Gulf Research Center

Knowledge for All

Alternative Energy Trends and Implications for GCC Countries

GRC Report

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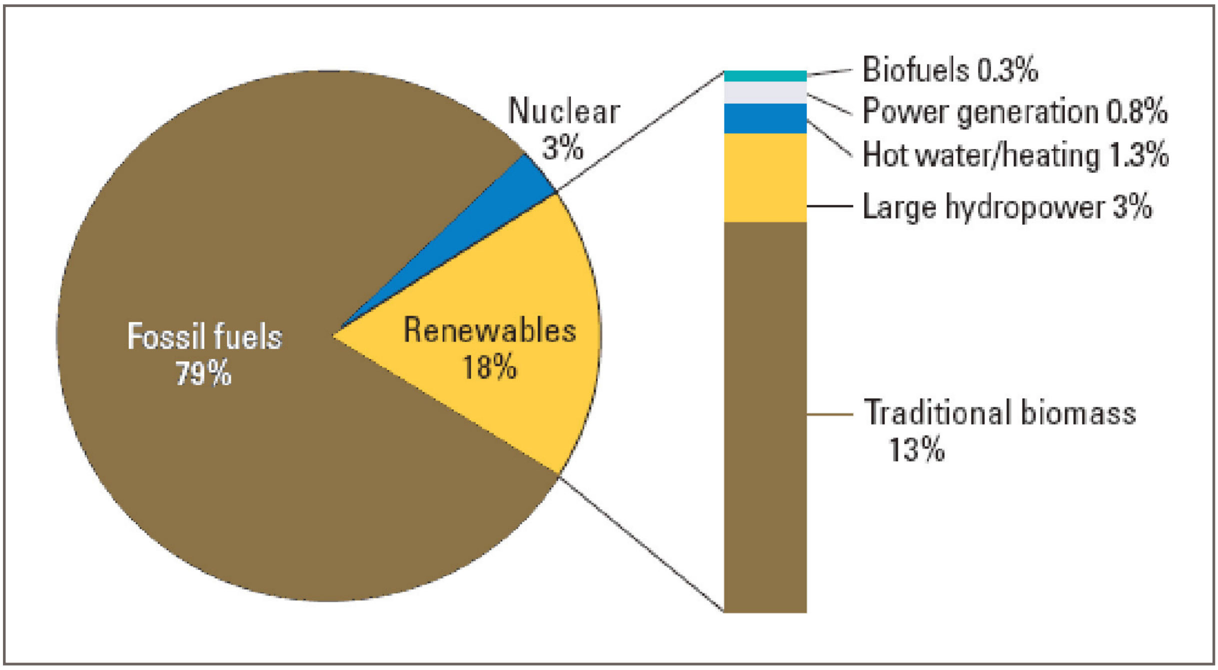
Contents

Introduction

Alternative energy describes energy sources used as an alternative to fossil fuels. Generally, it indicates energies that are non-traditional and have low environmental impact. The term "alternative" is used to contrast with fossil fuels and some may use it interchangeably with renewable energy. The Oxford Dictionary defines it as "energy fuelled in ways that do not use up natural resources or harm the environment." Alternative energy sources are biomass, hydro power, geothermal, solar energy, wind energy, and wave power. In some cases nuclear energy is included as well, although it is not renewable and can have a considerable environmental impact. This paper tries to give an overview of major trends in the alternative energy scene and discusses related implications and opportunities for the GCC countries.

The share of renewables in world final energy consumption is surprisingly high if traditional biomass, which is still largely used for heating and cooking in Africa, Asia and Latin America, is included. But traditional biomass is not necessarily renewed if it is not accompanied by reforestation and can actually generate harmful environmental effects like deforestation and erosion if used excessively. There is ample room to improve the efficiency of such traditional biomass (wood, dung etc.) with modern stoves and improved insulation, but its growth potential is limited – one cannot run modern societies on wood.

Renewable Energy Share of Global Final Energy Consumption, 2006

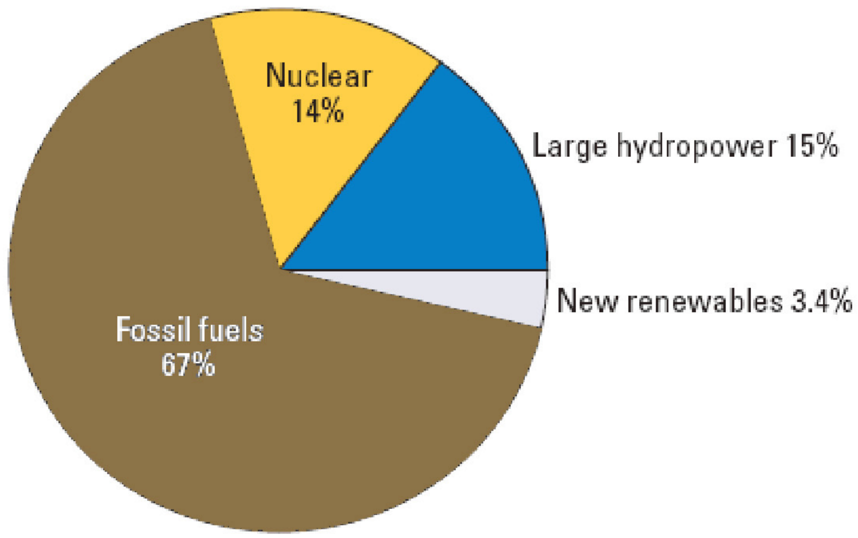


Source: REN 21: Renewables Global Status Report 2007

Note: The concept of final energy consumption as adopted by the European Commission in 2007 is different from the concept of primary energy as used by the IEA. The latter measures the energy input into an electricity plant without taking into consideration energy losses in the transmission process, while counting the power plant output of renewable plants, thus disadvantaging them to a considerable extent. According to the IEA, the renewables' shares in energy provision are therefore lower, while that for nuclear is considerably higher.

If one talks about the future potential of renewables, the so called "new renewables" come into focus. Most notably, solar power, wind power and biofuels have attracted most of renewable energy investments in recent years. Large hydro power is still the most important form of renewable energy worldwide, especially in the field of electricity generation, where it has a worldwide share of 15 percent, but as in the case of traditional biomass, its growth potential is limited because of lack of further suitable locations and increased environmental concerns. The same could be true for first generation biofuels – in the wake of recent food price hikes, they have been critically scrutinized as trade offs exist between food production and production of biofuels. The environmental effect of biofuel monocultures is also far from negligible.

