

## **Prospects and Sustainability of Green Power: Case Study of Tidal Power**

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### **Abstract:**

Recently worldwide has a great trend towards green power, because burning of fossil fuels is a serious threat to global warming and climate change. Green power like solar, wind, hydro, tidal, wave and others have the separate potentiality in terms of geographical location, social and economic viability, and environmental acceptance. Tidal power is a green power, which has a lot of potentialities and benefits. But till now, there are very few tidal power plants around the world, mainly because of their environmental concerns and high capital cost. Recently these problems of tidal energy have been resolved by the application of modern appropriate technologies. The paper will discuss a comparative prospects and sustainability of green power, emphasising on tidal power. Finally, the paper will recommend a policy framework for the prospect and sustainability of tidal power around the world.

**Key Words:** Green power, Tidal power, Environmental impacts and Sustainability.

### **Introduction**

Global warming, air pollution, water pollution, land pollution, habitat destruction, and resource depletion are the results of the world's ever-increasing consumption of energy derived from fossil fuels. The impact of the use of fossil fuels is hitting closer and closer to home and the public is awakening to the situation and asking for solutions. But in the public's view, there are few apparent solutions: hydroelectric sites have been fully exploited and further development meets strong resistance; nuclear power has been a dramatic disappointment; alternative energy sources are not technologically ready to compete economically with fossil fuels (Ullman, 2002). Renewable energy can provide a substitute for oil and other non-renewable polluting sources of energy. Conservation is put forth as a preferred method of reducing toxic and CO<sub>2</sub> (greenhouse gas, GHG) emissions, but few experts assume that the conservation as a realistic solution. Economic development of the third world is dependent upon the availability of electricity and consumption continues to rise in developed nations, despite some over-capacity conditions. The world continues to use electricity in ever-increasing amounts, despite the problems associated with power generation that uses fossil fuels. Therefore a shift from oil to renewable energy sources would be a strategic way to maintain environmental management and sustainable development. Green environment means sustainable environment and sustainable environment means ecological balance and integrity, intergenerational equity, sustainability of clean air, clean water and clean soil. These are fundamentals for earth's life support systems within and between generations and

fundamental to maximising human welfare. Green power (GP) enhances this human welfare system. Green power or green energy or green electricity are generic terms for electricity generated from clean, environmentally preferable energy sources such as wind, water, solar, tidal, energy-from-waste and energy-from-crops (bio-mass), collectively known as renewable energy. GP enhances to establish the green environment, because of its low-to-zero carbon content. Therefore the use of GP is seen as a desirable and important option for the UK and many developed country's carbon emission reduction strategy (Lipp, 2001). Although GP is produced in many countries, it is usually integrated and sold as conventional electricity (ie. no distinction is made between 'brown' and 'green' electricity). By selling it separately, consumers are given a choice regarding the environmental impact of their electricity use, and the opportunity to 'vote' for this choice (Lipp, 2001).

The market has had positive beginnings with almost all electricity suppliers offering a green power product around the world after the UNCED conference in 1992, in particular from the Kyoto Protocol Agreement in 1997. Marketing has been launched and consumers are beginning to make the switch to green power despite the premium charged. An accreditation scheme guarantees that the green purchases match power entering the grid (Lipp, 2001). While the groundwork has been set for a progressive market to emerge, recent energy policy proposals may undermine the progress made. Green renewable energy such as tidal energy is a candidate for maintains these balances. Now green energy is popularising around the world very rapidly. Recently, the German Environment Ministry is reporting that 5.3 million residents now have their power supplied from green sources and another 1 million will go green by the end of the year. In the past three years the German utility industry and the government have invested 13.7 billion Euros (\$11.9 billion) in the development of renewable energy - a cost equal to four nuclear power plants. But the cost is recovering easily, eg. their annual sales of green power have reached a volume of 8 billion Euros (US\$6.96 billion). It is expecting that by 2010 300,000 jobs could be in the renewable energy sector in the country<sup>1</sup>. The US Environmental Protection Agency has announced the start of the Green Power Partnership, a voluntary program it says is aimed at boosting the market for power alternatives that reduce the environmental and health risks of conventional electricity generation<sup>2</sup>. China and the Netherlands have signed an agreement for a joint energy-saving technology development project valued around US\$580,000 to reduce the greenhouse gas emissions in rural areas. The project has to implement as part of their commitments under the 1995 United Nations Framework Convention on Climate Change (The Carbon Trader, 2002). The city of Chicago and 48 city government agencies signed a contract with local utility ComEd to purchase 10% of their electricity from renewable sources, a figure due to increase to 20% in five years (ENS, 2002). This is the largest such purchase in the United States, but Chicago is just one example of the many cities, businesses, and individuals who are buying 'green power'. Utilities in eight states and many other industrial countries now offer such purchases. In October 1999, Leeds Metropolitan University in the United Kingdom started buying at least 30% of its energy from green power. Six months later, Edinburgh University signed an agreement to obtain

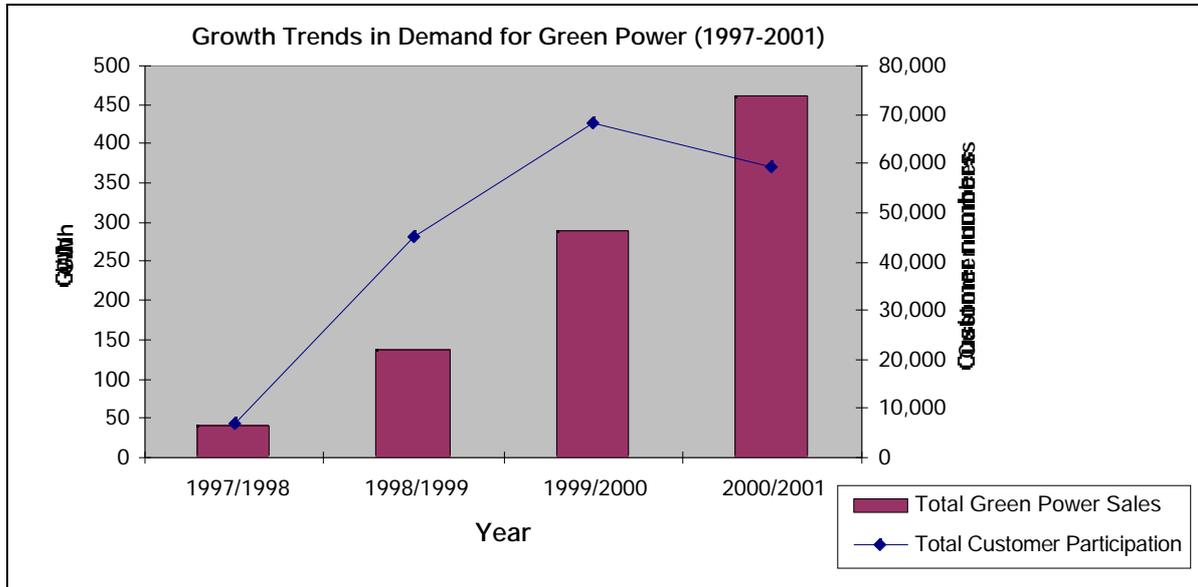
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<sup>1</sup> Visit the Federal Environment Ministry at <http://www.bmu.de/>

<sup>2</sup> Source: [http://www.greenbiz.com/news/news\\_third.cfm?NewsID=17408](http://www.greenbiz.com/news/news_third.cfm?NewsID=17408)

40% of its energy this way. The Netherlands has more than 775,000 green energy customers, which represents 5% of the population. The number of customers has tripled in just one year (ENS, 2002). Germany has approximately 280,000 green energy customers. Many large German companies are buying green power, helping to create consumer demand to move beyond fossil fuels (ENS, 2002). In Australia, green power demand is also increasing rapidly (fig. 1).

Fig. 1: Growth trends in demands for green power in Australia<sup>3</sup>.



Increased demand for renewable energy due to accredited Green Power products has led to a growth in new installed capacity - over 100 new approved projects have been installed or committed in Australia since 1997, including the most recent Albany wind farm in Western Australia, so far the largest in Australia (21.6MW) (SEDA, 2001).

