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Energising Agriculture Through Sun in Bihar

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Centre for Environment and Energy Development (CEED)

December 2019

Acknowledgement

The report commissioned by CEED and prepared by KPMG

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The initiative is supported by

Shakti Sustainable Energy Foundation (SSEF)

Shakti Sustainable Energy Foundation (SSEF) works to strengthen the energy security of India by aid-ing the design and implementation of policies that support renewable energy, energy efficiency and sustainable transport solutions.

Executive Summary

The recent growth trajectory of Bihar has strongly placed her as one of the fastest growing state economies on India's roadmap of development; however, for years the state has also witnessed mounting rise in energy and electricity demand which is expected to continue in the foreseeable future. Bihar faces the herculean task of energizing the rural economy and uplifting millions of masses out of abject poverty and darkness. This poses a formidable challenge for the state to build energy infrastructure with robust planning followed by effective implementation with transforming schemes to keep pace with the ever-growing economic and societal changes. Although the reach and quality of electricity supply has improved in the last 4-5 years due to some effective and efficient government initiatives particularly the Deen Dayal Upadhyay Gram Jyoti Yozna (DDUGJY) and 'Subhagya' scheme, however the same has not yet reached its full potential in the agricultural sector (only 43% metered agriculture connections in electrified villages in 2017). As important preconditions of development, energy and agriculture are intertwined and are an important prerequisite to monitor growth trajectory in a state where a large segment of the population is dependent on agriculture and allied activities. The agriculture sector contributes 21% to Bihar's GDP with employing 80 percent workforce, whereas it consumes less than 2% of electricity consumption making it heavily under-utilized as well as a promising sector to put further emphasis upon.

Ramapati Kumar
CEO

Center For Environment and Energy Development (CEED);

As of 2017, there were only 43% metered agriculture connections in electrified villages.

This report, prepared conceptualized by CEED and prepared by KPMG, captures moments of success and pitfalls of the energy scenario in Bihar and clearly demarcates the transforming role of renewable energy in ensuring a holistic development pathway. As per baseline and optimistic estimations, this report suggests that electricity demand for irrigation purposes of Bihar is likely to grow at CAGR of 16-20% and for 'other agricultural activities' is likely to grow at a CAGR of 15% till the year 2032. This will indeed amplify several challenges and create a multitude of opportunities for a host of stakeholders located at different levels such as government agencies, DISCOMs, developers, social as well as private entrepreneurs and end-users alike. This calls for an energy transition roadmap across the value chain in the agriculture sector for revolutionizing the rural economy.

Electricity demand for irrigation purposes in Bihar is projected to grow at a CAGR of 16–20%, and for 'other agricultural activities' at a CAGR of 15% till the year 2032.

Some of the key aspects that this report highlights are as follows.

Transforming Energy Paradigm: Clean Energy for Greener Farms

Farm productivity for wheat and rice in Bihar is approximately at 30–40%, which is lower than the national average.

Although Bihar is endowed with one of the most fertile soils in the Indo-Gangetic region but it faces the problem of fluctuating agro output and low yield, e.g. farm productivity for main crops e.g. wheat and rice is at around 30-40%; that is lower than the national average. The main reason behind this under-achievement is lack of sustainable irrigation facilities due to low levels of credible electricity supply in the vicinity of a farmland. This forces farmers (around 91%) to depend largely on costly diesel pumps or tube wells (around 67%) for irrigation, which contributes to heavy carbon footprints in the atmosphere. Bihar has initiated several phases of 'agriculture roadmaps' to strengthen and increase productivity, farmer's income, and equitable agricultural growth with broader focus on irrigation and post harvest facilities. Recently Bihar Government has launched "Jal-Jeevan Hariyali Mission" that puts focus on renovating water bodies and irrigation structure in every village for meeting drinking water and agro needs with broader look on climate impacts. Since it strives to cash in on solar technologies thus solarization of agriculture is very much aligned with this remarkable and timely initiative. In fact the riddles of agriculture can be resolved by sustainable and clean energy transition, which on the one hand increases the irrigation facility through solar powered individual and community owned pump-sets, whereas on the other front decentralized applications of solar energy enabled micro grids (connected and off grid systems including standalone models, and with separate feeders) can boost a wide array of local enterprise activities while altering the age-old subsistence nature of Bihar's agriculture sector. Inclusiveness, sustainability and affordability have been hallmarks of cleaner energy paradigm and these tenets fit into the scheme of things in Bihar.

Jal-Jeevan Hariyali Mission has been launched by the Bihar Government to focus on renovating water bodies and irrigation structure in every village to meet drinking water and agro needs.

Solarization of Agriculture

Since much policy emphasis has been given to recalibrate the energy-mix favouring cleaner energy transition in India, solar is destined to play a big role and it has the ability to leapfrog the ailing rural economy of Bihar through sustained energy planning. It is a matter of huge concern that Bihar is hugely dependent on the central sector for the power requirements, which accounts for 87% of the total 4567 MW power installed capacity, therefore renewable energy sources are harnessed at a local level, through innovative and customized use, and can act as an exceptional alternative to overcome the current energy crisis.

For off-setting the catastrophic impacts of climate change and following the global shift towards the renewable energy (RE), India is committed to reduce its emissions intensity of GDP by 33-35% over year 2005 levels by the year 2030 and has therefore planned to increase the share of RE to 40% by the year 2030. Government of India has already planned to increase RE capacity of 175 GW by the year 2022. On the other hand, the total installed RE capacity in Bihar, as of March 2019, is just 326 MW which accounts for 7% out of the total installed capacity. However, the Renewable Purchase Obligation (RPO) target for Bihar set for the year 2021-22 is 17%, where 8% is for Solar and 9 % for non-solar. Given the huge scope of strengthening energy-agriculture nexus in Bihar, the vision for the year 2032 could be 50% of the electricity demand for irrigation and it can be met through distributed solar, which can materialize savings of INR 9,900 Cr. towards subsidy to agricultural consumers for the state exchequer.

India is committed to reducing its emissions intensity of GDP by 33-35% over year 2005 levels by the year 2030.

Reviving the Rural Economy with multitudes of RE options

The solar energy has huge potential in Bihar as the state is blessed with ideal sunny days and adequate solar radiations along with good ground water level of between 2-10 meters across all districts; therefore these natural attributes can leverage the accessibility and affordability of solar photovoltaic (SPV) system (80% reduction in its cost since 2009 as per estimates of IRENA) for statewide replication particularly in the rural hinterland with arrays of options. This roadmap shows a long-term transition from diesel and electric pumps to solar based pumps for irrigation in the state with strong preference for feeder solarization at large scale for agriculture while minimizing the burden of DISCOMs and also alternatively creating scope for them to procure power from distributed solar projects that ultimately benefits farmers. Apart from irrigation and household lighting needs the solar applications are instrumental in augmenting allied agricultural activities specifically processing and preserving industry like increasingly perishable fisheries, dairy, animal husbandry products etc through integrated approach of rooftop solarization of cold storages in tandem with food processing units. Yet there are various issues like suitability, affordability, farmers' engagement, scalability, financing and asset security etc. during deployment and functionality of these diverse models that needs to be properly addressed.

It is estimated that the ideal sunny weather conditions, adequate solar radiations and good ground water level in Bihar can result in an 80% reduction in the cost of solar photovoltaic (SPV) system.

There are only 881 food procession units in Bihar contributing to only 1% of the total output.

As per Ministry of Food Processing Industries (MoFPI), there are only 881 food processing units in the state contributing to only 1% of the total output which calls for more capacity building measures in this segment. For years lack of institutional credits and inefficient market linkages have marred the farming practice. Here comes the enabling atmosphere created by the Ministry of New and Renewable Energy (MNRE) and remarkable Kisan Urja Suraksha Utthan Mahaabhiyan (KUSUM) schemes and state agencies for enlarging the access to financing and market linkages for farmers, Farmer Producer Organizations (FPO) and cooperative societies that can revive the rural economy. A host of measures taken by agriculture ministry for phasing out diesel set through subsidies, incentives, promotion of off grid solar pumps and micro irrigation systems, and overall fulfillment of set targets therein may result in avoided CO_2 emissions of 2.56 million tonnes for the period FY 2020-21 to FY 2031-32.

This report presents some of solar based diverse successful models and pilot projects, supported by either grants or individual enterprise, that are transforming rural landscape namely, ITC – Solar bulk milk chillers & Branding local milk in Munger, Roof-top Solarization of Cold storage in Begusarai, Community owned Off Grid Solar Powered Irrigation Service Model in Samastipur, Micro Solar Powered Cold Storage in Fatuha, and Solar Cold Storage & Solar Dryer in Gaya district of Bihar. These success stories are recharging the local enterprising activities, enlarging the scope of rural economy and providing additional income sources for farmers, entrepreneurs and people of other occupations.

Several measures taken by the agriculture ministry and the fulfilment of set targets therein may result in avoided CO_2 emissions of 2.56 million tonnes between FY 2020-21 and FY2031-32.

In every crisis, lies great opportunity!

As Bihar is looking to overcome energy crisis, there exists multiple nodes of challenges and sector specific barriers located at socio-economic, market, regulatory and institutional realms which may prevent government in implementing the proposed roadmap for sustainable energy transition. These challenges specifically can be enumerated as lack of market of decentralized RE products and absence of MSME in agro-processing industries, lack of maintenance and technical support for local developers, perceptions related bias on adoption of new age technologies, and ushering regulatory reforms for preparing a level playing field for multiple players along with providing sound financing and incentives for the novel and scalable models for ensuring round the clock credible electricity supply at the countryside. This situation calls for synchronized roles and accountabilities of state government departments (namely energy, agriculture, industry and finance) and its allied institutions (such BSEB, DISCOMs, BREDA, Banks, Agriculture and Water Department) on formulation of common regulatory frameworks, creation of conducive market environment, designing of specialized solarization programs, and formation of joint committee for monitoring mechanism, so that the private players (e.g. developers, bidders, entrepreneurs and farmers) can move ahead on investment in infrastructure, promote technological demonstration and know-how, and replicate pilot projects into scalable and commercialized models, which as corollary effect may provide much needed relief and services for end users and primary beneficiaries (like farmers, FPO and cooperative) in achieving the long term shared vision. As important stakeholder think-tanks and advocacy groups can channelized their roles in dissemination of domain knowledge and provide handholding support in various activities such as need and impact assessment, capacity building, grass-root campaigning, and awareness generation during interplay and trade-off between these hosts of actors.

There is a need for synchronized roles and accountabilities of state government departments and its allied institutions.