Share of Global Electricity from Renewables, 2006

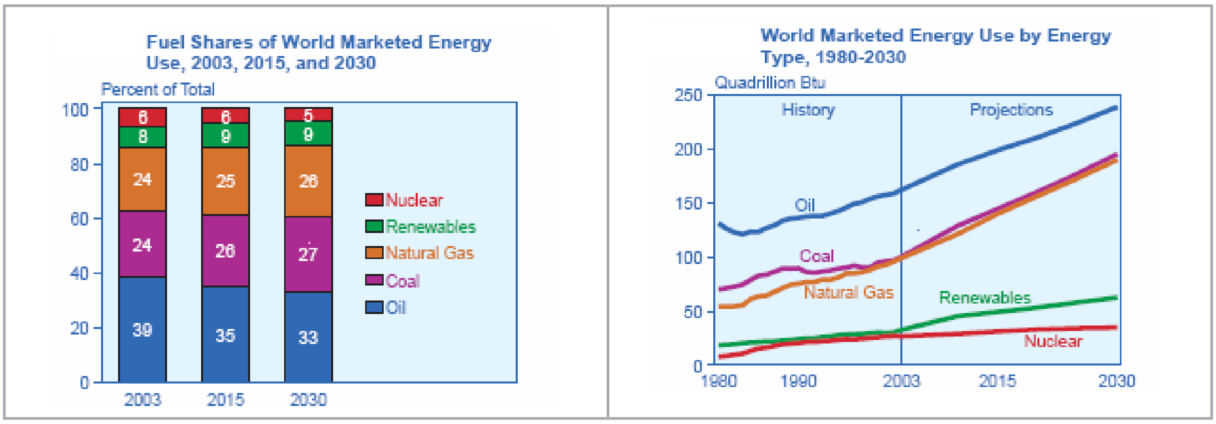


Source: REN 21: Renewables Global Status Report 2007

In terms of growth rates, solar and wind energy have the highest growth rates of all energy forms worldwide, though coming from a low statistical base. Considerable hopes are pinned to them, and if renewable energies acquire a larger share of the global energy mix in the future, it will come from these two energy forms. Thermal solar power in the form of Concentrated Solar Power, thin film PV cells and offshore wind power could prove to have large scale applications in the future. Theoretically, the sunlight that shines on the earth in 40 minutes is equivalent to the global energy consumption of one year. Researchers at Stanford University have published a worldwide wind map maintaining that wind power plants at all indicated locations could supply worldwide energy demand several times over. They identify 13 percent of the world's surface as endowed with winds suitable for efficient wind energy generation, mainly in Northern and South America, Northern Europe, North-West Africa and Australia, while Asia is less suitable for wind energy generation. The authors conclude: "As such, the amount of wind energy over land could potentially cover over five times the current global energy and about 40 times the current electricity uses with little incremental pollution."[1]

Of course, these calculations need to be taken with a pinch of salt, as economics, intermittency of renewable energy sources and technological challenges need to be taken into consideration. Still, growing economies of scale, technological breakthroughs and rising costs of competing fossil fuels play in favor of renewables, and official institutions like the EIA or the IEA may be too conservative when they only assume a slight rise in relative importance of renewable energies until 2030, with a continued overwhelming dominance of fossil fuels and a remarkable rise of coal:

World Market Energy



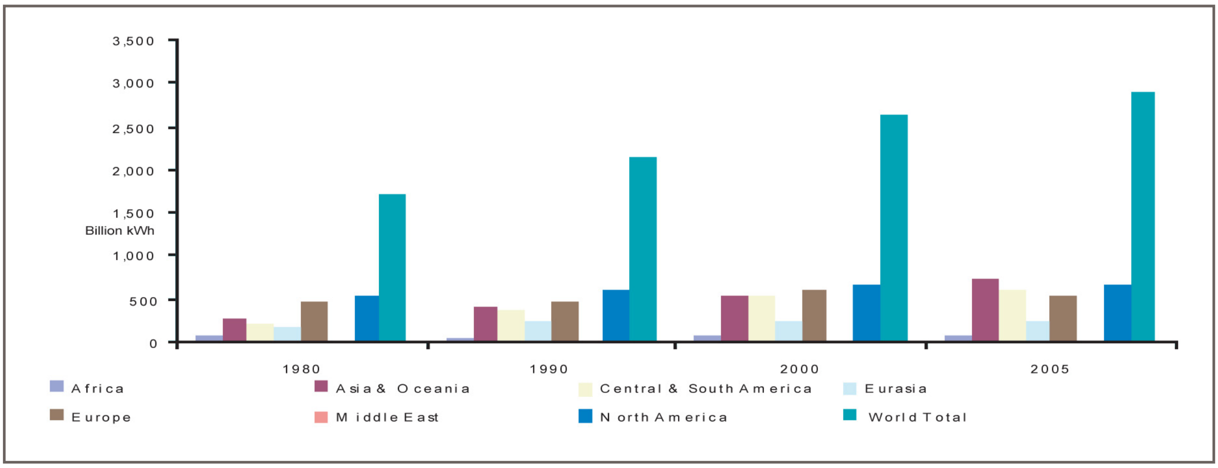
Source: EIA

For the GCC countries and their most important export good, it needs to be stressed that with the exception of biofuels, renewables are used for electricity and heat generation. For the foreseeable future, renewables are not in a position either to substitute oil as a transport fuel or replace oil and gas as feedstock for the petrochemical industry on a large scale in the form of bioplastic.[2] In current tight energy markets one might therefore think about them as a welcome addition to the energy mix rather than as a competition to oil, which captures about 90 percent of the market for transport energy. This would only change if in the very long run alternative fuels or new technologies would be developed (e.g. hydrogen generated from renewable energy or electric cars).

Sources of Alternative Energy

Large hydro power still plays the most prominent role among renewable energy sources. But its growth potential is limited, while solar and wind energy have experienced rapid growth rates. Hydro power generation is heavily dependent on location (rivers, mountains), with some nations particularly advantaged like Austria, which in 2006 was able to generate 62 percent of its electricity from renewables, mainly hydro energy. Most of hydro power is generated from large dams, which raise considerable environmental concerns and often require large scale resettlement of the local population. In recent years, expansion has taken place predominantly in China, while in developed nations growth has only taken place in the field of small hydro power stations if at all.

World Net Hydroelectric Power Consumption



Source: EIA

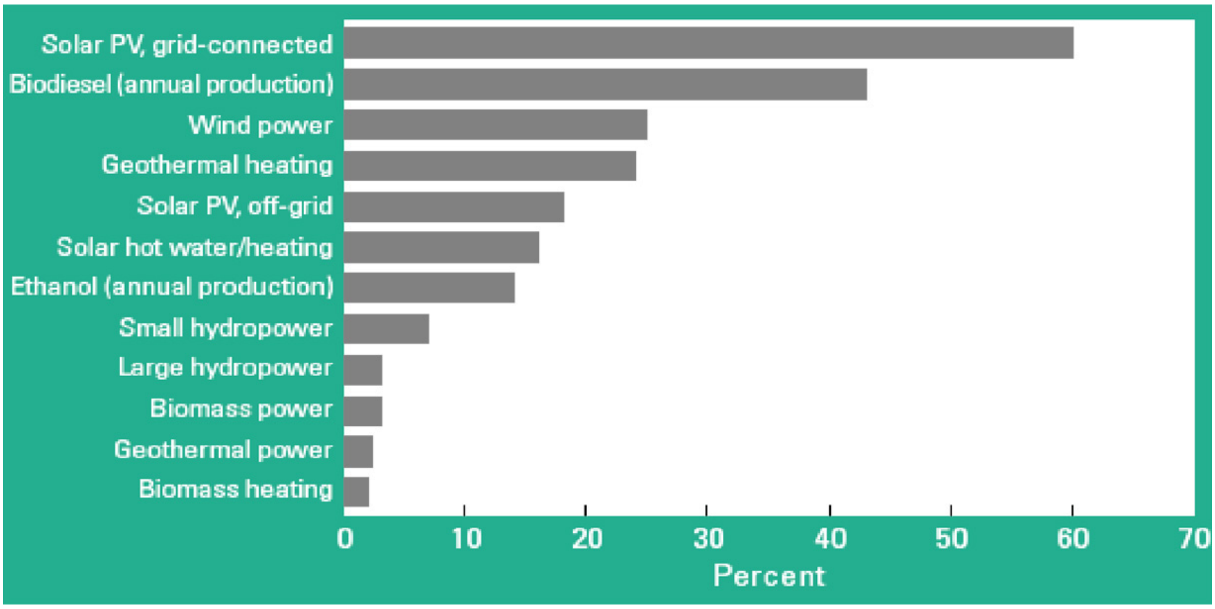
Renewable electricity generation capacity excluding large hydro power reached 240 GW in 2007, increasing over 50 percent since 2004. **Wind power** capacity grew by 28 percent in 2007 and **grid-connected solar photovoltaics** by 50 percent. Capacity of **solar heat collectors** increased by 19 percent in 2007, with China constituting the major market. Biodiesel production increased by 50 percent, and ethanol production constituted about 4 percent of the 1,300 billion liters of gasoline that are consumed annually. No doubt the renewable energy market is booming and is facing capacity constraints like availability of silicon for PV cells and wind turbines, land for farming of biofuels or installing onshore wind power plants in developed markets like Germany.

