BOLOURI CORPORATION

Hydro-Solar Electric Production Memorandum

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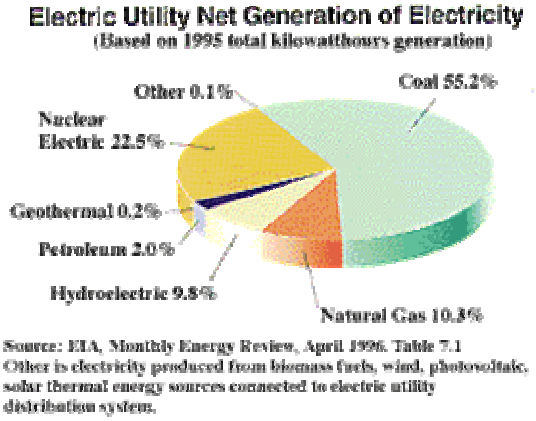
Economic Potential

Electricity has a fundamental influence on global development and electricity markets are now open to compete globally. The introduction of competition in the generation and supply of electricity is expected to improve the economic efficiency of the power sector, to reduce overcapacity of generation and eventually to reduce electricity prices for consumers.

Electricity generation is expected to face major challenges in the decades ahead with heavy investment requirements, rising fuel prices and growing focus on environmental impacts. For the challenges ahead, a strong case can be made for adopting a systematic and sustainable approach to energy. This will require improved power station efficiency, energy source diversification and fuel flexibility.

The variety of fuels used to generate electricity has adverse impact on the environment. Fossil fuel power plants release air pollution, require large amounts of cooling water, and can mar large tracts of land during the mining process. Nuclear power plants are generating and accumulating copious quantities of radioactive waste that currently lack any repository. Moreover, these reserves of energy, especially of fossil fuels as well as other fuels are limited.



Source: EIA, Monthly Energy Review, April 1996, Table 7.1
Other is electricity produced from biomass fuels, wind, photovoltaic, solar thermal energy sources connected to electric utility distribution system.

Generating electricity from renewable resources is ecologically sustainable solution. A non-polluting renewable energy source, hydroelectricity accounts for 20% of the electricity consumed around the world. Worldwide hydroelectricity consumption reached 816 GW in 2005, consisting of 750 GW of large plants, and 66 GW of small hydro installations. The available solar energy resources are 3.8 YJ/yr (120,000 TW). Less than 0.02% of available resources are sufficient to entirely replace fossil fuels and nuclear power as an energy source.

Global Facts

Electricity continues its penetration in all regions, accounting for almost a quarter of final energy demand; coal declines in industrialised countries; biomass is progressively phased out in developing countries. Oil remains the dominant fuel, with a share ranging from 40 to 50 % in 2030 according to the region.

Coal is projected to continue to retain the largest market share of electricity generation, but its importance is expected to be diminished somewhat by the rise in natural gas use. In 2025, coal is expected to account for 31 percent of the world's electricity fuel market, slightly lower than its 34 percent share in 2001.

The nuclear share of energy use for electricity production is expected to decline in most regions of the world as a result of public opposition, waste disposal issues, concerns about nuclear arms proliferation, and the economics of nuclear power.

At world level, the per capita electricity demand rises at sustained rates with the per capita GDP over the projection period: 1.2%/year between 1990 and 2000, 1.4%/year in the next decade and up to 2.2%/year from 2010 to 2030.

Electricity is consumed in great quantity by every sector of the global economy -- industrial, commercial, and residential. It is predicted that total electricity demand will grow exponentially even if the world GDP falls due to financial crisis as individual consumption needs will remain always.

- Worldwide net electricity consumption in 2001 was estimated to be 13.9 trillion kilowatt-hours. If global electricity demand grows at the average annual rate of 2.4 percent predicted by the EIA, 24.7 trillion kilowatt-hours would be consumed in 2025.

- China's electricity consumption is projected to nearly triple over the next two decades, growing by an average of 4.3 percent per year.

