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Integration of Biomass and Tidal Power

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***Abstract* – In this paper, an attempt has been made to propose a way of providing auxiliary power to a nuclear power plant using the combination of two different renewable energy sources. The two renewable energy resources discussed here are Biomass and Tidal Energy, which on integrating will provide the starting power to the nuclear Power Plant. Various nuclear power plant that are near the coastal areas across the world have been taken into consideration, so that, there is a room for harnessing Tidal power in that area. Similarly, biomass in those areas have been considered. The working, drawbacks, average power generation of all the three power sources have been discussed.**

***Keywords* – Auxiliary power, renewable energy, average power generation.**

I. INTRODUCTION

In this paper we are mainly focusing on how the two different forms of power can be integrated to provide the auxiliary power to the third source of power. Here we are integrating biomass with the tidal energy to serve the auxiliary power required by the nuclear power plant. On an average a nuclear power plant requires 20-25% of its full load at the time of startup. We can call this as an auxiliary power required for startup. Thus for instance for a 1000-1200 MW nuclear power plant, we require on an average 200-300 MW of auxiliary power. This can be done by integrating biomass and tidal power.

Studies have shown that this technology of integration is quite possible as we have quite a no. of nuclear power plants in the coastal areas. So by utilizing the slight potential of tidal & biomass power in a particular area we can save a lot of power which otherwise would have been consumed just for the startup. So this integration can be quite useful & efficient for the economic growth of the power plant.

II. BIOMASS

A. *Introduction*

An organic material of recent origin, Biomass can be used as a source of energy. Generally, it consists of crops and other plants, as well as agricultural, forest, sawdust and agro-industrial waste. Electricity can be produced by utilizing surplus biomass sources into energy. This is considered as Biomass power.

Power generation using biomass represents cost-effective and cleanest way which provides renewable electricity in regions with high levels of biomass resources and its processing activity. Also, we can become more energy independent by using this energy source and the use of a locally derived fuel will also provide employment and direct economic benefits to local communities.

B. *Working*

Combustion of biomass takes place in a boiler which produces steam. This steam then drives a turbine generator set that produces electricity. This electricity will be fed into the high voltage transmission grid so as to be transported to the end-users.

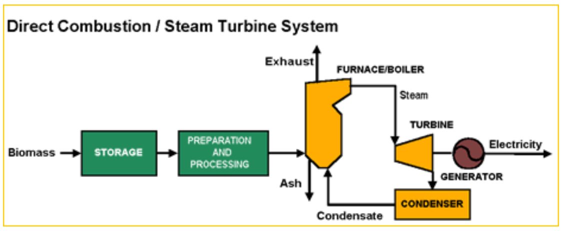

Figure 1 – Direct Combustion/Steam Turbine System

Converting Biomass to Bio power

- Direct combustion

This is the oldest and is the most common way of converting biomasspower to electricity by combusting it to produce steam, which in turn rotates the turbine and produces electricity. The direct combustion of biomass have some problems that much of the energy is wasted and it may also cause some pollution if not carefully controlled.

- Co-firing

We can increase the use of Biomass energy by mixing it with coal and burning it at a power plant which is designed for coal—a process known as "co-firing." Co-firingBiomass at natural gas-powered plants through gasification is also possible.

The benefits associated with co-firing of biomass includes lower operating costs, reductions of harmful emissions like sulphur and mercury, more energy security and, with the use of beneficial biomass, lower carbon emissions. One of the most economically viable ways, co-firing increases biomass power generation today, as it is done with modifications to existing facilities.

- Repowering

A Coal plant can be converted to run entirely on biomass, this is known as "re-powering." (Similarly, natural gas plants could also be converted to run on biogas i.e. made from biomass)

- Combined heat and power (CHP)

The heat produced in direct combustion of biomass can be used for heating buildings or for industrial processes. The heat energy which otherwise is wasted is better used. CHP facilities are more efficient than the direct combustion systems.

- Biomass gasification

Biomass can be converted into a mixture that consists of hydrogen and carbon monoxide, a gas called syngas. This can be done by heating biomass under pressure and in presence of controlled amount of oxygen gas. This syngas can be refined to remove contaminants present in it.

