

COMPARATIVE ANALYSIS OF NUCLEAR AND COAL FIRED POWER PLANT IN PAKISTAN

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ABSTRACT: In this study, the comparative analysis of both coal and nuclear power plants are described based on cost, electricity production capacity and environmental impacts considering the fuel quantity requirement, availability and safety. Energy production from two most prominent resources like coal and nuclear based power plants are still in progress in Pakistan. Coal fired and nuclear power plants require fuel 86, 00,000 kg and 74 kg, respectively for equivalent electricity production of 1000MW. Coal fired power plant is the cause of higher pollution. Both current and old coal technologies release more pollutants like NO_x, CO, CO₂ and SO₂. An advantage for nuclear power plants is that they generate no carbon emissions during operation of the plant. Vattenfall finds out that 400 gram and 700 gram CO₂ will be emitted from natural gas and coal, respectively for KW-hr electricity generation. Electricity production from nuclear power plants is cheaper in comparison to coal fired power plant while involving the cost of the carbon tax in future. Coal is cheap, but its mining is difficult process and its transportation cost is high. It can be concluded that nuclear power plants are more desirable and cheaper technology than coal power plants to meet electricity demand in Pakistan.

Keywords: Coal; Comparative analysis; Nuclear power; Safety;

1 INTRODUCTION

The biggest challenge in Pakistan is the energy crisis, which is the disturbance in the incessant supply of electricity and erroneous distribution mechanism. Energy is being produced from different resources such as hydel power, oil, gas, coal and nuclear energy. Energy production from two most famous resources like coal and nuclear based power plants are still in progress in Pakistan. There is a lot of struggle to fully utilize coal and nuclear power resources [1]. Each energy resource has a specific contribution for electricity production in every country as depicted in Table 1. There is a continuous research about different energy technologies. The purpose of this article is to do comparative analysis of both nuclear and coal fired power plant based on fuel cost, energy production, operation and maintenance cost, safety and environmental impacts considering the fuel quantity demand, availability and safety. As energy demand is increasing in Pakistan, it is essential to take better decision for energy resource selection. Each energy resource has some merits and demerits [4].

Table 1. Comparison of power production utilizing various resources [2, 3]

2012	Gas	Oil	Coal	Hydle, Nuclear or import
India	9.2%	0.8%	71.0%	19.0%
Bangladesh	73.0%	20.4%	3.4%	3.2%
Pakistan	29.0%	35.0%	0.1%	35.7%
World	21%	6%	41%	32%

In the current scenario of energy crisis, Punjab Government has discovered different raw sites for installation of coal based power projects in the premises of industrial sector, which would be a source of uninterrupted power supply and each power plant has a capacity of approximately 50MW as shown in Table 2 [5]. In Table 3, it has been presented the progress in nuclear power that different nuclear power plants are still working in Pakistan and some are under construction.

Table 2. Status of Coal fired power plant in Pakistan

Industrial Estate	Expected Load by Dec 2014 (MW)	Current Status
Sundar Lahore	60	95 % completed
Multan-I	50	100% completed
Quaid-e-Azam Lahore	50	100% Colonized
Multan-II	-	80% Completed
Bhawal	-	Construction in Process
Rahim Yar Khan	-	Construction in Process
VAC Khurianwala	25	40% colonized
M3 Faisalabad	50	25% Developed

Table 3. Major development in nuclear Sector [6]

Year	Development/Progress
1972	In operation 137 MW KANUPP Plant
1989	Pakistan Became member of WANO and COG
1991	Signed contract for Chasma-1Plant
2000	In operation 325 MW Chasma-1 Plant
2001	Creation of Pakistan Nuclear Regulatory authority organization
2004	Signed Contract for Chasma-2 Plant and KANUPP relicensed beyond design life
2005	Pakistan energy security plan allocated 8,800MW to nuclear by 2030
2011	In operation 325 MW Chasma-2 Plant and first concrete port of Chasma-3 Plant and first concrete pour Chasma-3 & Chasma-4

2. METHODOLOGY

Every power plant has almost same methodology for electricity production and the variance is in just the energy resource. In coal fired power plant, electricity is generated by coal combustion. Firstly, coal has to be purified from thorium, uranium, aluminum, sulfur, iron and further impurities [7]. Coal fired power plant can contribute major part in energy development programs and largely rely on coal quality. The nuclear power plant produces electricity by

extracting energy through fission reaction from uranium (U-235) and any other nuclear fuel. Power is global and therefore to reach at right decision and choice, it is compulsory to study thoroughly about cost, electricity production capacity and environmental impacts of both nuclear and coal fired power plant [8].

