<u>TITLE:</u> Elion "Three-in-One" Photovoltaic Sand-Fixing in Kubuqi Desert, Ordos City


<u>ISSUE AREAS</u>

☒ **ICT and SMART technology** ☐ Sustainable mobility ☒ **Land use and nature-based solutions**
☒ **Clean energy** ☐ Sustainable solid waste management ☐ Building energy efficiency
☐ Innovative urban governance ☐ Low carbon consumption

<u>OVERVIEW</u>

The Elion "Three-in-One" model of photovoltaic energy generation comprises, namely, three parts: 1) on the solar panels, it generates photovoltaic energy, 2) under the panels, it fosters sand-fixing plants, and 3) between the panels, it promotes livestock and poultry breeding. This model combines low-carbon development and resilience building as well as disaster risk reduction. Up to 2020, the model has become a 710MWp grid-connected PV power station, upgraded resilience by sand control and management, and benefited local residents financially and ecologically.

<u>THE CHALLENGE - WHY HAS THE CITY TAKEN ACTION</u>

Land degradation and desertification lead to infertile soil and frequent sandstorms, which threatens the life and livelihood of people in Ordos. The Kubuqi Desert extends 400 km from west to east and 50 km from north to south. Moving dunes account for 61 per cent of its area. The surface is covered by loose sand and more than 81 per cent of the surface sand particles are graded as fine sand. Land degradation brought by grazing had denuded the land of vegetation, and along with the low precipitation (average annual 280 mm) and its 2,630 mm annual water pan evaporation, the wind leads to frequent gales (24.6 days per year on average) in the spring. Sandstorms occur on an average of 13.2 days per year.

With the carbon neutrality pressure from the national design, local government and the private sector seek to transform this fossil fuel-reliant city into a clean energy model. Ordos is abundant in coal resources, and the estimated reserves account for two thirds of Inner Mongolia and one sixth of China. However, Ordos is faced with the imperative to accelerate energy transition from fossil fuels to renewables as China speeds up its national progress in carbon peak and neutrality agenda. Both governments and private sector, therefore, have realised that researching and developing renewable energies would fundamentally change Ordos's energy structure and help to contribute its efforts in China's sustainable development roadmap.

Kubuqi and Inner Mongolian desertification deteriorates climatic conditions for other related or surrounding localities. The environmental change of Kubuqi not only exerts negative impacts on the Ordos city per se, but it also worsens adverse conditions for the surrounding areas such as the Yellow River and Jing-Jin-Ji Area. Kubuqi is located in the south of the Great Bend of the Yellow River, and the sandstorms as well as the incremental soil erosion cause serious silting in the river. In addition to that, as suggested by

China's meteorological authority that the sandstorms in Inner Mongolia would also influence the capital area, bringing the dust to its 800 km-away neighbours.

GOALS AND OBJECTIVES

- Through sand fixing and management to reduce the threat of natural disasters and to improve the land quality.
- Through photovoltaic power to contribute to the low-carbon development of the City of Ordos, reducing the GHG emissions.
- Through PV industry to promote the economic development and to facilitate green poverty alleviation.

HOW DID STI PROVIDE A LOW CARBON AND CLIMATE RESILIENT SOLUTION?

(STI as a means of implementation)
☐ Improved decision making ☐ Offering a low-cost solution ☒ **Inclusive decision making**
☒ **Improved governance** ☐ Behavioural change

(STI as a direct technical solution)
☒ **Cleaner/more eco-friendly infrastructure** ☐ Cleaner/more eco-friendly equipment
☐ Faster/better/larger data availability/processing

- How was it innovative? (What enabling policies were employed? What were the local/national governments policy targets, goals and strategies? Were new S&T approaches developed or existing S&T approaches enhanced? Was the cities geography/culture capitalised upon?)

  Framework Policies: in 2006, China passed its legislation to promote renewable energy development, defining government bodies' responsibilities in strategy formulation, technical guidance, subsidization, and incentive mechanism. In 2017, China issued its 13th Five-Year Plan for Energy Development, and highlighted that government would support the moderate expansion of wind and solar energy, aiming to make renewable electricity generation installed capacity account for 39% of the total capacity by 2020.

