Electric Power Generation Technologies Environmental Impacts and Future

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***Abstract*—Electricity nowadays is taken for granted and life depends heavily on it in all aspects. The generation of this electricity takes several forms and each one has different issues and varies in the level of environmental, economic and social impacts. Most of the conventional ways to generate power are non-sustainable. Dependency on conventional generation is declining and alternative generation is being explored and high targets are set to lower the costs and have sustainable energy without any effects to the environment. This paper discusses different conventional and non-conventional generation methods functions, issues and the future of each technology.**

***Index Terms*—conventional generation, non-conventional generation methods, sustainable energy, generation issues, generation future, solar PV, thermal solar, wind, generation technologies efficiencies and impacts**

I. Introduction

Over the years, different technologies have been developed to generate electric power. Each technology has its own advantages and disadvantages from many aspects. The environmental impact to generate power varies from one technology to another. Also, the efficiency of the generation plant depends heavily on the technology used and type of fuel burned to generate the required power. This paper discusses the technological, economic and environmental issues for the different conventional and non-conventional generation types. Also, this paper compare between coals based generation plant, natural gas combined cycle unit generation, hydroelectric power, geothermal plant, solar and wind power plants in term of economic and environmental impacts.

II. Electrical Power Generations Resources

Thermal generation plants: In all thermal-generating stations today, including nuclear generation plants, have similar operation cycles. First, the energy of the fuel is converted into heat energy and this heat energy expands the gases in the cylinders of a combustion engine to produce mechanical work directly. It may also be transferred in boilers to fluids such as water to produce steam. This energy can be converted into mechanical work by expansion to a lower pressure through a turbine engine. The mechanical energy is then converted into electrical energy by an electric generator. The types of thermal generation plants are discussed below based on the type of fuel burned to produce the heat energy.

A. Fossil Fuels Generation Plants

Most of today electricity is produced by burning fossil fuels to produce steam which is used to drive a steam turbine that drives an electrical generator. It provides an opportunity to have the power generated anywhere since the fuel can be transported. The world supply of fossil fuel is large but not sustainable. Coal and natural gas which are two major fossil fuels will be discussed to understand the technology, economic and environmental impact of each generation method.

1) Coal generation plants

The first power plant that was built in the United States in the 1880's was based on coal to heat a boiler and produce steam. This steam was used in steam engines which turned generators to produce electricity. In the 1920s, the pulverized coal firing was introduced and brought advantages that included a higher combustion temperature, improved thermal efficiency and a lower requirement for excess air for combustion. After that in the 1940s, the cyclone furnace was developed and this new technology allowed the combustion of poorer grade of coal with less ash production and greater overall efficiency. Nowadays, coal power is still based on the same methods started over 100 years ago, but the improvements in all areas have brought coal power to be the inexpensive power source used in the world.

Coal is a fossil fuel like oil and gas. Coal is one of the most important sources of energy providing an easy way to generate energy in very low cost. The availability and low costs of using coal has made it the first choice of fuel for building power plants in the world and US mainly. The world coal consumption was about 7 billion tons in 2010 and expected to increase to 9 billion tons by 2030. United States consumed about 13% of the world total in 2010 that is equivalent to 951 million tons and about 93% of it was used for power generation. Currently, one third of total United States electricity comes from coal power generation plants [1].

The cost to generate power using coal fuel is quiet low. However, the construction cost of building the coal generation plant includes a coal delivery system to the plant. Some of the plants are built near coal mines and

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uses conveyors to deliver the coal. Also, other plants might use a large coal train containing 130-140 continuers each with 100 tons, for a total load of over 15,000 tons. In a large plant under full load requires at least one coal delivery this size every day and may reach three to five trains each day when power consumption is high [1].