3. RESULTS AND DISCUSSION

The figures and facts collecting in this article are described in the successive part. While information can change from one source to another, many factors are used to compare power resources. Multiple sources are used to compare data and acquired perception which one energy resource is a better choice in Pakistan.

3.1 Cost

Economics and cost of any power plant are the most important factors while constructing any power plant. Both nuclear and coal power plants has lower electricity production cost in comparison to other technologies. While, electricity production cost for nuclear power plant is less per kWh than coal fired power plant because of increasing coal price [4].

While considering fuel cost, it is necessary to include all processing cost to purify fuel from impurities plus raw material cost as shown in Table 4. It is represented that all cost related to fuel processing has been included in determining the cost of 1kg uranium [9]. Fuel cost for nuclear power plant is continuously declining due to price reduction of uranium as well as process efficiency is increasing with the passage of time. One kg uranium fuel can produce almost 36,000 kWh electricity. Nuclear fuel is cheaper and easiest to transport. The best factor is that fluctuations in price of nuclear fuel are less. Even though, somehow increase in cost of nuclear fuel will not have large impact in the energy production cost [4].

Table 4. Estimated cost of 1kg uranium fuel [9]

Uranium	8.9kg U3O8 ×\$146	US\$1299
Conversion	7.5kg U×\$13	US\$98
Enrichment	7.3SWU×\$155	US\$1132
Fuel fabrication	per kg	US\$240
Total:		US\$2769

On the other hand, coal price is continuously increasing. Price of one short ton of coal has been increased from US\$30 in 2000 to US\$150 in 2008. 1910KWh electricity can be generated from one short ton of coal [4]. Analysis of electrical energy production has been depicted in Table 5.

Table 5. Analysis of electrical energy cost utilizing various energy technologies [10]

Plant	Electrical cost Range (US cents/KWh)	Most Probable electrical Cost (US cents/KWh)
Coal-fired Power Plant	4.5-6.3	5.2
Nuclear Power Plant	4.2-5.8	4.8

In case of nuclear power plant, capital investment is approximately 50% larger than coal power plant for 60 years operation as depicted in Table 6. On the other hand, fuel cost for nuclear power plant is half that of coal fired power plant.

Decommissioning and decontaminating cost at the end of life span of nuclear power plant also have to include [4].

Table 6. Total cost of electricity generation [11]

Fuel	Internal Cost of electricity Generation*				Median External ** cost	Total Cost
	Fuel	O&M	Capital	Total		
Coal Thar	2.5	1.0	2.5	6.0	6.8	12.8
Coal Imported ***	2.4	1.0	2.3	5.7	6.8	12.5
Nuclear	1.1	4.6	5.7	0.3	6.0
LNG	4.1	0.9	...	6.7	2.8	8.1

*Ahmed 2007; Exhibit 9, pg.27

** European Commission 2003

***Delivery price of imported coal at US \$ 75/ton

The most important factor is to include cost related to treatment of affected population working and living surrounding the nuclear and coal fired power plants [4]. The most important point is to be noted that nuclear power plant are strictly operating under imposed government regulations to prevent public from its dangerous effects. If coal fired power also works under same government regulation equivalent to nuclear power plant, cost for coal power plant would increase and would be expensive to generate electricity [7].

3.2 Energy Generation Capacity

Ultimately, the objective of every technology is to generate electricity. Coal and nuclear fuels both have high energy density. For production of 1000MWe electricity, 1-4Km² land is required for both nuclear and coal fired power plant. While, nuclear fuel has higher energy density than coal and one inch pellet of uranium (U-235) fuel has larger energy as compared to one ton of coal. But both nuclear and coal resources are finite energy resources [4].

On the other hand, fission reaction is the most fast and energetic as compared to burning process of coal. Two ton of oil or three ton of coal can produce energy almost equivalent to one gram of uranium fuel. One kg of nuclear fuel and coal can power 60W light bulb for 685 and four days respectively. [12]. Coal contributes to approximately 40% in global energy generation. In world, many developing countries have huge coal reserves and can meet energy demand by utilizing these coal reserves. [8].