  National and Local Subsidy Policies: from 2006 to 2021, Chinese central government has allocated more than ¥600 billion to electricity generated from renewables, including photovoltaics. In 2016, the national fiscal budget underscored that the subsidization mechanism to renewable electricity should be further improved. From a local lens, the subsidization in Inner Mongolia would continue even with the national-level lift of subsidy, announced in early 2021. Besides, the government also exempted Elion's income taxes in photovoltaics development in the first three years.

  Innovative Synergy Creation: the core of this model is the synergies created on/under/between the panels. It is innovative in a sense that it combines low-carbon development with resilience building and poverty alleviation, with the help of other smart technologies in its operation.

  Enhanced Scientific Approaches: plant selection is a science-based process which has been enhanced in the application of Elion's three-in-one model, specifically, in the sand-fixing planting under the panels. Details are shared in the next column.

New S&T Approaches: the first 710 MWp PV electricity project involves IoT technologies, cloud data management, and artificial intelligence technologies. It also engages the application of robot cleaning and drone inspection in its operation.

- What science and technologies were used? (What does it do? How does it work? How does it address the challenge?)

  Internet of Things: IoT technologies in this model are designed to gather real-time operation information, to monitor geographic and climatic conditions, and to facilitate the Smart PV Irrigation and Fertilization System with solar power automated water pump and water-fertilizer integrated technology. For the information collection part, IoT technology is manifested by different types of sensors built by or in the photovoltaics components and modules. For the irrigation system, it operates by the electricity generated from the system itself and decides to conduct drip irrigation based on the collected information and statistics about the soil humidity and moisture. Also, by this technology, the model's three parts have higher interconnectivity.

  Cloud Data Management: based on the IoT technology application, Elion group developed a cloud data management system specifically for the operation of the PV station. The system monitors and analyses the information that sensors have collected so that the personnel and designated team are well informed about the situation and condition for the station remotely. The cloud system is also connected via mobile terminals, and operation team could control the system or get warnings from the site through the APP installed in their smart phones.

  Artificial Intelligence: building on the foundation of the IoT and Cloud technologies, the model can also help maximize the irradiation, monitor and maintain operations, and to assist drone inspection as well as robot cleaning. Based on the cloud system analysis with IoT collected information about the landscape, climatic conditions, and irradiation, the AI centre could adjust the angle of the panels to minimize the inter-array shadows and to maximize the irradiated areas. Also, the AI processed information could facilitate the robot cleaning and drone inspection process to reduce laborious manual work.

  Plant Selection: the main type of plant in this model bred under the panels is liquorice, a local drought-resistant medicinal plant. The planting itself can stabilize the sand; the superterranean parts could be used to feed the poultry and cattle; and the rhizome parts are of pharmaceutical values.

KEY AREAS OF CONSTRAINT/SUPPORT

- INFRASTRUCTURE REQUIREMENT

  The photovoltaics power station is easy to be established in a technical sense. Construction duration, regardless of planning, procurement, and financing, is usually around three months. No specific infrastructure is required except for an established power grid for electricity connection later.

- POLICIES AND REGULATIONS

National and local promotive policies have been demonstrated above. In general, there are three types of policies and regulations:

- Overall legal or policy framework for photovoltaics development and promotion
- Subsidization mechanism to the photovoltaic electricity in early stage when cost keeps high
- Taxation policy for exemption or reduction in the first 6 years in China

❖ THE SCALE OF THE PROGRAMME/PROJECT

70,000 mu (about 47 square kilometres) in terms of area

❖ TECHNOLOGY CAPACITY

Photovoltaics storage technologies are not well developed yet, so the electricity from solar power should be connected to the grid as soon as it is generated from the power station.

❖ FINANCE

Specific financing and investment model in this project is PPP, while the main financing approach in the Elion model is private sector investment with commercial bank loans.

Phase One	2015-2016	¥1.6 billion RMB (about $248 million USD)
Phase Two	2016-2018	N/A
Phase Three	2018-2019	N/A
In Total	2015-2019	¥5 billion RMB (about $775 million USD)

❖ HUMAN RESOURCE CAPACITY

Local residents have been trained to be the manual maintenance and operation personnel, which also increases employment opportunities.