Although power plants are regulated by federal and state laws to protect human health and the environment, the activities involved in generating electricity from coal include mining, transport to power plants, and burning of the coal in power plants have a lot of environmental and economical impacts. When coal is burned, carbon dioxide, sulfur dioxide, nitrogen oxides, and mercury compounds are released. According to US Environment protection agency, the average emission rates in the United States from coal-fired generation are: 2,249 lbs/MWh of carbon dioxide, 13 lbs/MWh of sulfur dioxide, and 6 lbs/MWh of nitrogen oxides. [2]

2) Natural gas power generation plants

Although coal is the cheapest fossil fuel, it is the dirtiest fossil fuel to generate electricity. Natural gas is very popular fuel for power generation because of its clean burning nature. Before 1980s, if a utility company is planning to build new generation facility the only options would be coal or nuclear powered plants. However this is not the case anymore due to economic, environmental and technological changes. Natural gas started to be the most environmentally friendly fuel compared to coal and become the primary fuel source for generation plants in 1990s. In fact, generation from natural gas increases by an average of 1.6 percent per year from 2011 to 2040 [3].

Firing natural gas to produce electricity can be in a variety of ways or technologies. Each technology has its own efficiency and depends on the nature of the power plant location and the availability of resources and the main need of the power plant. These technologies are listed below.

3) Steam generation units

Natural gas can be fired in electric generation facility consists of a steam generation unit. The natural gas is burned in a boiler to heat water and produce steam that in turns drive a turbine to generate electricity by turning a generator. These basic steam generation units have fairly low energy efficiency. Around of 33 to 35% of the thermal energy used to generate the steam is converted into electrical energy in these types of units. [3]

4) Gas turbines

Gas turbines and combustion engines are also widely used to generate electricity. In these technologies, the burning natural gas produces hot gases that are directly used to turn the turbine and generate electricity. Gas turbine and combustion engine plants are traditionally used to meet peak demands. The main feature of this technology is the quick start of these units to generate electricity. These plants have increased in popularity due to the availability of natural gas, but still less efficient than the steam units. A large single-cycle gas turbine has 35% to 40% thermal efficiency. [4]

5) Combined cycle units

The combined cycle plants are preferred over the gas turbines and many of the newly installed natural gas fired power plants are using the combined cycle units. In the combined cycle generating facilities, both the gas turbine and a steam unit are installed in blocks to have efficient process. The gas turbine operates in the same way as a normal gas turbine that uses the hot gases to turn a turbine and generate power. What is different in combined-cycle plants, the waste heat from the gas-turbine is directed toward a heat recovery steam generation (HRSG) to generate steam and then drive steam generator to produce electricity. Combined-cycle plants are much more efficient than steam units or gas turbines alone because of the efficient use of the waste heat. The combined-cycle plants can achieve thermal efficiencies of up to 60 percent. [4]

6) Distributed generation

Distributed generation refers to the placement of individual, smaller sized electric generation units at residential, commercial, and industrial sites. The trend towards what is known as 'distributed generation' is supported to enhance the power system reliability, more efficient and cheaper than centralized plant. These small scale power plants, which are primarily powered by natural gas, operate with small gas turbine or combustion engine units, or natural gas fuel cells. Distributed generation can take many forms, from small, low output generators used to back up the supply of electricity obtained from the centralized electric utilities, to larger, independent generators that supply enough electricity to power an entire factory.

There are many reasons for this increased use of natural gas as fuel to generate power. Regulations surrounding the emissions of power plants have forced these facilities to come up with new methods of generating power. New technology has allowed natural gas to play an increasingly important role in the clean generation of electricity. Natural gas produces less carbon dioxide than oil and coal. In 2004, natural gas produced about 5.3 billion tons a year of CO_2 emissions and coal and oil produced 10.6 and 10.2 billion tons. The Natural gas CO_2 emissions will increase to around 11 billion tons due to the increase demand on electricity by 2030. [3]

B. Solar Thermal Power Plants

The solar thermal technology produces electricity from the sun's radiation indirectly. It converts the Sun's radiation into heat that can be used to produce steam which can be used to rotate a conventional steam turbine and generate electricity. The solar thermal technology is classified into three types depending on the applications: low, medium and high temperature (concentrated) solar thermal power systems. The solar thermal technology is used in many applications; however, this section discusses only the applications that are related to power generation. The types of solar thermal power plants are discussed and presented thoroughly here since the future generation is depending on how to utilize the solar energy.