New Renewables (excl. large hydro) Worldwide Indicators

Selected Indicators	2005	2006	2007 (estimated)
Investment in new renewable Capacity (Annual)	$40	55	71 billion
Renewables Power Capacity (existing, excl. large hydro)	182	207	240 GW
Renewables Power Capacity (incl. large hydro)	930	970	1.010 GW
Wind Power Capacity (existing)	59	74	95 GW
Grid-connected solar PV capacity (existing)	3.5	5.1	7.8 GW
Solar PV Production (Annual)	1.8	2.5	3.8 GW
Solar hot water capacity (existing)	88	105	128 GWth
Ethanol Production (Annual)	33	39	46 billion liters
Biodiesel Production (Annual)	3.9	6	8 billion liters
Countries with Policy Targets	52		66
States/ Provinces/ countries with Feed-in Policies	41		46
States/ Provinces/ countries with RPS Policies	38		44
States/ Provinces/ countries with biofuels manadates	38		53

Source: REN 21: Renewables Global Status Report 2007

Average Annual Growth Rates of Renewable Energy Capacity, 2002-2006



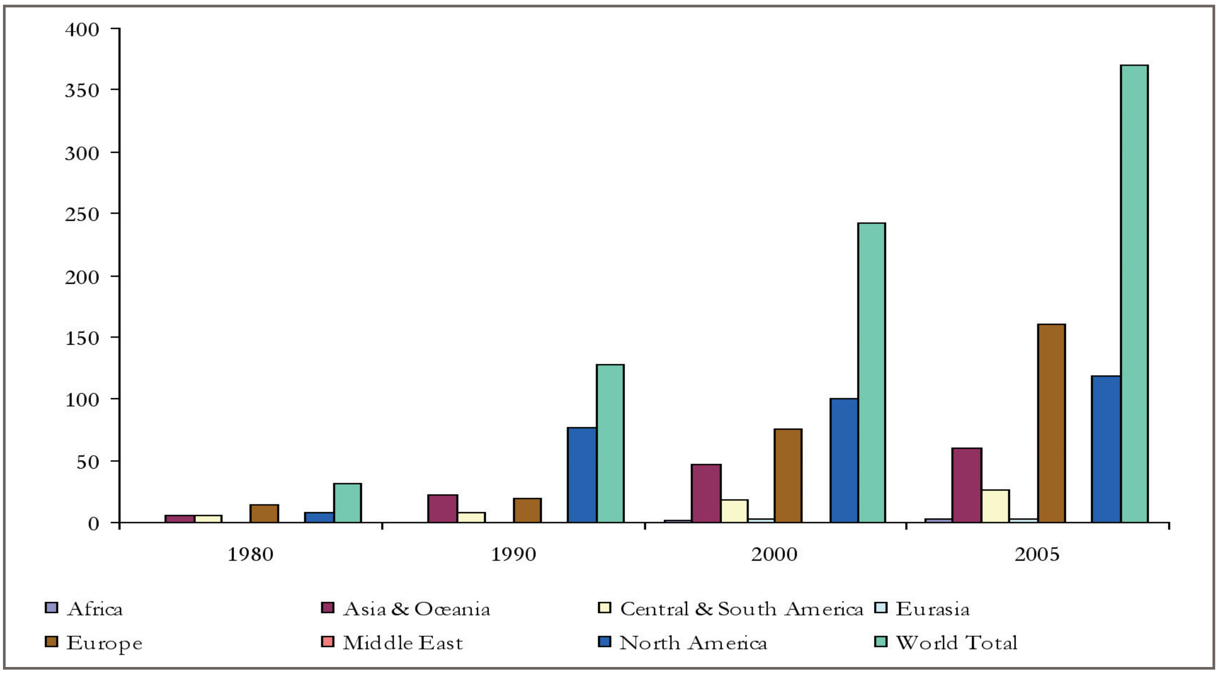
Source: REN 21: Renewables Global Status Report 2007

With 9.5 GW installed capacity worldwide, **geothermal power** production plays a niche role and is concentrated in a number of countries like Italy, USA, New Zealand, Japan and Iceland. The latter is particularly advantaged and derives about 85 percent of its space heating from geo-thermal power. Estimates of potentially available geothermal energy on a global scale vary from 65 GW to 138 GW. **Tidal power** still plays a minor role with 0.3 GW worldwide installed capacity.

The above statistics do not include **Concentrated Solar Power (CSP).** In the wake of the oil shock of the 1970s pilot plants were built in the US in the 1980s, but with declining oil prices, CSP has been dormant from the early 1990s to 2004. It is more cost efficient than the dominant PV market which produces electricity directly from sunlight via PV cells. CSP collects solar heat via different mirror constructions (e.g. parabolic troughs) which heat a fluid, which in turn powers a turbine like in a conventional power plant. It is cheaper than production of electricity from PV cells (see comparative cost table in the appendix) and is at the center of European and American initiatives to produce electricity on a large scale basis in North Africa and the south-west of the US.

A major disadvantage of renewables is intermittency. If the wind does not blow or the sun does not shine, there is no energy production. A major challenge will be to develop storage facilities. First positive experiences have been made with pumping pressurized air in geological formations and releasing it at night or when the wind does not blow. Also storage with the help of molten salts can last to up to 7 hours. It will be a major challenge to develop such systems and apply them on an industrialized scale. Computer simulations for the UK have established that a sufficiently large grid for wind power plants in different parts of the country would provide acceptable continuity of generation, as an average occurrence of wind is sufficiently guaranteed over a wider area of regions.[3]

World Net Geothermal, Solar, Wind, and Wood and Waste Electric Power Consumption, 1980-2005