- According to EIA, India has emerged as the world's fifth largest energy consumer, and is projected to exceed Japan and Russia to take third place by 2030. The government hopes to maintain an annual GDP growth rate of about 8 percent over the next quarter century which will require India to at least triple its primary energy supply and quintuple its electrical capacity. This will force India, which already imports a majority of its oil, to look beyond its borders for energy resources.

Electricity production increases steadily at an average rate of 3 %/year. More than half of the production in 2030 will be provided by technologies that emerged in the nineties and afterwards like combined cycle gas turbines, advanced coal technologies and renewable fuels.

Electricity Production in UAE

Since its independence in 1971, UAE took a giant leap toward achieving a high economic growth and urbanization. Consequently, the demand for electricity in the UAE is not only increasing but accelerating due to numerous real estate projects, particularly the mega shopping malls, large amount of office space and their particular energy needs and the ever increasing population. Anticipating this increase in demand, there are plans to raise the country's capacity for electricity generation by as much as 60 per cent by 2010, according to a report by Emirates Industrial Bank (EIB).1

Total installed electricity generating capacity in the UAE was 12,800 megawatts (MW) at the end of 2004. This will increase to 19,400 MW by 2010 to meet the 6 to 7 per cent annual growth in demand dictated by the escalating needs of industry and private consumers.

Approximately 97 per cent of production is fuelled by natural gas. Abu Dhabi, Dubai and Sharjah are responsible for 90 per cent of capacity, with 14 federal plants in the smaller Northern Emirates accounting for the remaining 10 per cent. Abu Dhabi, which has the largest capacity and the highest growth in the industry, dominates electricity production in the UAE.2

Energy consumption in the United Arab Emirates is growing at an average rate of 10% per annum, more than double the global average of just 4%. Power consumption rose last year by 15%.

Key Facts:

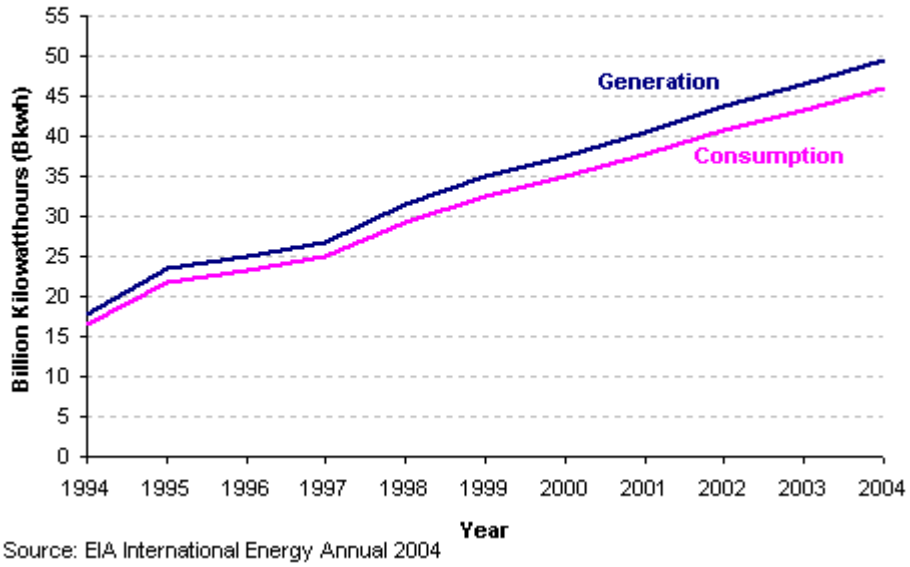
- The number of electricity consumers in the UAE rose by 19% last year
- Energy consumption in the UAE is forecast to triple by 2020
- Arab nations are to spend over US$120 billion on new power projects between 2008 - 2012
- Private sector companies are now able to construct power generation and water desalination facilities in the UAE

Dubai
Dubai has the greatest demand potential and is growing at about 12 to 14 per cent per annum compared to Abu Dhabi and Sharjah.