1) Low and medium temperature

Solar ponds: A solar pond is a pool or reservoir of salty water which stores the solar heat and uses it for power generation. A solar ponds plant, which has an output about 5MW, was built at the north of the Dead Sea in Palastain [5]. However, this technology is not currently developed for large scale commercial power generation.

Solar chimney: A solar chimney consists of heat collectors, wind turbines and a very tall chimney. The electricity is produced in a solar chimney by the wind turbines which are driven by an upward flow of hot air induced by heating the air at the base of a tall chimney. Many modeling studies and research have been conducted and published to optimize and commercialize this technology; however, it has not yet been proven for wide commercial operation [6].

2) High temperature "concentrated"

The concentrated solar thermal power system (CSP) collects and concentrates the solar radiation. Then, it is used to produce high temperature that can be used in conventional power generators to produce electricity. The CSP system consists of three main components [7]:

- The solar concentrator: collects and concentrates the solar energy from the sun.
- The solar receiver: absorbs the concentrated solar energy and convert it to heat to be used in conventional power generators.
- Electric power generator: utilizes the produced heat to generate electricity.

There are many systems utilizing the CSP technology. However, only those based on parabolic trough, power tower, Fresnel system and paraboidal dish are under development.

Parabolic trough: The parabolic trough system uses curved parabolic mirrors that focus the solar energy onto a central receiver tube running through its length. The parabolic trough moves on one axis to track the Sun during the day. The central receiving tube is filled with heat transfer fluid, usually oil, which is heated by absorbing the solar energy. The temperature of heated oil is approximately in the range of 750 ℉ [7]. The produced heat is used to form steam that can be used to drive a conventional steam turbine generator.

Power tower: The power tower system consists of reflectors called heliostats and collector or receiver tower(s). The heliostat is a highly reflected mirror which tracks the movement of the Sun. The heliostats concentrate the solar radiation on the central receiving tower. The system could reach a temperature of 1830 ℉. The receiver tower absorbs the solar radiation and transfers it to heat by utilizing heat transfer fluid, mostly oil, which produces steam and is able to drive conventional steam turbine generators [7].

Fresnel System: The Fresnel system consists of many flat mirrors which concentrate the solar radiation onto one or two shared tubes located at the center of the system. The tube is filled with heat transfer fluid, mostly oil, which absorbs the solar radiation and produce heat that can be used in steam turbines to generate electricity. The Fresnel system has lower efficiency than the parabolic trough system. However, the Fresnel system costs less and requires less land [8].

Paraboloidal dish: The paraboloidal dish system has two axis tracking mirrors which focus the Sun's radiation onto a receiver located at the focal point of the dish. The concentrated Sun radiation heats the fluid or gas located in the receiver to about 1380 ℉ [7]. The heated fluid or gas is used to generate the electricity by utilizing conventional power generators. The potential benefit of dish technology is low capital costs and high temperatures that provides higher energy conversion efficiencies.

During solar plant operation, solar power does not produce any harmful emissions. However, the production of the solar panels can produce a certain amount of pollutions. The greenhouse gas emissions production from solar thermal power plants is 22g/kWh compared to 500g/kWh out of fossil fuel power plant with a potential to reduce up to 15g/kWh in future [8]. The concentrated solar thermal plants require huge surface area to collect the sun radiation and reflect it to the power tower or focal point. Also, like any other fossil fuel plant, the solar thermal require an access to water supply for steam production and cooling purposes and most of the solar thermal plant are located in desert areas or locations where high sun radiations are available.

C. Geothermal Power Plants

Since the early of the last century, the geothermal energy was used to heat houses in United States and mainly in Idaho and Oregon. The increase in electricity demand led to the consideration of geothermal energy to produce power. The first geothermal power generator was tested back in 1904 at Larderello dry steam field and it successfully lit four light bulbs [9]. Later, the world's first commercial geothermal power plant was built there. It was the world's only industrial producer of geothermal electricity until New Zealand built a plant in 1958. In 2012, it produced around 600 MW.

