considering safety and environment issues.

Learning from experience was highlighted as a very important part from the development as well as to have a defined policy and to raise the awareness of consumers. As a short term process it was recommended to focus on efficient use of energy

Chapter 6: Conclusions and Recommendations

6.1. Conclusions

The continued expansion of RE's in the electricity industry has been, and remains, a key government objective. It is essential to define the future role of the different sources of energy and to outline the required steps to move into a sustainable future energy system. This paper has looked into the UAE current strategies as well as its future plans and targets. It has been revealed that UAE needs a policy to unlock the RE market and to start to develop in the RE sector. Moreover, one of the primary goals is to make this research as a valuable reference for energy policy makers and planners on national and in international levels to achieve environmentally sustainable power development.

Different experiences and lessons from the leading countries in the RE technology sector have been considered to develop a policy draft that matches with the UAE conditions and status to achieve an effective implementation of RES-E. In this paper, we were able to prepare a policy that considered feedbacks from experts and stakeholders in this field and has been revised as per their comments to provide a RE policy applicable to the UAE. Moreover, the prepared policy has been set to be achieved in three stages; short, medium and long terms to be able to implement RE policies in the country gradually. The system proposed here is considered to be technically and environmentally feasible and could meet the near environmental objectives. It has been concluded that the UAE is able to apply RE policies and that it requires strong and continued political commitment to support this move. Additionally, the need for integrated government policy making is important. One of the main policy terms was to assign a ministry to the development of RE. Other important policies were as a start for a deregulation and combination of financial incentives, soft loans connected to allowance to connect to the grid. The outcome of this study was the proposed policy which contained the applicable policy terms which can be applied in the UAE and in different stages as follows:

1. Short term policy included but is not limited to a deregulation plan on emirate level, soft loans to be provided for investors and customers, RE grid access and the use of Domestic Solar Water Heater (DSWH).
2. Medium term policy included but is not limited to a deregulation plan on country level, improvement of grid access to 10%.
3. Long term policy included but is not limited to deregulation on Gulf level and introduction to Feed in Tariff policy.

6.2 Recommendations

The RE policy prepared has been only discussed with Dubai local authorities and with the Ministry of Energy. The revised policy would have been improved if it has included feedbacks from other local authorities for example, Abu Dhabi Water & Electricity Company (ADWEC) and “Masdar”. This would have enhanced the overall policies based on different feedbacks from different experiences and authorities.

Other issues such as infrastructure support, security incentives and safety issues are considered to be important issues that could be developed as the second stage of this report. Moreover, an expand discussions and information about the RES and technical issues of these technologies as well as examples of successful technologies including advanced systems will have added to the scope of this paper as a further and developed step. Furthermore, continued studies shall be considered to cover issues of planning, transmission, grid connection which are all fundamental to a successful RE market. In addition, the development of RES sector can help in creation of jobs and different investments, which can contribute to the country’s economy.

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Appendices

Appendix - A

Annual Statistical Report for electricity and water-United Arab Emirates 2005-2009

Appendix-B

Policy of the United Arab Emirates on the Evaluation and Potential Development of Peaceful Nuclear Energy

Appendix-C

Highlights of the U.A.E Government Strategy 2011-2013, Putting Citizens First. An Accountable, Lean, Innovative, and Forward-Looking Government. UAE Government Strategy 2011-2013

Appendix – D

Official circular from The Cabinet of the UAE to integrate RE in the energy sector