Carbon dioxide that are present in concentrated form can be removed or separated by adding equipments. This syngas produced can be run directly through a gas turbine or can be burned or run through a steam turbine so as to produce electricity. Biomass gasification is generally cleaner and is more efficient that direct combustion of biomass.

- Anaerobic digestion

Biomass can be used to produce methane and carbon dioxide as micro-organisms breaks it down. This occurs in a carefully controlled way in an anaerobic digesters i.e. used to process sewage or animal manure. Processes related to this happens in a less-controlled manner in landfills, as biomass in the garbage breaks down. A part of this methane can be captured and it can be burned for producing heat and power. Thereby it can contain methane from escaping to the atmosphere and reducing the emissions of a powerful global warming gas.

C. Output

The estimated power potential of biomass from surplus agro residues in the country is about 17,000 MW. In addition to this, about 5000 MW of power can also be produced, if the sugar mills are switched to modern techniques of cogeneration. The current availability of biomass can produce around 4 hrs. of electricity generation a day. Some case studies displayed at MNRE website talks about 6-7 hours of electricity daily in villages using a 10 KW plant.

D. Drawbacks

- To generate biomass energy, we require continuous supply of biomass.
- A Biogas plant requires space and it also produces dirty smell.
- Improper construction of many biogas plants results in inefficient working.
- Storing biogas in cylinders are difficult.
- Transporting biogas through pipes over long distances is difficult.
- The crops that produces biomass are seasonal and over the course of year are limited and not available always.
- The production of biomass based fuels are costly, therefore, research is needed to reduce the cost.

PLANT NAME	LOCATION	GENERATION (in MW)
William Lake Power Plant by EPCOR Power LP	North America	60
Okeelanta Cogeneration Biomass Facility	Florida	74.9
Pannon Power Biomass Plant	Pecs, Hungary	50

Therefore, Average Generation is 61.63 MW

III. TIDAL

A. Introduction

The energy of tides can be converted into electrical energy or other useful forms of power by tidal energy which is a form of hydropower. The gravitational effect of the sun and the moon on the earth causescyclical movement of the seas thereby creating tides. Tidal power has potential for future electricity generation.

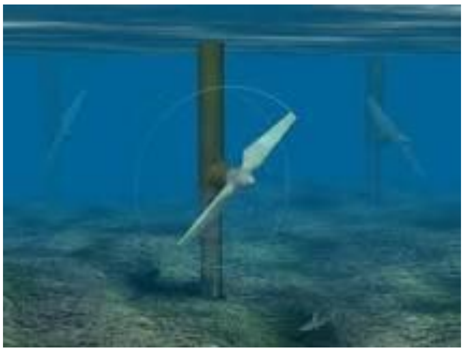

Figure 2 – Impression of Tidal Turbine Farm

B. Working

Tidal power is taken from the oceanic tides of Earth. The gravitational attraction of forces exerted by celestial bodies have periodic variations which are tidal forces. These forces are responsible for creating corresponding motions or currents in the world's oceans. Due to the strong attraction to the oceans, a bulge in the level of water is created, which causes a temporary increase in sea level. The water from middle of ocean moves to the shorelines when the water level increases, this creates tide. The effect of Earth's rotation and its changing position with respect to the sun, and the consistent pattern of the moon's orbit around the earth, this occurrence takes place in an unfailing manner. The energy of tidal flows is converted into electricity by a tidal generator. The site for tidal electricity generation depends on more tidal variations and higher tidal current velocities.

