A PROPOSAL FOR USING ZAFARANA AREA FOR SITING OF A HYBRID WIND AND NUCLEAR POWER PLANT IN EGYPT

SHERIF ALGOHARY and ALY I. M. ALY
Siting and Environmental Department,
Egyptian Nuclear and Radiological Regulatory Authority (ENRRA)
3, Ahmed El-Zomor St, Nasr City, Cairo, P.O. Box 7551
EGYPT
Sh_algohary1@hotmail.com, alyi45@yahoo.com

Abstract: - Siting is considered as an important crosscutting issue for all power plants and it plays a big role in forming the nature and geographic distribution of these plants.
Zafarana was selected from the Egyptian government to have the biggest wind farm in the country with a capacity of 545 MW. However, it is located in one of the ambitious new development mega projects for the development of Gulf of Suez and Galala city which is a part of the Egyptian government strategy for 2030.
This paper discusses feasibility of a proposal for introducing hybrid wind and nuclear power plant in Zafarana site. It describes different siting considerations for wind farms and also the nuclear power plants in general.
According to different studies Zafarana has a high seismic risk. New trend in the world for use the seismic isolated foundations, which was implemented in 6 nuclear power plants for reduction of seismic risk and reducing the construction cost of the NPP.
It can be concluded that the proposal of siting hybrid wind and NPP power plants in Zafarana is feasible and can be studied as one of the potential sites from the technical, environmental point of view. More investigation should be done in the seismic risk reduction.

Key-Words: - Siting, Hybrid, Nuclear, Wind, Zafarana

1 Introduction

The siting of power plants in Egypt is mostly a technical process; normally it is done on a national level by the Ministry of Electricity and Energy. Different countries all over the world are supporting R&D that could lead to efficient utilization of energy sources with hybrid approach such as renewable energy and nuclear options, to meet the huge amount of energy needs in the different development sectors. According to previous study done by the authors [1], which assessed and evaluated the new trend of hybrid nuclear renewable energy system, it was found that nuclear and renewable energy offer the potential for plentiful long-term supplies of heat and power at prices not subject to the variations of fossil-fuel prices, and for producing lower Green House gases (GHG) emissions than alternative fossil-fuel sources. It is concluded that a new proposal for using land efficiently with new trend of nuclear renewable hybrid energy system need to be addressed in Egypt, [1].

Egypt has ambitious plans for the development of the Red Sea coast and especially along the Gulf of Suez, it is planned to allocate and introduce logistics, touristic, educational, and industrial facilities. These new development needs a vast amount of energy to fulfill their energy needs. So, the government allocated different sites for wind and conventional power plants. On the other hand, the Egyptian government is looking for an energy mix of power systems to meet its future energy capacity needed as part of its overall future energy plans. So, introducing hybrid power plants will be the future of Egypt power sector.

Renewable energy systems in general including wind and nuclear power plants face different siting and infrastructure challenges that are unique to the resources involved. Siting considerations are especially important in the case of wind energy projects because there is no option but to place the wind turbines in locations where adequate wind resources exist.

Nuclear Power Plants (NPPs) need special consideration for siting. According to IAEA, siting of NPP is the process of surveying and selecting a suitable site for a nuclear installation. The siting process and the site evaluation process include five different stages. The siting process for a nuclear installation consists of the first two stages of these five, i.e. site survey and site selection. In the site

survey stage, large regions are investigated to find potential sites and to identify one or more candidate sites. The second stage of the siting process is site selection, in which unsuitable sites are rejected and the remaining candidate sites are assessed by screening and comparing them on the basis of safety and other considerations to arrive at the preferred candidate sites [2].
Zafarana site is allocated by the Egyptian government and a big wind farm was installed. In this paper, siting of both wind and NPP will be discussed in general. A preliminary evaluation of Zafarana site will be investigated for its feasibility to be a potential site for hybrid wind and NPP.

2 Site Selection of Wind Farms

Wind energy projects are facing the same siting challenges that confront traditional and conventional power plants. Although wind power produces no air pollution, concerns are often raised regarding some environmental and social issues such as noise and visual impacts, big size land requirements or effects on wildlife specially birds. Different criteria are applied for site selection of wind farms, and these criteria consist of technical, economical, and environmental criteria [3]. These criteria include the followings:

a) Wind Energy Potential
Generally, an average annual wind speed below 6 m/s is considered to be no longer economically feasible and, therefore, areas with a wind speed of less than this speed are excluded and should not be considered for wind energy.