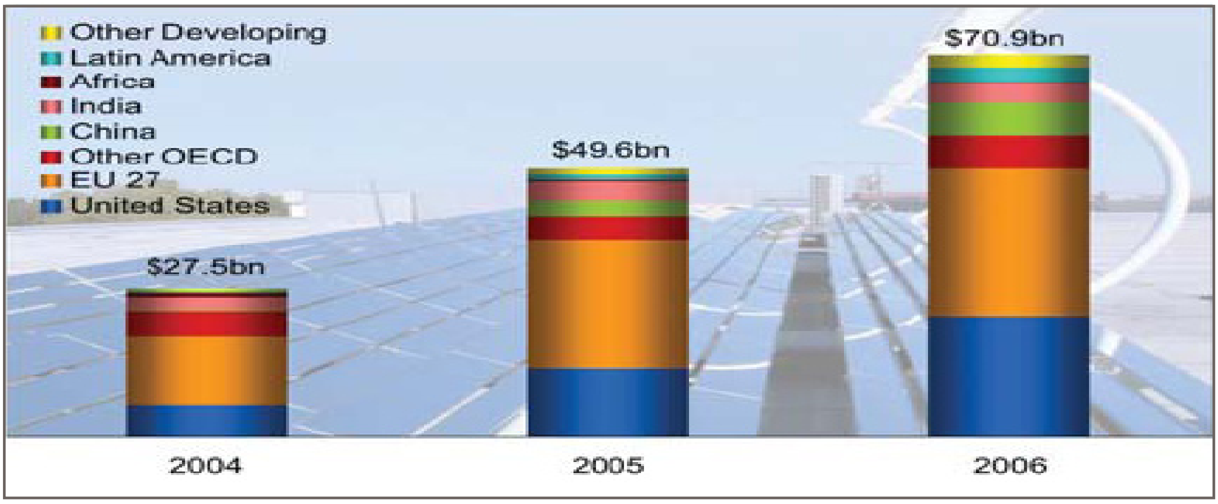
Source: EIA

In terms of geographical distribution, there has been a strong concentration on a few countries with Germany, USA, Spain, Japan and China undertaking the vast majority of investments. The Middle East thus far plays only a minor role, although it does offer suitable conditions for the generation of solar power. Internationally, the number of states which actively encourage renewable energy has increased considerably over recent years. Feed in laws for renewable energy electricity exist now in 46 countries and several countries have targeted higher shares of renewable energies in their overall energy mix. The EU, for example, currently has a 8.5 percent share of renewables in final energy consumption and aims to increase this share to 20 percent by 2020.

Investments in Alternative Energies and Related Research

Sustainable energy investment was $70.9 billion in 2006, an increase of 43 percent over 2005.[4] The sectors with the highest levels of investment are wind, solar and biofuels, which reflects technology maturity, policy incentives and investor appetite. Investments are heavily concentrated in the US and the European Union. Levels of investment are similar between the two, with US companies receiving more private and research-related investment, and EU-27 capturing the majority of publicly quoted companies. Investments in developing countries still play a minor role in comparison but are increasing quickly and have reached considerable levels already in China, India and Brazil.

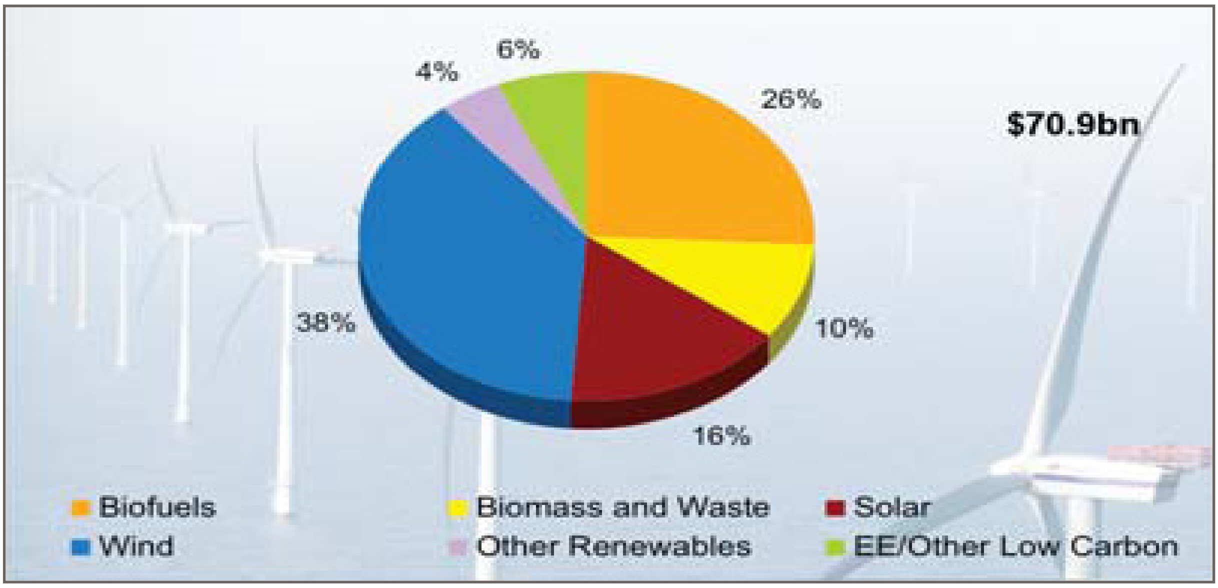
Global Investment in Sustainable Energy by Region, 2004-2006: in $ billion



Source: SEFI, New Energy Finance

Note: Grossed-up Values Based on Disclosed Deals. The Figures Represent new Investment only, and do not Include PE Buy-outs, acquisition of Projects, nor Investor exits made through Public Market /OTC Offering.

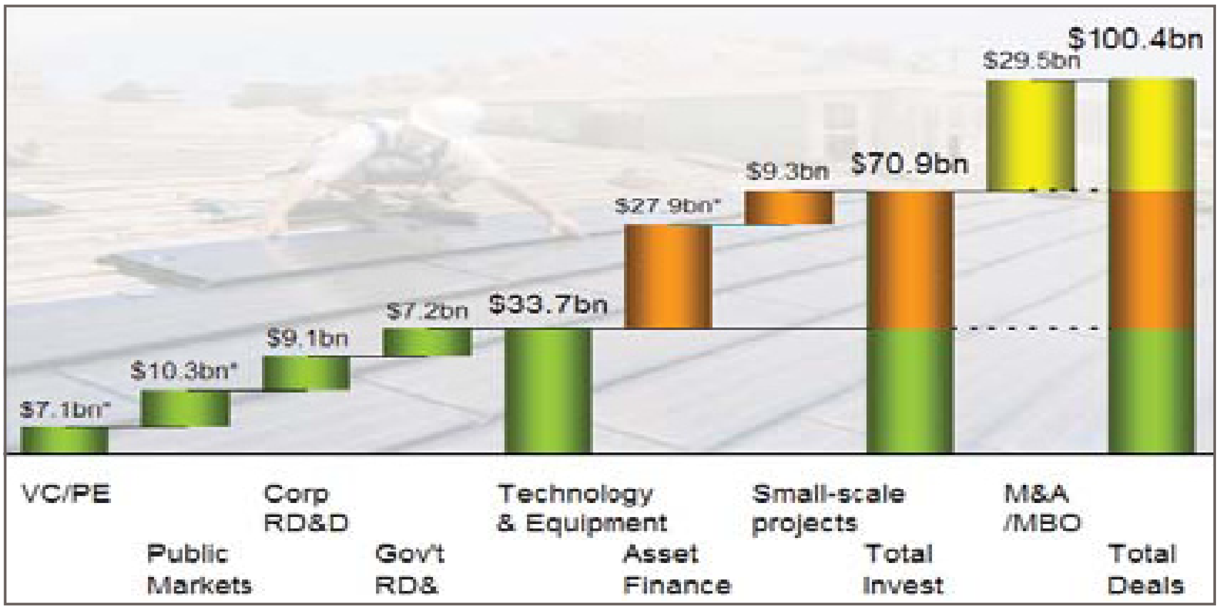
Global Investment in Sustainable Energy by Technology, 2006



Source: SEFI, New Energy Finance

Research and Development (R&D) increased to $16.3 billion in 2006, from $13 billion in 2005. The EU-27 lags slightly in new technology investment, which may be due to the comparatively low level of private sector involvement. Business funds 55 percent of R&D in the EU, as compared with 64 percent in the US and 75 percent in Japan. The number of incubators rose globally during 2006, as did the number of incubated renewable energy companies and successful transitions to the next stage of financing.