Bihar essentially requires multi-stakeholderism approach, policy incentivization, single window mechanism for entrepreneurs and farmers, promotion of technology demonstrations and developers, synergy between DISCOMs and local energy producers, and above all a strong political will along with creation of an enabling and conducive atmosphere of monitoring and effective implementation of schemes which can change the energy paradigm. We, at CEED, urge state government to seize the moment and embark on a distinct solarization pathway with a pro-active approach that not only nurtures the mutually beneficial bonding between private and public entities for ensuring growth trajectory but also puts peoples of Bihar at forefront in realizing the dream of sustainable, cleaner and greener future.

An enabling and conducive atmosphere of monitoring and effective implementation of schemes is crucial in changing the energy paradigm in Bihar.

The history and saga of Bihar reminds us the dawn of state formation and empire building in Indian subcontinent that set the destiny of India for centuries. Bihar has often shown the ways in socio-cultural and political realms. Today, Bihar has the extraordinary opportunity to become a torchbearer in the field of clean and green sector, and in this connection 'powering through the sun' opens up gateways of umpteenth opportunities for multiple stakeholders particularly millions of masses at the periphery.

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Message

I am delighted to write this foreword, not only because CEED has been successfully establishing the need to do more towards renewable energy, but also because I believe deeply in clean energy sources. I also believe that renewable energy can transform Bihar, as at every level and stage we need to create an enabling environment for the deployment of clean sources of energy. The commitment towards sustainable development and promotion of renewable energy is the top agenda of Government of Bihar.

The growth of agriculture is critical for the development of state and we are working towards providing all kinds of support for inclusive growth. The initiative of Government of Bihar to provide electricity access to every household has been achieved, and very soon the dedicated agriculture feeder will energize diesel pumps in the state. This will transform the agricultural sector in leaps and bounds. At the same time, our dependence on fossil fuel needs to be reduced and deployment of renewable energy needs to be promoted.

I am glad that CEED is releasing a new report "Energising Agriculture Through Sun in Bihar", which will enrich and enlighten us with new learnings. This report is the outcome of generous contributions from a varied array of stakeholders who have generously contributed their time, effort, resources and creativity to suggest a roadmap for energy transition in the agricultural sector in the state of Bihar. This collective effort will, in time, promote positive results.

The roadmap for energy transition in agricultural sector in Bihar is a framework establishing parameters within which the electricity department will be empowered to design and propose a new approach to transform the agricultural sector by adopting renewable energy. It will certainly help us to identify new areas of interventions, policies and programs to provide uninterrupted electricity supply in the agricultural sector to improve the farm income. Simultaneously, it will help us in moving towards deployment of renewable energy in the state, creating jobs and achieving an overall development. Our department will consider all the recommendations and, if needed, will frame new policies and programs to transform the energy sector.

I wish the team all the best for the launch of the report and hope that it will enlighten the stakeholders with new learnings.

(Bijendra Prasad Yadav)

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Message

Bihar is predominantly an agrarian state with 76 percent of the state population dependent on agriculture. In terms of the contribution of agriculture to the state GDP, it contributes to the extent of almost 21 percent. The state government is giving the highest priority to the development of agriculture in the state. Three agricultural roadmaps have been implemented since 2008. Through its agricultural roadmap, the state is committed towards a holistic development of agriculture. The third agricultural roadmap for 2017–2022 has 23 department programs, including the program for meeting the energy requirements of agriculture. It is common knowledge that the state agriculture is heavily dependent on diesel for irrigation. The agricultural roadmap has a comprehensive plan for meeting energy requirements, including both conventional and non-conventional energy sources.

To reduce dependence on monsoons, farmers have been using diesel pump sets with which they pump up groundwater for irrigation. A separate agriculture feeder to energize all pump sets in Bihar has been proposed with forecast of electricity demands for agricultural sector going up to approximately 4,500 MW by 2022. However, the high cost of fossil fuel-based electricity might be a burden for agricultural farmers in Bihar. Therefore, we need a robust energy transition powered by renewable energy to make energy for farming affordable and reliable.

Renewable energy is a major element in competitiveness and sustainability of the Bihar farming sector. It really stands at the heart of a new model for productive and ecologically responsible agriculture. In this regard, it has been the central focus for various programs and action plans to promote renewable energy in the agricultural practices in Bihar. The present roadmap prepared by CEED describes the links between agricultural activities and energy-related issues. I am delighted to see the roadmap which covers the entire value chain of agricultural activities starting from irrigation to harvesting and storage.

I am sure that "Energising Agriculture Through Sun in Bihar", prepared by CEED, will empower stakeholders, including the policy makers. I am fully convinced that the ever decreasing prices of renewable energy will provide a win-win situation for both the Government and farmers. Renewable energy-based electricity for farm sector will help farmers in doubling their income and reducing their dependence on monsoons as well as boosting the fiscal health of the state electricity distribution company. The agriculture department of Bihar will consider all recommendations for the use of renewable energy to make farming profitable.

I wish CEED all the best for the launch of the report and hope that it will enlighten the stakeholders with new learnings.

(Dr. Prem Kumar)

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GSDP	Gross State Domestic Product	IWMI	International Water Management Institute
GSVA	Gross State Value-Added	NGO	Non-Governmental organizations
GOB	Government of Bihar	SPIS	Solar Powered Irrigation System
CAGR	Compound Annual Growth Rate	SPCS	Solar Powered Cold Storage
MOSPI	Ministry of Statistics and Programme Implementation	S-ISP	Solar Irrigation Service Provider
RBI	Reserve Bank of India	RABC	Rural Agri Business Centers
MOFPI	Ministry of Food Processing Industries	BREDA	Bihar Renewable Energy Development Agency
ASI	Annual Survey of Industries	BERC	Bihar Electricity Regulatory Commission
HP	Horse Power	EPS	Electric Power Survey
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana	PBI	Procurement Based Incentive
CEA	Central Electricity Authority	PPA	Power Purchase Agreement
MIS	Minor Irrigation Schemes	FPO	Farmer Producer Organization
GIA	Gross Irrigated Area	KVKs	Krishi Vikas Kendras
GSA	Gross Sown Area	JREDA	Jharkhand Renewable Energy Development Agency
RE	Renewable Energy	RESCO	Renewable Energy Service Company
RPO	Renewable Purchase Obligations	KUSUM	Kisan Urja Suraksha evam Utthan Mahabhiyan
BSKSY	Bihar Saur Kranti Sinchai Yojana	DCS	Dairy Co-operative Societies
IRENA	International Renewable Energy Agency	MNRE	Ministry of New and Renewable Energy
NABARD	National Bank for Agriculture and Rural Development	EPC	Engineering Procurement Construction
GRN	Goods Receipt note	NHB	National horticulture board

BACKGROUND

Bihar's Agriculture Sector

Bihar envisages accelerated agricultural development by strengthening its agriculture value chain with a special focus on energization of irrigation pump sets and agro-based industries.

Agriculture is the backbone of Bihar and is key to the overall development with 88% of its population residing in rural areas. Despite being one of the fastest growing agrarian economies (with real Gross state Domestic Product growth rate of 11.3% in 2017-18), the state struggles with low agricultural productivity, and fluctuating agricultural output [1]. Bihar state has taken an initiative in the form of agriculture roadmap to increase production, productivity, farmer's income, and equitable agricultural growth.

Recognizing a strong **Agriculture-Energy nexus** at different points in agriculture value chain, the agricultural roadmap has given a special focus on energizing tube wells to reduce its vulnerability to extreme climatic conditions and energizing cold storages and agro processing units to reduce post-harvesting wastages.

Figure 1: Key Highlights of Bihar's Agriculture Sector

Major contributor to state's economy

Contributes ~21% to Bihar's GSDP

Employs ~80% of workforce against national average of ~58%

Irrigation potential

Endowed with fertile Gangetic alluvial soil &abundant water resources for irrigation

69% of cultivated area is irrigated.

High potential for increasing irrigation intensity

Among top agriculturalproduction states

3rd largest producer of vegetables

8th largest producer of fruits

8th largest producer of food grains

87% Cereal dominated cropping pattern

Land utilization and distribution

Net sown area is 56% out of total land against national average 42%

Cropping intensity is 1.45 in 2016-17

~91% are marginalized farmers who owns 58% of area

Fluctuating agricultural output

Average CAGR of 1.8% for agricultural GDP with 6-7 drought years in last 10 years (2006-07-2016-17).

CAGR of 8.8% for 2007-08-2011-12 and -0.4% during 2012-13-2016-17, Growth of 11% in 2012-13 and 13.2% in 2016-17

Lack of infrastructure

67% of Gross Irrigated Area is irrigated by wells and tube wells. But the sector consumes less than 2% of total electricity consumption of Bihar and depend heavily on diesel

High Gap in actual and required cold storage and agro processing capacity. Lack of access to finance and poor market linkages resulting in low farmer incomes.

Agricultural roadmap highlights

Roadmap 1 2007-2012): Rainbow Revolution

Roadmap 2 (2012-2017) & Roadmap 3 (2017-2022): Vision: "One Bihari Dish on Every Indian's Plate"

Stress on Organic Farming Production, Promotion of post-harvest storage facilities and agro- processing industries

Allocation of 1.5 lakh crores in agricultural value chain and aims to double the income of farmers by 2022

Aims to setup exclusive 1,500 MW power network for agriculture.

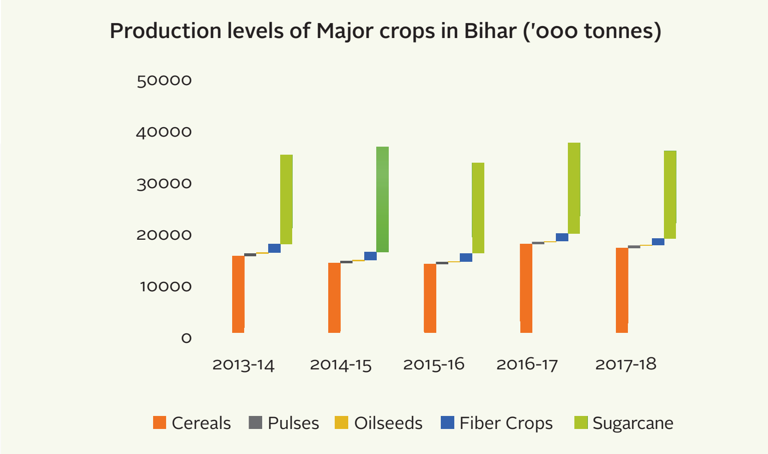
4120 MW required for tube wells

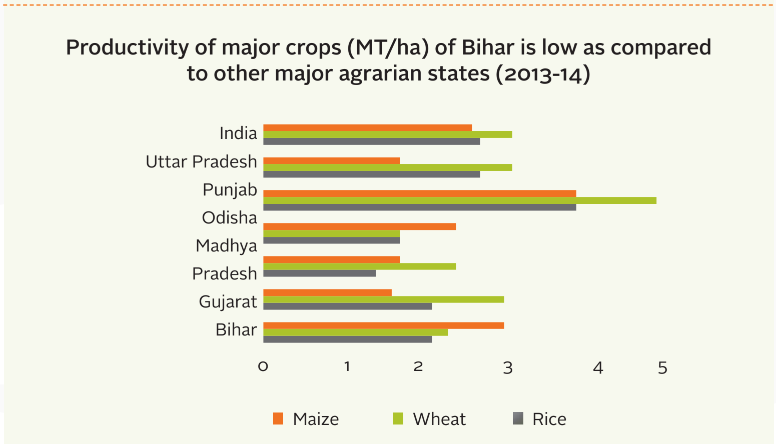
160 MW for cold storages and Agro-based industries

Source: MOSPI, Various Sources [1] [7] [5] & KPMG in India Analysis

Bihar's Agriculture Sector

Figure 2: Production levels and productivity of major crops





Source: *KPMG in India Analysis based on data from Directorate of Economics and Statistics, GOB*

One of the major issues agricultural sector is facing in Bihar is low yield: Bihar's farm productivity for wheat and rice is 30–40% lower than that of all-India average.