This rapid growth is due to an energy tax exemption for green electricity, green energy deregulation, and successful marketing campaigns. In the U.S. State of Colorado, the Grassroots Campaign for Wind Power has educated citizens about the benefits of wind power and encouraged a shift in purchasing behaviour. As a result, Colorado has 20,000 residential green power subscribers and numerous commercial ones, including IBM, Hewlett-Packard, and Patagonia Clothing, as well as the cities of Denver, Fort Collins, and Aspen. Even the governor's mansion buys green power (ENS, 2002). Presently, a large number of U.S. businesses and other commercial customers have also signed up. In addition to large, high profile companies like Toyota and Kinko's, lesser known companies are aligning the purchasing decisions with their environmental values. Fetzer Vineyards, for example, began buying five million kilowatt-hours of renewable energy annually for its organic wine operations in Hopland, California. Government agencies are also signing up for green power. The U.S. Environmental Protection Agency (EPA)

<sup>3</sup> Source: Green Power Annual Audits, June 2001 Quarterly Report, SEDA (Sustainable Energy Development, Australia) [[www.greenpower.com.au](http://www.greenpower.com.au)].

purchases 100% green power at five of its facilities across the country. In so doing, EPA currently obtains 9% of its overall electricity consumption from green power (ENS, 2002)

Ironically green power offers an opportunity for citizens and corporations to act on their environmental concerns and to demonstrate support for public policies supporting renewable energy. In Colorado of USA, for example, the demand for green power is driving the investment in wind farms, a fast-growing source of power in the state. Still, it is clear that green power purchase options alone, even in fully deregulated markets, will not bring about the large scale changes needed to move the world to a sustainable energy economy. Individual and corporate choices based on environmental concerns cannot replace the role of public policies. Indeed, tax restructuring and renewable portfolio standards, acting in concert with energy efficiency and green power programs, may represent the best hope for creating an ecologically sustainable energy economy. The ideal green power products such as tidal power do not contribute to climate change, air pollution, or acid rain (ENS, 2002). The paper will discuss a comparative study of green power prospects, focusing on tidal power and give a recommended policy framework for the sustainability of tidal power around the world.

### **Why Tidal Power is a Green Power?**

Tidal power is a green power, because it does not produce any greenhouse gas. Besides it has the following characteristics:

- Lifecycle: Very high life time typically exceeding 120years (Day, 1994; Baker, 1991; Middleton, 2001);
- Capital and management cost: High capital cost, long term maintenance cost is almost zero;
- Non-fuel operating capacity ie, no fuel requirement;
- It produce no waste streams;
- Air Pollutants: SO<sub>2</sub>: No emissions; NO<sub>x</sub>: No emissions; CO: No emissions; Particulates: No emissions; and Hydrocarbons: No emissions; and
- Carbon Emissions: Makes no contribution to global warming. By displacing fossil fuels, a tidal barrage can prevent nearly one million tons of carbon dioxide emissions per TWh generated (Day, 1994).

### **Principle of Tidal Power**

Tidal power is a form of hydroelectric generation in which the water resource is replenished by tidal movements. It is truly renewable green power and clean source of energy creating no pollution and thereby helping to reduce green house gas emissions, which is simple, reliable and predictable.

Tidal power utilises the twice-daily variation in sea level caused primarily by the gravitational effect of the Moon and, to a lesser extent the Sun on the world's oceans. The interaction between the Sun and the Moon on the rotating Earth results in the ocean's water bulging upwards called Tide. Tides are the daily movements, with 2 high tides occurring every 24 hours and 50 minutes, with every rise and fall storing large amount of

potential energy. The energy of the tides comes from the rotational energy of the earth (Derby Hydro, 1999, Baker, 1991, Middleton, 2001).

Tidal power works from the power of changing tides, called Tidal range (difference between height of high tide and low tide point). This tidal change in sea level can be used to generate electricity, by building a dam across a coastal bay or estuary with large differences between low and high tides. The high tides allow the water to rush into the bay. The gates (sluice gate) of the dam then shut when water level is at its maximum height. The flow of water generates enough power to turn the turbines, which creates electricity. The generation of electricity from tides is very similar to hydroelectric generation, except that water is able to flow in both direction and in this way electricity can be created utilising two-way turbines. Three chambers of an enclosure generate power in sequence (fig.2).

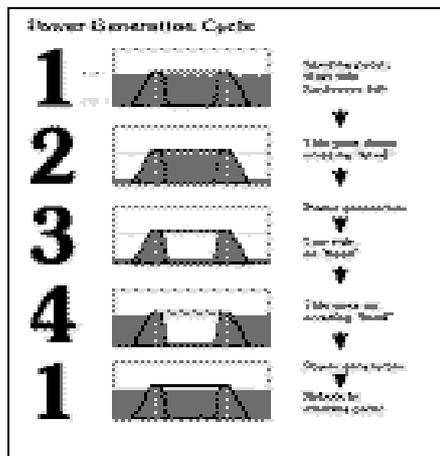


Fig. 2: Tidal power generation cycle (Source: <http://www.tidalelectric.com/technology/>)

The sequence can be optimised to meet the needs of the operator. For example, if the need is for maximum output, all three enclosures generate only during the extreme high tide periods and the extreme low tide periods. If the operator needs a continuous output, then the chambers generate sequentially, reducing the over-all output, but providing continuous power. The continuous power option is important to the operator. Other forms of alternative energy have been plagued by the inability to generate on demand (Ullman, 2002).

The amount of power generated is strongly related to the size of the tidal range. The output varies with the square of the tidal range. That is, if a tidal range of  $x$  gives a power output of  $y$ , then a tidal range of  $10x$  will give a power output of  $100y$  (Ullman, 2002). Next, the power output is directly related to the area of the impoundment structure that, in turn, dictates the amount of water passing through the turbine during each generating phase. Hydroelectric generating equipment is very efficient compared to other types and, in general, the bigger the equipment the higher the efficiency.

### Why Tidal Power is Far Behind in the World

Tidal power remains well below its potential in terms of its application in the field. Only few tidal power plants exist around the world. Although there are many possible sites of tidal power around the world. At present, the design of tidal power does not arise new

scientific issues. Nevertheless, additional research and development should be carried out in three fields: interface of the tidal power station output with National Grids and above all a sound assessment of its economic interest; design and implementation of the works according to the site; and environmental effects. On November 26, 1966, La Rance tidal power station was inaugurated. After 25 years of design in various fields, and 25 years afterwards it is still the only industrial prototype of a great size tidal power station and it brings us a lot of interesting data (Baker, 1991; Day, 1994. Middleton, 2001). Currently several important schemes are under study throughout the world. The usual technique such as 'barrage' technology is to dam a tidally-effected estuary or inlet, allowing the incoming tide to enter the inlet unimpeded then using the impounded water to generate power. The main barriers to uptake of the technology are environmental concerns and high capital costs. In recent years, these problems have been mitigated considerably by design, by involvement of experts and local communities in the identification and installation of new plant and by a growing understanding of how to achieve more sustainable energy development (Salequzzaman *et.al.*, 1999; ISTP, 1999; Derby Hydro, 1999). However there have been very few studies in the academic literature that analyse this process of how a new form of sustainable energy has been changing to become more main stream and acceptable (Baker, 1991). In general public, it is assumed that tidal power stations are very expensive to build and they often create electricity when it isn't needed as much. The tides are always changing, but the need for electricity much smaller at night than in the day. Tidal power stations also have environmental problems. Many fish like salmon swim up the estuaries where the barrages are situated and are killed by the turbines. The barrage also destroys homes to many birds, fish and other animals. Another arising problem is the effect of tidal stations on river/estuaries/marine ecosystems. Many rivers, before dams store the water during tides and used to have spring floods that washed out river backwaters and deposited silt to form sandbars. But dams put an end to those spring floods and allow vegetation to clog up river backwaters. This kills many different kinds of fish that live in those areas. Another problem exists in the planning of large dams. Large dams require large discharge areas. Many people have to be evacuated to make room for these discharge areas. Using modern appropriate devices now has solved these problems and technologies, such as the environmental effects would mitigate considerably through application of improved technology. The new and improved system for harnessing the oceans' tides and that the economic and environmental problems of the barrage technology are resolved by the new approach as 'tidal power generation as one of the options for cost competitive, environmentally-friendly, commercial-scale electrical power generation' (Tidal Electric, Inc, 1999; Derby Hydro; 1999, ISTP, 1999).

