Design and Flood Control Assessment of 5MWp Fishing and Photovoltaic Power Project in Xinghua City

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Abstract: In order to reduce coal consumption in Jiangsu Province and develop new energy sources, considering on the distribution of geology, solar energy resources, traffic and grid connection in Xinghua City, the aim is to determine the configuration of photovoltaic modules and photovoltaic array tracking mode, design photovoltaic array and layout scheme. But the project is a wading project, it is built in Dong Tan Lake polder I115, it needs scientific and reasonable evaluation to the effect of Dong Tan Lake’s flood storage and discharge. The results can provide guidance for similar engineering’s design.

1. Introduction
"Power generation is mostly based on coal" is a distinctive feature of energy consumption in Jiangsu province. Latest data show: in the province's total energy consumption, coal is accounted for 67%, 60% of which is for power generation, the power industry has become the focus of air pollution’s prevention and control. Solar photovoltaic power generation has the advantages of sufficient cleanliness, absolute safety, relative universality and potential economy[1], it can solve the problem of air pollution better. This paper fully bases on more fish pond advantages of Xinghua City, designs "fishing and photovoltaic grid connected power generation project" (hereinafter referred to as project), it does not occupy farmland and affect fish ponds to raise fish. Because the project’s area is located in Dong Tan Lake I115, in order to ensure the safety of project itself and regional flood, this paper analyzes the influence of Lake flood control after the completion of project, calculates the safety of flood control’s design, demonstrates its feasibility, and forms a comprehensive evaluation of flood control’s impact. At the same time, prevention and remedial measures are proposed for possible project’s impact on flood control and flood control’s impact on project[2], the aim is to provide a scientific basis for similar engineering’s design.

2. Project’s Overview
2.1. Project’s location and geology
"5MWp Fishing and Photovoltaic Power Generation Project ” is located in the western suburbs of Xinghua City, near Zhu Dang Town. According to the engineering geological survey and exploration results, PV site area is within the prospecting depth of quaternary deposits, top to bottom of strata from provided with soil layer, silty and clay layer, clay layer, silt and clay layer, silt and soil layer.
2.2. Project’s design

(1) Design’s scale and grade

This project’s installed capacity is 5MWp, it will be expanded to 50MWp in the future, located in the protected scope of Dong Tan Lake, the total area is about 0.127km², fish ponds account for about 95.3% of total area (0.121 km²). Land area is about 6160 m², it is concentrated in the east of fish ponds. The PV module and the inverter boost platform are distributed in the fish ponds, 10KV switch station and SVG room are distributed on the land which is on the east side of fish ponds. The seismic fortification category of the main buildings and structures in project’s area is c-class, and the designed safety standard is a secondary grade.

(2) Design’s content

This project has capacity of 5MWp and grid connected photovoltaic power generation system, block power generation and centralized grid connection scheme are adopted. The system is divided into 5 sub squares, each sub square is consists of 1MWp, and the sub square adopts a centralized inverter[3]. Each 500kWp photovoltaic component, the confluence device and one 500kW inverters constitute one photovoltaic generating units. Each photovoltaic unit converts the direct current into a low-voltage alternating current through an inverter. The two photovoltaic units are fed by one 1000kVA double split winding step-up substation to boost the AC to 10kV. Photovoltaic components use 310Wp polysilicon dual glass battery components[4], use fish ponds in Xinghua to construct photovoltaic power plants. The number of total installed components is 16400. The bracket of photovoltaic component is installed by fixed type, and the dip angle of component bracket is 25°. Each PV supported unit is consisted of twenty 1968mm * 992mm polysilicon components. The PV modules are arranged in 2 rows and 20 columns, the distance of component before and after the column is 4.5m. 3280 prestressed concrete pipe piles shall be adopted for the foundation of the support. The minimum elevation of the bottom edge of the PV module is 3.85m(Wasted Yellow River Elevation, below is the same).

Three inverter step-up equipment’s supported platform size is 11m*6m, each platform is supported by 6 pipe, pile’s length is 12m, platform’s elevation is 4.2m.

One 10KV switch station’s length is 20.9m and width is 16.1 m, total construction area is 336.49m², it is supported by square piles, and the platform’s elevation is 4.8m.

One container type SVG room’s supported platform adopts 6 prefabricated piles, the pile’s length is 8m, the elevation is 4.2m.

3. Comprehensive evaluation of flood control about project

3.1. The checked calculation of flood control’s safety

The designed water level at different recurrence periods during 1952-2011 years at Xinghua station was calculated by Pearson III type frequency[5] (See Figure 1).
Figure 1. Annual maximum water level P- III frequency curve of Xinghua station

As you can see from figure 1, once-in-a-fifty-years flood level of Xinghua is 3.25 m, once-in-a-hundred-years flood level of Xinghua is 3.44 m. The highest historical water level in Xinghua’s inner river planning is 3.35m. In order to ensure safety of the project itself, according to the designed specification of photovoltaic power station, the project’s checked safety water level is sum of Dong Tan Lake’s historical highest flood water level and 0.5 meter freeboard[6], it is 3.85m altogether.