Nowadays, the world largest geothermal power producer is the United States with a total production of 3,389MW [8]. The Philippines is the second highest producer, with 1894 MW of capacity online. Geothermal power represents approximately 27% of the Philippine electricity generation. [9] Geothermal electric plants are built where high temperature geothermal resources are available near the surface. However, the development of technology enabled us to utilize cooler geothermal reservoirs and improvements in drilling and extraction technology provides a much greater geographical range [10]. A drilling activity is required to circulate fluid to carry the hot energy to the earth surface and use it to produce steam and drive e steam turbine generator. The geothermal plants will not produce high temperatures to produce steam like boilers and for that reason the thermal efficiency of geothermal electric plants is very low which is around 10% to 23%. The system efficiency does not significantly affect operational costs since there is no fuel associated except for the pumps. The low efficiency will affect the return on the capital investment [10].

The geothermal energy use provides several environmental benefits over the other forms of conventional energies. Geothermal power plants need small land and the installation does not require any river dam construction, fossil fuel movement and oil spills. This technology is clean and considered as renewable resource since the extraction rate is less than the injection rate. No solid wastes are associated during operations and if the extracted fluids contain any minerals, it can be recovered and recycled for industrial use.

The more dependence on geothermal energy will have a large net positive effect on the environment gaseous emissions in comparison with the development of fossil fuels. Geothermal power plants emit small amounts of CO_2, SO_2 and absolutely no nitrogen oxides in comparison to thermal plants. These small quantities from geothermal plants are not emitted during power production as a result of combustion but are natural components of a geothermal energy. The development of geothermal energy does not cause adverse impacts to the environment compared to other conventional energy sources and all of them can be mitigated [10]. Geothermal power requires no fuel, it is therefore immune to fuel cost fluctuations. However, capital costs tend to be high. Drilling accounts for over half the costs. The future of geothermal energy is promising to expand the use of this sustainable energy around the world. Many countries who rely on fossil fuel to generate power are investigating the potential use of this technology such as Saudi Arabia. Most of the energy in the Kingdom of Saudi Arabia is produced using fossil fuel sources. Saudi Arabia contains several thousand MW of unused geothermal energy. The economic growth in the Kingdom will lead to an increase in energy demand over the coming years and for that reason King Abdullah City for Atomic and Renewable Energy (K.A.CARE) was created and tasked to investigate geothermal energy and enable renewable development [11].

D. Nuclear Energy

The first nuclear reactor produces electricity was in 1951 at the EBR-I experimental station near Arco, Idaho in the United States and the world's first full scale power station, Calder Hall in England was opened on 1956. The nuclear power plants are similar to the conventional thermal power station as the heat is used to generate steam which drive steam turbine generator to produce electricity. Currently, there are 439 nuclear power reactors operating in 31 countries. The fuel represent small portion of production and the operation nature of nuclear power plants make them a base load stations. There are two types of nuclear power plants based on the technology used to produce the heat energy.

1) Fission nuclear plants

Fission is a reaction when the nucleus of an atom that captured a neutron splits into two or more nuclei and releases a significant amount of energy as well as more neutrons. These neutrons then go to split more nuclei and form a chain of reaction. Nuclear fission is a mature technology and is the current method of nuclear power generation. Fission does not naturally occur and has some downsides. One of them is the possibility of overheating and causing a fire that could release radioactivity into the air similar to what happened in Japan in 2011. Although nuclear fission plants are highly regulated with many effective safety precautions, there are possibilities for human errors or design deficiency that can cause a radiation release [12].

2) Fusion nuclear plants

Fusion reaction is the opposite of the fission reaction. Nuclear fusion occurs when two or more atoms are combined into one. Fusion reaction produces no radioactive particles, no possibility of overheating, and the power generated by nuclear fusion is three or four times that of nuclear fission. Nuclear fusion power generation is a very attractive source of energy. It is more productive, safe, sustainable, and environmentally friendly than current energy sources. The future is toward limiting the use and construction of nuclear fission power plants. The governments started to invest more to proof the nuclear fusion concept to produce power commercially such as ITER project. The future to generate power is going to be through clean resources such as renewable and safer nuclear plants. Fission technology is available and mature but with the repetitive incidents, several countries took the initiative to limit building any new plants. However, in order to meet the increase demand on power, the fusion reaction technology might be the solution to provide safe, clean source to meet this demand sufficiently [12].