B) Distance from Road Network
The distance from roads network is one of the criteria for wind farms, which can be reflected in cost reduction of constructing new roads and leading to environmental degradation by soil removing and pavements. Different distances has been suggested according to legal regulations in different countries, a minimum distance of 20 m from federal highways to the rotor blade tip of the wind turbine has to be kept. In some countries like Germany, areas with a larger distance than 500 m from roads get the lowest value score in the siting evaluation process of wind farms [3].

C) Distance from Electrical Grid
The distance to the electrical grid is another important criteria. Depending on the number of wind turbines installed, wind farms are either connected to the medium voltage grid (10, 20, and 30 kV), the high voltage grid (110 kV), or the extra-high voltage grid (220 kV and 380 kV). Large wind farms with an installed capacity of more than 10-15 MW are usually connected to the high voltage grid and commonly require the construction of a new grid substation [3].

D) Slope of Terrain
Steep slopes of a terrain can reduce the accessibility of wind farms equipment such as cranes and trucks and increase construction costs. Recommendations for the maximum slope threshold had been suggested and it ranges from 10% to 30% [3].

E) Distance from Urban Areas
Different countries put some limitations to allocate wind farms near urban areas. In Germany, the siting of wind turbines in or close to urban areas is restricted in order to prevent noise and visual impacts or massing effects caused by wind turbines. To prevent massing effects, areas closer than 550 m to residential areas and 400 m to mixed-use areas are excluded. However, besides those minimum distances, further potential visual impacts, such as landscape impacts, shadow flicker, or light reflections, have to be considered. Among different international practices, buffer zones around wind farms vary from 500 m to 2,500 m [3].

F) Distance from Archaeological Sites and Places of Interest
In some countries a ‘distance from places of interest’ is emphasized as a social acceptance-related issues. In this context, to reduce public concern towards wind energy, it might also be beneficial to locate wind turbines far away from places of interest areas, such as tourist attractions sights, or monuments.
Tegou et al. (2010), created three zones around archaeological sites; a 500 m restriction zone, a 3,000 m zone, and a 6,000 m zone with different value scores [4].

G) Distance from Natural Environments
The ‘distance from natural environments’ comprises national parks, natural reserves, bird reserves, biotopes, water bodies, etc. These areas serve the protection of nature and wildlife and are therefore excluded from wind energy development. A major concern is the potential collision of birds and bats with wind turbine blades if wind turbines are located too closely to their habitats or migratory routes [3].
In some countries like Germany, the wind energy decree states that a ‘no building zone’ of 300 m should be created around areas that particularly protect bats or bird species.

H) Land Cover Type
The suitability of an area for the siting of wind turbines also depends on the prevalent land cover type. From a social acceptance point of view, some land cover types can be considered to be more preferable than others. It is widely recognized in the literature that 'shorter' vegetation is preferable to 'taller' species. Thus, agricultural land, barren land, grass land, and shrub land can generally be considered to be most suitable, whereas forest land is considered to be less suited.

I) Landscape Architecture
Wind turbines emit noise and might have negative effects on birds, bats, and the landscape. The aim of including a criterion that takes a landscape architectural perspective is to minimize adverse environmental effects and to reduce concerns with regard to social acceptance. For this purpose, wind turbines should be built in or close to areas that are already negatively affected by comparable impacts, such as in the proximity of highways, and railroads, or on former dumps, landfills, and strip mines.

J) Lifetime of Wind Turbine Generators
The expected lifetime of wind turbine generators is typically around 25 years, and planning permission is usually granted for this period. Decommissioning of the turbines at the end of this operational phase is often a specific condition of planning permission and is an important consideration when designing and assessing a wind farm [5]. Figure (1) shows the classification of the criteria for siting wind farms.

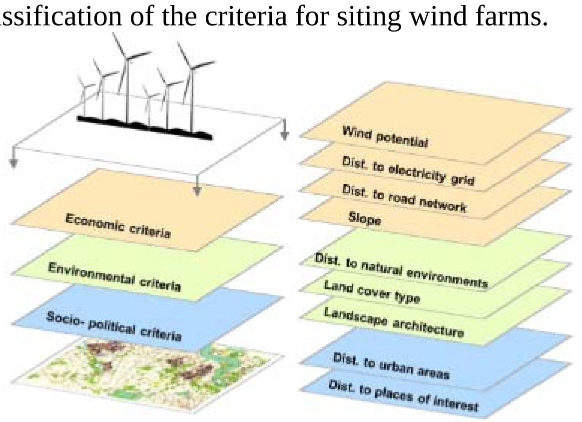


Fig.1 Classification of the Criteria for Siting of Wind Farms [3].