### **Advantages of Tidal Power**

The first advantage of tidal energy is found in the high energy density of ocean currents. Seawater is 832 times as dense as air, providing an 8 knot ocean current with the equivalent kinetic energy of a 390km/h wind (Blue Energy, 2001). The second advantage of the turbine of tidal energy design is allowing the turbine to optimally capture the kinetic energy of the flowing water. Tapping this power, can satisfy electricity demands in the multiple-gigawatt range by linking 'Ocean Class' Hydro Turbines (7-14MW each) in series across an ocean passage (Blue Energy, 2001). Smaller energy loads can be met

by deploying the 'Mid-Range' 250kW power system in off-grid communities, remote industrial sites and regions with established net metering policies. An additional advantage for the tidal energy power system is common to other ocean energy extraction technologies, PV systems and wind power generations, namely, that the technology does not rely on fuel to produce electricity nor does it emit greenhouse gases (Blue Energy, 2001). The main advantages of tidal power are: renewable energy and needs no fuel or oil, easy to operate and maintain, suitable for use in isolated locations, non-polluting and almost silent when running, can move with site conditions, can design for local manufacture and maintenance, and can operate almost 24 hours a day without a full time attendant. But tidal barrages can cause significant modifications to the basin ecosystem. However, they can also bring benefits like flood protection, road crossings, marinas and increased tourism. Tidal power plants have an extra opportunity to produce clean hydrogen 'The Fuel for the Future' by electrolysis, especially during non peak operations and when there is excess power being produced, or if it is not in a grid. The different advantages of tidal energy are discussed below:

**Economics:** Tidal power has been used to limited extent over several centuries, but only recently has any significant effort been put forth to realising its vast potential. Today sites suitable for the utilisation of tidal power exist in many places around the world. Except its massive capital cost, tidal power can provide extremely low costs per Kw.hr (negligible), once it is built.

**Renewable:** Although not entirely solar (as it is mostly lunar power), tidal is truly renewable. Long after fossil fuels have gone, the tides will still be running. This is increasingly important in a post Kyoto world.

**Predictable:** Unlike wind and solar p.v., tidal power is entirely predictable. It provides therefore the potential to be used (more like hydro) as a Base-load power supply and is immune from climatic conditions and anthropogenic demands. For example, the amount of power generated is strongly related to the size of tidal range.

**Long Useful Life:** Tidal power has a long period of life, sometimes 120 years. Like hydroelectric turbines and generators, tidal power equipments are extremely durable and highly efficient. Monitoring equipment is capable of detecting the slightest variation in functioning and adjustments are made instantaneously, thereby avoiding downtime. Dams built in the Roman Empire Era still function today. Hoover Dam began power generation in 1936 and continues to function without any indications of potential failure (Ullman, 2002). According to Tidal Electric's tidal generator, it will last for many years, far beyond the normal 20 to 30 years life expectancy of other forms of power generation. Because the tidal generator uses no fuel and maintenance is minimal, it is easy to estimate the cost of electricity after the capital costs have been paid off in 15 or 20 years: nearly zero (Ullman, 2002; Salequzzaman *et.al.*, 2000). The world's largest tidal power station at La Rance on the coast of Brittany has a design life for 120 years for the civil structures. The maintenance period on the turbines is 40 years. At the present time, the turbines are being progressively refurbished in accordance with this forty-year maintenance refit period (Newman *et.al.*, 1999).

**Capital and Operating Costs:** Tidal power stations are low maintenance structures and have low operating expenses despite being in a marine environment. Barrages are similar to sea walls and are designed and built to cater for harsh marine environments. Gate structures are designed to cater for the marine environment and are generally simple in operation typically being radial or vertical-lift gates. The generators require low maintenance because they are cooled by the surrounding marine conditions while the blades of the turbines are long lived because they are very slow revving and operate in a fluid environment. The capital costs of a tidal power plant are competitive with other power sources, in that the resulting electricity will be cheaper. The capital costs alone are higher, but the operating costs are considerably lower. Tidal Electric's tidal generator is highly cost-effective in respect to operating costs: 35% of the operating costs for fossil fuels goes for fuel and 25% goes for pollution controls and environmental regulations compliance (Tidal Electric Inc., 1999). Availability will be much higher for the Tidal Electric tidal generator, thereby effectively increasing the output by that factor (ie. 100% for tidal vs. 82% for fossil fuels or 58% for nuclear) (Tidal Electric Inc., 1999). The long useful life will effectively reduce the capital cost because of the residual value of the plant after its capital costs are paid. However capital cost is lower where the engineering structure has already present (e.g. coastal embankment and sluice gate in Bangladesh to protect the coastal people from the natural disaster). In general, the larger the project, the smaller the capital costs per unit capacity. Thus, bigger projects will be more economical than smaller projects. At 100 MW, the capital costs are estimated to be US\$1200 to US\$1500 per kilowatt capacity. Operating costs are minimal at US\$.005 per kWh (Ullman, 2002; Middleton, 2001).

**Continuous Output:** The technology of tidal power can be optimised to meet the needs of continuous power supply. For example, if the need is for maximum output, all enclosures of tidal power plants can generate the tidal energy during the extreme high tide periods and the extreme low tide periods. If there is a need for a continuous output, then the chambers generate sequentially, reducing the over-all output, but providing continuous power. The continuous power option is important for the local need. Tidal generator allows the operator to shape the output curve to the demand curve and to either enhance existing generation or to stand alone as a sole power source (BlueEnergy, 1999).

**Hydrogen Storage:** In tidal power plant, electricity is continuously producing (as I mentioned before). Electricity could not be used same amount continuously, e.g. at night, it is used at low amount. Therefore, sometimes in its day-cycle, some amount of electricity will have excess. This excess electricity could be used for hydrogen production through electrolysis. Presently environmentalist and planners of the national government of USA, Japan, UK, many European Countries, and many other countries are consider that hydrogen is to become the fuel of the future for vehicles. Alaska project of Tidal Electric Inc. is planning to use excess output of electricity to hydrolyse water and create hydrogen gas which will be stored and used to power fuel cells during low output periods. There is considerable loss of overall mechanical

efficiency, but, because the system uses excess capacity to make the hydrogen, there is an economic logic to this practice. The use of hydrogen as a storage medium is particularly interesting in rural Alaska where there are few roads and small local grids with no inerties. Hydrogen can be transported by ship to outlying communities and used in fuel cells for home heating, electricity, and transportation. Hydrogen production is an ancillary opportunity for tidal power generation (Ullman, 2002).

***Replacing the Nuclear Power Dependency:*** Presently the world's 333 nuclear power plants are aging and many are due for decommissioning or are encountering needs for extensive uneconomic repairs (Ullman, 2002). Presently many developed countries are not wanting on dependency on nuclear power. Sweden has voted to eliminate all nuclear power plants by the year 2010 (Ullman, 2002). Pollution and global warming are of varying concern to the public and of growing concern to business, but the profit motive is a universally potent motivator. As businesses look at the options for replacing obsolete and uneconomic generating capacity, they will look to the cheapest source, tidal power is such a candidate. Because the environmentally friendly aspects of tidal power encourage its implementation and enhance its economic attractiveness. Recently, after the Kyoto Protocol agreement, all European countries, Japan, USA and global initiatives mandate and encourage the use of non-polluting, green, renewable-fuel technology for power generation. Extra financial benefits such as pollution credits (clean development mechanisms, CDM), freedom from fuel cost rises, exemption from global warming initiatives, and the general reliability and predictability of low-head hydroelectricity/tidal power will appeal to decision-makers.

***Climate Change, Global Warming and Sea Level Rise Favour the Tidal Power Technology:*** The present problems will be dramatically aggravated if the greenhouse predictions come true. The increased intensity of all convective processes in the atmosphere will force up the frequency and severity of tropical cyclones, tornadoes, hailstorms, floods, and storm surges in many parts of the world with serious consequences for all types of property insurance, because of sea level rise (Ullman, 2002). These disasters increase the ocean tidal range that favour the tidal energy technologies more effectively (Salequzzaman and Newman, 2001). Because higher the tidal range, more energy output from any type of tidal energy technology.

***Tidal Power may attract from Oil Importing Nations:*** Tidal power is attractive to oil importing nations, because it will decrease or eliminate their dependence upon imported fuels and create electricity for export. Most industrialised nations have pledged to reduce their emissions of greenhouse gases, because of Kyoto Protocol principles. Tidal energy will help them achieve those principles and the commitments made in UNCED (The biggest world environmental congress) of Rio de Janeiro, Brazil.

***Tidal Power enhances the development of tourism industry:*** Tidal power is a green renewable energy. Presently environmentally friendly technology is available to harness the tidal power. On the other hand, presently world population is more

conscious on environment and day by day the environmentally conscious people on green energy are increasing. Now people want to see and visit the spot of the real technology of green energy. Therefore, tidal power plant is significantly increased the tourism industry. Tangentially, the tidal barrage in Nova Scotia has 36,000 visitors annually (a number of visitors that is competitive with many Caribbean islands), thus providing a beautiful but remote and chilly location with a significant year-round tourist business (Ullman, 2002).