The recent nuclear incident took place on Fukushima in Japan. Fukushima Nuclear Power Plant consists of six separate boiling water reactors designed by General Electric (GE) and maintained by the Tokyo Electric Power Company (TEPCO). The power plant experienced an explosion and radiation release due to the tsunami following an earthquake on March, 11th 2011. The tsunami caused damage to the cooling system equipments which cause an overheating to the nuclear fuel rods, containments meltdown and releases of radioactive materials. It is the second largest nuclear disaster after Chernobyl in 1986 that have a Level 7 on the International Nuclear Event Scale [13]. The incident investigation report revealed that the Fukushima nuclear power plant accident was a manmade disaster caused by poor regulations and neglecting prior calls to consider the effect of tsunami on the nuclear power plants. The accident could be avoided with the implementation of several precautions. To Avoid Similar Accidents, the operators must plan for events beyond the design bases. Also, more strict standards for protecting nuclear facilities against terrorist damage or stronger international emergency response should be established. An international review of the current security and safety precautions should be carried out and the lessons learned from this incident should be implemented in all nuclear plants. Fusion nuclear power plants is a developing technology still under research that relies on combining rather than splitting atomic nuclei, using very different processes compared to current nuclear power plants. This technology is safer than the fission technology and more efforts are required to lunch commercial plants using this technology [14]. The construction cost to build a new nuclear power plants is high, but have very low fuel cost. The future of nuclear is toward safer and cleaner fission reactors. Also, fusion reactors which may be viable in the future will eliminate many of the risks associated with nuclear fission.

E. Hydropower Plants

The most widely used form of renewable energy is hydropower plants. The hydropower plants produce electricity through the use of gravitational force of falling water. It represents 16% of the world generation and is expected to increase about 3.1% each year for the next 25 years [15]. Hydropower was used long time ago to perform many tasks other than producing electricity. Then, with development in hydraulics the first Edison hydroelectric power began operating in 1882, in Wisconsin with an output of about 12.5 kilowatts [15]. The United States currently has over 2,000 hydroelectric power plants that supply 6.4% of its total electrical production output, which is 49% of its renewable electricity [15].

To construct a hydropower, a dam has to be built to trap the water, usually in a river. Water is allowed to flow through tunnels in the dam, to turn turbines and thus drive generators. Hydropower stations can produce a great deal of power very cheaply. Hydro-electric dams are very expensive to build. However, once the station is built, the water comes free of charge, and there is no waste or pollution. The great height of the water at the dam, it will have high pressure when it arrive at the turbines and can extract huge energy from it. In mountainous countries such as Switzerland and New Zealand, hydro-electric power provides more than half of the country's energy needs [16].

1) Conventional hydropower dams

Most hydroelectric power plants have only dams that contain potential energy of water driving a water turbine to produce electricity through the coupled generator. The extracted power will depend on the water volume and the height of the water falling.

2) Pumped storage hydropower plants

In order to meet high electrical demand the pumped storage technique is used by moving water and storing it at different elevations. Once there is peak demand for electricity the water is released to drive water turbines and generators to produce electricity in seconds. During low demand time, the extra generation is used to pump water to the higher elevation reservoir. This scheme represents the largest grid energy storage. In some conventional dams, the pumped storage concept is added to the design in order to enhance the overall efficiency. [16].

The major advantage of hydropower plants is the elimination of the cost of fuel since the main source of energy here is water which available through rivers. Hydro is a flexible source of electricity since the plant is easily dispatched to meet high or low power demand. Hydropower plants can last for very long period and the labor cost is minimal since most of the hydropower plants are automated and have few personnel on site during normal operation. Hydropower plants are clean and do not produce any carbon dioxide.