In Egypt, The site selection for wind farms is most commonly based on an exclusion approach, which results from legal, economic and technical aspects. Thus, areas are excluded which lack sufficient average wind speeds, as well as areas where wind farm siting is restricted, such as residential areas, natural resources areas, archaeological sites and water bodies. Furthermore, certain buffer zones are assigned around those areas which are subject to planning considerations of the General Organization for Physical Planning (GOPP).

3 Nuclear Power Plants Siting

Site selection is one of the vital steps in designing and construction of nuclear power plant (NPP) and also it is a complex process. This step involves the study of a large region to select preferred and potential sites and followed by detailed evaluation of the preferred site. In the siting process of selecting sites for construction of a nuclear power plant, different factors should be evaluated: geologic/seismic, hydrologic, and meteorological characteristics of proposed sites, determination of exclusion area and low population zone (Population considerations are important as they are related to protecting the general public from the potential hazards of serious accidents), potential effects on a plant from accidents associated with nearby industrial, transportation, and military facilities, emergency planning and security plans. Although each of the previous factors should be evaluated independently, the final evaluation of the NPP site should involves the interrelation of all these factors [6].
According to IAEA regional criteria are generally related to national legal policy, economic policy, environmental protection or other related policies of the country. Technical constraints and the availability of resources (e.g. infrastructural constraints, availability of water) on a regional basis should also be important considerations for regional analysis. The regional criteria should identify all possible potential sites and no site should be discarded without appropriate justification. All potential sites in a region should be taken to the next step (screening) unless their exclusion can be appropriately justified. The second step is screening in which the potential sites are screened to choose the candidate sites. The principal objective of this step is to exclude unfavorable sites on the basis of both safety related considerations and non-safety-related considerations. The third step is evaluation, which include the comparison and ranking [2].

3.1 Classification of Siting Criteria of NPP

According to the Egyptian legislation, The Egyptian Nuclear and Radiological Authority (ENRRA) is responsible for issuing the siting requirements for any nuclear facilities including NPP. There are two types of criteria used in site selection process; these criteria are defined based on the severity of constraints imposed by underlying regulatory requirements. These criteria are:

3.1.1. Egyptian Rejection Criteria

According to Site Evaluation Requirements for Nuclear Installations issued by ENRRA in 2016 [7], different rejection criteria were identified for site evaluation of nuclear installations in Egypt including the followings:

a) Areas that show evidences or have potential for fault displacement at or near the site. Preference should be given to sites located at a sufficient safety distance from capable faults (at least the site and site vicinity must show the absence of capable faults).

b) Areas covered with, deep unsuitable soil where soil has a potential for ground collapse e.g karstic hazard or cavities.

c) Areas containing extensive and important ground/ surface drinking water (e.g. Nile Valley and Delta).

d) Areas subjected to high flood events and not compensated by practical engineering solution.

e) Areas where a feasible emergency plan cannot be implemented.

f) Areas that are possibly affected by volcanic hazard (e.g. fall of pyroclastic deposits) or active mud volcanism.

3.1.2. Suitability Criteria

According to IAEA [2], criteria used in the siting process for a nuclear installation are classified as follows: Safety related criteria; Criteria relating to nuclear security; Non-safety-related criteria.

a) Safety Related Criteria

According to IAEA, Safety related criteria are classified into four sets as follows:

1) The first set of criteria is related to the potential impact of natural hazards on the safety of the nuclear installation. In this context, the following natural hazards should be considered: Capable faults, Vibratory ground motion due to earthquakes, Volcanic hazards, Coastal flooding or low water intake level, River, Blockage of intake channels , Combinations of coastal and river flooding , High winds , Local phenomena such as sand storms and dust storms, Other extreme meteorological events such as droughts, extreme precipitation, including snow pack, extreme hail, lightning and extreme temperatures, including the temperature of the source of cooling water, Geotechnical hazards such as slope instability, soil liquefaction, landslides, rock fall, avalanche, permafrost, erosion processes, subsidence, uplift and collapse, Forest fires, Credible combinations of events.