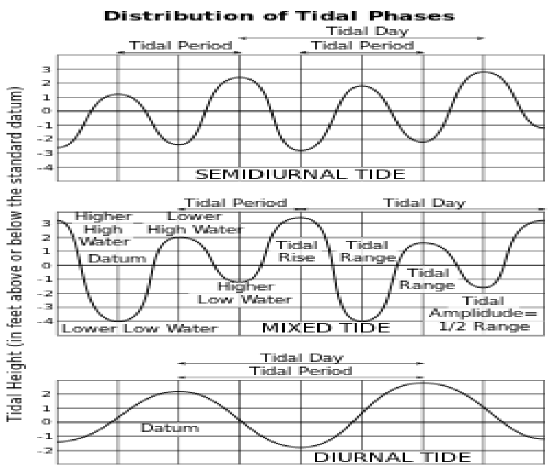

Figure 3 - Variation of tides over a day

A dam is built or erected across the opening of a tidal basin. This dam includes a sluice which allows the tides to flow into the basin, this sluice is then closed, and when sea level drops, traditional hydropowertechnologies are used to generate electricity from the elevated water in the basin. At least 16 feet of difference between the low tides and the high tidesare needed. Tidal power can be utilized by developing tidal turbines. Theblades of these turbines rotates at a consistent speed with the fast moving current of waves. The rotor which is attached with the turbine uses power of moving blades and drivesthe generators to produce electricity. The water turbine blades are relatively shorter than the blades of wind turbine.

The four methods of generating power from Tidal energy are -

1. Tidal Steam Generator
2. Tidal Barrage
3. Dynamic Tidal Power
4. Tidal Lagoon

1. Tidal Steam Generator

Tidal stream generators (TSGs) make use of the kinetic energy of moving water to power turbines, in a similar way to wind turbines that use wind to power turbines. These turbines can be horizontal, vertical, open, or ducted and are typically placed near the bottom of the water column.

2. Tidal Barrage

Tidal barrages make use of the potential energy in the difference in height (or hydraulic head) between high and low tides. When using tidal barrages to generate power, the potential energy from a tide is seized through strategic placement of specialized dams. When the sea level rises and the tide begins to come in, the temporary increase in tidal power is channeled into a large basin behind the dam, holding a large amount of potential energy. With the receding tide, this energy is then converted into mechanical energy as the water is released through large turbines that create electrical power through the use of generators.

3. Dynamic Tidal Power

Dynamic tidal power (DTP) is an untried but promising technology that would exploit an interaction between potential and kinetic energies in tidal flows. It proposes that very long dams (for example: 30–50 km length) be built from coasts straight out into the sea or ocean, without enclosing an area. Tidal phase differences are introduced across the dam, leading to a significant water-level differential in shallow coastal seas – featuring strong coast-parallel oscillating tidal currents.

4. Tidal Lagoon

A newer tidal energy design option is to construct circular retaining walls embedded with turbines that can capture the potential energy of tides. The created reservoirs are similar to those of tidal barrages, except that the location is artificial and does not contain a preexisting ecosystem. The lagoons can also be in double (or triple...) format without pumping or with pumping that will flatten out the power output. The pumping power could be provided by excess to grid demand renewable energy from for example wind turbines or solar photovoltaic arrays. Excess renewable energy rather than being curtailed could be used and stored for a later period of time. Geographically dispersed tidal lagoons with a time delay between peak productions would also flatten out peak production providing near base load production though at a higher cost than some other alternatives such as district heating renewable energy storage.

C. Drawback

Tidal Energy is a clean source of energy and doesn't require much land or other resources as in harnessing energy from other sources. However, the energy generated is not much as high and low tides occur only twice a day and continuous energy production is not possible.

1. Cost of construction of tidal power plant is too high.
2. There are very few ideal locations for construction of plant and they too are localized to coastal regions only.
3. Intensity of sea waves is unpredictable and there can be damage to power generation units.
4. It also influences aquatic life adversely and can disrupt migration of fish.
5. The actual generation is for a short period of time.
6. There are some other obstructions like frozen sea, low or weak tides, straight shorelines, low tidal rise or fall.

PLANT NAME	LOCATION	GENERATION (in MW)
Rance Tidal Power Plant Station	France	240
Sihwa Lake Tidal Power Station	South Korea	254

Therefore, Average Generation is 247 MW

IV. NUCLEAR

A. Introduction

Nuclear Power,or Nuclear energy, is the use of exothermic nuclear processes to generate useful heat and electricity. The term includes nuclear fission, nuclear decay and nuclear fusion. Along with other sustainable energy sources, nuclear power is a low carbon power generation method of producing electricity, with an analysis of the literature on its total life cycle emission intensity

finding that it is similar to other renewable sources in comparison to greenhouse (GHG) emission per unit of energy generated.