Abu Dhabi
Abu Dhabi power demand is set to increase by 80% by 2012

Ras Al Khaimah (RAK)
RAK is rising to the challenge of meeting the emirate's energy needs, planning to increase electricity generation capacity and diversifying sources of power and fuel. RAK has long relied on electricity from the grid operated by the United Arab Emirates' (UAE) Federal Electric and Water Authority (FEWA), but is increasingly looking to develop its own generating capacity as the demand placed on the authority's network rises.

UAE's Electricity Generation and Consumption, 1994-2004



Source: EIA International Energy Annual 2004

Going forward, UAE has the highest projected increase in demand within the GCC region that is expected to continue to grow at a minimum rate of 10% per annum until 2010. Dubai is estimated to have the greatest demand potential and is expected to grow by 12% to 14% per annum.

To fulfil the huge requirements for electricity in the coming years almost all emirates invest in power generation and water desalination projects.

Renewable Sources of Power Generation

The three choices of renewable power generation are wind, solar and hydro.

Existing Solutions

Wind

For a wind operation it is recommend that you first install a wind totalizer, which will give you daily wind speed totals so you can decide if this is an economical method for your location. Wind is a very good choice for those who live on the coasts or other high-wind areas. This is the most economical way to generate electricity from nature, providing you have ample wind.

There is some maintenance involved with this form, as it does have moving parts. With a good location, you can generate your electricity and use your power for less than $0.05 per KWH.

Solar

For solar generation you will need several solar electric power panels. These should be mounted on a pole that will follow the sun during the day so you get maximum power from your panels. There is no maintenance when you use solar panels to generate your electricity, but it is a very expensive way to produce your power.

Solar panels have no maintenance, make no noise and do not harm the environment. The disadvantage is the cost. To generate and use your electricity with solar will cost you approximately $0.45 per kilowatt hour.

Solar power can be generated anywhere on the earth but some regions are better than others. Places where the sun shines frequently and regularly are preferable to regions where cloud cover is common. Many of the world's developing countries, where demand for electricity is growing rapidly, offer good conditions for solar electricity generation.

Solar generating stations do not take up enormous amounts of land but they do require many times the space of a similarly sized fossil fuel power plant.

Hydro

The installation of a small Micro Hydro unit is an excellent choice if you have a stream or large spring for power generation. There is available a small pelton wheel mounted below a cast frame, which has a car alternator atop that generates your electricity.

It is a preferred form of power generation, if you have flowing water, as it is the most economical. These units do need maintenance every year, which is easily accomplished. The cost of generation this way is about $0.05 per KWH.

Large scale hydro-electricity generation depends on the building of dams and creation of reservoirs. Water trapped in a reservoir has only one means of escape to continue its journey downstream - passing through a generator at high pressure and making electricity.

Electricity generated in turbines driven by falling water accounts for about 6 percent of electricity generation globally.

Summary of Fuel Needs for Electricity Generation without Technology Improvements for year 2050 (in EJ = 10^{18} J)

Region	Oil	Gas	Coal	Nuclear	Solar	Hydro	Total
US	*1.30*	*2.90*	*6.84*	*1.71*	*1.71*	*1.08*	*15.54*
Canada & W Europe	*1.10*	*2.54*	*8.25*	*2.92*	*2.92*	*2.08*	*19.82*
OECD Pacific	*0.92*	*1.02*	*4.35*	*1.08*	*1.08*	*0.47*	*8.91*
E. Europe	*1.29*	*0.60*	*3.71*	*0.70*	*0.70*	*3.27*	*10.27*
China	*0.71*	*0.32*	*2.01*	*0.38*	*0.38*	*3.13*	*6.93*
Middle East	*0.03*	*0.40*	*0.48*	*0.18*	*0.18*	*0.38*	*1.66*
Africa	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*4.40*	*4.40*
Latin America	*1.21*	*0.57*	*3.55*	*0.66*	*0.66*	*4.29*	*10.95*
South-East Asia	*0.30*	*0.34*	*2.12*	*0.39*	*0.39*	*2.35*	*5.90*