***Developing Countries Need Power: Tidal Energy is a Good Option:*** The developing economies are desperate for power to run hospitals, schools and to put their human and natural resources to work. Estimates vary, but every estimate of the demand for new power sources is huge. The strong demand for generating capacity reduces the sensitivity to the environment in these countries, but the World Bank, OPIC, and other funding sources have been careful to monitor environmental impact and to encourage non-polluting and renewable energy sources. Many tidal energy company has had extensive discussions with many of these multi-national funding sources and they welcome tidal power as a power source that will provide commercial-scale electricity to meet their policy needs for non-polluting power sources (Ullman, 2002). Tidal energy company, particularly Tidal Electric expects the enthusiastic support from the World Bank, OPIC, IDB, and other multi-national lenders whose policy priorities call for reducing emissions and pollution (Ullman, 2002).

***Tidal Power is used for Air Quality Improvement and Reduction of Greenhouse Gas:*** As tidal power is a clean green energy, it definitely improves the air quality. In Pennsylvania of USA alone more than 30,000 people have made the switch to renewable power like tidal energy, which is equivalent of removing 51,000 cars from the road or planting more than 28 million trees, in which each family that buys renewable power removes an amount of pollution equal to planting 950 trees or not driving 20,000 miles (Ammunition, 2002). At the end of June 2000, the total number of customers to have signed up for a GP tariff was approximately 16,000 across the UK (Lipp, 2001). The majority of these are domestic customers, with only about 100 non-domestic users, including government, business and NGOs. This is equivalent to only 0.07% of UK households. Total demand equates to 215 GWh electricity per annum, and an estimated saving of about 26,000 tonnes of carbon for 2000 (Lipp, 2001). These numbers are very low especially when compared with UK market research indicating '25% of domestic electricity customers, representing 5.7 million house-holds, would be interested in a green electricity tariff, even if this means paying a little more than the lowest prices to ensure their electricity comes from renewable sources' (Lipp, 2001). This estimates about the growth of consumer uptake vary by marketing study and have ranged from 1% to 55% (Lipp, 2001). However green power markets have achieved 2% of households buying green electricity<sup>4</sup> (Greenprices, 2000). The Market Research Company Data-monitor has recently estimated 250,000 UK customers will switch to GE by 2005<sup>5</sup>. In the Netherlands 140,000 households are buying green electricity.

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<sup>4</sup> Trends in Renewable Energies, issues #100-2, and #116 (October 1999–February 2000).

<sup>5</sup> Trends in Renewable Energies, Issue #139 (July 2000).

In Kyoto Protocol, clean development mechanism (CDM) has been introduced to mitigate the greenhouse gas by the developed country from developing country. This emissions trading has become the policy of choice for addressing climate change rapidly in nations around the globe (Pew Center, 2002). Because the on-going negotiations of the Kyoto climate protocol, which will impose limitations on greenhouse gas emissions, have prompted many nations. Among the forces bringing trading in greenhouse gas credits to center stage are progress in the international climate talks, new carbon trading systems in Europe, and private sector trading initiatives in the United States and elsewhere. Governments and businesses around the world understand that emissions trading is essential if they are going to address this issue in the most cost effective way possible (Pew Center, 2002). Under the 1997 Kyoto Protocol, 38 industrialised nations are committed to cut their greenhouse gas emissions to an average of 5.2 percent below 1990 levels by the period 2008-2012 (Pew Center, 2002). Trading of emissions credits, earned by companies that exceed mandated emissions cuts, is one of the mechanisms promoted by the protocol for combating global warming.

***Tidal Power Does not Produce any Waste:*** Tidal electricity generation would not require waste disposal nor would it result in acidic emissions (the greenhouse effect) by 17 million tonnes per year (Ullmun, 2002). Work on environmental and regional issues has identified possible benefits that would accrue with the barrage in operation. These include protection of a large length of coastline against storm surge tides (as with the Thames barrier in UK), a road crossing, opportunities for water-based recreation and amenity, increased land values and substantial creation of employment.

### **Significant of Tidal Power for Sustainable Development**

The relative motions of the moon and the sun generate tidal power ie. by the rotation of the earth within the gravitational fields that cause the surface of the ocean to be raised and lowered periodically. The oceans cover some three-quarters of the world's surface. It has been estimated that if less than 0.1% of the renewable energy available within the oceans could be converted into electricity it would satisfy the present world demand for energy more than five times over (Wavegen, 1999). Peoples are now begun to comprehend the full significance of the seas in their ability to sustain both humans and the natural environment (Gardiner, 2002). It has become increasingly clear that the marine environment plays a central role in supporting sustainable development (WECD, 1987), especially once it begin to identify the many areas which all interact with the oceans and seas. Tidal power is such an important area, which is still underscored. There are diverse human interactions, such as from agriculture and food production, tourism, coastal development and transportation, which needs electricity. Tidal power can give complete support to the integration of all of these activities (Salequzzaman and Newman, 2001; Middleton, 2001; Day, 1994; Corry and Newman, 2000; Baker, 1991). Thus tidal power from the marine environment - the oceans, seas, and adjacent coastal areas – can be characterised as providing the 'glue' for the world's sustainable development. According to Gardiner (2002), the diverse resources and functions of the marine environment can give the overall ecological value of the goods and services provided have been estimated

to total some US\$23 trillion, a similar level to the total global GNP and about six times the estimated value for the terrestrial environment. Tidal power technology is now available around the world (Tidal Energy Inc., 1999), but its utilisation is yet to be fully understood (Salequzzaman and Newman, 2002).

## **Trends in Generation Technologies of Tidal Energy**

### **1. Past Tidal power Projects**

❖ *Tidal Wheel and Tidal Mill:* The waterwheel/tidal wheel is one of the oldest known sources of tidal/water power. The first reference to its use dates back to about 4000 BC, where, in a poem by an early Greek writer, Antipater, it tells about the freedom from the toil of young women who operated small hand mills to grind corn (Day, 1994). Later waterwheels were used to drive sawmills, pumps, forge bellows, tilt hammers, trip hammers, and to power textile mills. Prior to the development of steam power during the Industrial Revolution, waterwheels were the only sources of power (Day, 1994). In the 11<sup>th</sup> century, the ocean's tides were used to power mills for grinding wheat and corn (Middleton, 2001). At the time of the Domesday Survey in 1086 over 5000 water mills were recorded in England (Day, 1994). Some of these mills were tidal mills. Comparatively recently, until 1824, tidal flow energy was used to pump all of London's water supply (Baker, 1991). Over the last few centuries, the coast of England and Wales contained up to 200 tide mills (Day, 1994). The last tide mill to operate was the Woodbridge mill at Suffolk, in the United Kingdom, which ceased operation in 1957, ending eight centuries of milling on that site (Day, 1994).

### **2. Existing Tidal Power Projects**

❖ Tidal Power has been used to limited extent over several centuries but only recently has any significant effort been put forth to realising its vast potential. Tidal power has on a small scale been used through out the history of mankind. It was not until the twentieth century that large-scale tidal projects were considered. Many are strategically located close to populated areas where they can be economically harnessed using an ecologically benign, low head technology, developed by Blue Energy Canada Inc. Today, sites suitable for the utilisation of tidal power exist in many places around the world, such as France, United Kingdom, Former Soviet Union, Canada, United States and others. The extraction of large quantities of tidal energy is possible. However, large-scale tidal power operations are far lack behind, because very little research on technologically or economically feasible study has been conducted yet. Tidal sites are therefore limited to more modest developments. The existing tidal power around the world are as follows (Day, 1994; Middleton, 2001; Baker, 1991, Ullman, 2002):

- 240 MWe plant in France on the Rance River, St. Malo since 1966 (situated between the estuary of Dinard and Saint Malo), which has 750 meter long dike to impound tides that can be as high as 13 meters;
- 400 kWe plant in Russia (since 1967);
- 20 MWe plant in Canada (since 1984); and
- 100 MWe plant in China (since 1987).

In La Rance Tidal Project, daily tidal range averages 8.5 metres and its 24 turbines provide a total of 240 MW of electrical generation capacity. This and the Annapolis Royal in Canada are single basin designs that generate on the ebb tide only. The La Rance station is interconnected to an extensive electricity grid and therefore offsets the use of fuel from 'fossil fuelled' power stations. After the construction of La Rance tidal power station, developing adaptable technologies, which have less impact on the environment, has mitigated a lot of environmental effects. After some commissioning difficulties with the turbines the Rance scheme has operated regularly and reliably till now.