❖ POLITICAL COMMITMENT

Strong political will in every level of government is necessary and fundamental to the development and deployment of photovoltaics industries. Most countries, including China and Mongolia, have shown firm political commitment in developing renewables.

❖ KEY BENEFICIARIES

- Businesses who own the operations and invest the power stations
- Residents who rent out the wasteland or work for the site
- Local governments with GHG emissions targets

IMPACTS

❖ CARBON REDUCTIONS

According to Elion Group's published documents and reports by Ordos and Inner Mongolia governments, the area of sand control in Kubuqi by Elion "Three-in-One" Model is about 47 square kilometres, and the annual power generation is 1.25 billion kWh, with 3 billion kWh cumulative power

generation. It can save about 720,000 tons of standard coal, about 1.89 million tons of CO2, about 60,000 tons of SO2, about 30,000 tons of nitrogen oxides (NOX), and about 490,000 tons of dust every year.

❖ CO-BENEFITS

Ecological Restoration: Up to now, Elion's "Three-in-One" photovoltaic model has achieved 70,000 mu (about 47 square kilometres) of sand control. For the Kubuqi Desert, photovoltaic panels can shade the wind, reducing the evaporation by 800mm/year and the wind speed by 1.5m/s. Licorice, pasture and ground-cover plants are bred under and between the panels, using water-saving technologies such as drip irrigation and infiltration irrigation, which could save groundwater resources to the greatest extent. Compared with conventional desert planting and irrigation models, it can save water by more than 90% and increase the survival rate of planting by more than 30%. Together with Elion's other demonstration projects in Kubuqi, over 10 million tonnes of sand per year have been stopped from flowing into the Yellow River. Also, the plants serve as a shelter to reduce the frequencies of sandstorms to Jing-Jin-Ji Area.

Poverty Alleviation: the poverty alleviation was realised through two means. First, the power station construction land is rented out of unused wasteland by local farmers and herdsmen, which has increased the income. Second, the model trained farmers and herdsmen to participate in the operation of the power station. So far, the project has helped 57 poor households get rid of extreme poverty and increase their income by planting and breeding. The average household can increase income by ¥32,000 RMB (about $5,000 USD). In 2017, the project created a total of more than 1,700 employment opportunities, benefiting more than 10,000 farmers and herdsmen. It increased the income of farmers and herdsmen by ¥29.45 million RMB (about $456,744 USD).

TIMELINE

- Phase One: 2015-2016, 310 MWp
- Phase Two: 2016-2018, 200 MWp
- Phase Three: 2018-2019, 200 MWp

FACTORS FOR SUCCESS

- Flexible and effective financing approach
- Supportive policies and regulations
- Advanced smart technologies

LESSONS LEARNED

- Opportunities, Challenges and Scaling Up
  - Opportunity: the decreasing cost of the photovoltaic modules and components provides further ground for the expansion of the PV electricity power station application.
  - Challenge: the technologies in photovoltaic power storage remains to be improved, so that the grid-connection of PV electricity is still limited in certain period of time of a day, and may be influenced by natural and climatic reasons.

- Sustainability

  The major part of the ensuing cost after the construction comes from the operation maintenance and equipment depreciation as well as damage.

- Transferability

  The main issue in its transferability is the financing and investment approach. Elion itself has been involving in Kubuqi ecological restoration for more than three decades and it also provides the funding for the "Three-in-One" photovoltaics project, while when the model is transferred, the local bodies should design its own context-specific financing approach. For other aspects, the project is very transferrable in a sense that the construction duration of the photovoltaics site is short, and electricity generation repays the investment fast. It is worthwhile to highlight that government policies to support the PV businesses play an important role especially in the first years of its operation.

- Efficiency / effectiveness

  N/A

- Institutional constraints / supports
  - Supports: subsidization and taxation policies; government's assistance in project operation and loan application; government's endorsement in all life cycle

FURTHER INFORMATION / CONTACT

Prof. Mantang Cai (mtcai@pku.edu.cn)
Mr. Yiran He (yiran.he@stu.pku.edu.cn)