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Original Article

Empowering Farmers socially, Economically, and Technically by Integrating Agriculture and Photovoltaics into PM KUSUM Scheme

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Abstract: *India is a developing country and so its economy and population are expanding rapidly. Due to this expansion, there is an increase in demand for food and electrical energy production. This results in a struggle for the land between food and energy production. To tackle the problem of Energy Production, the Government of India started a PM-KUSUM scheme in 2019. PM-KUSUM scheme can be integrated with Agrivoltaics (an approach combining Solar power energy generation and agriculture). This integrated approach is a promising solution to tackle this ongoing competition between food and energy production. The following research investigates the challenges and benefits of growing the Agrivoltaic approach. This research aims to empower farmers by making them self-sufficient and lead role players in India's sustainable development.*

Keywords: *Pm-Kusum, Agrivoltaics, Solar Energy, Sustainable Development.*

I. INTRODUCTION

The Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) Scheme is a government initiative in India to promote the use of Solar energy among farmers. About 60% of people in India depend upon agriculture, therefore PM-KUSUM has enormous potential to enhance farmers' income and provide energy security. The scheme focuses on installing Solar pumps, solarizing existing grid-connected agriculture pumps, and setting up Solar power plants on barren/fallow land. It aims to make agriculture more sustainable and reduce dependence on traditional energy sources.

The PM-KUSUM program has many obstacles, such as funding limitations, implementation difficulties, and getting farmers to use Solar-powered agricultural pumps. Other significant hurdles include resolving technological concerns and coordinating among stakeholders. On the other hand, the program's emphasis on providing farmers with Solar pump subsidies and encouraging the use of Solar energy in agriculture is essential to lowering operating costs and eventually raising total profitability. The program also promotes money production via the selling of excess Solar electricity to the grid, which adds to its sustainability and cost-effectiveness.

Simultaneously, the rise of agrivoltaics offers a novel method of combining agricultural practices with Solar energy production. Agrivoltaics maximizes land usage efficiency by producing renewable electricity and shading crops simultaneously. In addition to enhancing land productivity and environmental sustainability, this dual-use model supports sustainable farming methods and adds to a dual-purpose land utilization strategy. Agrivoltaics is also a solution for farmers to reduce their environmental effects.

India's agricultural sector will be developed sustainably if PM-KUSUM and agrivoltaics are integrated as they share the same objectives of empowering farmers and promoting the use of renewable energy. The combination of PM-KUSUM and agrivoltaics can boost India's transition to a more resilient, environmentally friendly, and economically successful agricultural future with steady policy backing and ongoing technology improvements.

II. PRADHAN MANTRI KISAN URJA SURAKSHA EVAM UTTHAAN MAHABHIYAN(PM-KUSUM)

The KUSUM scheme aims to reduce the dependency of the agricultural sector on diesel, providing energy and water security, it also provides an additional income source to the Indian farmers which allows them to be dependent on other sources rather than farming, and the scheme helps to deal with pollution caused in the agricultural sector. The Central Govt is also providing subsidies to promote the scheme and to achieve all its goals. There are three main components of the scheme:

A. COMPONENT A: Decentralized Grid-Connected Solar Power Plants

The aim is to set up 10,000 MW of Ground/Stilt Mounted Grid Connected systems that are decentralized, Solar, or other Renewable Energy Power Plants on farmers' land. Solar Energy Power Plant (SEPP) with a capacity ranging from 500W to 2KW decided to be established by various organizations such as Individual farmers, groups of farmers, panchayats, Farmer Producer Organisation (FPO), and Water User Associations (WUA) on barren/ fallow/marshy/ pasture or cultivable lands.

Under this component, the government has sanctioned around 4766 MW of Solar capacity power plants out of which they have installed a total of 143.33 MW in different states of India, Rajasthan with the highest installed Solar plants producing around 102.5 MW of Solar Energy.

B. COMPONENT B: Installation of Standalone Solar Powered Agriculture Pumps

This component helps to replace the existing diesel pumps of individual farmers with Solar pumps, this will not only reduce the irrigation costs of around Rs. 50,000/Yr. (for a 5HP pump) but will also reduce the pollution caused by the diesel pumps. This component will prove beneficial to around 20 lakh individual farmers in off-grid areas, where the source of electric energy is not available. The reduced cost of irrigation is indirectly helping to increase the income of farmers.