### **3. Potential Tidal Power Projects**

- ❖ Tidal Electric, Inc. (TE) has developed and patented a tidal generator capable of inexpensive commercial-scale electrical power production that utilises the oceans' tides as its sole power source. Tidal Electric's tidal generator combines existing hydroelectric power generation technology with conventional maritime water-impoundment techniques and configures a system of delivering large amounts of electrical power, on a scale comparable to nuclear and fossil fuel power plants (Ullman, 2002). The design locates the impoundment structure offshore, making it completely self-contained and independent of the shoreline (visualise a circular dam, built on the seabed), thereby eliminating the environmental problems associated with blocking and changing the shoreline. Migratory fish simply swim around the structure and ships and boats simply sail on past the structure. The generator seeks the shallow water of near-shoreline areas, while shipping lanes are typically in deeper water. The offshore siting is the distinctive characteristic of its design and one of the fundamental claims. Turbines are situated in a powerhouse that is contained in the impoundment structure. Power is transmitted to shore via underground/underwater cables and connected to the grid. The structure need not be more than a few yards beyond the low tide level and the optimal site is one that is as shallow as possible. The impoundment structure is a two-directional dam and uses conventional dam design techniques. The impoundment structure can be built from the most economical materials available. The equipment consists of a turbine, a generator, and the control system. Low-head hydroelectric generation equipment has been in existence for more than 100 years and state-of-the-art equipment is mature, mechanically efficient (96+%), familiar (over 100,000 units in use world-wide), reliable, and durable (the equipment comes with performance guarantees and a design life of over 50 years) (Ullman, 2002). This enclosure system of tidal generator can be used for pumped storage by pumping the enclosure out during low tide or pumping water in at high tide and thereby increasing the head, which effectively increases the tidal range (Ullman, 2002). The pumped storage usage of the tidal generator will increase the electrical and financial output without substantial additional capital expense and shift the timing of the generation into the more lucrative peak hours. Thus Tidal Electric's technology is ready for rapid, commercial-scale deployment throughout the world's power markets. TE's design concept has been thoroughly reviewed the by faculty at Yale and Emory University of Canada with a group of engineers and research scientists at several large power generating equipment manufacturers, and by several public and private utilities. The mechanical feasibility of the design concept has been

acknowledged and accepted by all experts. TE's tidal generator is sited offshore and thus eliminates the environmental problems of previous systems for tidal power generation (Ullman, 2002). According to analysis of TE, the potential sites are vast ocean areas with large tidal ranges occurring in many locations worldwide. Preliminary projects have been identified TE in Africa, Mexico, England, and Chile, and feasibility studies have commenced for projects in India and Alaska. Tidal power offers the dual incentives of cost-competitiveness and environmental friendliness. This strong combination will eventually make tidal power the new capacity of choice. There are many thousands of low-head hydroelectric turbines are in use today. The French and Canadian tidal power plants prove the applicability of the turbine/generators in a low-head tidal setting (Ullman, 2002). The following locations are now in consideration by TE:

- **Alaska Tidal Power Project:** Alaska has significant tidal ranges in many sites along its southern coastline, making it an attractive potential site. Alaska's economy is narrowly based on its oil and gas revenues, which have been in decline in recent years. Forward-thinking government and business leaders see the vast tidal power potential of Cook Inlet of Alaska as a means of attracting new business and broadening the base of Alaska's economy. Cheap, pollution-free green electricity is attractive to many industrial users and it offers a strong job-creation potential. Presently a decentralised diesel-powered generator is the source of Alaska's power, which is produced from a village schoolhouse, situated at outside of the railbelt area (a remote area of Alaska). For electricity generation, fuel must be transported in by any means available and, during the ice-bound winters, fuel is sometimes flown in or transported by snowmobiles. The theoretical potential amount of tidal power is enormous: enough to meet Alaska's existing load many times over, thereby reducing the cost of power in rural Alaska and making more natural gas available for profitable export. However, at a small-scale, Alaska's remote location offer an opportunity to build small tidal generators (1 to 10 megawatts), sized to the small populations, and free from the highly competitive energy market pressures of Railbelt.
- **Maine Tidal Power Project:** Maine has significant tidal ranges along the northern part of its extensive coastline of Canada, making it a strong candidate for extensive tidal power generation. Much of Maine's electricity generation capacity comes from the Maine Yankee Nuclear Power Plant which has been plagued by maintenance problems and prolonged shutdowns. Therefore, electricity prices are very high and constitute a disincentive to much-needed new business development in Maine. Tidal power has been studied many times in Maine since date from as long 50 years ago. Presently TE has introduced a new and improved system for harnessing tidal energy from Maine's ocean tides, which is accepted by all kind of stakeholders from the society. This new system has resolved the economic and environmental problems of the barrage technology.
- **Mexico Tidal Power Project:** TE recently have made a memorandum of understanding with Mexico government (Bufete Industrial, a Mexican construction and development company) to develop a 500 MW project in the Sea of Cortez, situated at the just 150 miles from San Diego, the site is at the mouth of the Colorado River, just over the Mexico-USA border. This Mexico project has

the opportunity to sell the produced electricity into California and Arizona of USA. The area is sparsely populated area, mostly desert and lack of fresh water, making it an area of little interest to most people. The Mexican Government is eager to build small assembly plants that employ relatively low cost Mexican labour, but the lack of water and power is frustrating this goal. A tidal power plant could provide power for local development, destination, and for export into the nearby California and Arizona markets. California has several market incentives for renewable energy, including development funds, tax credits, and monthly premiums (50% customer/month). Arizona has made serious investments in renewable energy and is presently buying geothermal power from Mexico. Thus, it appears that the Mexico Tidal project will have significant help in competing in the US market.

- **Wales Tidal Power Project, UK:** Tidal Electric Ltd. is proposing to build two artificial islands off the coast of Wales where the tide fall is extreme. One 30 MW project near Swansea would cost about US\$55.57 million. Another, much larger, 432 MW project near Rhyl would cost US\$675 million, would be nine miles long. Aesthetically, tidal power islands would be barely visible from shore. The island's artificial shoreline would stand only a few feet above the waves at high tide. The environmental impact, such as possible damage to marine habitats, will be studied. But TE does say that the islands would offer a protective barrier to the mainland. TE also notes that the tidal power islands could be platforms for offshore wind turbines to supply even more electricity to mainland grid (Ullman, 2002).
- **Around the world's Tidal Power Project:** The southern portion of Chile's long coastline has very large tidal ranges. The population becomes increasingly sparse, the further south one proceeds. Presently, TE/Chile is looking at a small village in the Chiloe Islands area for its first installation. Although it is rather isolated, there are nodes at which it connects to the grid in Chile and Argentina, thus opening up very large markets for future projects. India's economy needs electricity to power its rapid growth and modernisation and the Government of India has contacted TE regarding a potential 1000-megawatt tidal power plant. TE is assembling the team and the resources to pursue this opportunity. Tidal Electric of India has been formed and has received seed money from the Indian Government with which to pursue financing for a 1000 MW project in Gujarat, India.
- ❖ **Western Australia Tidal Power:** The North-West coast of Australia (at Cape Keraudren, to the east of Port Hedland in Pilbara region, Derby, Kimberleys of Western Australia) has long been regarded as one of the location in the world for tidal power. The regional centers of population are small and separated by hundreds of kilometres. It is an unique combination of a series of inlets and bays coupled with a large tidal range, typically in excess of 10 metres, contains enough tidal energy to meet all of Australia's electricity needs. Presently, Tidal Energy Australia Pty Ltd has undertaken a 120 MW a double basin tidal power station at the mouth of Doctors Creek, 12 km north of Derby. The proposed 120 MW capacity scheme has 40 MW in the high basin and 40 MW in the low basin with another 40 MW in cross flow between the basins (Lewis *et.al.*, 2001). The project has the potential to supply electricity to the towns of Broome, Derby and Fitzroy Crossing, and to the Western

Metals lead/zinc mine at Pillara. Western Power (Western Australian power company) has been supportive of the project because it has the potential to offer an economic source of energy as an alternative to their existing uneconomic diesel power stations. It would also make a major contribution to the federally mandated requirement for an additional 2% of power to be generated from renewable sources by 2010. Western Metal is supportive of the project because of their concern about their dependence on the diesel fuel rebate for provision of economically viable power supply. This tidal power project has design advantages because it uses the natural forked bay at Doctors Creek to create a double basin scheme, which will provide continuous but variable power. One basin will retain a high water level and the other a low level. A Channel cut between the two would hold the turbines used for power production. At high tide, water would be let into the high basin, and at low tide, water would be let out of the low basin. The Tidal Power Station at Derby provides many related economic opportunities through enterprise developments. Principally, these opportunities are in the field of aquaculture, tourism and service provision employment. Employment related directly to the operation of the tidal power station and maintenance of the extensive transmission line and systems throughout the region may be minimal. With the construction of the tidal power station the resultant 12 sq km high basin lake becomes very attractive to fishing fleets as a secure base for servicing and safe anchorage.

