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Research Article

Power Station Waste Utilization in Arab Gulf Countries: Fly Ash Production and Economical Potential

Afaf Ghais*

Department of Chemical Engineering, University of Applied Sciences, Oman, Sohar

ABSTRACT

The energy mix petroleum, pet coke, coal, heavy fuel plants can apply solid waste management methods for clean, economical solutions within the GCC region. The use of cheap building materials which generate in the power plants, can be applied in the Gulf area. The GCC electricity production plants with will produce huge fly ash amount. As an example, 50-60 tons of heavy fuel fly ash formed from a mid-capacity power plant of 2300 mw. The GCC power stations are the main supply of ash that is currently imported from outside the region. This research bestowed the expected fly ash resources and amounts within the Arab Gulf states, from the operating and planed electricity plants. The results showed that a substantial proportion of fly ash can be locally collected and utilized. Cheap and environmental applications are often extended from native ash utilization for the construction and water treatment sector.

Keywords: LGCC energy resources; Energy scenarios; GCC Ash production; Ash applications.

INTRODUCTION

Arab Gulf Countries [GCC] includes King Saudi Arabia [KSA], United Arab Emirates [UAE], Kuwait, Oman, Bahrain, and Qatar. fifty-seven of world fossil oil reserves and twenty eighth of world gas [NG] reserves originated within the GCC. Despite the excessive quantity of gas within the Arab Gulf countries and the dependency of the energy field on NG. There's a thoughtful lack in gas to run the power Plants [PP], due to the rising in population and consequently the power consumption [1–5]. The highest lack gap is 93% lack in Qatar, while the lowest shortage is 4% in UAE (Figure 1). the actual fact that different energy alternatives can have a good share within the GCC energy field. Using of coal, petroleum and heavy oils in power generation can introduce a solid waste ash generated from fuel burning. Fly ash is often landfilled or utilize in construction fields as studied and tested within several researches, found that fuel ash [FFA] produced in Shuaiba desalinization plant in KSA can utilized in soil stabilization to increase its strength. Most of the studies in GCC targeted within the applications of ash. Few data were found about the fly ash quantity in GCC region. This study aims to estimate the fly ash quantities and resources in GCC power stations operated or planned to work with by fossil fuels, in line with the Visions of the Gulf countries for sustainable development. The paper concerned about the GCC fly ash data banking, to include the fly ash in the Arab Gulf industrial and construction applications by utilizing this low-cost raw material in many fields.

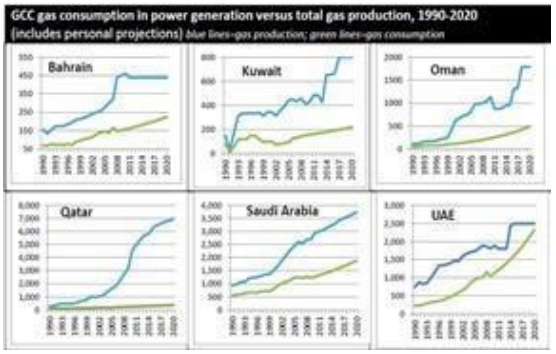

Figure 1: Gap between the NG Production and Consumption in GCC.

MATERIALS AND METHODS

This study followed the data collection method, about the operated and planed power stations in GCC which worked with crude oil, coal, heavy oil, pet coke and the municipality waste. The expected fly ash production based on the station's electricity capacity were calculated.

Energy resources in GCC

Natural gas is the most used fuel for GCC thermal power

Correspondence to: Afaf Ghais, Department of Chemical Engineering, University of Applied Sciences, Oman, Sohar, Email: afafg.soh@cas.edu.com

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generation. This is due to the availability of fossil fuels resources in the states and their low prices. The fuel used for electricity production in 2011 consisted of 65% fuel from natural gas, 18% from crude oil, and the rest is distributed between light oil, heavy fuel oil, and diesel. In GCC energy generation field, natural gas represents 75% then comes crude oil with 14.4% and the 10% comes from light oil, heavy fuel oil, and diesel. Depending on the technologies many fuels applied in electricity generation inGCC.

GCC energy scenarios for 2040

Energy scenarios in GCC are demonstrated for long sustainable development plans [2020-2040] to give specialized, conservative, and reasonable proposals to improve the energy circumstance. Energy challenges are the flocculation of worldwide oil and gas costs, deficiency in energy assets contrasting and the populace development, and the pattern toward environmentally friendly power.