Cereal Dominated Cultivation with low productivity levels

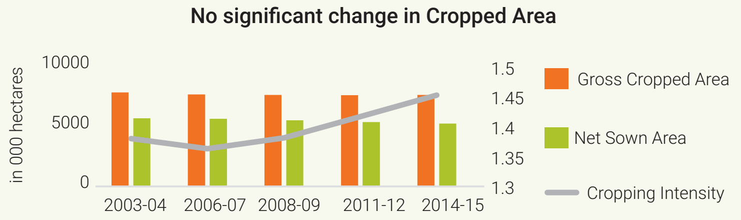
Cropping pattern is skewed towards cereals which signifies the subsistence nature of Bihar's agriculture sector. Even the cropping intensity has marginally changed from 1.37 in 2003–04 to 1.45 in 2016–17.

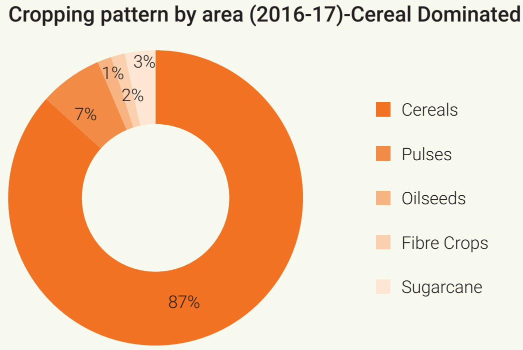
The state struggles with low agricultural productivity, and fluctuating agricultural output.

Fragmented landholdings with subsistence crops discourage technological innovations.

Bihar's agricultural sector faces a major issue of low yield: its farm productivity for wheat and rice is 30-40% lower than that of all-India average.

Figure 3: Cropping Pattern of Bihar



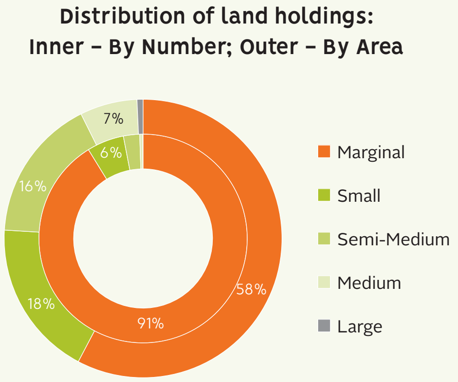


Source: KPMG in India Analysis based on data from MOSPI, Economic Survey of Bihar (2018-19)

Fragmented landholdings with low average size per farmer leading to low farmer's incomes

One of the major reasons for low productivity in Bihar is that the average land holding size in Bihar is very low with 91% of them being owned by marginal farmers covering 58% of the area. This is further intensified by the fact that they are fragmented landholdings, a single farmer owns land in small parcels at various places. This makes the penetration of technological innovations difficult in Bihar. The low productivity leads to low farmer's income in Bihar.

Figure 4: Distribution of Landholdings in Bihar



Average Size of Operational Holdings (Hectares)

Marginal	0.25
Small	1.25
Semi-Medium	2.60
Medium	5.29
Large	14.48
All	0.39

Source: KPMG in India Analysis based on Agriculture Census 2015-16 data

Lack of institutional credit and inefficient market linkages.

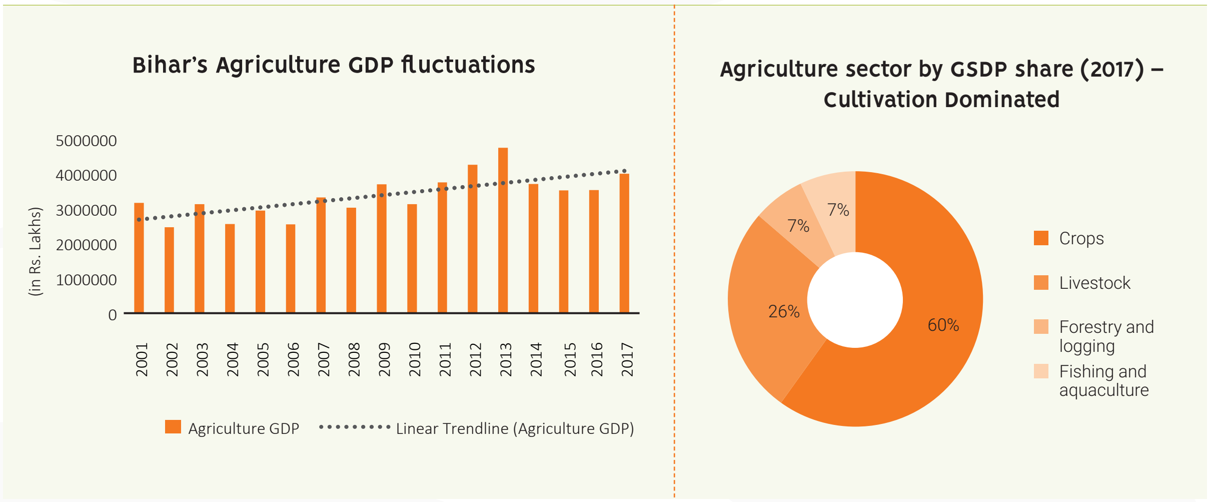
Most small and marginal farmers face lack of credit availability, access to better quality of inputs and new technology. This is evident from low prices prevailing in mandis of Bihar owing to lack of cash flow. In addition to lack of credit, most marginal farmers sell their produce to traders and moneylenders of the village at a very low price. Small and marginal farmers also sell the produce in weekly village markets popularly known as 'haats'. Bihar has about 1794 rural haats [2] but these haats lack adequate infrastructure. Robust and efficient agricultural marketing system is especially important for ensuring that a larger share of profit from the final prices goes to the farmers.

High dependence on monsoons for irrigation despite having best pool of ground water resources

Bihar is endowed with very good ground water level (ranging from 2-5 m in North Bihar to 5-10m in South Bihar on an average) with a favorable replenishment rate [3]. However, only 69% of the cultivated area is irrigated in 2015-16 [4] and some farmers still depend upon the southwest monsoon rains for irrigation. High dependence on monsoons for irrigation is the one of the numerous factors responsible for the fluctuating trend in agricultural GDP in Bihar.

In the primary survey conducted by KPMG in India and CEED, it was found that many farmers around Ganga flood plain are not able to cultivate kharif crops during monsoons due to floods and cultivate only Rabi crop based on the natural soil moisture as result of flooding in Kharif. The farmers reported that their income can double with Zaid crop if they can get access to a cheaper source of irrigation through solar as expensive diesel is not be feasible for Zaid season during which crop cultivation requires much higher water for cultivation due to dry soil.

Figure 5: Bihar's agriculture GDP trend and segmentation by GSDP share



Source: KPMG in India Analysis based on MOSPI, RBI Handbook of Statistics (2018-19) data

Lack of infrastructure such as inadequate post-harvest storage capacities and agro processing capacity leads to 15-30% agricultural wastage and affects farmer's income.

The soil of Bihar is fertile in most regions and farmers can grow varied crops. Two major cropping seasons are – Kharif and Rabi. The gross area irrigated under crops in Bihar increased by only 12% from year 2008-09 (4,692,000 hectares) to 2015-16 (5,268,000 hectares) [4]. There exists a high potential to increase agricultural productivity by expanding gross irrigated area in Bihar. For example, there is a huge potential for cultivation in the third cropping season (Zaid crop) which can be tapped by providing a reliable and cheap source of irrigation to farmers in this season.

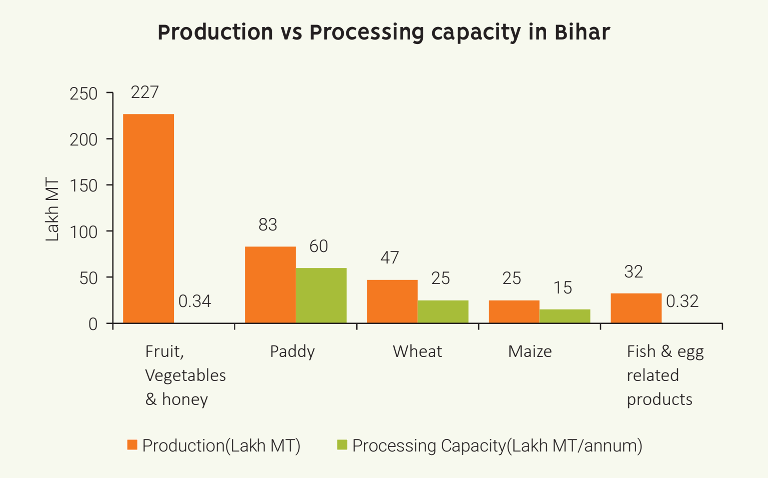
Also, the northern parts of Bihar are prone to frequent floods while the southern parts are vulnerable to severe droughts. Both the environmental conditions make the cultivation difficult and the situation is aggravated due to high dependency on rainfall. The diverse environmental conditions along with high dependence on rainfall creates a huge opportunity for water management and sustainable development of ground water resources.

Presently, Bihar has a total processing capacity of 100.7 Lakh MT/annum, which is 24% of total production in 2016-17. The commodity wise annual production and the corresponding processing capacity are shown in the adjacent figure. Despite being a major producer of fruits and vegetables, available processing capacity in the state is only 0.15% of its total production.