Under this component, the government has sanctioned around 1223721 Nos. Solar standalone pumps out of which the government has successfully installed 284607 Nos. Solar pumps to different states, Maharashtra with the highest number of Solar pumps which is around 76119 Nos.

C. COMPONENT C: Solarization of Agriculture Feeders

This component is responsible for the Solarization of 35 Lakh Grid-connected agricultural pumps including feeder-level Solarization.

a) Individual Pump Solarization (IPS)

This component gives the flexibility to Solarize the individual grid-connected Solar pumps up to the capacity of 7.5 HP. Also, Solar PV Capacity is up to twice of pump capacity in KW is granted under the scheme. The individual farmers can also sell the excess Solar energy to DISOMS at decided rates by the government.

So far, the government has sanctioned a total of 159286 Nos. Individual Solar pumps out of which they have installed about 1957 Solar pumps, Rajasthan with the highest number of installed pumps around 1375 among all the states.

b) Feeder Level Solarization (FLS)

The government can Solarize the agricultural feeders instead of Solarizing the individual pumps. The total number of sanctioned feeder-level Solar is 3312466 and about 3288 are installed with Kerala having the highest installation of about 2152 all over India. The PM-KUSUM Scheme set a goal to add about 34,800 MW of Solar capacity by March 2026 with the financial support of about Rs. 34,422 crores from the central government of India[1][2].

III. CENTRAL FINANCIAL ASSISTANCE (CFA)

A. Component A

The government is incentivizing DISCOMs with a 40 paise/kWh incentive or Rs. 6.6 lakh per MW of capacity installed for 5 years serves as a compelling motivator to DISCOMs to buy solar power from farmers/developers.

B. Component B&C

The Central Financial Assistance (CFA) covers up to 30% of the benchmark cost, as annually stipulated by the Ministry of New and Renewable Energy (MNRE)—another subsidy of 30% after CFA by the respective state governments.

Farmers have to contribute 40% of the total cost, with an option to apply for a bank loan over 30% of their contribution. So initially, farmers have to pay just 10% of the overall pump cost[3][4].

IV. CHALLENGES

A. Land Availability and Aggregation

There is a challenge in acquiring suitable land for solar power plants and also aggregating smaller lands to install a massive renewable energy plant. The problems they face like dealing with different landowners, and laws, and making sure communities are okay with it. Also, it’s harder to gather smaller pieces of land in one place for solar plants.

B. Geographical Variation

Varying solar radiation at different geographical locations has an impact on the efficiency of solar power production.

C. Grid Infrastructures

In certain regions of the country, the grid infrastructures are not in a healthy condition which makes them unreliable or weak for integration with solar power.

D. Poor Water Regulation

The sustainability of groundwater resources is directly impacted by the adoption of solar energy. The absence of adequate water regulation policies is impacting sustainability[5].

V. EXPECTED OUTCOMES

A. Reliable Daytime Power for Irrigation

Farmers mostly get electricity for irrigation at night which causes inconvenience for the farmers to irrigate the field and also leads to wastage of water as they leave the pump running for the whole night. KUSUM scheme gives solar panels for irrigation which provides sufficient power during the daytime which not only makes irrigation easier but also saves water.

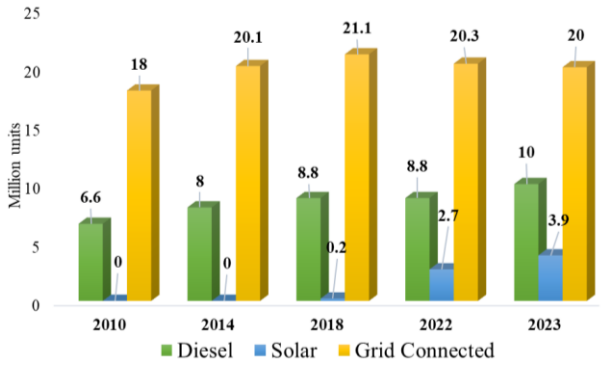
B. Strengthening Famers' Economically

Elevating farmers' income by replacing high-cost diesel with cheaper solar energy under component B and allowing farmers to sell surplus solar power to DISCOMs at some fixed rate under component

C. Reducing Dependency on Diesel

Replacing diesel pumps with solar pumps reduces the dependency on diesel, and makes irrigation cheaper and more reliable for farmers by cutting the cost of diesel.