- ❖ **Bangladesh Tidal Power Project:** Bangladesh has a long coastal area (710 km) with 2~8 m tidal height/head rise and fall (in a large number of deltaic islands, where barrages and sluice gates already exist) (BIWTA, 1999). Tidal Energy Australia Pty Ltd has proposed a application of diversified, decentralised community based renewable energy supply systems of tidal power, which offers sustainable alternatives for the provision of energy to the fast growing demand in rural and coastal Bangladesh. Therefore, the potential for tidal power to be applied is significant, because the barrages necessary for creating controlled flow through turbines (to tap tidal power) are also needed for flood control. This therefore avoids the problem of high capital cost as the engineering is either already there or is needed for cyclone protection (ISTP, 1999; Corry and Newman, 2000). According to the proposal, the barrage and sluice gate could be used for electricity generation by applying simple tidal wheel technology that can have widespread application. The existing technology of undershot paddlewheels is historical, and generally uses a greater head as the energy source. It is hoped that the project will provide an integrated approach to island development where the tidal power outcome is part of a bigger concept involving aquaculture and water management.

### **Marketing or popularise the Tidal Power**

Tidal power or any green power marketing has been referred by some as a means to create a private market for renewable energy that is driven by customer demand for green products (Wiser, 2000). There is a concern in some quarters that renewable energy (primarily solar, wind, tidal, geothermal, and biomass) will fare poorly if traditional policy measures designed to support these technologies are abandoned as electricity restructuring is introduced. To capture the social benefits that renewable energy can provide, some therefore advocate continuation of policy incentives targeted at renewable

generators (Rader and Norgaard, 1996). At the same time, restructuring and the advent of retail competition are also increasing product differentiation as power marketers compete for customers. Green power marketing and selling electricity products based on their environmental attributes and has emerged as a way for marketers to attract customers (Joskow, 1998). Three important lessons have been learned from the literature on markets and market intervention. First, to create a competitive electricity market where one has not historically existed and to ensure that the market operates consistent with the public interest, it is not enough to simply mandate customer choice and call the market 'open'. Instead, though conceptions of 'the market' have historically varied across disciplines (Swedberg, 1994; Abolafia and Biggart, 1991), there is wide acknowledgment that some form of government intervention is an inescapable element of all markets. After all, though capitalist societies emphasise private exchange as the primary method of resource allocation, markets cannot generally be found in a 'state of nature' (Harris and Carman, 1983). Instead, the economics literature shows that all markets exist within an institutional (Furubotn and Richer, 1991; North, 1999) and social (Abolafia and Biggart, 1991; Granovetter, 1985) environment and are defined in part by the government rules under which they operate (Williamson, 1996; Norgaard, 1995; Porter, 1996). As noted by Harris and Carman (Harris and Carman, 1983), these rules unavoidably shape the outcomes of market transactions. The relevant question then becomes not whether there should or should not be government intervention, but rather what the nature and scope of that intervention should be. Consequently, because the electricity industry has traditionally been governed by economic regulation, the structure and operations of the new competitive market will need to be defined and interactions between regulated and unregulated industry segments stipulated. These policy decisions will clearly help shape the competition that emerges. Second, the range of policy instruments available to encourage the green market need not be limited to the extremes of Soviet-style central planning or unfettered free choice. Rather, a wide variety of policy options exist and attention must be directed to how alternative policies will work in practice rather than to hypothetical ideals. While the traditional 'market failures' framework of neoclassical economics provides only limited guidance to policymakers on when and how governments should intervene in markets, the institutional and transaction-cost economics literature provides more useful general guidance. A market failure exists when any of a number of conditions exists: few buyers and sellers, significant barriers to entry or exit, externalities or public goods, and costly and imperfect information (Bator, 1958; Samuelson, 1947). Market failures are common pervasive, even in the real world, however, and the institutions that seek to correct them are neither perfect nor costless themselves (Stiglitz, 1989; Harris and Carman, 1984; Nelson and Winter, 1982). Consequently, this framework provides only weak guidance regarding the infinite range of policy choices that may be usefully employed in emerging markets (Friedman, 1981). It need to recognize the real limits of markets when public goods are involved, a great deal of theoretical, experimental and empirical work shows that individual consumers are sometimes able to provide public goods to some extent (Ostrom, 1998; Wiser, 1998). Third, and finally, it also find that economic theory provides only limited guidance about how to create specific markets where they have not historically existed and about how to design and implement effective policy measures. There is, after all, a tendency for

academic models to rely on theoretical constructs and to thereby oversimplify policy reform challenges (Friedman, 1981; Hahn, R. and Stavins, 1992).

Recent events in UK renewable energy policy may mean that domestic customers will not form the main demand pull for green electricity in any case. The Utilities Bill will place the onus on suppliers to achieve a renewable energy target, while the Climate Change Levy is expected to stimulate demand for green electricity through the non-domestic sector. There are two broad classifications of green electricity products (also known as green tariffs) currently on the UK market. These are described as 'green source' and 'green fund'. Green source consumers buy electricity from suppliers marketing renewable generation. Although the electrons entering customers' homes and business cannot be guaranteed as green (because all electricity is mixed within the grid), customers are guaranteed that for every unit of electricity they consume, the corresponding amount of renewable generated electricity will enter the network over one year. Green fund customers, on the other hand, donate money into a fund that supports new renewable capacity or other related initiatives (Lovell, 1998). Green funds are often administered through an independent body established by the supplier, or through an unrelated charity. In some cases the fund will pay for new capacity to be developed by the utility and in others it is invested in new generation by a generator (Lipp, 2001).

### **Barriers of Popularise Tidal Power**

***Lack of customer education on renewable energy, especially Tidal Power:*** Literature said that lack of customer education on renewable energy as one of the 'most serious' market barriers. Interestingly, though most marketers support publicly funded education campaigns on renewable energy, as with broader campaigns on retail choice, there is a divergence in the perceived importance of these efforts. However, most of the times it is found that consumers are poorly informed about the source of their electricity supply, such as the reliability of renewables, and its environmental concerns (Moskovitz *et.al.*, 1998). Therefore, it should be offering general education on retail choice of green power to policymakers, marketers and other stakeholders. Some states of USA, such as California, have already established renewable energy education programs. The market barrier results that marketers generally believe that broader educational efforts on retail choice should be the first priority but that programs targeted specifically at renewable energy could also be an effective use of public funds.

***Transmission pricing, ancillary services, and bidding rules that penalise renewable generators:*** The pricing of transmission service, the provision of ancillary services, and the rules and procedures for ISO/bidding are each the subject of significant. Concerns have been raised that these operational rules could (unintentionally or deliberately) penalise some forms of renewable energy relative to more traditional generation sources (Ellison *et.al.*, 1998; Stoft *et.al.*, 1997). For example, firm transmission service has historically been sold on a take-or-pay basis, meaning that generators must reserve transmission capacity in advance and pay for what is reserved regardless of how much electricity is actually transmitted. Because of the intermittent nature of tidal power or any kind of renewable energy, such as solar and wind power, the generator typically pay for transmission that is never used. Similar issues exist in

the pricing of ancillary services. Generally renewable sources of power are often located some distance from load centers, renewable generators often incur additional distance-based transmission costs. Distributed generation facilities, which can provide transmission and distribution (T&D) support benefits, are frequently not remunerated for these services. Finally, if ISO/bidding and dispatch rules penalise generators for not being able to precisely estimate future deliveries, intermittent generators will be further disadvantaged.

***Insufficient definitions of green power:*** Though there is no single, unambiguous definition of 'green power', policymakers may want to define this term to protect customers from false and/or misleading advertising by marketers. Experience shows that some marketers make misleading claims about their products in order to attract customers. The UK Federal Trade Commission's (FTC) green marketing guidelines, past actions by attorneys general to thwart 'green-washing', and a wide variety of government-run certification programs all suggest growing recognition that the government should play a role in defining green marketing terms. One approach to defining green power would be standard marketing guidelines. Another approach, which is already being taken in some US states that, would have state legislatures, and/or attorneys general define green power. These definitions may play an important role in customer protection. However any approach is not mutually exclusive, marketers appear to more strongly support a voluntary (rather than regulatory) approach to defining green power; endorsements by environmental groups and third-party certification of green power products are both viewed very positively by the marketers. The value of certification and endorsements has been actively debated (Abt Associate, 1994; Taylor, 1958; Parkinson, 1975; Laric and Sarel, 1981; Phelps, 1949; Rabago *et.al.*, 1998).