2) The second set of criteria is related to the potential impacts of human induced events and nuclear security events on the safety of the nuclear installation. The following origins of potential human induced hazards should be considered:

a) Stationary sources which include the other nuclear installations, oil and gas operations, chemical plants, processing of hazardous materials, mining or quarrying operations. Also, military facilities (permanent or temporary), especially shooting ranges and arsenals.

b) Mobile sources which include surface transportation (e.g. railways and roads, and oil, gas and other pipelines), airport zones and harbor zones (military and civilian), air traffic corridors and flight path zones (military and civilian) and electromagnetic interference.

3) The third set of criteria is related to the characteristics of the site and its environment that could influence the transfer of radioactive material released from the nuclear installation to people and the environment. In this context the following phenomena should be considered:

a) Atmospheric dispersion of radioactive material;

b) Dispersion of radioactive material in surface water;

c) Dispersion of radioactive material in groundwater;

d) Population density and population distribution and distance to centers of population, including projections for the operating lifetime of the nuclear installation.

4) The fourth set of criteria is related mainly to the demonstration of the feasibility of implementation of the emergency plan for the nuclear installation. The following phenomena should be considered:

a) Physical characteristics of the site that could hinder implementation of the emergency plan (in particular, geographical features such as islands, mountains and rivers).

b) Infrastructural characteristics relating to the implementation of the emergency plan (especially local transport infrastructure and communications networks).
c) Considerations of populations (e.g. special population groups with regard to protective actions in the event of a nuclear or radiological emergency, such as elderly and disabled persons and hospital patients and prisoners), and land and water use considerations;
d) Specific requirements of the regulatory body for special zones, such as emergency planning zones and distances;
e) Industrial facilities that could involve potentially hazardous activities and impacts of concurrent external hazards on infrastructure.

b) Criteria Relating to Nuclear Security

Nuclear security aspects should also be considered in siting of nuclear installations, taking into consideration involving of relevant national competent authorities. Typically, this includes consideration of site characteristics that could affect the ability to implement physical protection measures and the capability to deter, detect, delay and respond to nuclear security events, [2].

c) Non-Safety Related Criteria

In the site survey and site selection process, another set of criteria are concerned with considerations that are not directly related to nuclear safety (e.g. availability of cooling water, topography, access to electrical grid, non-radiological environmental impacts, socioeconomic impacts). Such non-safety-related criteria should be considered together with other criteria, [2].

4 Results and Discussions

4.1 Zafarana Site and Mega Projects in the Gulf of Suez

Egypt has a good chance for achieving sustainable urban development depending on mega urban development projects. Renewable energy is one of these projects. Mega projects of renewable energy can create new opportunities of jobs in remote areas; therefore, attracting population towards those areas.
The government has started the development of a mega urban city in the Gulf of Suez. This project is Galalah City, which is a new city with an area about 17000 acres, located on the highest mount plateau in the Red Sea area between Ain Sokhna and Zafarana. The plateau sits over 650 meters above sea level. The new city is one of the government's national efforts to develop the vast and empty eastern desert to solve the problem of over populated cities in the Delta and create work and living opportunities for the youth as well as generating investment opportunities, [8].
The project includes the establishment of the Galalah City, the King Abdullah University and a tourist resort overlooking the Gulf of Suez in addition to construction and redevelopment of Ain Sokhna-Zafarana road. There is a plan to provide fresh water to Galalah city through the construction of a 150,000 m3/year desalination plant. There is, also, a plan to establish a touristic resort on an area of 1000 feddans, two hotels: one on the top of the mountain and the other by the beach, a water park and a yacht marina as well. The current strategy of the government for supplying the electricity needed for the project is based on upgrading the Ataqa power plant in Suez and the use of the wind farms of Zafarana [8]. Figure (2) shows urban development map for Egypt, depending on mega projects of renewable energy and the map showing Zafarana as one of these projects, [9].