Pakistan Atomic energy commission (PAEC) has a target to install power plants of 8,800MW capacity up to 2030. PAEC has proper engineering and technical infrastructure to support existing and future power plants. Pakistan has well established educational institutions and training center to support nuclear power plants [2].

3.3 Environmental Implications

Environmental impacts are having a special importance while taking decision for installation of any power plant. Coal fired power plant releases approximately in the range of 700 to 950 g CO₂ per kWh. Coal ash consists of oxides of iron, aluminum, silicon, calcium, titanium, magnesium, potassium, arsenic, mercury, sulfur and sodium, additionally small amount of thorium and uranium [7]. Coal fly ash contains

mostly glass, which is derived from the non-combustible silicon in the coal.

An advantage for nuclear power plants is that they generate no carbon emissions during operation of the plant. This is an important parameter while considering the impact of a carbon tax in the future [4]. Environmental effects from the power plants are having a special concern. Power plants can be a source of pollution and increase global warming with CO₂ emissions. During the past 20 years, half of all the energy related carbon dioxide emissions are from electricity generation. The operation of nuclear plants releases approximately no carbon emissions as depicted in Table 7 [13].

Coal fired power plant is the cause of higher pollution (classic pollutants and GHGs). Both current and old coal technologies release more pollutants like NO_x, CO, CO₂ and SO₂. The environmental protection agency (EPA) determines the average emission of various pollutants for the production of 1MWh electricity. In Pakistan, emission level is somehow high due to scarce environmental regulation and lax implementation. Still, there is no estimation of external cost to use alternative fuels and technologies. It is sure that emission of CO, PM10, NO_x and SO₂ would be high than that of pollutants in US and Europe. This is the reason that external cost will be greater in Pakistan [11]. Safety always comes at the priority for public and workers working in the plant [14].

Table 7. Comparison of life cycle emission of coal-fired and nuclear power plant [14]

	Coal fired power plant	Nuclear power plant
Overall Emission	98%	2%
CO	91%	9%
CH ₄	99%	1%
NO _x	96%	4%
SO _x	91%	9%

4. SUMMARY

According to National Transmission Dispatch Company (NTDC) information, it is predicated that annual energy demand rate will be 5 to 6% in the coming ten years. It could not overcome with the existing power plant capacity. That’s why it is mandatory to do fast development in energy development programs otherwise it will affect economic growth of country [2].

Vattenfall finds out that 400gram and 700gram CO₂ will be emitted from natural gas and coal, respectively for KW-hr electricity generation. Nuclear power supporters claim that third generation nuclear reactor will produce electricity less than half the cost of second generation nuclear reactor as well as approximately ten times would be safer. They also claim that now there are reliable and safe sources to disposal of nuclear waste for prolonged duration. Moreover, they also believe that fourth generation nuclear reactor will utilize completely thorium or U-238 present in natural uranium and will produce 1/10 to 100 nuclear wastes as compared to current nuclear reactors. If it would be true, there is enough thorium and uranium for nuclear reactor to produce sufficient electricity to meet energy requirement of every person living

in modern civilization for one million years. The best achievement in nuclear industry is that second generation nuclear reactor is currently producing electricity at low cost as well as consistency at high reliability with no emission of greenhouse gases. [12]. Median of European external cost added to the internal cost of Pakistan electricity production is to estimate the lower limit of cost. This estimate represents that nuclear power is the most cost effective in Pakistan (as depicted in Table-6) [11].

5. CONCLUSIONS

The objective of this study is to compare nuclear and coal fired power plant based on economics, environmental impacts and energy production capacity. From the above study, it can be concluded that nuclear power plants are more desirable and cheaper technology in Pakistan than coal power plants. Cost of electricity generation from nuclear plants is cheaper in comparison to coal fired power plant while involving the cost of the carbon tax in future. Coal fired and nuclear power plant requires fuel 86, 00,000 kg and 74 kg, respectively for equivalent electricity production of 1000MW. Coal is cheap, but its mining is a difficult process and its transportation cost is high. Emissions of pollutants from nuclear power plant are negligible as compared to that of coal fired power plant. The nuclear power plant will play the most important role to meet electricity demand in Pakistan. When nuclear power plant is compared with coal fired power plant, it is analyzed that nuclear power plant is better choice for electricity production in Pakistan.

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