Hydrogen as an efficient fuel

Hydrogen is the lightest of all materials. A hydrogen atom is the smallest and simplest atom possible, containing only a single proton and a single electron. As a fuel, hydrogen has a high calorific value, yielding about 2.8 times as much energy as an equivalent mass of gasoline. So instead of a tank holding 70 kg of gasoline motor fuel, a car running on hydrogen combustion could run a similar distance using only 25 kg of hydrogen.

Hydrogen is considered a clean reliable fuel once it is produced because the combustion of hydrogen produces water vapor. A particularly costly problem with hydrogen is that hydrogen is not available as free hydrogen and must be freed before it can be used as a fuel.

Over the past decade, a frenzy of research on the hydrogen fuel cell, an electrochemical device, has led to the development of a variety of fuel cell types designed to produce electricity to meet just about every kind of energy need.

Power Plant – Costs and Barriers

Solar power converts the sun's energy into a pollution-free source of heat, lighting and electricity. Electricity from concentrated solar power plants costs about 10 to 14 cents per kilowatt-hour, while electricity from a coal or natural gas power plant costs about 4 cents per kilowatt-hour. But these prices should continue to fall thanks to lower installation costs and technological advancements.

Current prices for solar electric power systems are about $2.50 per peak Watt, a price that has been declining about 7% per year for the last few decades. The day/night cycle, non-ideal sun angles, weathering, and cloud cover reduce power output enough to make the final cost per average Watt $10 or more. Terrestrial solar power is still too expensive for wholesale utility use, but it is now competitive for home owner installation in many areas. 6

All of the current methods and the projected technologies for producing hydrogen from solar energy are much more expensive (greater than a factor of three) when compared with hydrogen production from coal or natural gas plants. This is due partly to the lower annual utilization factor of about 20 percent (as compared with, say, wind of 30 to 40 percent).

Capital Costs of Current Electrolysis Fueler Producing 480 Kilograms of Hydrogen per Day

	Unit Cost ($)	Total Cost ($ millions)
Electrolyzer unit	1,000/kW	1.17
Hydrogen compressor	3,000/kW	0.16
Hydrogen storage	100/gal.	0.24
Hydrogen dispenser	15,000/unit	0.02
Total process units		1.59
General facilities	20%	0.32
Engineering, permitting, start-up	10%	0.16
Contingencies	10%	0.16
Working capital and miscellaneous	5%	0.08
Total capital		2.31
Siting factor (110% of Gulf Coast)		0.23
Total		2.54

Barriers

Solar energy isn't produced at night and can also be unreliable due to cloudy weather, making it necessary to store the produced electricity or use backup generators. The number of usable sun hours for each site varies depending on latitude, cloud cover, and other obstacles. This means that photovoltaic systems are not a cost-effective option for all locations. Large-scale solar electric systems need large amounts of land to collect solar energy, which can cause conflict if the land is in an environmentally sensitive area or is needed for other purposes. One solution is to locate large-scale solar electric systems in deserts or marginal lands. 4

The main technical barrier is to design the plant and grid interactive inverter, which can withstand the fluctuations in the grid voltage and frequency.

Geographical necessities

Solar plants perform well in very sunny locations, specifically the arid and semi-arid regions of the world. Although the tropics can have high solar radiation, the high diffuse solar radiation and long rainy seasons make these regions less desirable for STPP. Promising geographic regions for solar plants are:

- Africa,
- Middle East
- Southern Europe
- Parts of India and Pakistan,
- Parts of Brazil and Chile,
- Mexico and southwest U.S., and
- Australia

With solar now providing less than one percent of the world's energy, that would take "a massive scale-up," At present levels of efficiency, it would take about 10,000 square miles (30,000 square kilometers) of solar panels—an area bigger than Vermont—to satisfy all of the United States' electricity needs. 5

Hydro-Solar Project - *Proposed Solution for Electricity Generation*

The transition to a hydrogen economy would begin in the context of a mature and reasonably efficient energy system; indeed, hydrogen technologies must compete effectively with that system if the transition is to occur at all.