Nuclear Power Plants are usually considered to be base load stations, since fuel is a small part of the cost of production.

Figure 4 -The Susquehanna Steam Electric Station, in Pennsylvania, United States

B. Working

In a nuclear-fueled power plant, much like a fossil-fueled power plant, water is turned into steam, which in turn drives turbine generators to produce electricity. The difference is the source of heat. At nuclear power plants, the heat to make the steam is created when uranium atoms split which is called fission.

The heat is produced by fission in a nuclear reactor. The pressurized steam produced is then usually fed to a multistage steam turbine. Steam turbines in western nuclear power plants are among the largest steam turbines ever. After the steam turbine has expanded and partially condensed the steam, the remaining vapor is condensed in a condenser. The condenser is a heat exchanger which is connected to a secondary side such as a river or a cooling tower. The water is then pumped back into the nuclear reactor and the cycle begins again. The water-steam cycle corresponds to the Rankine cycle.

1. Fuel - The fuel used in nuclear generation is primarily uranium 235. It is manufactured as small round fuel pellets. A single pellet is less than an inch long, but produces the energy equivalent to a ton of coal. The pellets are placed end-to-end into fuel rods that are 12 feet long. Over 200 of these rods are grouped into what is known as a fuel assembly.
2. Reactor - The process of producing electricity begins when uranium atoms are split (i.e., fission) by particles known as neutrons. Uranium 235 has a unique quality that causes it to break apart when it collides with a neutron. Once an atom of uranium 235 is split, neutrons from the uranium atom are free to collide with other uranium 235 atoms. A chain reaction begins, producing heat. This reaction is controlled in several ways, including by control rods which absorb neutrons.

3. Pressurizer – The heat produced in the reactor is transferred to the first of three water systems, the primary coolant. The primary coolant is heated to over 600 degrees Fahrenheit. In a pressurized water reactor, a pressurizer keeps the water under pressure to prevent it from boiling.
4. Steam Generator – The hot pressurized water passes through thousands of tubes in nearby steam generators. These tubes are surrounded by another water system called the secondary coolant. The heat from the primary coolant is transferred to secondary coolant, which then turns into steam. The primary and secondary systems are closed systems. This means that the water flowing through the reactor remains separate and does not mix with the water from the other system or the lake.
5. Turbine – The steam is piped from the containment building into the turbine building to push the giant blades of a turbine. The turbine is connected to an electric generator by a rotating shaft. As the turbine blades begins to spin, a magnet inside the generator also turns to produce electricity.
6. Condenser coolant – after turning the turbines, the steam is cooled by passing it over tubes carrying a third water system, called the condenser coolant like or what. The steam is cooled so it condenser back into water and is returned to steam generator to be used again.
7. Lake and Cooling Towers – at some nuclear stations, lake water flows through thousands of condenser tubes to condense steam back to water. It is then discharged down a long canal (for cooling) and eventually enters the main part of the lake.

   At other plants, the condenser cooling water is circulated through cooling towers to remove the extra heat it has gained. The water is pumped to the top of the cooling towers and is allowed to pour down through the structure. At the same time, a set of fans at the top of each tower pulls air up through the condenser water. This lowers the temperature of the water. After it is cooled, the condenser water flows back into the turbine building to begin its work of condensing steam again.

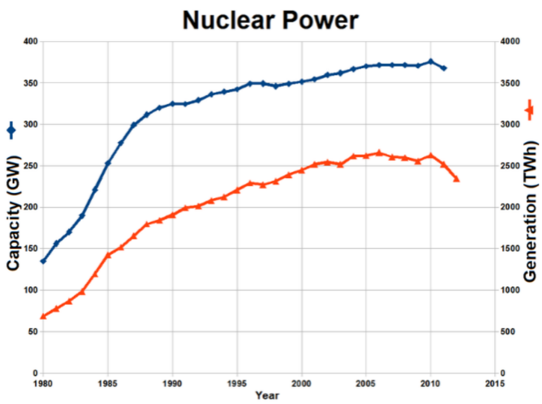

Fig 5 - Worldwide nuclear power installed capacity and generation, 1980 to 2010 (EIA)

Boiling Water Reactor

In Boiling Water Reactors (also known as BWRs), the water heated by fission actually boils and turns into steam to turn the turbine generator. In both PWRs and BWRs, the steam is turned back into water and can be used again in the process.