Similarly, for cereals as a percentage of total production, Bihar has 72% paddy processing capacity, 53% wheat processing capacity and 60% maize processing capacity [5].

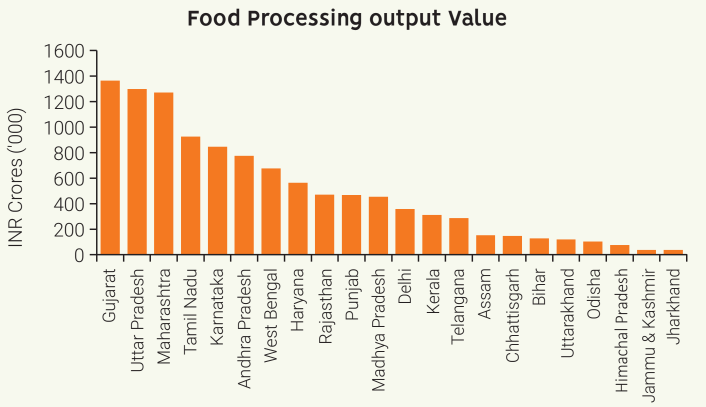
About 15%-30% of the Agriculture produce is wasted in the state due to lack of basic infrastructure facilities. The Agriculture road map envisions the reduction in the wastage to 5% and increasing the processing capacity by 50% till 2027. As per the roadmap, investing into efficient post-harvest management practices may result in increasing the farmers income by 30% and creation of 10-15 Lakh new employment opportunities. [5]

Figure 6: Production and Processing Capacity for Bihar, 2016-17



Source: KPMG in India Analysis based on Agriculture Roadmap (2017-22) data

Figure 7: State-wise Food Processing Output in India, Mar 2016-17



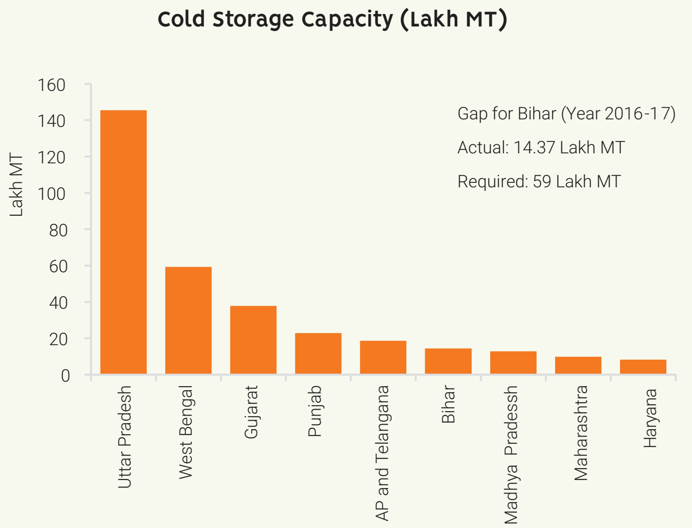
As per MOFPI data there are only 881 food processing units in Bihar contributing to only 1% of the total output (in terms of value) in India. Thus, the state needs to enhance capacity in the Agro-processing sector [9].

As per primary survey of 243 farmers undertaken in 37 districts of Bihar, 83% sample farmers responded that there are no Agro processing units in their village.

45% farmers reported there are no dairy farms/ units/milk collection centers in their village.

Source: *KPMG in India Analysis based on data from MOFPI [9]*

Figure 8: State-wise Cold Storage Capacity in India, March 2019



Source: *KPMG in India Analysis based on ASI Database 2019 data*

As far as the cold storage capacity requirements are concerned, there is a huge gap in the requirement and the availability of cold storage capacity in Bihar. The state lags in terms of cold storage infrastructure when compared to other states.

As per the primary survey only 17% of the sample farmers had access to the cold storage facility.62% of farmers not having cold storage expressed the requirement for the same to enable them to fetch better prices in the market.

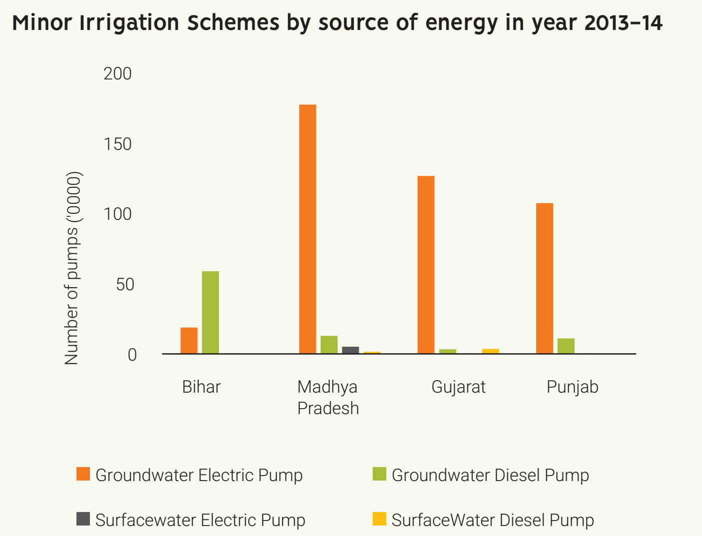
The state was unable to cover this gap over the years, in 2012 a total of 42.4 Lakh MT cold storage capacity was required as against availability of 11.47 Lakh MT [10]. For the FY 2016-17 a total of 59.07 Lakh MT cold storage capacity was required as against availability of 14.16 Lakh MT [12].

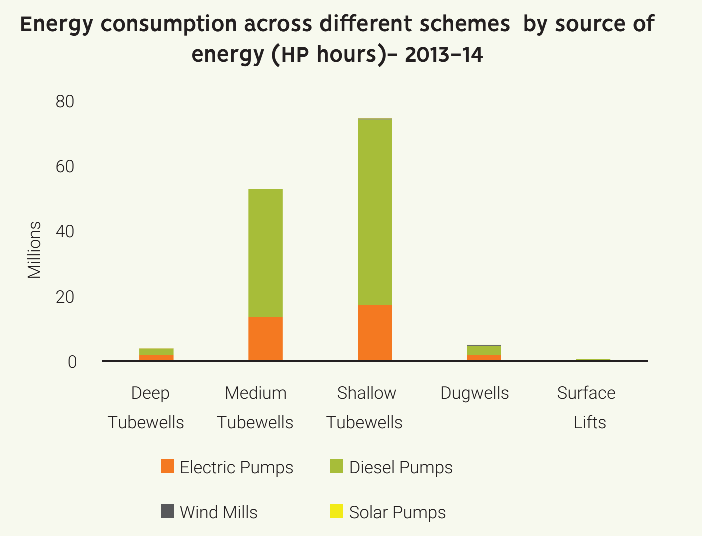
Prevailing Electricity Demand-Supply Gap

While the agriculture sector contributes 21% to Bihar's GDP, it consumes less than 3% of electricity consumption and depends heavily on costly diesel pumps for irrigation due to lack of reliable electricity supply.

Irrigation is mainly dependent on the tube wells covering 67% of the gross irrigated area,[1] which are majorly run by diesel making the marginal farmer at a disadvantage due to its high cost.

Figure 9: Energy Consumption across Different Minor Irrigation Schemes for Bihar (2013–14)





Source: KPMG in India Analysis based on Minor Irrigation Census, 2013–14 data

The primary survey highlighted that 98.35% farmers were using electricity for domestic purposes, however, only 37.86% farmers were using electricity for agricultural purposes. About 50% farmers reported daily voltage fluctuations in electricity supply. Approximately 91% of farmers were using Diesel Pumps for meeting full or partial irrigation demand.

[1] Data from Directorate of Economics & Statistics (Agriculture) Bihar

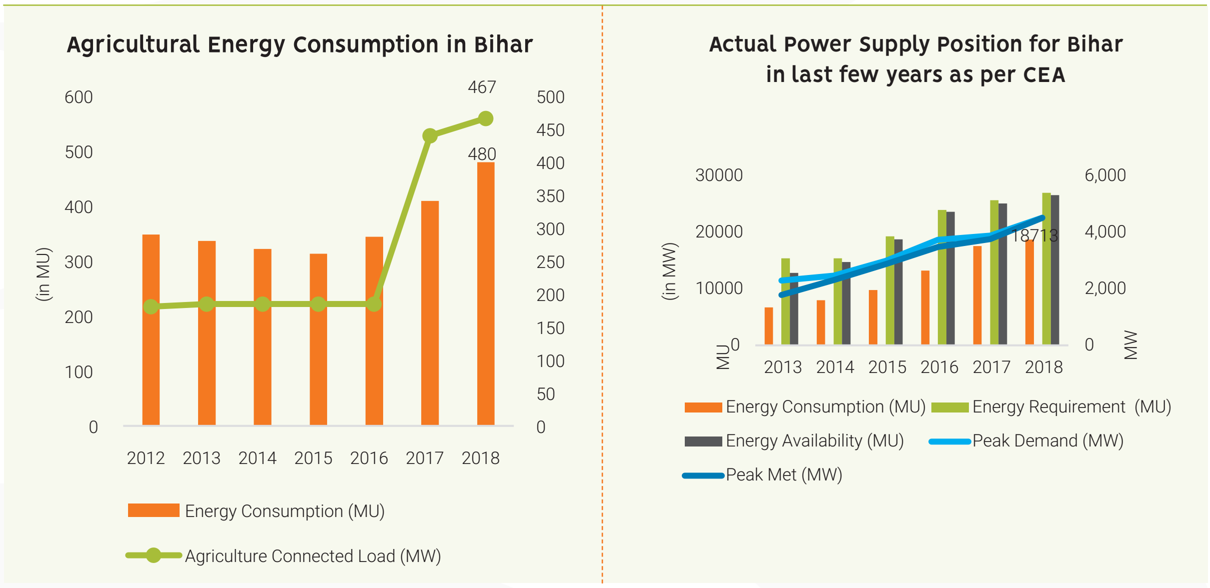
The electric pumps in Bihar account for 1.26 percent of all the electric pumps in India (groundwater and surface water schemes). However, it accounts for 10.15 percent of the total diesel pumps in all India. According to the 5th minor irrigation census for Bihar, the number of total pumps in 2013-14 is 7,81,674, out of which 1,89,307 are electric pumps and 5,88,397 are diesel pumps while number of solar pumps is only 830. This is a clear indicator of high dependence of the state on diesel for irrigation.

One of the major factors for low usage of electric pumps is irregular electricity supply making it an unreliable source of energy at present. While the quality of electricity supply has witnessed an improvement in all the sectors in last 4-5 years, the improvement in the supply situation in the agricultural sector is relatively slower.