On the other hand, large reservoirs to support the plant operation will result in destroying lands downstream of the constructed dam. Currently, we can see many conflict between governments due to this fact such as Ethiopia and Egypt conflict of building a dam on the Nail river. Generation of hydroelectric power changes the downstream river environment. Also, building a dam will result in moving the people living where the reservoirs are planned [17].

F. Wind Power

Wind energy is very useful if utilized and converted to other form of energy such as electrical power using wind turbines or mechanical power through windmills or wind pumps. Wind farms can be constructed onshore or offshore. Onshore wind farms are cheaper to construct and can supply power to isolated areas. Offshore farms are better since it has less visual or environmental impacts, but the construction and maintenance costs are higher than the onshore farms. [18]

People have harnessed the energy of the wind long time ago. Wind energy propelled boats along the Nile River as early as 5000 B.C and by 200 B.C simple windmills in China were pumping water. At the 11th century, people in the Middle East used windmills extensively for food production. Returning merchants and crusaders carried this idea back to Europe. The Dutch refined the windmill and adapted it for draining lakes and marshes in the Rhine River Delta. In the late 19th century, People began using windmills to pump water for farms and ranches and later to generate electricity for homes and industry. In the 20th century, larger utility-scale wind farms were developed and connected to electricity grids. During World Second War, a 1.25-megawatt turbine known as Grandpa's Knob fed electric power to the local utility network at Vermont, United States. Due to the oil Shortage at 1970s, the U.S. and the world started to explore alternative energy sources, paving the way for the wind turbine to generate electricity.

Wind power can be divided into three size ranges that are used for different applications. The sizes are as following:

- Residential wind power scale that have output power below than 30kW, blades diameter range of l-l3 m and height of 18-37 m.
- Medium wind power scale with output power of 30-500kW, diameter of 13-30m and height from 35 to 50m.
- Commercial wind power scale (usually fed into the grid) can have output power range of 500kW-2 MW, blades diameter of 47-90m and height of 50-80m.

The wind energy provides many positive environment impacts, but these positive impacts do not eliminate the need to consider the local environmental effects of the installation. These issues include; visual impacts: Wind turbines are large structures and usually built in open areas making them visible from a distance. Building these turbines away from these areas can minimize this impact. Visual impacts include views and visual flicker effects on sunny days when the sun is at certain angles. Sound impacts**:** While noise from wind turbines is minimal, at sites very close to population centers and residences it can become an issue. At present there are some limits to how much a new development can increase the sound level, but standards are evolving. Again, siting turbines away from population centers will reduce this impact. Birds and bats: the wind turbines might be in bird migration paths. Most projects will require environmental impact studies reviewing visual and noise impacts, potential effects on wildlife and wetlands, and Federal Aviation Administration determination of "no hazard" if the project is near any airports.

G. Solar Photovoltaic Cells

Solar Photovoltaic produces electricity by converting the solar radiations into Direct Current (DC) using special types of semiconductor chips. The generated direct current (DC) is converted to alternating current (AC) through inverters to be injected to the electricity grid. The materials used for Photovoltaic include amorphous silicon, polycrystalline silicon, microcrystalline silicon, cadmium telluride, and copper indium selenide/sulfide. Solar Photovoltaic generation technology is advanced and commercially proven technology that has been used in many solar power plants since the 1990s. This technology has been used to generate electricity in more than 100 countries and it is considered the world's fastest growing power-generation technology.

The cost of producing Photovoltaic (PV) cells has decreased steadily since the first solar cells were manufactured. This is due to the improvements in technology and growths in manufacturing scale and sophistication. The average cost of producing electricity using PV technology has dropped more than 30% since 1998 [19]. The solar photovoltaic (PV) cells are produced in two types of panels: fixed flat panel and tracking flat panel.

1) Fixed flat panel module

As the name implies, it is a fixed position flat panel module which is tilted at the site's latitude angle. The fixed flat panel has no moving parts; therefore, it has less output power compared to the tracking flat panel.