<u>Priming</u>

On an average, a nuclear power plant takes 20% of its full load power as auxiliary power. So, 1000-1200 MW will take on an average 220-300 MW of auxiliary power.

C. Drawback

1. Accidents happen – the radioactive waste can possess a threat to the environment and is dangerous for humans.
2. Radioactive Waste – The nuclear power plants emit negligible amounts of carbon dioxide into the atmosphere. However, the processes in the nuclear fuel chain such as mining, enrichment, and waste management does.
3. High Cost – Nuclear energy needs a lot of investment to set up a nuclear power station. It is not always possible by the developing countries to afford such a costly source of alternative energy.
4. Fuel Availability – Uranium is very scarce resource and exist in only few of the countries.
5. Non Renewable – once all extracted, nuclear power plant will not be of any use. Due to hazardous effects and supply, it cannot be termed as renewable.
6. Impact on Aquatic Life

D. Output

As of January 21, 2015 in 31 countries 439 nuclear power plant units with an installed electric net capacity of about 377GW are in operation and 69 plants with an installed capacity of 66GW are in 16 countries under construction. As of end 2011 the total electricity production since 1951 amounts to 69,760 billion kWh. The cumulative operating experience amounted to 15,080 years by end of 2012.

PLANT NAME	LOCATION	GENERATION (in MW)
Tarapur Nuclear Reactor	Tarapur, Maharashtra (India)	2*540
St. Lucie Nuclear Power Plant	Port St. Lucie, Florida	1002
Turkey Point Nuclear Generating Station	Homestead, Florida	2*693

Therefore, Average Generation is 1156 MW

As we can see that the data for the power plant taken above are of those besides the see shore.Like in case of the nuclear power plant the average power is around 1150 MW (With around 220-300MW of auxiliary power required).Same in case of both Tidal & biomass power plant the combined capacity is around 300MW which will meet the desired auxiliary power requirement.

V. CONCLUSION

This integration can be implemented in coastal areas where we have nuclear power plant already installed. Now if the site has good scope for the tides then this can be used to harness the tidal power in that region.So a tidal power plant can be set up around the nuclear power plant shore. Now if we can somehow manage to install a biomass power plant at the vicinity of these two then the latter two can be combined to form a good amount of power which can then serve for the starting power required by the nuclear power plant.

VI. FUTURE SCOPE

1. This integration of tidal and biomass to serve as an auxiliary power for Nuclear power plant come into existent.
2. Similar integration can work for different energy sources (say, thermal power plant).
3. Different energy sources can be integrated, like, near coastal areas there is a prevailing wind, which can be harnessed using Wind Farms and integrating it with other sources.

VII. ACKNOWLEDGMENT

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Figure 1 – Picture Courtesy –

www.wbdg.org/resources/biomasselectric.php

Figure 2 – Picture Courtesy -

http://www.esru.strath.ac.uk/EandE/Web_sites/01-02/RE_info/Tidal%20power%20files/image016.jpg

Figure 3 - Picture courtesy_
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Figure 4 - Picture Courtesy:

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Fig 5 - Picture Courtesy:

http://en.wikipedia.org/wiki/File:Nuclear_power_capacity_and_generation.png

ABOUT THE AUTHORS

Anish Agarwal is pursuing his B.Tech in Power System Engineering, from College of Engineering Studies, University of Petroleum and Energy Studies. He is currently in third year of his undergraduate program. He is currently working on the minor project “Gravity Based Lamp” which is a gravity powered lamp designed to power a 1W power LED using a DC Generator driven by a bag filled with rocks or earth, attached to a cord, which slowly descends due to gear arrangement attached to the pulley arrangement driving the generator.

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