The third agricultural roadmap (2017-22) has aligned its electricity targets with the DDUGJY scheme (2014) to provide reliable electricity to agriculture sector by separating the agriculture feeders. The separation of feeders was planned to be finished by 2018 but is still ongoing. In total, 1289 agricultural feeders are scheduled for separation, but only 285 are separated yet. There is still a balance of 1004 feeders which needs to be separated [6].

In addition, the electricity consumption for agriculture sector in Bihar in 2018 is 480 MU which is only 2.56% of the total electricity consumption in the state. The current low level of electricity consumption and expected improvement in the electricity supply situation for agriculture indicates high potential for future electricity consumption growth required for expansion of irrigation capacities for achieving vision of agricultural roadmap.

Figure 10: Agricultural Electricity Consumption & Overall Actual Power Supply Situation in Bihar



Source: KPMG in India Analysis based on CEA Data

High Potential for Future Electricity Demand Growth

Existence of Large Latent Demand for Irrigation

Electricity demand for irrigation purposes of Bihar is likely to grow at CAGR of 16–20% till 2032 as per KPMG in India analysis based on data from CEA and BERC.

The existence of high number of diesel pumps indicates high latent demand in agriculture sector for irrigation purposes. However, in past 2–3 years the situation of electricity supply has significantly improved in Bihar and DISCOMs have released large number of electric connections to replace diesel pumps. The agricultural roadmap (2012–17) envisions to phase out all the diesel pumps by electric or solar pumps in the future.

Electricity Consumption Projections for Irrigation

The projections for electricity consumption for irrigation in Bihar are estimated using a bottom up approach considering the change in land use pattern and change in irrigation system efficiency with time while assuming the total transition of diesel pumps to electric pumps. The projections along with the formula used are given below.[2]

Projected Electricity Consumption =

*(Number of pumps / Area Irrigated by Minor Irrigation Schemes (MIS)) *(Area Irrigated by MIS to GIA ratio) * (Projected GIA/ GSA ratio for that year) *Projected GSA for that year * Average Number of Hours of pumping per day * Average number of days pump is in operation*Average Capacity of pump*

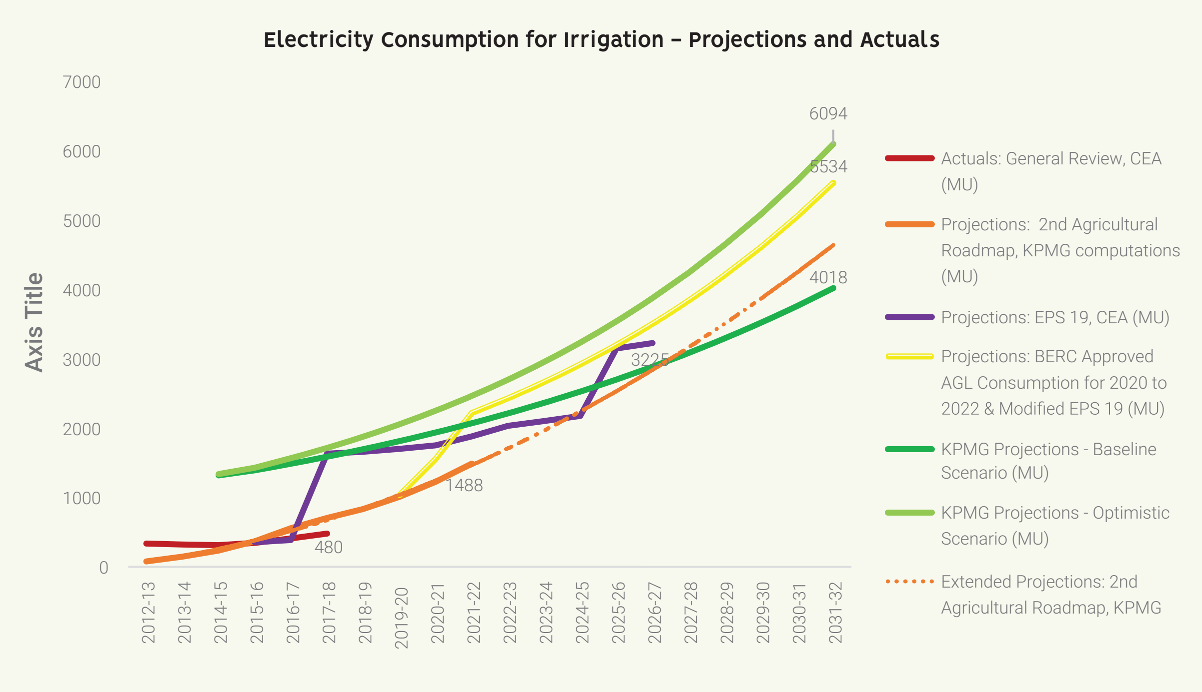
Efficient supply of electricity and solar energy can replace the use of expensive diesel pumps.

The baseline scenario is worked out considering the same historical growth rates of the parameters. While the optimistic scenario considers the growth rates based on following assumptions.

- Bihar were to irrigate all the gross sown area.
- Bihar were to reach Punjab's current value of area irrigated by MIS to GIA
- Enhanced pump capacity and total annual number of hours in lieu of changed cropping pattern

[2]Please refer to appendix for detailed assumptions and methodology.

Figure 11: Electricity Consumption for Irrigation – Projections and Actuals



Source: KPMG in India Analysis based on data from CEA General Review Reports, CEA Report– EPS 19th, [7], [6]

The electricity consumption for irrigation currently is 480 MU in 2017–18. It is projected to increase at a CAGR of 16% in the baseline scenario and 20% in the optimistic scenario and is expected to range between 2070–2463 MU in 2021–22 and between 4018–6094 MU in 2031–32 under these two scenarios. The projections under the optimistic scenario matches well with the modified EPS projections[3] in which the electricity demand is likely to grow at a CAGR of 19% till 2032.

Electricity demand for Other Agricultural Activities of Bihar is likely to grow Optimistically at a CAGR of 15% till 2032 as per KPMG in India analysis based on data from Agricultural roadmap of Bihar

Electricity demand for Other Agricultural Activities of Bihar is likely to grow Optimistically at a CAGR of 15% till 2032 as per KPMG in India analysis based on data from Agricultural roadmap of Bihar.

At present there are 350 existing cold storages and 850 food processing industries [8] & [9]. However, this number is likely to grow significantly in future pertaining to the thrust of

[3]Modified EPS 19th Projections: Approved agricultural consumption for the period 2019–20 to 2021–22 is considered from BERC Tariff Order. Agricultural electricity consumption for the period 2022–23 to 2031–32 is projected using the CAGR of 9.6% based on the electricity demand projections for the period (2019–20–2026–27) in the 19th EPS report.

agricultural roadmap to enhance the processing capacity and cold storages and with the increasing irrigation intensity resulting in crop diversification in favor of fruits and vegetables requiring greater processing and preserving capacity in Bihar. As the cold storages and food processing industries are highly energy intensive, the capacity expansion will have implications for increasing electricity demand significantly.

Demand for electricity is likely to grow to accommodate the growing need for cold storages and food processing industries.

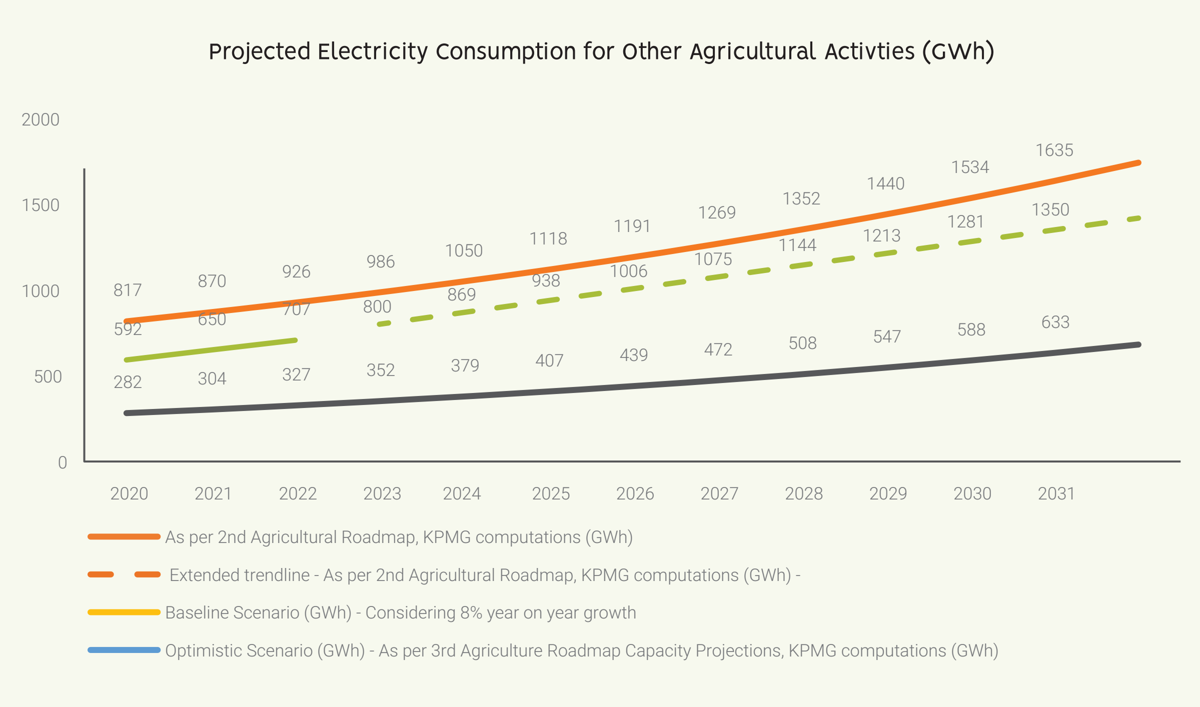
The projected electricity consumption till 2032 has been evaluated for two scenarios- baseline and optimistic. Estimations show that for Agro-processing industry and cold storages taken together, the electrical energy requirement ranges between 327-926 MU by 2022 and between 682-1742 MU by 2032 under both these scenarios.

The policy measures taken between 2008 to 2016 did not give the expected outcomes in the food processing industry, thus there has been a sharp correction with regards to the state's industrial policy in 2016 [10]. Thus, in the baseline Scenario electricity consumption for food processing and preserving industries is projected for future based on the rate of growth for a recent year (i.e. 2017). Under this scenario, the electricity consumption is expected to grow at 8% annually from 226.3 MU in 2017 to 682 MU in 2032.