Three main energy scenarios can be applied in GCC:

- The business-as-usual scenario [BAU] in this scenario, the existing energy system is extended into the future without any changes, with the same structure and characteristics [6].

- The netback-pricing scenario [NB] in this scenario, all fuel costs are increased to the international market price; which will accordingly change the electricity generation options. Furthermore, this scenario examines different carbon tax options of 0, 20, 30, 40, and 50 dollars per kilotons of CO2 emissions. These scenarios can be notated as follows NB00, NB20, NB30, NB40, NB50, depending on the Dollar taxes per kg of CO2.

- The Nuclear hub scenario [Nuc Hub] GCC plans encourage the thinking of a "nuclear hub" for the region by possessing the "know-how" and logistics technologies to provide sufficient nuclear energy share in the energy field.

GCC energy plants wastes

Wastes from fossil fuel combustion and municipality inclinators waste treatment units in GCC and all around the world are vaporous and solid wastes, the vaporous are carbon dioxide and nitrogen oxides. The solid waste is [Ash] which comprises of 10% of bottom ash stays in the reboilars. While the rest are 90% of fly ash, Fly ash [FA] is trapped by electrostatic precipitator, then it can be landfilled or reused. With the assortments of energy mix scenarios in GCC, crude oil, heavy oil, Petroleum coke, coal, and municipality inclinators can be realistic fly ash source in Gulf Arab region. In 2009, ASHTECH International Company opened a terminal at Al Ghail in the Ras Al Khaimah Free Zone-UAE to encourage the fly ash to the GCC clients. Likewise, there are different activities incorporate the Palm Islands, Dubai Marina, F1 Theme Park, Etisalat head office, Madinat Jumeirah [Phases One and Two], all in the UAE; Sheik Khalifa Port, the Bahrain Financial Harbor, and Shaikh Khalifa Causeway projects in Bahrain; and Khalifa Sports City and the New Doha International Airport in Qatar, utilizing fly ash in the construction projects.

Industrial value of fly ash in GCC

The fly ash global submissions are well known, examined in many fields. For the GCC countries, the fly ash tender will be a new W to E [Waste to Energy] source that increases the GDP, with virtuous environmental and economic revenues. The FA can be used in adsorption, metal extraction, concrete production, and in other industrial zones. There are Some fly ash studies which verified in GCC in industrial applications: Geopolymers: Yahya's study showed that 41.7% wt of HFFA can be applied in stable geopolymers with high compressive strength and low water absorption. Mixing FA with Geopolymers had reduced metal migration into the environment [7,8].

Concrete and Asphalt: Saudi Arabia environmental studies used 15% HFFA as replacement of cement/sand concrete blocks, which showed reasonable strength when it was exposed to the sulfate solution for ten months. Also, the HFFA was applied as a filler [50%] in asphalt concrete blocks, which exhibited an improvement in stiffness and fatigue life of mixes, [Mohammed A. Al-Osta]. Dubai Municipality had distributed a circular to all stakeholders of the construction sector to use eco-friendly and sustainable concrete materials [fly ash, silica fume] in building construction, which will reduce carbon emission and create an environment-friendly urban environment, Soil Stabilization: The COFA was added to the Saudi soils at 5%, 10%, and 15% with and without the addition of cement. The Results identified that COFA is suitable as a chemical stabilizer to treat the soil.

Economic value of fly ash

Fly ash main usages is the substitute for traditional cement. Globally the renowned bridges, skyscrapers, roads, dams were built using high-performance fly ash concrete mixes to achieve higher strength and durability. Constructers use 40-70 percentages fly ash mixes in their projects.

Global fly ash resources

The fly ash can be produced from the burning of the following materials:

- Combustion of coal as coal fly ash
- Combustion crude oil as crude oil fly ash
- Combustion of heavy fuel oil as heavy fuel fly ash
- Combustion Petroleum Coke as petroleum coke fly ash
- Combustion Municipal Wastes as Fly Ash [9-11].

Expected fly ash sources in arab gulf countries:

In spite that fly ash is imported to GCC from many countries, India, South Africa, and China. The electrical power plants and petroleum refineries in the Gulf area can apply solid waste management or Waste to Energy [WTE] program to reuse the fly ash generated from fuels burning in power and water desalination plants. The expected fly ash generation is about 1 million MT per annum, while the imported fly ash in the GCC is 50,000 MT per year approximately.