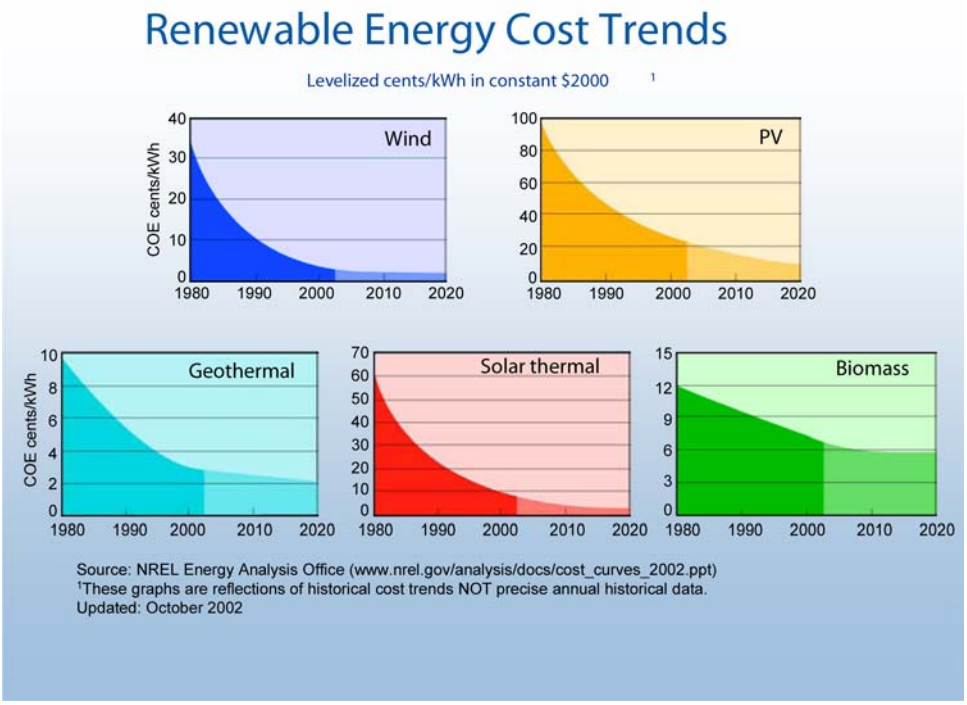
Hydrogen can be produced by electrolysis. When electrolysis is completed, we can produce hydrogen and oxygen from water molecules. However, electrolysis is considered a net energy consuming process as it needs more energy to separate hydrogen from water than energy provided by the produced hydrogen.

Hydrogen from solar energy can be produced through two methods. In one method, solar energy is converted into electricity using a photovoltaic (PV) cell and then hydrogen is generated through the electrolysis of water. In the alternate method, photoelectrochemical cells are used for the direct production of hydrogen. The photoelectrochemical methods are still in the early stages of development.

The hydro-solar electric generation is a complete system for supplying low-cost, non-polluting energy anywhere in the world, using an increasing proportion of renewable sources. Inspired by the photosynthesis, it will allow the sun's energy to be used to split water into hydrogen and oxygen gases. Later, the oxygen and hydrogen may be recombined inside a fuel cell, creating carbon-free electricity to power your house or your electric car, day or night.

In the solar-hydrogen energy system, some photovoltaic arrays would provide current electricity demand while others would be used to produce hydrogen electrolytically for storage and later use in fuel cells to generate electricity.

The project is expected to help stabilize electricity costs for residents and businesses in UAE. On the success of the project, consumers will be able to power their homes in daylight through photovoltaic cells, while using excess solar energy to produce hydrogen and oxygen to power their own household fuel cell.