As per the Agriculture roadmap the total processing capacity requirements should increase by 50% from existing 100.7 Lakh MT/annum in 2016-17 to 150 Lakh MT/annum by 2026-27.

The optimistic scenario is based on the enhanced capacity targets for processing and cold storage set by the agricultural roadmap and Department of industries. As per the Agriculture roadmap the total processing capacity requirements should increase by 50% from existing 100.7 Lakh MT/annum in 2016-17 to 150 Lakh MT/annum by 2026-27. This is further projected linearly to reach 185 Lakh MT/annum by 2032. Additionally, there is a large gap in the available and the required cold storage capacity in the state. Department of Industries, Krishi road map performance indicator and answer to Rajya Sabha questions provided the historical cold storage capacity requirements for Bihar [11] & [12]. It is observed that the required cold storage capacity is growing at 7% year on year, by this rate a requirement of 82 Lakh MT and 160 Lakh MT cold storage capacity by 2022 and 2032 respectively is estimated. The projections under the optimistic scenario is 926 MU in 2021-22, which compares well with derived electrical energy

Figure 12: Projected Electricity Consumption for Other Agricultural Activities



Source: KPMG in India Analysis based on data from Bihar Agriculture Road Map 2017–22, Report of the task force on Agriculture (Bihar Govt. & NITI Aayog, 2015), ASI database (2015-16 & 2016-17)

requirements implied by estimated power requirements of 160 MW by 2021–22 in the Agriculture roadmap [7]. The electricity energy demand for other agricultural activities is expected to grow at a CAGR of 15 % in the optimistic scenario till 2032.

Given that future energy consumption of Bihar is likely to increase significantly across the entire agricultural value chain, the shift towards renewable sources can help in diversifying electricity mix, reducing the dependence on fossil fuels and increasing reliable energy supply to farmers, thereby positively impacting productivity, and income of farmer households. However, such a transition will require sustained efforts from all the key stakeholders to bring clean energy transition in the agriculture value chain through formulation of a roadmap which can guide adoption of successful decentralized renewable solutions by Government of Bihar, farmers and agri entrepreneurs and right set of business models.

To meet the growing requirements of farmers, cold storage capacity should reach 82 Lakh MT and 160 Lakh MT in 2022 and 2032 respectively.

Need for Sustainable Energy Transition Roadmap for Agriculture

Given the huge scope of strengthening energy-agriculture nexus in Bihar, there is an imminent need to formulate the energy roadmap to provide a consistent framework to all stakeholders for sustainable energy transition.

The entire global economy is shifting towards renewable energy to reduce the use of fossil fuels and associated emissions. India is committed to reduce its emissions intensity of GDP by 33-35% over 2005 levels by 2030 and has therefore planned to increase the share of renewable energy to 40% by 2030. Government of India (GOI) has planned to achieve cumulative renewable energy installed capacity of 175 GW by 2022. Of this 57% of the capacity additions have been planned from solar energy. To achieve this target, GOI has provided indicative renewable energy capacity installation targets and renewable purchase obligations (RPO) for all the states.

Bihar is hugely dependent on the central sector for the power requirements, which accounts for 87% of the total 4567 MW power installed capacity. In addition, agricultural sector in Bihar is heavily subsidy dependent with Govt. providing electricity and diesel at subsidized rates for agricultural consumers.

The cost of conventional power is expected to increase over the years due to rising fuel costs and the subsidy support from State Govt. will have to be increased to sustain the agriculture sector.

Thus, solar energy can act as an alternative to meet the increasing electricity demand in Bihar. The total installed RE capacity is 326 MW which accounts for 7% of total installed capacity of Bihar as of March 2019. However, the RPO target set for 2021-22 is 17%, where 8% is for Solar and 9% for Non-Solar [6]. In addition, the penetration of solar energy into agriculture sector of Bihar can help in achieving its RPO targets.

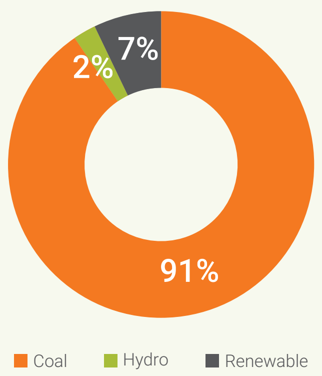
In the wake of this growing need for sustainable energy transitions, several initiatives have been taken by the state government (BSKSY & NABARD schemes) on small scale especially on the usage of solar energy for irrigation purposes in the past, but none of them have been able to achieve their intended targets. One of the major reasons for their failure was the non-availability of well-structured roadmap for different stakeholders involved.

Figure 13: Bihar's Installed Power Capacity

As of March,2019

Total Installed Capacity : 4567 MW

Renewable Energy : 326 MW



Source: CEA Monthly Report, March 2019

Bihar, being one of the fastest growing agrarian economies, has a high potential for meeting its rising agricultural electricity consumption at a much lower cost through distributed solar as compared to existing scenario due to high cost of supply in the agricultural sector.

Given that electricity demand across agricultural value chain is likely to increase significantly in future, there is a need for a structured roadmap to deploy decentralized solar solutions in agriculture sector and related activities for greening electricity consumption, reducing subsidy burden on the State Govt, increasing electricity availability and reliability and thereby positively impacting incomes and productivity of farmer households.

In the present study, the sustainable energy roadmap across the agricultural value chain has been designed for Bihar. This roadmap sets out a path for sustainable energy transition in agriculture sector in Bihar through solar-based interventions by 2032. The key objective of this roadmap is to analyze existing solar interventions in the agriculture value chain with a focus on irrigation and post-harvesting preserving and processing activities, their relevance to Bihar and to propose a comprehensive sustainable energy transition pathway for Bihar along with key policy guidelines. The proposed roadmap could be used as the guiding document for all the stakeholders involved in the entire agricultural value chain.

Key learnings from different types of existing models and programs from other states are discussed in detail in the next section for identification of appropriate business models and programs for scaling solar investments in Bihar. Key factors associated with success from existing models and programs are then synthesized and mapped to Bihar.

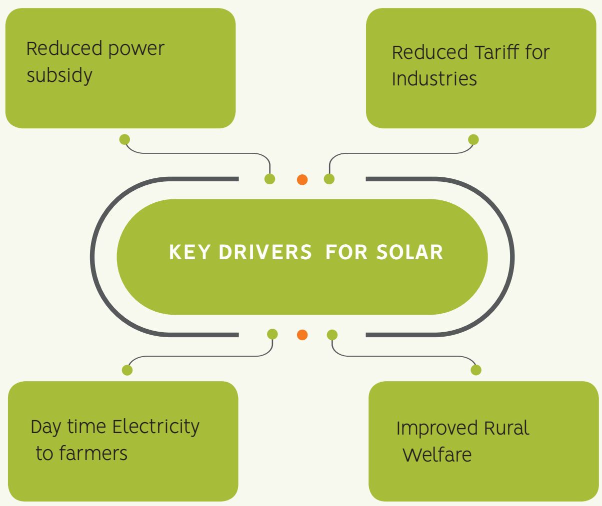
Solarization of agriculture: What may work for Bihar?

The abundance of solar energy and cost decline makes it the technology of choice for bridging the energy gap in a sustainable manner. This can not only enhance the energy access but can play pivotal role in increasing income levels in rural Bihar.

Solar energy has a vast potential in Bihar as it receives adequate solar irradiance and approximately 250–300 sunny days across all districts. Adequate solar availability along with good ground water levels indicate suitability of solar pumps for enhancing the irrigation practice and for addressing the energy requirements of other agricultural activities. According to IRENA, the cost of setting up Solar PV projects has gone down by 80% since the end of 2009 and solar provides a very good alternative to grid electricity at present.[4] This can also help in replacing the existing diesel pumps and diesel generators which have significant carbon footprints on the state's environment.

In the primary survey of 107 solar pump adopters in Bihar it has been found that diesel consumption for the adopters have fallen 38% after the adoption of solar pumps.

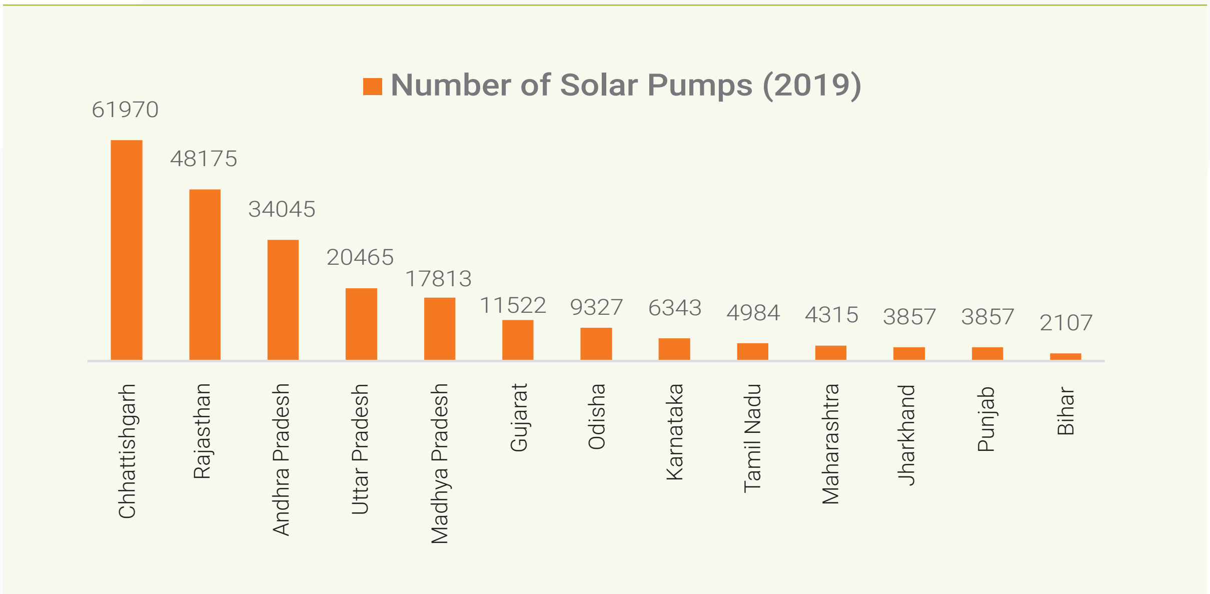
About 18% and 28% farmers reported increase in cultivated area and production for traditional crops respectively after Solar Pump Adoption. There is some evidence for crop diversification with adoption of solar pump and reliable supply of water. For vegetables, 16% and 21% farmers reported increase in cultivated area and production respectively after Solar Pump Adoption. Approx. 32% farmers reported an increase in fodder availability (about 10–25% increase) after adopting Solar Pumps due to availability of more water. Additionally, 43% farmers reported an increase in Animal Produce and Health due to Solar Pump Adoption.