Global Investment in Sustainable Energy, 2006



Source: New Energy Finance

*Note: Grossed-up Values Based on Disclosed Deals. Figures Marked * are Based on NEF Desktop Database; all other Figure are Based on Industry Estimates Derived from Various Sources*

What Developments Could Be Expected Within the Next Decade? What Is the Worst Case Scenario Effect on Oil?

Scenarios

High costs of fossil fuels alongside technological breakthroughs and decreasing costs with growing economies of scale will play out well for renewable energies in the future, despite capacity constraints that need to be overcome. Renewable energies have developed into an industry to reckon with and are also underpinned by growing government support and concerns about global warming.

Wind power plants have already become competitive with newly built coal plants and contribute 20 percent and 5 percent of electricity supply in Denmark and Germany, respectively. A considerable part of future expansion will come from offshore plants. In solar energy, productivity gains can be expected with larger trough CSP plants, maturing solar tower CSP technology and the wider distribution of thin film PV cells, which thus far only constitute 6-8 percent of the PV market. Thin film cells only need 1 percent of the silicon that is being used in conventional PV cells and can be more easily used on facades and rooftops. They thus offer the opportunity of massive cost decreases and decentralized large scale application, as every house theoretically can become its own power station. Masdar of Abu Dhabi has just committed to invest $2 billion in two thin film PV factories in Germany and Abu Dhabi. Large CSP plants currently are under construction or projected in Nevada, Spain, Algeria, Israel, Mongolia, Morocco, Tunisia, Egypt and Abu Dhabi and could lead to usage of solar energy on an industrial scale.

For a fair assessment of renewable energies, a simple microeconomic cost comparison with traditional fuels is, however, not sufficient as they come with substantial macroeconomic and non-monetary benefits.[5] On a macro level they create fewer socialized costs in the form of environmental damage, but they also do not have the same infrastructure needs as traditional fuels. As they can create energy in close vicinity to its consumption (e.g. solar assisted cooling of buildings), they rely less on large grids and fuel supply chains. Due to their decentralized nature they are also less vulnerable to sabotage and terrorist attacks unlike large oil and gas ports, pipelines or nuclear plants and do not incur the associated costs for security. Finally they do not need to pay for fuel; most costs are capital costs and once the plant is built the energy comes for free. Renewable energies thus offer an economic planning security that fossil and nuclear fuels simply cannot provide in today's volatile energy markets – the business plan of a traditional power plant that was built five years ago is null and void today because of the rise in energy prices, while the one for a renewable energy plant built at the same time has not been affected by this price hike and may even enjoy unchanged costs amidst rising revenues.

The exact share of renewable energies is thus impossible to predict at this stage; it will depend on:

- Price of fossil and nuclear fuels and existing subsidies for such fuels in various countries
- Improving economics of renewables via better economies of scale and via technological breakthroughs (e.g. thin film PV, offshore wind parks, solar tower CSP)
- Further development of storage systems like pressurized air or molten salts
- The amount of government support and the government's industrial policies, which is dependent on issues like environmental concerns and energy security
- Environmental concerns and trade offs with regards to renewables. This is particularly true for biofuels and large hydro power generation.

Biofuels

Biofuels will contribute 331,000 b/d or 75 percent of non-OPEC supply growth in 2008 and will reach a daily production of 1.4 mbpd by the end of the year, according to the IEA. Both high oil prices and government policies in the US, Europe, Brazil and elsewhere have promoted biofuels as an alternative to petroleum. This has led to significant shifts in acreage as well as use of certain grains. For example, in 2006, the US diverted more than 20 per cent of its maize production to the production of ethanol; Brazil used half of its sugarcane production to make biofuel, and the European Union used about 50 percent of its vegetable oil production as well as imported vegetable oils, for the same purpose.[6] Since early 2004, ethanol and bio-diesel production in OECD countries has risen sharply, and this has naturally reduced the land available for producing food. On the other hand, the influence of biofuels was concentrated on specific crops and countries; land use for biofuels currently constitutes only 1 percent of total acreage worldwide (14 million hectares), a figure that the IEA sees increasing to 35 million hectares by 2030. But first generation biofuels are unlikely to lead to large scale replacements of fossil fuels due to limited availability of land, competition with food production and a questionable energy balance in the case of ethanol production from corn.[7] There is simply not enough land to allow for a large scale substitution of fossil fuels by first generation biofuels.

Estimates to which extent biofuels have caused the recent surge in food prices vary greatly and range from less than 3 percent according to the US government to 10 percent according to the FAO, 20-30 percent according to the IMF, and up to a staggering 75 percent according to a recent but unpublished World Bank study.[8] A detailed study by New Energy Finance assumes a number at the lower end of estimates, with biofuels responsible for up to 8.1 percentage points of a 168 percent grain price increase since 2004 and up to 17 percent of a 136 percent price increase in food oils.[9] The contribution of other factors was more important; in the case of the 168 percent price hike of grain these included cost increases of oil (32.5 percent), other input factors like labor and land (7.4 percent), dollar weakness (17.9 percent) and supply demand factors other than biofuels like population growth and droughts (49.6 percent).

Further acceptance of biofuels will depend on the development of second generation biofuels with a more favorable energy balance that do not rely on food crops for their production, can be planted on poor soils and have considerable drought resistance.[10] But even here a certain competition with food for arable land and water could be a given. Third generation biofuels from algae might change that. They could have the potential to be used on a larger scale as they do not compete with food crops for fresh water and arable land. Algae are a high yield high cost crop as they produce 30 times more energy per acre than terrestrial crops. Research by the US Department of Energy estimates that biofuel from algae could theoretically replace all the petroleum consumed in the US. Of course one cannot describe it as a proven technology yet and possible detrimental ecological effects cannot be ruled out, but according to these preliminary studies, it would require an area of 40,000 square kilometers, which is slightly larger than Maryland, and less than 15 percent of the area of corn harvested in the US.[11] Equally Salicornia, a plant belonging to the species of halophytes, thrives on little more than sea water and can withstand a very sunny climate. Known as “sea asparagus,” it can be eaten or processed to biofuel. NASA has estimated that halophytes planted over an area the size of the Sahara Desert could supply more than 90 percent of the world’s energy needs.[12] More research and development will need to show whether second and third generation biofuels could live up to these lofty expectations. At least they seem to have more potential to substitute hydrocarbon fuels on a large scale than first generation biofuels, which show some negative impact on food security. GCC countries therefore would need to closely monitor any large scale development of such third generation biofuels as they could have an impact on oil demand.

Large-Scale Power Generation

Overall, there is reason to believe that the share of renewables in the power generation sector in 2030 could be higher than the 9 percent in the reference case scenario of the IEA and its World Energy Outlook 2006:

Renewable Energy Power Sector. Growth Trajectories to 2030

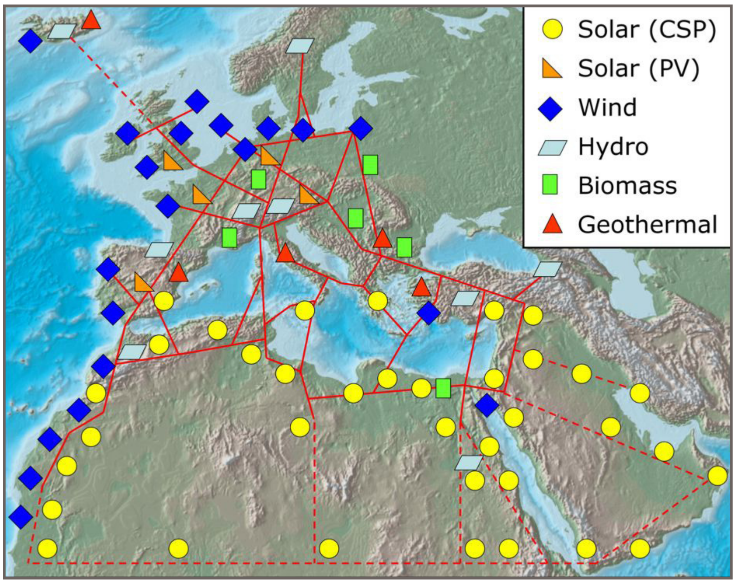
Power Sector RE Growth Scenario (2007-2008)	RE Capacity in 2030 (GW)	RE Share and Rank of New Capacity Additions (2004-2030)	RE Share and Rank of 2030 Installed Capacity
RE grows at 7% the rate needed to reach 9% of 2030 installed capacity (figure forecast by WED 2006)	674	15%, ranking 3rd, after gas and coal	9%, ranking 4th, after coal, gas and hydro
RE grows at 10%	1300	32%, ranking 1, ahead of gas and coal	17%, ranking 3th, after coal and gas
RE grows at 19% until 2010 (forecast by GWEC), then 10% therafter	1781	44%, ranking 1, ahead of gas and coal	23%, ranking 3th, after coal and gas

Source: SEFI, New Energy Finance

Two initiatives in Europe and the US are of particular interest in this regard. The Trans-Mediterranean Renewable Energy Cooperation (TREC) is pursuing the Desertec project, which aims at building large-scale CSP plants in North Africa and transport the produced electricity via high voltage direct current cables to Europe, both already proven technologies:

"Satellite-based studies by the German Aerospace Center (DLR) have shown that, using **less than 0.3% of the entire desert areas** of the MENA region, **solar thermal** power plants can generate enough electricity and desalinated seawater to supply current demands in EU-MENA, and anticipated increases in those demands in the future."[13]

Euro-Supergrid with a EU-MENA-Connection: Sketch of possible infrastructure for a sustainable supply of power to EU-MENA, by Trans-Mediterranean Renewable Energy Cooperation (TREC)



Source: TREC

Desertec aims to produce 10-25 percent of Europe's electricity needs by 2050 from North African CSP plants. In the US, researchers have proposed a similar Solar Grand Plan.[14] It aims at producing 70 percent of the US electricity requirements by 2050 and 35 percent of its total energy demand from CSP plants in the south west of the country. By 2100, they even envisage 100 percent of the country's electricity demand and 90 percent of its total energy demand as hydrogen could be produced by CSP plants for transport needs. For the UAE, scenarios have been developed on how it could maintain its share in the world energy market during the course of the century by producing hydrogen from solar power.[15]

Very intriguing applications could develop out of the research that Prof. Norbert Auner of the University of Frankfurt is conducting about silicon as an energy carrier. Silicon can be produced out of sand; approximately 75 percent of the earth's crust comprises quartz sand/silicon dioxide. Silicon has considerable advantages over hydrogen as its transport is not hazardous, and it can be produced out of sand and not out of scarce water resources. Furthermore, ammonia and hydrogen could be produced out of it via chemical processes, and it thus could be used as an intermediate carrier in an emerging decentralized renewable energy/hydrogen economy. Silicon could also function as a direct fuel in ceramic engines – the fumes out of the exhaustion pipe would be sand again once the silicon cycle closes! Silicon produced out of sand with solar power – a compelling business model for desert countries which have both in abundance.[16]

These are just scenarios for sure, but the economics and the political backing for such initiatives are increasing. The Desertec studies have been funded by the German Ministry for the Environment and other institutions.[17] If such projects succeed, they will target the electricity market first; they would not produce transport fuels nor would they provide feedstock for the petrochemical industry. Only towards 2050, there might be further applications like the production of hydrogen from renewables or a further development of bioplastics. Thus, the Gulf countries should not regard renewables as unwelcome competition to their own energy products; they should rather embrace them as a welcome addition to tight global energy markets. Rising domestic energy needs for power generation and desalination, favorable conditions for solar energy production and interest in acquiring technological know-how also make a perfect argument for renewable energy in the Gulf. The Masdar initiative in Abu Dhabi is a first step in this direction.

Renewable Energy Projects in the GCC

Pilot projects in Saudi Arabia in the 1980s and 1990s

GCC countries have been reluctant to adopt renewable energy. Although they have favorable conditions to produce solar energy, the prevailing attitude has been that the Gulf countries are sitting atop a sea of oil and gas that will last forever and, therefore, alternatives need not be contemplated. This is understandable to some extent, as low oil prices in the 1980s and 1990s put renewable energy initiatives in other parts of the world on hold as well. The US, for example, did not initiate further CSP projects after the completion of pilot plants in the 1980s, and in a highly symbolic move, President Ronald Reagan removed the solar panels on the White House, which his predecessor Jimmy Carter had installed.

Nevertheless, Saudi Arabia made some foray into solar power projects in the 1980s; the King Abdulaziz City for Science and Technology (KACST) was established in 1977 and its Energy Research Institute (ERI) has conducted research in the field of renewable energies and energy efficiency since then.[18] It published the Solar Energy Atlas for Saudi Arabia in 1983 and the Saudi Arabian Wind Energy Atlas in 1986 in cooperation with King Fahd University for Petroleum and Minerals in Dhahran. Saudi Arabia also signed two major international agreements to promote solar energy: one with the US ("Solar Energy Research American-Saudi"/SOLERAS) and the second with Germany ("Hydrogen from Solar Energy"/ HYSOLAR).

SOLERAS was established in 1975 and concluded in 1997, and the funding of $100 million was jointly provided by the Saudi and American sides. A second program was started in 1989 with the US Department of Energy (DOE), which addresses various other renewable energy technologies in addition to solar energy.[19] Within the framework of SOLERAS, Al-Jubaila and Al-'Uyaina, two villages located 45 kilometers north of Riyadh with about 3,000 inhabitants, were supplied with electricity by one of the largest PV systems worldwide at that time (350 kW). The supply of energy in remote areas was a main concern of SOLERAS and PV technology offered obvious advantages like decentralized usage and non-dependence on grids. Other projects included a PV system to power a desalination plant in Jeddah, solar assisted technology to fend off corrosion in underground pipelines, solar powered greenhouses and installing the heating system of a school in Tabuk.[20] KACST has implemented other solar power projects as well like solar cooling, PV powered highway lighting and use of solar dryers in agriculture.

HYSOLAR started in 1986 and concentrated on solar hydrogen technologies. It had a project value of over EUR 40 million (DM 83.5 million), and was jointly financed by KACST, the federal German government, and the regional government of Baden-Württemberg. The program had two five-year phases and ended in 1995, but the involved universities continued cooperation on a lower level afterwards. HYSOLAR comprised research plants in Stuttgart and Jeddah and a 350 kW PV production and demonstration plant in Riyadh. It investigated how the efficiency of PV plants and the solar-based production of hydrogen can be improved. Notably the salty, humid and dusty air of the Jeddah region affected the longevity of the respective PV modules negatively.[21]

Renewed Interest in the New Millennium: Saudi Arabia, Oman, Kuwait

But these initiatives remained essentially pilot projects and were not developed further. They faced deteriorating economics as oil prices plummeted in the second half of the 1980s and remained low for the rest of the 1990s. Following the recent surge in fossil fuel prices, however, the interest of GCC countries in renewable energies has resurfaced. With the exception of Qatar, every GCC country faces a gas shortage now. There is an urgent need for new discoveries, improved recovery rates, better energy efficiency and intra-regional gas trading schemes from Qatar and Iran. The Dolphin pipeline from Qatar to Abu Dhabi and the pending Iranian gas deal of Sharjah-based Danagas are cases in point. Large-scale projects like the planned aluminum smelter of Rio Tinto in Al Ruwais, UAE have been put on hold already for the lack of gas, and gas-fired power stations had to switch to more expensive fuel oil in the summer months when electricity demand is up to 40 percent higher due to the rising need for air conditioning.[22] The GCC countries are increasingly aware of this problem which is likely to worsen in the future with growing populations and economies. Oil is in good demand and yields higher profits as an export item than being fired in gas strapped power plants at home. Therefore, the GCC countries now envisage nuclear energy, coal and renewable energies as additions to their energy mix. The aim is to extend the lifeline of their most precious export good and use it more efficiently.