## **Solution of Market Barriers of Tidal Power**

***1. Solution from Market transformation (MT) Perspectives:*** MT can be described as a strategy to move the market from a point of tidal power production site has a low or very low market penetration, to a point where it has a very high or completely competitive penetration. While many GP products are left to the natural forces within the market to make this transition, it may socially or environmentally desirable to accelerate the less polluting product's uptake (Lipp, 2001). Accelerating the movement from low to high market penetration can be achieved by applying a number of policies including incentive, regulation and information type approaches.

### ***i. Information Type Approaches:***

***Information and education:*** In order to penetrate any market, consumers, suppliers and other market players need to be aware of the existence of a product. Widespread knowledge of tidal power as a green electricity as a choice for all consumers has not yet been achieved, and consumers need to become informed and educated about green electricity as a product option (Lipp, 2001). Moreover, those who might be aware of tidal power may not necessarily make the connection between their energy use and its environmental consequences and thus see no reason to switch to green. To this end, the case for the creation of a carbon market is made (Fawcett *et.al.*, 2000). Creating a carbon market in which carbon emissions are monitored not only at the national and industry level, but also the household level, could be a powerful way of

bringing together green electricity, energy efficiency and fuel-switching policies. Education and awareness complementing this approach are required to help inform consumers and other actors about their carbon impact.

*The power content label:* Developed in 1998 in California, the Power Content Label shows consumers have to supply a mix of their particular supplier in comparison with the average supply mix within the State. It provides the consumer for easily compare the power content of one supplier with that of another - providing transparency, consumer choice and education. The label appears on consumer bills and on all advertisements sent to customers (Davis and Tutt, 1996). One variation on the California label may include a measure of carbon intensity of the fuels in use, in this way linking the power content to its climate change implications<sup>6</sup>. The carbon content label would be appropriate for labelling bills of all energy consumers not only those purchasing a green electricity product. In this way the label is not a policy to promote green electricity specifically, but rather renewable energy more generally.

- ii. ***Incentives Type Approaches:*** Incentive-type policies can be targeted at any one, or all, of the market players. They are usually in the form of a financial inducement to the consumer to purchase a particular product or to the producer (supplier) to supply a product. Incentives can either be in the form of rebates and subsidies that lower the cost of a product, or in the form of a tax exemption which reduces the burden of purchasing the product, thereby making the purchase of a comparable product more expensive. In the case of tidal power and other green electricity, most suppliers are charging the consumer a premium for green electricity products, thereby introducing a disincentive to uptake
- iii. ***Regulation Type Approaches:*** Regulatory approaches aim to apply standards and minimum requirements to the producer or supplier of a particular product or service. This approach ensures that a certain standard or level is achieved within a set time frame. In the case of tidal power, the government has announced it will oblige electricity supply companies to supply a certain percentage of their power from renewable sources. A complementary approach may be to set a carbon target per household, which would encourage not only the purchase of tidal power or any green electricity but also the use of other lower carbon fuels (such as natural gas), and more efficient appliances.

***2. Solution from Policy Oriented Perspectives:*** A number of policies are now reviewing processes by different country to promote the tidal or any green market specifically and/or the renewable energy industry more broadly. Some of the most important programs/strategies are listed below:

- direct access phase-in exists, allow immediate access for all customers who are willing to purchase a certain percentage of renewable energy;
- offer monetary production incentives or rebates to customers who want to purchase green power;

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<sup>6</sup> <http://www.energy.ca.gov/consumer/power.content.label.html>

government should purchase the green power and should waive the tax or give the financial production incentives and/or low-interest loans to tidal power generation; to make the renewable contributions or purchases through their default utility service provider;

green marketers are concerned that policymakers will provide incumbent utilities 'undue' competitive advantages, therefore restricting the entry of the market opportunities for alternative suppliers. The regulators will make seemingly benign policy-design decisions. The fundamental concerns are reflected in the four general research findings highlighted below:

- (a) Marketers believe that profitable green power markets will only develop if a solid foundation of supportive market rules and facilitation efforts exists. Marketers hold strong convictions about which forms of policy would be most valuable, they do not uniformly express a preference for a single, 'optimal' approach to encouraging the green market;
- (b) Marketers consider establishing price competition and encouraging customer switching as top priorities. Marketers responses to other market rules, including those focusing on customer education, direct access processing and phase-ins, stranded costs, customer protection, and unbundling, also relate to encouraging price competition and customer switching. Marketers believe that their success in selling green products relates most directly to the amount of competition and customer switching in the market as a whole (Counihan, 1999; Electric Power Supply Association, 1999);
- (c) Marketers are somewhat leery of government-sponsored or mandated public information programs. Some market rules may directly increase the level of 'green' sales whereas other ('information-based') regulations are intended to enhance the veracity of green claims and the environmental value of green offerings. Mandatory disclosure is not uniformly hailed as an essential policy, and governmental definitions of green power are not viewed with great enthusiasm ((Porter, 1980); and
- (d) Marketers often oppose three specific renewable energy policies that may have another example comes from the response to green power definitions; private and nonprofit efforts favour over governmental ones. The primary reason stated by the marketers' for their unenthusiastic reaction to governmental definitions is the potential down-side if the definitions 'overly restrict' the types of resources and products that can be classified as green, thereby limiting innovation in product design and reducing the availability of green resources.

### **Funding Initiative of Tidal Power**

Tidal power is a Global Public Good. Therefore it should be needed a global initiative for funding and implementation of clean, environmentally sound and renewable tidal power project around the world. Funding initiative should come from the Global Environment Facility, including the UN system. The following steps may be some sources of these funding initiatives:

Recently the United Nations Environment Program (UNEP) has begun a project to pinpoint the best sites for Green Energy such as solar, wind, wave and tidal energy in 13 nations, mainly from developing countries (Kenya, Ethiopia, Ghana, Bangladesh,

Brazil, China, Cuba, El Salvador, Guatemala, Honduras, Nepal, Nicaragua and Sri Lanka)<sup>7</sup>. When the project is complete, investors considering building green power plants in these nations will be able to use green power assessment or examine to determine the best, and most lucrative locations. The goal of the project is to encourage the development of new energy sources as a way to help reduce poverty in these nations.

**GEF (Green Environment Fund) Financing:** 17-20% of GEF funds are allocated to international waters programmes (ENS, 2002). However GEF needs significant replenishment if such work is to continue. Also a more ecosystems type approach could be adopted better to link up funding projects targeting different areas.

**Development Finance:** The World Bank earmarks funds for marine and coastal issues. This could be duplicated across WB initiatives, e.g. Poverty Reduction Strategies, as well as other development institutions (e.g. the regional development banks and funding bodies).

**New Financial Mechanisms:** As tidal Power is a clean renewable energy, therefore it may be fitted as a candidate for emission trading of CDM (clean development mechanisms)<sup>8</sup> principles of Kyoto Protocol Agreement<sup>9</sup> (Rosenzweig *et.al.*, 2002). In CDM, tidal power plant might be established in developing countries. Presently the CDM has attracted considerable attention and raised the greatest expectations around the world. Other funding for this project includes a mix of donor aid money, mixed credit with private sector contribution and soft loans as the community capacity building activities (Salequzzaman *et.al.*, 2000).

**Others:** Other prospective sources for financial assistance include the following:

- UNDP, World Bank, ESCAP, ADB, and AusAid;
- International GHG partnership program of governments from developed country; and
- Funding for community capacity building and institutional strengthening activities is sought from the private sectors, local NGOs and relevant other agencies.

### **Recommendations for the Policy Framework**

The challenge for tidal power is to set out a strategy to deliver real changes over the next decade and beyond. In broad terms, what is required in a package of mutually supportive measures, in order to focus the tidal power as a green power. At the global level, ministers need to bring a strong message of political intent regarding the implementation of key agreements, as well as increasing their support of the work of the UN. At the regional level, there is a need to modernise the approach and build up the capacity of the existing mechanisms around a common operational focus, based on sustainable

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<sup>7</sup> For SWERA visit the UNEP at <http://www.unep.org/>

<sup>8</sup> The CDM, which can bridge the North-South divide that has long characterised the international climate change negotiations, is the principal means by which industrialised and developing countries can work together to promote sustainable development, lower the carbon intensity of new investment, and reduce the cost of meeting Kyoto Protocol obligations.