The minimum elevation of bottom edge of PV module in project is 3.85m, three inverter boost equipment platform’s elevation is 4.2m, one container type SVG room equipment platform’s elevation is 4.2m, one switch station platform’s elevation is 4.8m, they can meet the checked safety water level’s requirement.

3.2. The influence of project’s occupancy on flood storage capacity
Dong Tan Lake’s effective storage capacity is nearly 18 million 434 thousand m³, I115 polder’s effective storage capacity is nearly 2 million 547 thousand m³. This project takes I115 polder’s effective storage capacity is about 7/10000 , it takes Dong Tan Lake’s effective storage capacity is about 1/10000. So this project has very little influence on the storage capacity of Dongtan Lake, it uses west side’s fish pond to carry on storage capacity’s compensation, it will not have an impact on Dong Tan Lake’s flood control.

3.3. The influence of project’s occupancy on lake’s area
The protected area of Dongtan lake is 8.778 km², I115 polder’s area is about 1.213 km². The actual storage area of the project is 237.4m², this project takes I115 polder’s area is about 2/10000 , it takes Dong Tan Lake’s area is about 3/100000. The project takes up little storage area, it uses west side’s fish pond to carry on storage area’s compensation, it has little influence on the protected area of Dongtan Lake.

3.4. Analysis of project’s influence on running water channel
This project is located in I115 polder of Dong Tan Lake’s protected area, it is situated on the west side of the XiaGuan river at the first class channel, it is also situated on east side of HengJing river at the second class channel. The project implementation’s area and the three rivers are not directly interlinked, does not occupy the water channel, so there is no impact on running water channel.

3.5. Analysis of project’s influence on lake’s water environment
Photovoltaic power generation is a kind of clean energy. It does not directly consume resources and release pollutants, it also will not produce greenhouse gases and destroy the atmospheric environment[7]. The main pollution currently considered is light pollution, solid waste pollution and so on.

The project’s location is around basically no large-scale centralized residential area, so the light pollution has little effect on the surrounding, its operation and maintenance is by professional persons who has excellent professional and technical level, removed components is recycled by manufacturers.

This project does not change the basic status of fish ponds, so this project has no influence on the water environment of lake.

3.6. Project’s Analysis of third legitimate rights and interests
The project is far from surrounding fairway and is not connected to the channel, it has no effect on the channel. There is no drinking water intake in the site area.

The project is fishing and photovoltaic power generation project. The photovoltaic support is set up in fish ponds, but fish ponds have not been changed. PV panels will block the sun, so the fish species will change, mainly raise some fish with high economic value, such as shade, tiger shark, catfish, it will greatly improve the breeding efficiency than before. So it has no influence on fish-pond culture.

4. Conclusions and Suggestions
(1) Photovoltaic power generation projects in the feasibility study stage is not only to consider the local geology, solar energy resources and other factors, but also consider the project’s area which is in lake’s area or not, it will be better to avoid the lake’s protected range.

(2) When photovoltaic power generation project is in lake’s protected range, designers should fully consider related water conservancy planning, lake water environment’s impact, third people’s legitimate rights and interests, flood’s and project’s safety impact. The designed plan shall be subjected to approval of the relevant water administrative department.

(3) When lake’s flood area and storage capacity is occupied by photovoltaic power generation project, designers should put forward a reasonable replacement scheme to ensure that lake's flood control area and storage capacity are not reduced.

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References:
[1] YT Tan, DS Kirschen 2007. Impact on the Power System of a Large Penetration of Photovoltaic Generation. Power Engineering Society General Meeting. 1-8.
[2] B.K. Mishra, K. Takara 2009. Hydrologic Simulation-aided Regional Flood Frequency Analysis of Nepalese River Basins. Journal of Flood Risk Management. 2 243-253.
[3] S Jain, V Agarwal2007. Comparison of the performance of maximum power point tracking schemes applied to single-stage grid-connected photovoltaic systems. Let Electric Power Applications. 1 753-762.
[4] SB Kjaer, JK Pedersen 2005. Review of single-phase grid-connected inverters for photovoltaic modules. IEEE Transactions on Industry Applications. 41 1292-1306.
[5] G Tasker, JRM Hosking 1998. Regional Frequency Analysis: An Approach Based on L-Moments. Journal of the American Statistical Association. 93 1233.
[6] Xu C Y, Singh V P2005. Evaluation of three Complementary Relationship Evapotranspiration Models by Water Balance Approach to Estimate Actual Regional Evapotranspiration in Different Climatic Regions. Journal of Hydrology. 308 105-121.
[7] T Esram, PL Chapman. 2007. Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques. *IEEE Transactions on Energy Conversion*. 22 439-449.