2) Tracking flat panel module

The tracking flat panel module is manufactured either as single or dual axis tracking modules. In a single axis tracking module, panels are moving on a single axis. However, in a duel axis module, the panels are equipped with both azimuth and elevation axial movements to keep them continuously pointed toward the sun. In comparison to the fixed system, the tracking system provides higher electricity output per module. However, the tracking system requires more capital and the operating and maintenance costs are high due to the complex moving parts. The cost of PV system can be reduced greatly by utilizing lenses or mirrors. These lenses or mirrors can be used to focus the Sun's radiation onto a smaller area of PV cells [19].

III. Different Power Generation Technologies Efficiencies and Impacts Comparison

A. Fossil Fuel and Wind Power Plants

Today most generation facilities all over the world depend on fossil fuel energy. The fossil fuel has severe affects on the environment and can be mitigated through the use of renewable energy resources to minimize the fossil fuel dependency to generate power. Renewable energy will eliminate any fluctuation in the electricity cost rate fuel or the effect of future environmental regulations on cost rates. Fossil fuel prices can dramatically increase over time which force the the utility rates to increase. Renewable energy such as wind turbines has no pollutants or greenhouse gases associated with its operation. Fossil fuels generation plants emit greenhouse gases and pollutants into the surrounding communities. Moreover, wind farms can be used for agricultural activities, whereas fossil fuel plants cannot be used for any other purposes. The value of the surrounding area losses some value due to the close proximity of the fossil fuel generation plant.

B. Hydropower and Fossil Fuel Plants

Hydropower does not have gas emissions like fossil fuel plants that produce pollutants such as SO_2, NO_2, CO_2, dust and mercury similar to coal plants. Hydropower does not have hazards like coal plants that require mining and have health effects on the workers and people nearby.

C. Hydropower and Wind Farms

Hydropower plants have predictable amount of energy from the stored water or the quantity of water flow through the turbine. Wind power requires more effort to forecast and predict the amount of energy and load. The major factor between different technologies is the amount of greenhouses emissions of each generation method. Table I summarizes the amount of CO_2 emissions, efficiency and cost of MWh for all power generation types.

TABLE I. Different Generation CO_2 Emissions, Efficiency and Capital Cost

Generation Type	CO_2 Emissions (g/kWh)	Efficiency	Capital Cost (USD/MWh)
Coal	1000	45%	65.7
Fuel Oil	760	45%	17
Natual Gas (Combined Cycle)	315	60%	15.8
Geothermal	122	35%	76.2
Hydropower	10	75% (turbine)	78.1
Wind	12	30%	70.3
Nuclear energy	16	40%	83.4
Solar Thermal	22	23%	214.2
Solar PV	36	20%	130.4

As per the US Energy Information Agency, the forecasted generation expansion to meet the increasing power demand is demonstrated in Fig. 1. Coal-fired power plants continue to be the largest source of electricity generation, but their market share declines significantly from 42 percent in 2011, 38 percent in 2025 and 35 percent in 2040. The natural gas firing and renewable energy utilization will increase significantly to meet the demand.

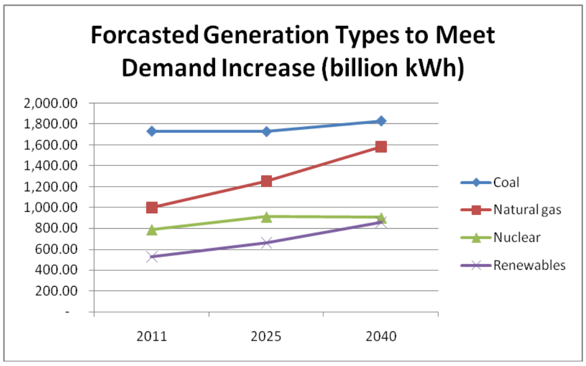

Figure 1. Future power generation types trend

IV. CONCLUSION

Each of the generation method discussed has its own advantages and disadvantages from many aspects. The environmental and social impact had become the main driver of the type of generation method instead cost of producing electricity. Initiating energy conservation programs and invests in new generation plants is costly and might reduce utilities energy consumers. For that reason, different states have adopted good incentives plans to provide programs to advocate the need of energy efficiency and help utilities to be more energy efficient. These incentives will help the increase use of renewable energy and minimize the conventional fossil fuel plants greenhouse emissions.

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