Coal fly ash in GCC

Coal limit in the GCC district is not as much as that of different energizes, contrasted and condensed flammable gas or oil based fills. Coal accounts are under 1% of essential energy creation in the district. Yet, there are a few nations in the Arab Gulf zone import coal for modern creation, in the United Arab Emirates [UAE], Fujairah Cement works a 40 mw coal terminated force plant to help its creation, and other concrete plants utilize imported coal to deliver clinker. Yemen and Kuwait likewise utilize little amounts of imported coal for concrete creation. As coal has so far been essentially imported from South Africa and Indonesia, with little

amounts of the fuel additionally sourced from Australia. Oman and the United Arab Emirates [UAE] have no existing coal-fired electricity generation, but they each plan to build coal plants shortly. The Hassyan coal power project is in line with UAE Clean Energy Strategy 2050 to diversify its energy mix to include 44% renewable energy production, 38% gas power generation, 12% coal power generation, and 6% nuclear power generation capacity by 2050.

Oman has announced plans for new coal-fired generators, Al Duqum Independent Water and Power Project of 1.8 gw electricity capacity. Saudi Arabia proposes the construction of 8.9 gw of supercritical coal plants by 2030, but its decision for a coal-fired plant and utilization levels will be affected by the coal import price. To estimate the fly ash expected from coal future plants in GCC, the data of coal and fly ash reports in other regions were applied. First, from the electrical capacity, the amount of coal used can be estimated then subsequently the fly ash is expected to be produced in each plant. Each ton of coal can generate about 2,500 kW-hours on average Wang Lan stated that 1 ton of coal burning in electrical power produces 250-300 kg of fly ash. Aadil Yousuf found that 1 ton of coal will produce 300-400 kg fly ash.

Crude oil fly ash [cofa] in GCC

COFA is totally diverse in many of its characteristics from the coal fly ash, therefore, its impact on the environment, its practices and ways of disposal are also different. The quantity and characteristics of COFA depend primarily on the fuel characteristics and the burning process. In addition to carbon, major elements in COFA include magnesium, vanadium, nickel, and sulfur. The high carbon content and presence of toxic heavy metals proposed that this COFA be considered as a hazardous material that needs careful handling and safe disposal [12].

King saudi arabia

One of the countries that burn crude oil directly for power generation, according to the Joint Organizations Data Initiative. Saudi Arabia burned 0.9 million barrels per day of crude oil in July, the highest ever recorded in JODI data for July globally. The bigger power plants in Saudi Arabia are driven by crude oil, which is not widely used in other parts of the world. Yanbu IWPP plant completed in 2012, operated as an oil-fired power plant which generates 2,500 megawatts.

Heavy fuel oil fly ash [HFFA] in GCC

Burning of a kiloliter of heavy fuel oil [HFO] yields about 3 kilograms [kg] of ash, approximately 90% is conceded through a flue gas stream, which is collected by air pollution devices as fly ash. The fly ash generated by the burning of HFO has generally termed heavy fuel of anode grade calcined coke, of which "the majority" will be delivered to EGA. Adnoc says that the agreement enables EGA to source up to 40% of its calcined coke requirement within the UAE. Sultanate of Oman: In March 2019, a meeting between Omani company Salmeen Industrial Projects LLC [SIP] and its UK-based BSW Group in Sohar, agreed on building of a petroleum coke calcining plant, to produce 450,000 metric tons per year of calcined pet coke. The project is expected to start its commercial operation by 2022, oil fly ash [HFFA]. On average, 50-60 tons of HFFA are generated per day from a mid-range [i.e., 2300 mw power generating capacity] power plant. The Heavy fuel oil ash is diesel and cracked fuel ash of carbonaceous matrix that contains V, Ni, Zn, Cr, Cu, and Pb with variable amounts. Kuwait in 2008, heavy fuel oil represented more than 55% of the total fuel used by power plants. Heavy fuel oil remains the least expensive fossil fuel in Kuwait's current fuel mix. Some gas turbines are adapted to run on different fossil fuels [mainly gasoil] which produce fly ash as waste of combustion. Saudi Arabia [13-15]. In Saudi Arabia, the water desalination and power plants consume around 40 million metric tons of heavy oil, resulting in vast quantities of heavy oil flying ash. UAE Madinat Zayed Oil power plant was, constructed in 1991 in Abu Dhabi- UAE It operates with mixed fuel of diesel and natural gas to produce an electrical power capacity of 126 mw.