Figure 1 : Agricultural Irrigation Pumps List Yearly.

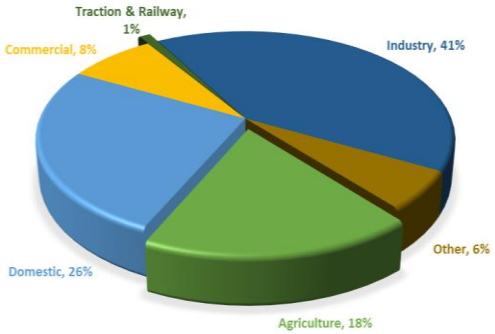


Source: Estimated stock of agricultural irrigation pumps in India, 2010-2022 – Charts – Data & Statistics - IEA

D. Reducing Subsidy Burden on States and Financially Backing DISCOMs'

The annual electricity consumption of the agricultural sector is about 18% of the total electricity consumption nationwide.

Figure 2 : Consumption of Electricity by Sectors in India During 2021-22



Source : EnergyStatisticsIndia2023.pdf(mospi.gov.i)

DISCOMs allocate around Rs. One lakh crore in electricity subsidies to the agricultural sector every year, sourced from the state's fund. Subsidized electricity has emerged as a significant challenge for DISCOMs financial health. PM-KUSUM scheme alleviates the issue by reducing the subsidy burden on states for electricity supply to agriculture. The yearly subsidy provided by states can be used to settle the loan within 5 to 6 years of span, following which solar energy will be available at no cost to the farmers, and the expenditure of the state's fund on electricity subsidy will come to an end. It also reduces the transmission loss of DISCOMs which will help them in enhancing their financial health.

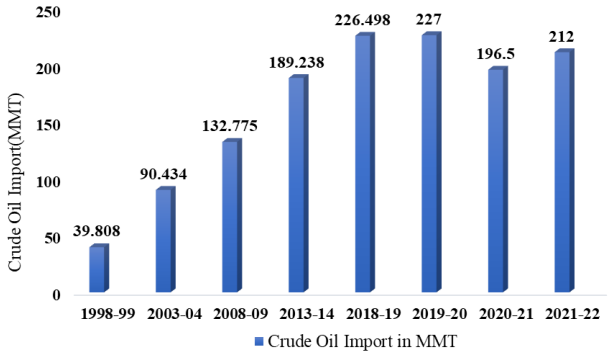
E. Reducing Climate Change

The use of diesel pumps for irrigation increases carbon emissions. According to MNRE, around 80 lakh pumps installed in India are diesel pumps out of approx. 3 crore pumps and their yearly diesel consumption is 5.52 billion liters which is equivalent to CO_2 emission of around 15.4 million tonnes. PM KUSUM if implemented fully will be able to reduce carbon emissions by 32 million tonnes yearly and will give a pollution-free environment to farmers for work.

F. Cutting The Import Bill

Petroleum import bill of India is so large and increasing day by day :

Figure 3:Crude Oil Import In India Yearly.



Source : doc202242548601.pdf (pib.gov.in)

G. Elevating Domestic Solar Manufacturing

The KUSUM scheme mandates the use of domestically produced solar panels and modules for standalone solar pumps which will boost India's solar manufacturing market by creating more demand [6].

VI. WHAT IS AGRIVOLTAICS?

Agrivoltaics is a process by which we can use land for both crop cultivation and energy production by using mounted or grounded solar photovoltaic cells allowing us to grow crops under them.

Figure 4 : Agrivoltaic System

Source : Dayalbagh Educational Institute solar farm[7].