Cost and Operating Availability of Electricity generation

Wholesale	Coal	Wind	S-Hydro	Biomass	Solar
COE (¢/kWh)	2-5	3-7	2-5	3-5	21-25
O-Availability	85-95%	30%	25-50%	0-60%	25%

How Hydro-Solar Electricity Generator Functions

Solar panels are a common technology used to convert solar power into usable electricity. These panels are made up of several layers of photovoltaic cells that convert solar energy into electricity. At present solar panels can typically convert approximately 15% of the sunlight in our atmosphere into electricity.

Many factors limit the efficiency of photovoltaic cells because in converting light to electricity it wastes most of the energy as heat. The amount of exploitable solar energy is based daily on cloud cover and how high in the sky the sun is. The other major limitation is the need of large lands to install power plant.

Hydro-Solar Electricity Generator generates electricity through electrolysis; electricity is passed through water to produce hydrogen and oxygen. Oxygen and hydrogen is again combined inside a fuel cell, creating carbon-free electricity to power a house or an electric car, day or night.

The fuel cell split water into its component elements, hydrogen and oxygen, which would then be combusted back into water vapor in a conventional internal combustion engine to produce net energy. In Hydro-Solar Electricity Generator, energy that is required to split water comes from solar radiation that can be trapped and stored for further use.

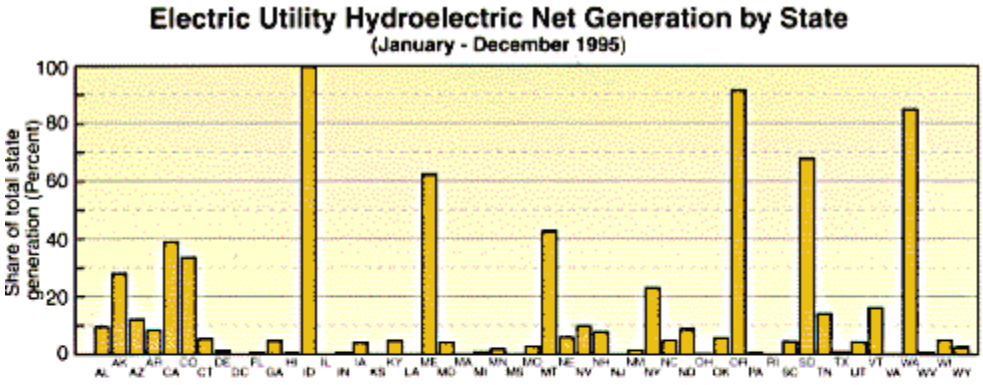
The major achievement of the project is that it is capable to produce electricity day and night without interruption and catalyst. The technology got its inspiration from the process of photosynthesis where plants store solar energy in the daytime and consume it night or cloudy days. Before that solar power has been a daytime-only energy source, because storing extra solar energy for later use is prohibitively expensive and grossly inefficient.

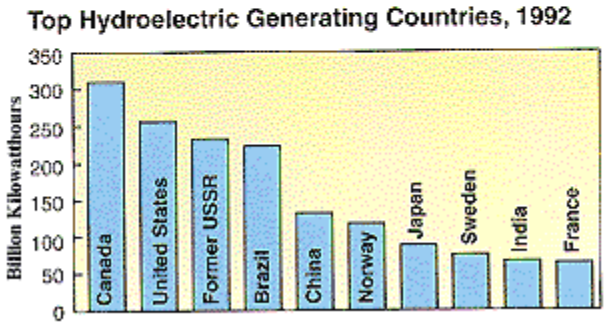
Water needed to produce a kilogram of hydrogen from wind or solar to power a fuel cell vehicle (2.4 gallons) is very less than the water required to produce the amount of gasoline needed to power a vehicle with an internal combustion engine for the same distance (2-5 gallons).