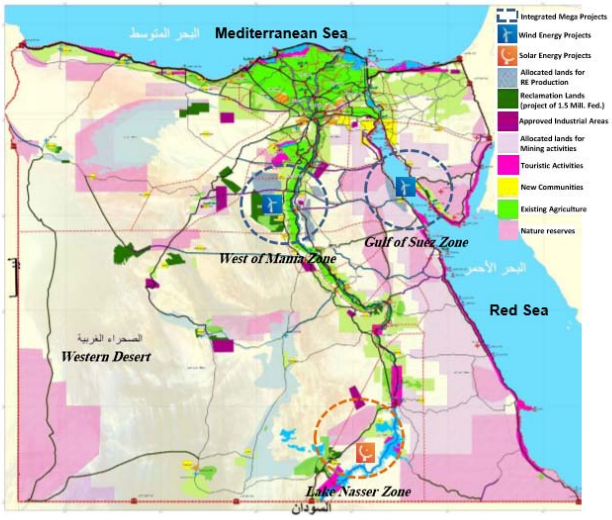


Fig.2: Urban Development Map for Egypt showing Mega Projects of Renewable Energy, [9].

Because of the above mentioned aspects, an ambitious new approach can be introduced to the governmental plan for supplying the energy needed of such mega project based on using the site of wind farm in Zafarana to combine a NPP in the same site.

4.2. Zafarana Wind Farm

The Zafarana Wind Farm is located 120 km south of Suez at the Red Sea coast. It is a location with extreme good wind conditions. Wind farm at Zafarana were constructed by different companies which include: Danish Vestas, German Nordex and Spanish Gamesa. Figure (3) shows the layout of wind farm at Zafarana Wind Farm. Zafarana Wind Farm currently has a generating capacity of 545 MW, making it one of the largest onshore wind farms in the world.

Fig. 3: Layout of Zafarana Wind Farm, [10].

4.3. Preliminary Study of Zafarana Area as a Potential Site for Hybrid Wind and Nuclear Power Plant

Zafarana area has been selected for constructing a big wind farm by the Ministry of Electricity based on the national wind atlas which shows that Zafarana is a unique site for installing wind turbines because of the continuous high speed wind in the site. In this research siting considerations of wind will not be evaluated but only we will evaluate the site for feasibility of construction a NPP beside the wind farm.

According to IAEA [2], siting criteria are used to evaluate specific site related issues, events, hazards and other considerations. So, the screening criteria which consist of both safety related and non-safety-related criteria and also the rejection criteria developed by ENRRA were used for evaluation of Zafaran site to be a potential site for NPP.

The preliminary study has shown that none of the rejection criteria can be applicable to Zafarana site and most of safety and non-safety related criteria can be applicable but only the earthquake and seismic hazards need some engineering solution to reduce the risk. It is concluded that the site can be consider as one of the potential sites for construction of NPP in Egypt. So, the research will evaluate the geological and seismic hazard of Zafarana site.

4.4. Seismic Hazard in Zafarana Area

The importance of the seismic hazard evaluation and safety of nuclear power plants (NPPs) was dramatically moved to a higher stage after the catastrophic sequence of events initiated by the tsunami attack on the Dai Ichi facility in Japan on March 11, 2011, [11].

4.4.1. Tectonics and Seismicity in Zafarana

Zafarana is located in an active seismic zone along the west side of the Gulf of Suez. The tectonics in the region is related to the movement between the African, Eurasian and Arabian plates. Figure (4) shows the Oligocene to Early Miocene rifting of the Afro-Arabian plate which led to the opening of the Suez rift [10].

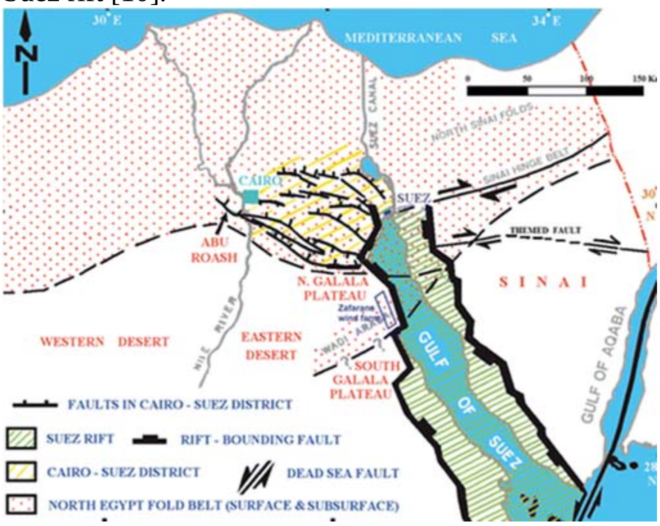


Fig.4: The Main Tectonic Elements in Northeast Egypt [10].