[4]https://www.irena.org/costs

The solarization of other agricultural activities specifically processing and preserving industries can help bring down their energy input costs. Thus, solar energy has significant potential not only for irrigation purposes but also other agricultural activities covering processing and preserving industry, fisheries, dairy, animal husbandry etc.

Figure 14: Number of Solar pumps deployed in selected states



Source: MNRE Annual Report 2018-19

Options for Solarizing Irrigation in Bihar

Solar pumps can be configured in different ways for varied applications. They can be either deployed as off grid model or on-grid model. They can used for irrigation activities and other livelihood purposes along with the income generation (in case of on-grid pumps) by giving excess power supply to the grid. The model can also vary in the mode of usage i.e. single user or multiple user (community based).

Bihar's roadmap for agricultural value chain advocates for sustainable energy transition through solar-based interventions by 2032.

In Bihar, only off grid standalone solar pumps have been installed so far both in individual and community set up, however the penetration is very low as compared to other states.

As per IRENA, the cost of setting up Solar PV projects has decreased by 80% since the end of 2009.

Recently, in February 2019 Cabinet Committee approved the KUSUM scheme for solarization of Indian irrigation system, under which tentative allocations to states[5] shows that Bihar's

[5]https://mercomindia.com/mnre-kusum-program-india-farmers/ (Last Accessed on 9.10.2019)

KUSUM scheme shows Bihar to have a minimal share in allocations granted for solarization of its irrigation system.

Non-adoption of solar pumps is due to lack of affordability and low awareness about schemes like KUSUM and BSKSY.

share is minimal, even though it has one of the highest penetrations of diesel pumps in India.

Many of the states In India – Andhra Pradesh, Punjab, Gujarat, Haryana, Maharashtra etc. have initiated various programmes both on-grid and off-grid to provide irrigation facilities to farmers in last few years. Several pilots have been conducted to study various implementation models with government or support from organizations such as GIZ, IWMI and local NGOs. Some such pilots conducted in Bihar are summarized below.

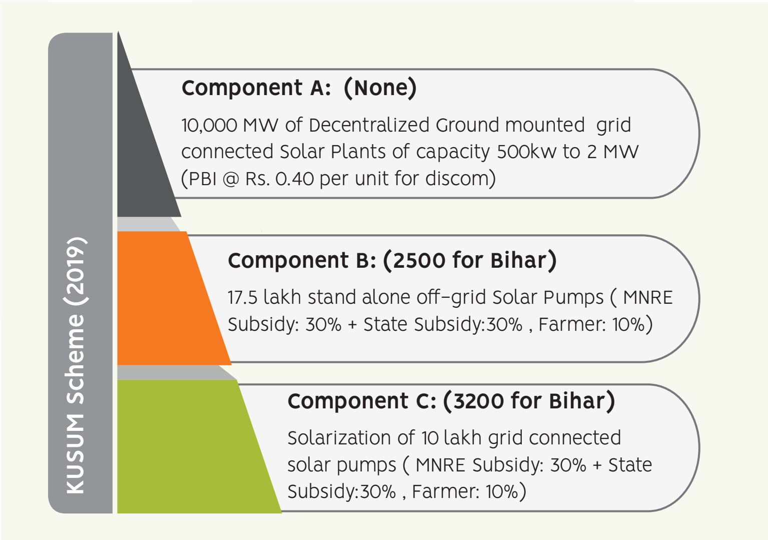


Table 1: Chak haji Case Study in Bihar – Irrigation as a Service SPIS Model

Chak Haji Village in Samastipur District, Bihar (2016): Irrigation as a Service Off Grid SPIS Model	
Implemented By International Water Management Institute (IWMI) & Aga Khan rural Support programme (AKRSP) **Brief Description** IWMI Installed 17 irrigation systems comprising of 5HP Submersible pump and buried piping distribution system (1000-1500 feet) in two phases, each catering to approximately 12 Ha and 100 farmers. 7 systems were installed in Phase 1 operational since Dec 2016 10 systems were installed in Phase 2 operational since Sep 2018 **Ownership** Individual farmer was designated as a Solar Irrigation service provider (S-ISP) in each irrigation system who further sells water to farmers through buried pipelines **Cost and Financing** Total system cost-625000 in Phase 1 and 4,40,000 in Phase 2. (solar pump prices reduced in second phase) Of the total system costs, buried pipelines per entrepreneur varies between 100000-125000 Rs. S-ISP: 50,000 upfront and Rs 1.5 lakhs in Installments over a period of 4 years IWMI: Remaining amount (solar pump and buried piping distribution) **Operations & Maintenance** S-ISP with the help of operator appointed by (AKRSP) in the initial stages **Cost of Water Supply** Rs 90/ hr in 2016, Rs 100 per hour in 2018	**Key Impacts of phase 1 – Success Factors[6]** ✔ Percentage of farmers doing summer cultivation increased from 54% to 100%. ✔ 20% increase in winter cultivation area and 127% increase in summer cultivation area ✔ Increased net annual income of 13840 due to increase in both winter & summer cultivation for farmers. ✔ The net income for the S-ISP in 2017-18 ranged between Rs 45343 - 89278 per year. ✔ Reduction in irrigation time and cost savings as compared to diesel pumps. Previously, farmer was paying 120 Rs for irrigating 1 Katha land for 1 hour. With the current irrigation system 1 Katha land can be irrigated in 20 minutes and the cost for the same turns out to be 30 Rs at the rate of 90 Rs per hour service charged by the entrepreneur. ✔ Competitive market price was observed due to overlapping command area served by S-ISPs. **Key Learnings** ✔ Proper training to S-ISP is crucial for its success ✔ Excess solar energy can be sold to the grid providing another income source to the entrepreneur ✔ Payment system needs to be improved to cater delays in farmer's payments to entrepreneurs

Source: [13], [14] & Stakeholders Interactions

[6] These figures are based on before and after comparison of the 180 farmers surveyed under the study.

Table 2: Mahagenco Case Study for Feeder level Solar Plant

Feeder Level Solar Plant Model – MAHAGENCO MODEL, Maharashtra

Implemented By

Maharashtra State Power Generation Company (MAHAGENCO)and Maharashtra State Electricity Distribution Company Limited (MSEDCL), under "Mahagenco Solar PV at Agricultural Feeders Scheme"

Brief Description

In a pilot phase, Mahagenco floated two tenders in 2016 for solar powered AG feeders in Ahmednagar (Karjulepathar substation, EPC model) and Solapur (Salse substation, PPP model) districts with a capacity of 2 MW each. In this phase, land was to be provided by Mahagenco. The bid tariffs were ₹2.94/kWh & ₹2.97/kWh. Both the pilots have indicated positive outcomes, and they have further invited tenders to scale this up

Mahagenco floated several tenders for grid-connected solar PV projects at feeder level across several locations in Maharashtra, with cumulative capacities in different phases Phase I: 50 MW (Dec 2017), Phase II: 300 MW (3 tenders in Dec 2017), Phase III-A: 50 MW (Mar 2018), Phase IV: 750 MW – with a green shoe option of additional 250 MW (Jun 2018).

Model Details:

DISCOM appoints a developer though competitive bidding process to install solar panels at the feeder mouth of an appropriate capacity.

Roles and Responsibilities

MAHAGENCO

Sign Power Purchase agreement (PSA) with MSEDCL and Power Purchase agreement (PPA) with selected developer at the lowest tariff rate for 25 years

Develop the land & basic infrastructure[7]

Developer

Develop the project

Responsible for the operations and maintenance for 25 years

DISCOM: (MSEDCL)

Provide required infrastructure for power transmission & evacuation

Maharashtra Energy Development Agency (MEDA)

Provide Viability Gap Funding (VGF) for the power evacuation and basic infrastructure to MSEDCL from Green Cess Fund[8]

Key Impacts – Success Factors

- Day time reliable electricity have made farmers really satisfied and happy at the pilot sites
- High potential for scalability
- Low feed in tariff as compared to the average cost of supply for the DISCOMs

Key Learnings

- Need to incorporate some farmer's incentive to keep a check on over exploitation of ground water and electricity usage.

Source: MNRE & MAHAGENCO Reports [15] & [16]

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[7] This is only for phase one projects. After wards its in the scope of selected developer.

[8] This is only for phase one.

Literature survey of all such studies reveals that the following models have indicated positive outcomes. Learning can be derived from these to evolve scalable business models for Bihar.

No/poor electricity supply High diesel dependence

Irrigation as a service model

Common solar pump deployed for group of farmers and water is sold on per hour or /L basis

- Successful pilots in Bihar & Gujarat
- Farmers buying water from other farmers
- Farmers with low landholdings size
- Suitable for small scale set up

Electricity Grid Network already connected to pumps

Grid connected solar pumps

Solar panels to farmers with existing grid electricity connection at the farm level

- SKY Scheme launched by Gujarat
- Streamlined financing mechanism
- Suitable for farmers willing to invest upfront amount
- Substantial farmer's involvement
- Extra energy pumped into grid

Electricity Grid Network with land available near sub-stations

Feeder-end solar power plant

Solar panel at feeder end and replacement of existing pumps with efficient pumps

- Successful pilots in Maharashtra (MAHAGENCO)
- Highly scalable
- Addressing financing challenges

In the primary survey, 40% of non-solar pump farmers were unwilling to adopt solar pumps in future. Of the 40% farmers who were unwilling to adopt Solar Pumps, the primary reason stated for non-adoption was lack of affordability followed by low awareness about Solar Pumps and their schemes

In the primary survey, about 38.68% were aware of Bihar Saur Kranti Sinchai Yojana however only 2-3% of farmers were aware of KUSUM & Drip Irrigation schemes.

Based on the analysis of the available options for Bihar, feeder- level Solar Plant Model is possibly more suitable for Bihar with regards to ease of scalability, affordability of low-income farmers and reduced subsidy burden on the government in the long run.

In the long term, feeder level solar power plant is more suited to meet the requirements of Bihar agriculture sector for its given benefits.

Suitability

- Aligned with agriculture feeder segregation program under DDUGJY
- Affordability & farmer's Involvement
- Benefit both large– and marginal farmers equally as no upfront cost is required from the famers.
- The involvement of farmers' during the setting up process is nil, which makes it more attractive to Bihar's farmers where awareness levels are low.
- No behavioral change is expected in this scenario. The only thing required is the shift from diesel to electric pumps.
- Does not involve any application process from the farmer side.
- It can also act as an extra source of income to the farmer who will lease out the land to the developer for setting up the solar power plant.