<sup>9</sup> Greenhouse gas trading has its origins in the United Nations Framework Convention on Climate Change (UNFCCC). Adopted in Rio de Janeiro, Brazil, in 1992, the UNFCCC established the goal for industrialised countries to return to their 1990 GHG emissions levels by the year 2000 and a long-term objective of stabilising atmospheric concentrations of greenhouse gases 'at a level that would prevent dangerous anthropogenic interference with the climate system'. In 1995, the Parties reviewed their progress and concluded that the non-binding goal would not lead to the achievement of the Convention's objective of atmospheric stabilisation. In response, Parties agreed to pursue a complementary agreement that would establish quantified emissions limitations and reduction obligations for developed countries. This culminated in the negotiation of the Kyoto Protocol in December of 1997. The process to develop rules, mechanisms, and institutions necessary to bring the Protocol into force is ongoing, including the seventh Conference of Parties (COP-7), held in Marrakech, Morocco, during November of 2001.

management and stakeholder involvement. At the national and local levels, there is a need to be an emphasis on building awareness, stakeholder partnerships and strategic policy integration and direction. Specifically, the necessary measures include:

1) *Global activities:*

- ❖ *UN Machinery:* In order to provide the necessary underpinning principles and ongoing high-level pressure for these initiatives, the following changes to the UN machinery of Government are important:

**International consultation:** Authorisation of the UN's Informal Consultative Process on the tidal to become a permanent part of the renewable green energy, to include wide stakeholder participation;

**Policy analysis and monitoring:** Strengthening the Intergovernmental Oceanographic Commission notably through co-operation with UNEP and IMO over marine science, research and monitoring, and thereby providing a focus for co-operation on ocean's tidal power and climate change issues; and

**Internal integration:** Establishing an effective and coordinated internal UN structure.

- ❖ *International regulation:* The following recommendations have been proposed for tidal power enhancement program toward enhancing international marine agreements and conventions, to:

**Coordination:** A clearer international framework on establishing and regulating the tidal power is urgently needed. Greater inter-agency coordination should be developed, for example GEF, UNDP and the International Maritime Organisation collaborated over a pilot project. Clustering of agreements which relate to marine and coastal issues, functions and regional activities for international agreements would also aid the processes of reporting and reduce burden on governments;

**Regulation:** The International community needs to address the present and future exploitation of tidal power, to define principles of sustainable management and use;

**Monitoring:** To harness the tidal power by using environmentally sound technologies, an international monitoring body should be established. High priority must be placed building international support for this process and particularly on the development of the coastal module and for capacity building in developing nations to help them contribute to and benefit from the observing system.

**Capacity building:** Supporting agencies like UNEP have historically focused on compliance and enforcement of the agreements to enable implementation will require more work on capacity building of countries to assist them in their progress. Twinning arrangements between industrial and developing countries may assist this further. The legislators themselves need to be further educated to address inter-linkages between international agreements and their implications for national legislation. There remains a massive need for the developed nations to invest in sustainable capacity building in developing nations.

**Integration of Tidal Power with Aquaculture/ Fisheries Sector:** Marine species are generally more effected by large scale industry than local practices, however, in developing countries where local communities are more dependant on coastal fisheries that needs electricity to develop as industry, further incentives need to be provided to encourage sustainable management from the fishery/aquaculture sector as a factor of tidal power integration.

**Tourism Sector:** Since tourism typically targets coastal areas, ecotourism and sustainable tourism could offer a means to protect the coastal and marine environment whilst also generating economic gains. However, such practices need thoroughly mainstream sustainability throughout their operations, including taking extra account of the benefits and costs of such tourism development to domestic and local economies, and ensure that local communities have a key part to play. Definitely tidal power project enhances the tourism sector.

**Other industries:** The polluter pays principle could be imposed through charges on industries (e.g. agriculture, oil, manufacturing and even households) that pollute and/or degrade the marine and costal environment.

## 2) *Regional activities:*

- ❖ Regional action needs to develop tidal power to be more explicitly linked to meeting the international obligations that underlie the principles for marine planning and management. Greater coordination within and between regional marine groupings has considerable potential to build a more integrated approach of tidal power to marine management.

**Regional Indigenous Organisations (RIOs):** RIOs, such as the Caribbean Community (CARICOM), the Pacific Island Forum, Med Forum, Association of South East Asian Nations (ASEAN), North America Commission for Environmental Cooperation are all seeking to mobilise ownership, management and policy recommendations for tidal or any renewable power throughout their marine areas. Such experiences should be shared and applied in regions elsewhere.

**Multi-stakeholder programs:** Revitalise the Regional Seas Programs through establishment of multi-stakeholder platforms, bringing together governments, UN agencies, MEAs, donors, regional financial and economic institutions, NGOs, representatives of fishing and coastal communities, the private sector and other groups, around the implementation of the programs, as well as agreements such as the GPA.

**Regional management:** Develop the Regional Renewables Groups into genuine cornerstones of sustainable regional renewable tidal energy management, with a particular emphasis on the initial process of capacity building, through encouraging and facilitating wider use of marine science and stake-holder collaboration. Regional Seas Conventions provide a useful framework for implementing the tidal power.

**Knowledge and capacity building:** Establish twinning and joint working arrangements, both within and between the Regional Seas and Renewable

Energy Commissions, as well as within and between the relevant MEAs and UN agencies.

3) *National activities:*

- ❖ Regional coordination is not a substitute for implementation and action at national and local levels. Activities from governments and other public institutions include:

**Integrated implementation:** Marine and coastal activities need to be incorporated, where applicable, into national sustainable development strategies, so contributing to the international development targets, as well as relevant educational programmes. Action between government departments and ministries needs to be harmonised.

**Monitoring:** National action program needs to be adopted so as to establish the tidal power priorities and link in with broader investment programs. This includes building the links with academic and scientific bodies that are actively researching and monitoring the marine and coastal environments. Greater linkages between marine science and policy makers need to be established, as well as support for wider marine community and multi-stakeholder involvement in monitoring of coastal and marine areas.

**Sharing knowledge and learning from experience:** This is key to assist implementation at national and local levels. For example in the marine environment, local authorities and governments can share experiences of establishing tidal power and integrated coastal management (ICM) plans.

**Public involvement:** Increase aware in the public about the need for management of tidal power in the marine environment e.g. through establishing national monitoring networks and ocean development plans. Greater participation of coastal and marine communities needs to be developed for marine policy making and implementation, e.g., incentives for tidal power, monitoring of the coastal and marine environments, implementing international agreements into national legislation, as well as involving a wide cross-section of society, particularly coastal residents, indigenous peoples and marine industries.

4) *Private Sector:*

- ❖ There is a substantial need for support from private sector for adapting the tidal power and its integration with aquaculture, agriculture, shipping, tourism, and other sectors, especially in developing countries for maintenance the good marine practice - both domestically and overseas. Governments could aid this process through enabling:

Wide dissemination and sharing of codes of conduct;

Support of independent certification and verification schemes; and

Regular environmental and socio-economic assessments and reporting from the private sector.

5) *NGOs and wider civil society:*

NGOs and civil society has a great role to enhance the marine and coastal environment for adapting tidal power or any type of green energy. The activities need to be recognised and encouraged through resources and more inclusive processes. These roles include:

Monitoring and information networks;  
Support for implementation, policy advocacy and capacity building e.g. WWF, Greenpeace, Climate Action Network;  
Create incentives to encourage sustainable and well-managed renewable energy like tidal power;  
Mobilise support for seeking larger solutions for sustainable development and policy-making thinking.

### **Conclusion**

To address climate change and sustainable living in this globe, the global energy policy must be fundamentally restructured. Adaptation of green power option, one instrument among many possible strategies, which can move the world towards cleaner energy generation. Presently, green power has taken its first tenuous steps in the liberalised world of electricity supply and demand. This option also goes to consumers and businesses, because they are generating demand. Tidal power is green power and it has a lot of potentialities and opportunities including abatement of greenhouse gas and impact of climate change. But it is far behind to its real application in the practical field, because of the lack of knowledge of its appropriate technologies and financial binding. Presently the technology is available and financial processes are going on. Therefore, it needs a strategic planning action to adapt the tidal power in its appropriate location around the world. This strategic planning action must come from global (such as UN), international, national and local level including NGOs and civil societies. Because they can play an important role in the adaptation processes by highlighting and endorsing a package of strategy that tidal power is an important source of green power. It is clear that the strategic action is no longer enough. What is needed now is a collective sense of urgency to put these proposals and principles into action. Once tidal power will adapt as the main sources of green power, peoples around the world will definitely enjoy their happiness with full satisfaction.

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