A previous study of the seismicity information around the Zafarana Wind Farm area, within a 300-km radius from 1900 to 2012 was collected from international seismological data centers and also from bulletins of the Egyptian National Seismic Network. Figure (5) shows the local seismicity around Zafarana Wind Farm on the Gulf of Suez [10].

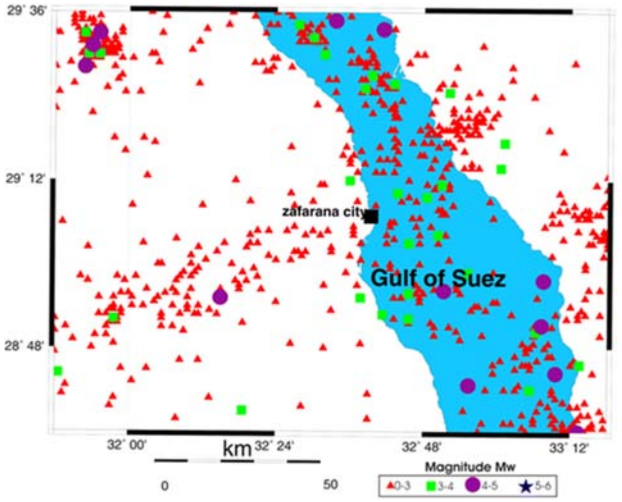


Fig. 5: Seismicity Map around Zafarana Wind Farm from 1900 to 2012, [10].

4.4.2. Subsurface Geological Features

The subsurface geological features indicate that the Zafarana project area consists of coastal and wadi deposits. There are no active faults in the Zafarana area [10].

4.4.3. Zafarana and Egyptian Codes for Structure Design

After the occurrence of the an earthquake of a Magnitude 5.9, October 12, 1992 in Cairo , the government gave great attention to revising code for seismic loads, and it was modified several times in the Housing and Building National Research Centre. Since October 1992, a set of Egyptian codes have been released. In these codes, Egypt was divided into five seismic zones depending on the seismic hazard.
By definition, the hazard within each zone is assumed to be constant. The seismic hazard is described in terms of a single parameter which represents the design peak ground acceleration (PGA) for rock. For zones 1, 2, 3 and 4, the acceleration of gravity (average values are 0.10, 0.125, 0.15 and 0.20 g, respectively. Zone 5 was subdivided into two sub-zones, 5a and 5b, with average values of 0.25 and 0.30 g, respectively. These codes provide the seismic zoning map, which depicts the seismic hazard in terms of Peak Ground Acceleration (PGA) with a 10 % probability of exceedance in 50 years, corresponding to a return period of 475 years.
Figure (6) shows seismic activity zoning map of Egypt, [12]. According to this map, Zafarana area is located in zone Z-4 which has a 0.2 g seismic activity.

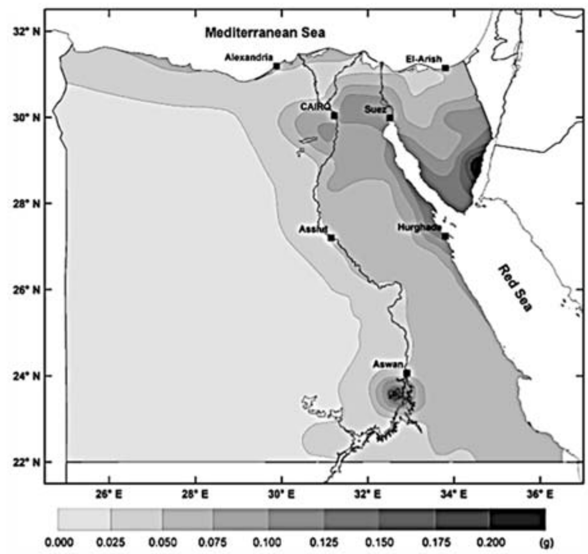


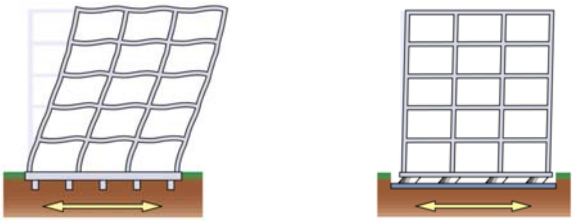
Fig. 6: Seismic Activity Zoning Map of Egypt, [12].