Petroleum Coke Fly Ash in GCC

Petroleum coke [pet coke], is by-product of the crude oil refining process, is it considered an attractive supplementary fuel for power generation. The Coke fly ash chemical and mineralogical composition are differ from other fly ashes since it consists of Ni, V, Mo and As, [Henke]. In the GCC construction and smelting process the pet coke had been started its utilization in the energy market:

UAE Dhabi state petroleum firm Adnoc announced an agreement with Emirates Global Aluminum [EGA] for the supply of petroleum coke for use in its smelting process. The pet coke will be produced in the carbon black and delayed coker [CBDC] unit within Adnoc Refining's Ruwais West refinery, which started up in 2018. The CBDC can produce[16].

RESULTS

Municipal waste fly ash [mswfa] in GCC

Municipal solid waste management is one of the major environmental problems, as well as other GCC countries. The solid waste management program works with recycling, composting, incineration [waste-to-energy], and landfilling facilities [17]. Incineration of wastes at first seems very feasible as the amount [1-30% of weight] and volume [5-15% of volume] of wastes are significantly reduced and energy is generated, however, the by-products of incineration [i.e. bottom ash and fly ash] have environmental threads and needs special disposal. The fly ash from municipality inclinators composed of carbon part, metals oxides in addition to ppm of heavy metals.

GCC fly ash challenging and benefits

In the GCC region, many countries have started to use fly ash in their industrial fields. UAE and Kuwait importing coal and pet coke for the cement industry. The average quantity of coal imported into GCC is between 3.0-3.5 million MT per annum, [Mubarak Hussain]. Despite the benefits of fly ash utilization, many challenges are facing the fly ash market in the GCC [18-19].

United Arab Emirates Abu Dhabi Waste-to-energy services based on the amount of waste generated in the city that can easily provide at least 100 MW of electricity. The need to build at least six incineration plants to overcome the increase wastes.

DISSCUSION AND CONCLUSION

The Gulf countries started new energy resources [conventional and renewable] to face the Gulf sustainable plans for the nearest future. Saudi Vision 2030 The Financial Sector Development Vision Realization Program aims to develop a diversified and effective financial sector to support the development of the national economy, diversify its sources of income, and stimulate savings,

finance, and investment.Oman Vision 2040 is the Sultanate's gateway to overcoming challenges, keep pace with regional and global changes, generate and seize opportunities to foster economic competitiveness and social well-being, stimulate growth, and build confidence in all economic, social, and developmental relations nationwide,Considering the ever-increasing energy demands in GCC, and it's a conventional energy system that depends on limited natural gas and oil reservoirs. The total GCC electricity demand will increase by [50 %] by 2030 and [40%] by 2040. The energy mix of crude, coal, pet coke, heavy oil, and municipality are electricity generation routs that have long global experiences. The technologies of applying mixed energy systems were studied and summarized in many research's. A proper waste management system can be applied in all the GCC, to concenter on fly ash generates in the working or planned power stations as economic and environmental opportunity enhanced by the sustainable clean environment plans. Practical and "clean" alternatives could precede the energy efficiency measures and modification of fossil fuels, municipality, and coal waste utilization to higher production values. The fly ash unless applications with low cost let the electricity generation waste be an opportunity for GCC new sustainable visions to be applied effectively [20].

RECOMMENDATIONS

Full Gulf fly ash data bank has to be built to collect local fly ash resources and applications. The clean environment strategies can lead to sustainable energy mix in the GCC, so the following points are recommended:

- Fly ash separation techniques are mandatory in all power plants.
- Collection and storage of fly ash are compulsory.
- Taxes credits applied for clean power plant stations.
- Chemical and physical properties data shall be prepared for fly ash kinds produce from Gulf energy wastes.
- Ash properties data linked to applications can be built from intensive research work.

CONFLICT OF INTEREST

We hereby declare that this paper entitled "Power Station Waste Utilization in Arab Gulf Countries - Case Study: Fly Ash Production and Economical Potential" is the result of our own work except for quotations and citations which have been duly acknowledged. All the data cited from an open access journals and chemical engineering references books. Also, the authors did not have any beneficial value from this work, only research work.

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