Saudi Oil Minister Ibrahim Al Naimi has clearly stated that Saudi Arabia is planning to make solar energy an important pillar of the national energy mix. While blaming biofuels for harmful ecological effects, receiving government subsidies and increasing food prices, he has hailed solar energy as "abundant, clean and available to all," and assured that Saudi Arabia is "giving that sort of energy special attention." He envisaged further productivity gains for solar energy via technological breakthroughs and said that Saudi Arabia could one day export solar-generated electricity in the same way it exports oil today. The country could be "a center for solar energy research and hopefully over the next 30 to 50 years (…and) will be a major megawatt exporter."[23] It remains to be seen to what extent Saudi Arabia will come up with sufficient financial backing for this vision in order to go beyond the pilot projects of the 1980s and 1990s and move to the next level. In a remarkable step, Gulf OPEC members pledged $750 million at a summit in Riyadh in November 2007 to fund research on clean technologies. But the emphasis in this case will be on carbon capture and storage in order to fight global warming.

In Oman, the Authority for Electricity Regulation has outlined a road map for the development of renewable energy resources in a landmark study. The establishment of large-scale solar thermal plants and a 750 MW wind farm in the south of the country rank prominently among the proposed projects. The study pays specific attention to the development of an appropriate policy framework and institutions to administer clean development mechanisms (CDMs) and assist renewable energy investment.[24] Oman, like Bahrain, also has some experience with solar powered reverse osmosis units for desalination and photovoltaic systems or wind power for water pumping and electricity generation.[25]

The Kuwait Petroleum Company (KPC) has earmarked $100 million for new energy technologies in 2004. Here, however, the focus has not been on renewable energies but on more environment-friendly use of fossil fuels by fuel cell technology, carbon sequestration and oil gasification, with the aim of taking advantage of the Clean Development Mechanism (CDM) of the Kyoto Protocol.[26] Although this is laudable one has to take into consideration that the GCC countries are classified as developing countries under the CDM mechanism, despite their high per capita hydrocarbon usage. They, therefore, do not face emission ceilings and the implementation of CDM projects comes at potentially no cost to them: Investments can be offset by earning emission certificates that can be sold to investors in industrial countries. The latter have to comply with emission ceilings and reductions under the Kyoto Protocol and, therefore, there is a demand for such certificates among companies that produce emissions beyond allowed limits. Earning CDM credits would, therefore, also be a possibility to make renewable energy projects in the GCC more cost efficient. Masdar City in Abu Dhabi, for example, will use CDM credits to partly fund its investments. But thus far renewables offer lower emission credits compared to other CDM projects like waste disposal or industrial efficiency and emissions trading. As a result, companies head first for these types of CDM projects – only 16 percent of all CDM funds worldwide go into non-hydro renewables. However, for a comprehensive development of renewable energies, the GCC countries would need to move beyond isolated CDM projects. They should seriously consider cutting back their large subsidies on oil and gas products and favor renewable energies instead by allowing for preferential feed in tariffs and other investment incentives.

Wind Energy and the Red Sea Coast, Niches for Geothermal and Biomass Energy

Although wind energy is the most developed and efficient energy source among the new renewables, the focus in the Gulf is more on solar energy. Conditions for its production are very favorable in the region, while the endowment of wind resources is not so impressive in international comparison. There are notable exceptions though; German engineering consultancy company Lahmeyer International has conducted studies about the potential of wind power in Yemen, the UAE and Iran on a more detailed level than the global study of Stanford University or the Saudi wind atlas of KACST mentioned above and has established its significant potential.[27] Wind power has considerable prospects on the Red Sea shoreline and the East coast of the Peninsula; Egypt, on the other side of the Red Sea, has already become the leading wind energy producer of Africa. Average wind speed on its Red Sea coastline is 10m/s, it has already built 227 MW of wind energy capacity and is currently constructing a further 320 MW. Most of the projects are in the Zafarana region, 250 km south of Cairo. Yemen, Saudi Arabia and Oman too could produce significant amounts of wind power; the wind power potential in the southern part of the Red Sea coast is higher. The construction of a 60 MW pilot plant in Yemen is likely. According to model calculations by Lahmeyer International, renewables like wind, CSP or geothermal power would be cheaper than the currently used diesel generators for the decentralized electricity supply in rural areas. The potential for wind power on the Gulf coast is more limited and confined to fewer spots. German GTZ has constructed a pilot wind generator on Sir Bani Yas island near Abu Dhabi, for example. Iran, on the other hand, has some wind potential in the northern Gulf region of Khuzistan and in selected spots in the north of the country close to the Caspian Sea.

Besides wind power, Lahmeyer International has also established considerable potential for geothermal power generation in Yemen, where it could acquire significance in some areas. Even biofuels might develop as a niche market in the GCC. The National Prawn Company Robian, which has a large shrimp farm in Al Leith south of Jeddah,[28] is currently experimenting with planting algae as food for its shrimps instead of fish powder, which has steadily increased in price. At a later stage, they are contemplating the use of algae also for the production of biofuels, according to the management. Algae as a third generation biofuel has considerable potential as it does not compete with food production for fresh water and arable land.

The Bellwether Project: Masdar in Abu Dhabi

Abu Dhabi's Masdar initiative is the most significant initiative for renewable energy in the

GCC thus far. It seems that the government of Abu Dhabi has taken on the Saudi initiatives of the 1980s on a much larger scale, in order to take advantage of the technological progress and the improved economics that have taken place in renewable energy since then.[29] Masdar has six main strategic thrusts:

a. Masdar City aims to be the first carbon neutral city in the world. It will house 50,000 people in close vicinity to their work places, educational facilities and light industries. It will be characterized by emission free energy supplies, mainly from solar power, modern ecological architecture with a good passive energy balance and high energy efficiency, extensive recycling of waste and a modern system of public transport. People will start to move in by 2010 and the city will be completed in 2013.

b. The Masdar Institute of Science and Technology (MIST) has been set up in cooperation with MIT (Massachusetts Institute of Technology) and aims at acquiring and developing know-how in the field of renewable energies. The ultimate goal is to convert the UAE from a technology importer to a technology exporter.

c. Like the Masdar Institute, the Masdar Research Network aims to conduct technology-related research in the field of renewables. To this end, Masdar will cooperate with research institutes in Europe, Asia and the US.