The previous part of research shows that Zafarana area is located in a high seismic hazard area and seismic hazard reduction should be considered in any structures especially NPP. Therefore, new trends in engineering solutions for reduction of the risk from earthquake hazard have been investigated.

4.5. Proposed Solution for Reducing the Risk from Seismic Hazard on NPP in Zafarana

Nuclear power plants should operate safely during normal operation and maintain core-cooling capabilities during off-normal events, including external hazards (such as flooding and earthquakes). Management of external hazards to acceptable levels of risk is critical to maintaining nuclear facility and nuclear power plant safety.
Seismic isolation (SI) is one protective measure showing promise to minimize seismic risk. Current SI designs (used in commercial industry) reduce horizontal earthquake loads and protect critical infrastructure from the potentially destructive effects of large earthquakes. Seismic Isolation (SI) is gaining importance in the nuclear arena, especially after the Fukushima accident in 2011, which made the nuclear community even more aware that it must design and construct structures capable of withstanding large earthquakes, [13].
Base seismic isolation has been implemented in many civil structures, including buildings, bridges, liquid natural gas tanks, and off shore oil platforms, both in the United States and other countries, to mitigate the damaging effects of earthquakes. Seismic isolation has also been implemented in

nuclear structures and to date, there are 6 nuclear power plants utilizing base isolation, all in France or South Africa, [14]. Figure (7) shows comparison of conventional and Base-Isolated structures showing laterally flexible layer between structure and foundation.



Conventional Structure Base-Isolated Structure

Fig.7: Comparison of Conventional and Base-Isolated Structures showing Laterally Flexible Layer between Structure and Foundation, [15].

SI has the potential to reduce horizontal earthquake loads for nuclear structures, systems, and components (SSCs). A substantial reduction in horizontal earthquake loading has the potential to increase the safety of nuclear SSCs by managing the risk associated with large seismic events. Installing horizontally flexible and vertically stiff seismic isolators between the superstructure and its foundation typically achieve isolation. Isolators serve two key functions: supporting gravity loads, and protecting the supported structure and its systems and components from the damaging effects of horizontal earthquake ground motion. Figure (8) shows the seismic isolators, [13].

Fig.8 Seismic Isolators (left) Lead-Rubber Bearing and (right) Friction Pendulum Bearing, [13].

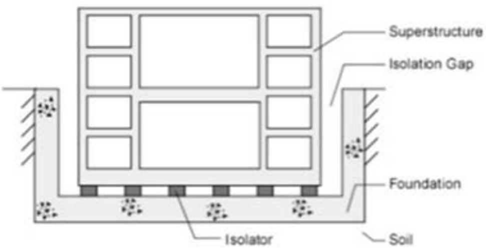


Fig.9: Components of a Base Seismic Isolated Structure, [16].

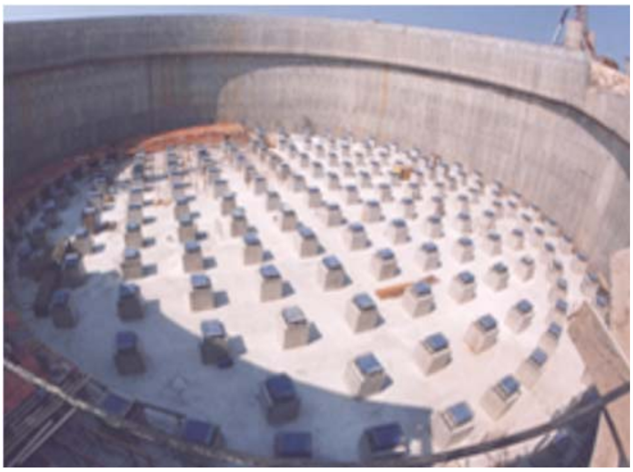


Fig.10: Overview of Seismic Isolators of NPP Structure, [17].

4.5.1. Cost Implications and Benefits of Seismic Isolation in NPP

The cost of constructing safety-related nuclear structures is driven in significant part by considerations of the effects of earthquake shaking, especially in nuclear power plants. According to Huang et al. (2008), it is demonstrated that seismic isolators can have a 70% reduction in seismic demands in secondary systems and a seismic risk reduction of about three orders of magnitude in a nuclear power plant structure due to the addition of an isolation system. In the nuclear power plant industry, seismic isolation could permit reactor designs certified for regions of low to moderate seismic hazard to be constructed in regions of high seismic hazard with minimal design modifications. Much of the re-licensing process and the additional seismic qualification for a site of higher seismic hazard would be avoided, which in turn would lead to significant reductions in cost and time, [17].