VII. NEED OF AGRIVOLTAICS

A. Overcoming Land Utilization Issues:

The land is a major resource for both food and solar energy production, both need a large area of land to fulfill the demand of the country. In comparison, PM KUSUM sees it as a challenge that can be solved by introducing an Agrivoltaic system into the scheme. Integrating this approach of food and energy production into the existing scheme which is more focused on renewable energy production can mitigate the problem of land utilization and make it a sustainable approach to using land resources.

B. Increasing Agricultural Productivity

The first crop has to be produced on fertile land as per the correct criteria.According to the minimum shading effect on APV, crops like leafy vegetables, lettuce, cabbage, tomato, chili, tea, etc. can be produced successfully.There is no effect of shading on the APV DEI model. Organic farming is being done on fertile land. The yield is very good.Work can be easily done under the APV solar plant with agricultural equipment.At present, tomatoes, brinjal, and cabbage are being grown on the DEI model and vegetables are being produced in large quantities.

C. Meeting Energy demands sustainably

In the DEI model, a 200 kW solar plant is installed at a height of 06 meters on 1.5 acres of fertile land.The electricity generated from the said solar plant is being used successfully in schools, colleges, universities, residential colonies, dairy, EV charging, irrigation agricultural drying, and harvesting, etc.This model is installed nearthe load center.Both electricity generation and crop production are done perfectly on cultivated land.Extra electricity issold to the concerned Distribution Company earning additional income.APV is an innovative technical model.APV will provide economic and social strength to farmers in the future.

D. Promoting Sustainable Development

Solar Energy is the third crop for farmers which helps in rural development.When the farmer will have energy available along with the crop on fertile land.Farmers can use solar energy commercially as a **"Vocal for Local".**For example, if the raw crop of chili remains cheap. If solar energy is available, a group of farmers can sell chilipickles and red chili powder in the market through the necessary machinery**.**Farmers' income, self-employment, and market value will increase through solar energy**.**Due to this the economic and social level of farmers will also increase.Solar energy makes a valuable contribution to the sustainable development of the nation.

E. Mission of APV integrating into PM KUSUM

Ground-mounted solar plants are being established on barren land under PM Kusum Yojana. Due to which the said land is being locked for 25 years, the rates of the said land will also become very high.A lot of electrical equipment and long lines are required to bring the generation to the load center, which costs a lot of money.There is a strong need to include APV under PM Kusum Yojana Component A.So that farmers can produce crops on fertile land as well as produce solar energy.Now the time has come that the Government of India should include APV in PM Kusum Yojana to provide technical, economic, social, self-employment, and clean environment to the farmers.The stronger the farmers are, the stronger India will be.Under APV, farmers should also be given the freedom to make commercial applications.Presently, the subsidy is being provided for solar rooftops on residential premises under PM Surya Ghar Yojana.A similar scheme needs to be launched by the government for farmers to install APVs above 20 KW.

F. Vision of APV integrating into PM KUSUM

India is a developing country where the energy demand is increasing every day. A large proportion of the population is dependent on agriculture.Farmers are only producing crops on fertile land.Farmersdo not want to give their land on lease for years.If the ownership of APV is kept in the hands of the farmer by giving publicity and explaining the benefits of APV. The farmer will install APV for additional income.There is a great need to connect APV with PM Kusum for rural development and empowerment.Like the policies in other countries like Japan, New Zealand, America, and South Africa, it is necessary to have an APV policy for sustainable development in India[8].

VIII. CONCLUSION

Effective steps have been taken by the Government of India to make farmers self-reliant through PM Kusum Yojana.Through this scheme, farmers are to be provided the right direction in the fields of irrigation and energy.At present there is a provision to install solar plants on barren land.A lot of expenditure is being incurred in bringing the power generation to the

load center and the price of land is also increasing in the future.In view of the increasing demand for energy and need for food, it is very important to do both works simultaneously on fertile land.To make the above research more effective, the following points are to be studied and analyzed according to the DEI APV model.

- Study of APV policy in India & Abroad.
- Study of various APVs in India.
- Techno-Economic analysis of APV
- Farmers – social acceptance & rural development.
- Improvement in the financial condition of Discoms through the PM KUSUM Scheme.
- APV policy recommendation of India.

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