d. The Special Projects business unit deals with production facilities for renewable energies, and especially eyes technologies that are close to commercial breakthrough and can be upscaled to marketable solutions. The $2 billion investment in two factories for thin film PV cells in Abu Dhabi and Erfurt/ Germany is a case in point. Initially, the two Masdar factories will have an annual capacity of 230 MW, which is enough energy to power 70,000 homes. By 2014, capacity will increase to 1000 MW annually, making Masdar a world market leader in thin film solar cells production.[30]

e. The Carbon business unit encompasses one branch for carbon emissions trading and CDM projects and a second branch for Carbon Capture and Sequestration. This technology offers the opportunity to make fossil fuels more environment- friendly, and if pumped into mature oil fields to keep up the reservoir pressure, it can also function as a substitute for natural gas, which is thus far used for this purpose. Masdar has commissioned a feasibility study for a multi-billion dollar project for Carbon Capture and Storage (CCS) and its usage in projects for enhanced oil recovery. Natural gas would be processed to hydrogen and carbon dioxide, with the former being used for power generation and the latter reinjected into oil fields. The Abu Dhabi initiative will be the largest CCS program worldwide.

f. The business unit “Innovation and Investment” comprises a $250 million Clean Tech Fund and a power plant project unit. The fund is financed by Masdar and Credit Suisse (one half each) and invests worldwide in companies that develop clean technologies. The power plant unit deals with the implementation of power plants that are fueled by solar, wind, biomass or municipal waste. The first project is the construction of a 100 MW Concentrated Solar Power (CSP) plant by 2011, with a possible extension to 500 MW at a later stage. This is equivalent to a mid-sized conventional power plant and would be a substantial addition to the UAE's currently installed capacity of 14,800 MW. Masdar also owns 40 percent of the Torresol joint venture, which it has started with Spanish Sener Grupo. Torresol will design, build and operate three CSP plants in Spain for $800 million and aims to launch at least two new CSP plants every year. Within 10 years it envisages a total capacity of 1000 MW.

According to Masdar officials, the projected overall investment volume over time for Masdar City is $22 billion and for Masdar renewable energy projects $15 billion. A substantial part will be earmarked for the construction of Masdar city and thus essentially for real estate. But it needs to be taken into consideration that appropriate construction and architectural design can yield massive gains in energy efficiency, through better insulation of buildings and green building architecture. The energy debate should not be looked at from the supply side only; arguably, energy conservation is the most important energy source in the GCC countries, which have one of the highest energy consumption rates per capita worldwide. Over the next seven years, the amount of energy required to power buildings in the UAE will double, according to Masdar. Dubai has launched a green building initiative and will introduce a sustainable building code in 2008, most likely modeled after the US Leadership in Energy & Environmental Design (Leed) standard. Abu Dhabi too aims to establish a green building code. The Masdar City will also reduce desalinated water consumption by 80 percent by using repurification techniques and domestic wastewater for irrigation. Similarly, the World Trade Center in Bahrain will produce 15 percent of its energy needs with three built-in wind turbines, and the Lighthouse Tower in Dubai International Financial Center (DIFC) will cut conventional energy consumption in the building by 65 percent by using solar and wind power.[31]

Conclusion

Renewable energies are about to capture a significant portion of the global energy mix. This portion is only likely to grow given rising energy demand, supply worries with regard to fossil fuels and environmental concerns. Especially solar energy in the form of Concentrated Solar Power (CSP) and thin film PV cells integrated in buildings offer huge potential for the GCC countries. Rising domestic energy needs for power generation and desalination, favorable conditions for solar energy production and interest in acquiring technological know-how make a perfect argument for renewable energy in the Gulf. Renewable energies can stretch the lifeline of the GCC's oil and gas exports, and in some decades from now, they even have the potential to develop into a major pillar of the economy. Energy created from renewables could gradually substitute oil as the GCC's major export item. A necessary precondition for this would be a wholehearted embrace of the renewable energy trend by the GCC countries and their development into technological leaders in the field. They should regard renewables not as unwanted competition to their oil and gas production, but rather as a welcome addition to tight global energy markets. Regarding renewable energies as the uneconomical hobby of esoteric tree huggers in Europe and the US would be a mistake as well; this point was passed a long time ago. Otherwise, the GCC countries may face the same fate as the Michigan Savings Bank, which denied Henry Ford an initial credit arguing that "the horse is here to stay, but the automobile is only a novelty – a fad."

Appendix: Status of Renewables Technologies – Characteristics and Costs

Technology	Typical Characteristics	Typical Energy Costs (U.S. cents/kilowatt-hour)
Power Generation		
Large hydro	*Plant size:* 10 megawatts (MW)–18,000 MW	3–4
Small hydro	*Plant size:* 1–10 MW	4–7
On-shore wind	*Turbine size:* 1–3 MW *Blade diameter:* 60–100 meters	5–8
Off-shore wind	*Turbine size:* 1.5–5 MW *Blade diameter:* 70–125 meters	8–12
Biomass power	*Plant size:* 1–20 MW	5–12
Geothermal power	*Plant size:* 1–100 MW *Type:* binary, single- and double-flash, natural steam	4–7
Solar PV (module)	*Cell type and efficiency:* single-crystal 17%; polycrystalline 15%; amorphous silicon 10%; thin film 9-12%	—
Rooftop solar PV	*Peak capacity:* 2–5 kilowatts-peak	20–80*
Concentrating solar thermal power (CSP)	*Plant size:* 50–500 MW (trough), 10-20 MW (tower); *Types:* trough, tower, dish	12–18†
Hot Water/Heating		
Biomass heat	*Plant size:* 1–20 MW	1–6
Solar hot water/heating	*Size:* 2–5 m² (household); 20–200 m² (medium/multi-family); 0.5–2 MWth (large/district heating); *Types:* evacuated tube, flat-plate	2–20 (household) 1–15 (medium) 1–8 (large)
Geothermal heating/cooling	*Plant capacity:* 1–10 MW; *Types:* heat pumps, direct use, chillers	0.5–2
Biofuels		
Ethanol	*Feedstocks:* sugar cane, sugar beets, corn, cassava, sorghum, wheat (and cellulose in the future)	25–30 cents/liter (sugar) 40–50 cents/liter (corn) (gasoline equivalent)
Biodiesel	*Feedstocks:* soy, rapeseed, mustard seed, palm, jatropha, or waste vegetable oils	40–80 cents/liter (diesel equivalent)
Rural (off-grid) Energy		
Mini-hydro	*Plant capacity:* 100–1,000 kilowatts (kW)	5–10
Micro-hydro	*Plant capacity:* 1–100 kW	7–20
Pico-hydro	*Plant capacity:* 0.1–1 kW	20–40
Biogas digester	*Digester size:* 6–8 cubic meters	n/a
Biomass gasifier	*Size:* 20–5,000 kW	8–12
Small wind turbine	*Turbine size:* 3–100 kW	15–25
Household wind turbine	*Turbine size:* 0.1–3 kW	15–35
Village-scale mini-grid	*System size:* 10–1,000 kW	25–100
Solar home system	*System size:* 20–100 watts	40–60

Note: Costs are economic costs, exclusive of subsidies or policy incentives. Typical energy costs are under best conditions, including system design, siting, and resource availability. Optimal conditions can yield lower costs, and less favorable conditions can yield substantially higher costs. Costs of off-grid hybrid power systems employing renewables depend strongly on system size, location, and associated items like diesel backup and battery storage. (*) Typical costs of 20–40 cents/kWh for low-latitudes with solar insolation of 2,500 kWh/m²/year, 30–50 cents/kWh for 1,500 kWh/m²/year (typical of Southern Europe), and 50–80 cents for 1,000 kWh/m²/year (higher latitudes). (†) Costs for trough plants; costs decrease as plant size increases. *Source:* See Endnote 18.

Source: REN 21: Renewables Global Status Report 2007

Note: Typical wholesale power generation costs from conventional fuels (oil, gas, coal, nuclear) are between 4 and 8 US cents per kilowatt-hour (kWh) for new base-load power. They can be higher for peak power and higher still for off-grid diesel generators.

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