The pipeline system will be able to collect hydrogen generated from coal or biomass gasification plants en route. Solutions to the problem of embitterment in hydrogen pipelines have been proposed and subject to satisfactory evaluation, hydrogen pipelines could displace natural gas pipelines in due course.

Market Overview

Although most energy in the United States is produced by fossil-fuel and nuclear power plants, hydroelectricity is still important to the Nation, as about 10 percent of total power is produced by hydroelectric plants. Likewise, until now, solar power was considered as a daytime-only energy source, because storing extra solar energy for later use was prohibitively expensive and grossly inefficient.





EIA, Annual Energy Review 1994. July 1995, Table 11.20.
Hydropower provides 19% of the world-wide generation of electricity (1992)

In the coming era, there will be a need for innovation of new sources of energy. Over the long term, the vision that will ultimately prevail is the one that relies on a diverse portfolio of clean, renewable forms of energy like wind, solar, hydro, ocean wave, geothermal, and biowaste. Hydrogen is the key to this sustainable energy vision. 3

Electricity and hydrogen are often seen as interchangeable sides of the same coin. Electricity is ephemeral in nature. It has to be used immediately or be stored in some other form. The best, most readily adaptable way to store large quantities of electricity is to convert it to hydrogen, which for many decades has been traded as a major industrial commodity. In 2004, more than 40 million tons of hydrogen was consumed by industries worldwide.

Market Opportunity

The electric generation sector is of central importance for economic growth and social development. Electricity generation is always associated with quite intensive energy consumption for the construction of plants, transports, fuel processing and waste treatment. In the near future, much energy will be required for desalinization of water as the need for drinking water is consistently increasing and our world water resource is depleted.

A report by the Emirates International Bank has revealed that there are plans in the UAE to boost electricity generation by up to 60% by 2010. The real estate boom and the rapidly increasing population is stoking demand. Currently, electricity production capacity is about 16.2 thousand megawatts but, by 2010, industry experts believe the capacity will have risen to 26 thousand mega watts.

The Hydro-Solar project is aimed to provide a complete system for supplying low-cost, non-polluting energy anywhere in the world, using an increasing proportion of renewable sources. The project is designed to help transform the global energy system to meet the needs of the future and to help build a bridge to that future by improving today's energy systems.

Regarding production costs, it seems that a photoelectrochemical device in which all of the functions of photon absorption and water splitting are combined in the same equipment may have better potential for hydrogen production at reasonable costs.

Growth Strategy

Accelerated technology developments for electricity generation have led to significant changes in the structure of electricity production. The availability of energy resources is clearly a potential constraint for the development of fossil fuel use in the long term. In contrast, large hydro and geothermal will remain stable; wind, solar and small hydro projects may jump up by a factor of 20.

At world level, the growth of electricity production from biomass, solar, wind and small hydro is remarkable (more than 4 %/year on average) although no policy targets for renewable have been taken into account. The growth is the most pronounced for solar and wind, whose production is expected to increase at an average rate of about 11 %/year over the 2000-2030 period.

Developing or investing in the development of renewable energy projects can be a good investment. Wind farms, small hydro power schemes and landfill gas recovery developments can all offer a good rate of return on investment. Hydro-Solar electricity generator offers additionally benefit as unlimited fuel supply, independence from resource availability and limitations, as well as a significant move towards a cleaner and greener world.

Solar-hydro project involves minimal labour costs and a cost-free power source.

Conclusion

Renewable energy can increase diversity of energy supplies and replace diminishing fossil fuel resources over the long run. They can also make use of indigenous resources to provide cost-effective and secure supply options. They can meet the needs of rural and developing urban communities provide energy to remote villages and can substantially reduce greenhouse gases and other pollutants if substituted for fossil fuels.

As the cost of natural gas rises and cheaper electricity from renewable sources becomes available, the relative cost of hydrogen will drop. However, given the bulkiness of elemental hydrogen and the huge amount of specialized capital required to develop a delivery system for it, it is likely that local on-site generation will have an economic advantage, at least in retail-scale applications.

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