A study by Stevenson (1981) calculated the incremental cost for increasing the seismic capacity of a sample 1100 to 1300 MW nuclear power plant, from zero to a safe shutdown earthquake (SSE) peak ground acceleration (PGA) of between 0.2g and 0.65g. The study concluded that the cost increase for seismic design ranges from about 2% at a PGA of 0.1g to about 9% at a PGA of 0.65g, [18].

A new study was published in 2017 for assessing the benefits of seismic isolation on a Generic Department of Energy Nuclear Facility (GDNF). The study has been performed for three case studies: the DOE site at Idaho National Laboratory (INL) which was chosen for the site of low to moderate seismic hazard (Case 1) and constructed on a conventional (non-isolated) foundation. The Los Alamos National Laboratory (LANL) which was chosen to represent the site of high seismic hazard site (Cases 2) and constructed on a conventional foundation and (Case 3) also in LANL as Case 2, but seismically isolated, [19].

The study concluded that the implementation of seismic isolation in the GDNF reduces the total construction cost for design peak horizontal acceleration greater than approximately 0.2 g. The percentage reduction in cost associated with the use of isolation increases beyond this threshold value and could be very significant for sites with moderate to high seismic hazard. The study has shown that isolated foundations could be used to simultaneously increase safety and reduce construction cost. Fragility and construction cost data for modern SSCs would enable more accurate estimates of the benefits to be made. Also a reduction in capital cost would result at sites with moderate to high seismic hazard, [19].

Finally, it is noticed from the above research that using seismic isolator in NPP has a proven engineering solution for high seismic hazard area and it will not have any cost implications, so, it is feasible to introduce this solution for the NPP which can be constructed in Zafarana and make the site as one of the accepted potential site for hybrid wind and nuclear power plant.

4.6. Proposed Location of the NPP in Zafarana Site

As the site of Zafarana was allocated for wind farm, so it is give a good opportunity to allocate the NPP in the same site. According to the prevailing wind NW direction and existing rows of wind mills in the site, the south eastern part is good location for installing the NPP. Figure (11) shows the proposed location to integrate the nuclear power plant in the wind farm site of Zafarana.

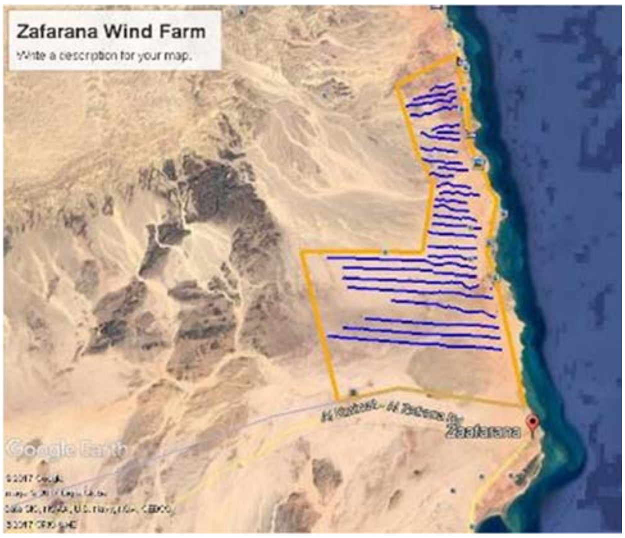


Fig.11: Proposed Location of NPP in Zafarana Wind Farm

5. Conclusion

The paper assessed and evaluated the siting considerations of wind and nuclear power plants. Then, a preliminary evaluation of the Zafarana site for constructing a NPP at the same site was made and it shows that no rejection criteria can be applicable. It was found that the site is located in a high seismic area and it needs engineering measures to reduce the risk effect of this hazard.

The seismic isolator system was studied and it is concluded that this technique are constructed in 6 NPP's and can be introduced as engineering solution for the NPP in moderate and high seismic areas and can make the site of Zafarana as one of the accepted potential site for hybrid wind and nuclear power plants.

Different studies and investigation were done for siting wind farm in Zafarana and these studies can be used a supplementary studies for the detailed investigation of the site for installing the NPP if the proposal is accepted.

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