Scalability

- Best scalability potential as compared to other models
- It can also cater to other future loads on farm. For example, electric vehicles or electric machinery usage in agriculture.
- Floating solar has a lot of potential due to presence of numerous water bodies in the region.

Financing

- Enable ease of financing as debt is taken by the developer who has a track record and aggregated portfolio
- Entails subsidy savings for Discom and cost of supply is lower.

Asset Security

- The prevailing concern of asset security which leads to less willingness of farmers to adopt is also covered in this model, as developer will be responsible for the operations and maintenance of the solar power plant

Options for Solarizing Agro processing units and Cold Storages

Investing in the solarization of the processing industry is greatly beneficial for the industrial consumer from the point of view of energy savings. The economics and payback period of the successful case studies in Bihar for decentralized cold storages along with small scale solar dryers indicates the potential for tapping of value-added activities to generate employment opportunities and income.

Solarizing bulk milk coolers & Cold Chains can be a first step to address sticky consumer behavior towards fresh foods

The consumers have a natural preference towards purchase and consumption of fresh products over stored ones. According to a study, the consumer in Bihar are less inclined towards purchasing cold stored fruits & vegetables compared to dairy products signalling that dairy supply chain is a possible avenue to be focused on when demand side constrained are factored in [10].

Rooftop Solarization of grid connected Agro Processing and Cold storages and Decentralized Solar options for small scale processing and preserving industries can enhance the farmer's income.

Table 3: Case Study on Rooftop Solarization of cold storage in Begusarai

Roof Top Solarization of Cold storage: Begusarai – Successful Case study in Bihar	
Brief Description For strengthening various post-harvest activities, Government of Bihar has established several Rural Agri Business Centres (RABC). These RABCs aid in strengthening agro economy in their catchment area. The RABCs assist in sale of agri-inputs and services, procurement and primary processing, storage and marketing. Average power requirements per day for this RABC's cold storage ranged from 320 kWh to 1200 kWh, thus on an average the facility had to use DG (Diesel Generation) sets for 4-6 hrs./day considering the state of power supply in the region leading to high input cost for power. As a cost-effective measure the roof top solar plant was adopted. A 100 kWp grid-connected rooftop solar plant was setup under the capex model. The financing was done by a mix of debt and equity, the debt was financed through a PSU bank and a subsidy of 30% of the capital cost was approved by SECI.	**Key Impacts – Success** ✔ Electricity accounts for 35% of the input cost for cold storage companies ✔ Savings in power bill for first year of INR 11 lakhs and for project lifetime (25 years) of INR 465 lakhs been estimated ✔ Expected payback period for the system is approximately 4 years ✔ By adopting roof top solarisation, dependencies on the conventional sources can be reduced, this leads to cost effective operations and reduced emissions ✔ Efficient model which can be replicated across RABCs

Source: [17]

Decentralized cold storages and small-scale solar dryers can produce demands for value-added activities, hence, generating employment opportunities and income.

Bihar has a large production & consumption of milk and there is a huge demand for processed milk products such as ghee, butter, ice cream etc in Bihar.

With 9242 thousand tonnes of milk production, Bihar ranks 9th in India contributing to 5% of the total milk production in the country [18]. Chilling facilities at the collection point along with refrigerated vans are essential for raw milk and fruit and vegetable juices. Electricity consumption is the largest operating cost component for these units and solar power may be used to minimize the operating expenditure.

Coolers and cold chain for dairy products require solar power to minimize the operating expenditure.

ITC - Solar bulk milk chillers & Branding local milk

ITC unit in Munger is packaging milk for sale within and outside the state and producing ghee for sale in the B2B and B2C segments for Southern states. Presently it has 1 Lakh liters per day milk collection capacity and 2 lakh liters per day milk processing capacity. It is generating incomes for around 4000 members from the nearby villages. This unit is using solar power for its bulk milk coolers and cold chain in the field [10].

Table 4: Micro Solar Powered Cold Storage (SPCS) Case Study in Bihar

Micro SPCS in FatuHa village, Bihar– Successful Case study in Bihar

Brief Description

A farmer is cultivating Gerbera flowers in a 2-acre land in Fatuha village near Patna and sells the flowers based on orders received from Patna flower market. The flowers blossom for 9 months (Jan to September) in a year. During the months from April to September, he was forced to throw a bulk of his flowers due to spoilage. Since the wastage levels were very high the farmer was facing losses. As the farm is not connected to the grid, the farmer planned to install a micro solar cold storage facility for keeping the flowers fresh up to 10-12 days which has enabled him to reduce the wastages and sell them at premium prices in the markets beyond Patna.

Financing

As reported, the SPCS was self-financed by the farmer and a subsidy of 50% of the capital cost was received under the NHM state plan for project-based subsidy on the component solar micro cool chamber.

Key Impacts – Success

- The flowers remain fresh up to 10 to 12 days
- The farmer can now time the market well and sell his produce at 67% higher price than before
- Enabled farmer to increase the market reach from Patna flower market to markets outside Bihar such as Ranchi and Lucknow
- The payback period is estimated to be around 0.83 years with subsidy and 1.46 years without subsidy*
- IOT based tracking of system parameters and proactive O&M support by technology provider

Cold Storage facility and Gerbera Flowers

Financial Assessment of the decentralized Cold storage Model

S. No.	Particulars	Units	Value	Value*
A	Cost of solar cold room	INR		13,000,00
B	Taxes + others (Transportation cost)	INR		2,000,00
C	Total Setup cost (A+B)	INR		15,000,00
D	Subsidy @ 50% of the cost	INR		6,50,000
E	Net Cost of cold room (C-D)	INR		8,50,000
F	Comparative analysis of cost savings*		Scenario 1 (Without Cold Room)	Scenario 2 (With Cold Room)
1	No of sticks produced per month	No.	40000	40000
2	Peak wastage months (April-Sep)	No.	6	6
3	Wastage (Apr-Sep)	%	40%	0%
4	Other Months (Jan-Mar)	No.	3	3
5	Wastage (Jan-Mar)	%	5%	0%
6	Total wastage (F1*F2*F3+F1*F4*F5)	No.	102000	0
7	No of sticks available to sell per year F1*(F2+F4)-F6	No.	258000	360000
8	Average selling price	INR	3	5
9	Total sale value (F7*F8)	INR	7,74,000	18,000,00
10	**Net benefit (Scenario 2(F9)-Scenario 1 (F9))**	**INR**		**10,260,00**
G	Payback period for the Farmer (without subsidy) (C/F10)	Years		1.46
H	Payback period for the Farmer (with subsidy) (E/F10)	Years		0.83

*As per the data provided by the Farmer

Source: Case Study developed by KPMG in India

Table 5: Successful case Study: Agri Entrepreneur Using Solar Cold Storage & Solar Dryer

Agri Entrepreneur Using Solar Cold Storage & Solar Dryer– Successful Case study in Badgaon Village, Gaya, Bihar

Solar Powered Cold Storage

Brief Description

An Agri-entrepreneur has adopted SPCS and SPFP modern technologies on the farm in Badgaon village near Gaya in Bihar on 5-acre land cultivating a variety of crops such as wheat, rice, bottle guard, lady finger, strawberry and flowers (marigold, sunflower) etc.

The entrepreneur also has association with an FPC "Tekari Agro Producer company Ltd." which is promoted by his enterprise Sumarth foundation. Sumarth foundation provides training and support to the 4000 farmers associated with the FPC.

The enterprise stores various crops depending on the cropping cycles and benefits from timing the market along with reducing the wastage of produce.

Financing

As reported, the SPCS was self-financed by the Agri-entrepreneur and a subsidy of 50% of the capital cost was received under the NHM state plan for project-based subsidy on the component solar micro cool chamber.

Key Impacts – Success

- Tapped summer cultivation of mushrooms (Apr to Jun) in a controlled temperature inside the cold room
- The payback period for micro SPCS is estimated to be around 0.26 years with subsidy and 0.44 years without subsidy*
- Enterprise ownership model ensures optimal utilization of the facility, best market linkages and market information

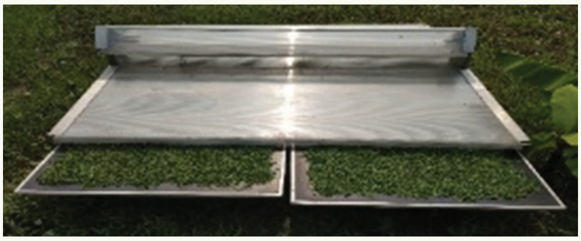
Cold storage facility & Solar weather monitor

Financial Assessment of the decentralized Cold storage Model

Sr No	Particulars	Units	Value	Value*
A	Cost of solar cold room	INR		13,000,00
B	Taxes+others	INR		2,800,00
C	Total Setup cost(A+B)	INR		15,800,00
D	Subsidy @ 50% of the cost	INR		6,500,00
E	Net Cost of cold room(C-D)	INR		9,300,00
F	Comparative analysis of cost savings*		Scenario 1 (Without Cold Room)	Scenario 2 (With Cold Room)
1	Quantity produced per month	Kg	10000	10000
2	No of months of cultivation (not using cold storage): Nov to Mar	No.	5	5
3	No of months of cultivation (using cold storage): Apr to Jun	No.	0	3
4	Total Production (Nov-Mar) (F1*F2)	Kg	50000	50000
5	Total Production (Apr-Jun) (F1*F3)	Kg	0	30000
6	Average selling price (Nov-Mar)	INR/Kg	100	100
7	Average selling price (Apr-Jun)	INR/Kg	120	120
8	Total sale value(F4*F6+F5*F7)	INR	50,000,00	86,000,00
9	Net benefit (Scenario 2(F8)-Scenario 1(F8))	INR		36,000,00
G	Payback period for the Famer (without subsidy) (C/F9)	Years		0.44
H	Payback period for the farmer (with subsidy) (E/F9)	Years		0.26

*As per the data provided by the Agri-entrepreneur

Solar Dryer

Brief Description	Key Impacts – Success
The Enterprise owns a conduction based Solar dryer from S4S technology. Mushrooms which are not purchased in the market just because of the aesthetic reasons, are dried and then powdered and further packaged. They also dry moringa leaves to make powder and package them. Both the products are very popular for their health benefits and have a huge market demand. Currently their market for processed items are local shops in Gaya and they also sell these products directly to some leading banks like ICICI in India.	✔ Tapped the market by preparing products with high market demand from nearly free/left-over agricultural produce ✔ Benefitting from selling processed good like Moringa powder, honey, mushroom powder etc. with no energy cost ✔ Solar dryer increases the shelf life of fruits & vegetables, spices, meat etc up to 6 months without using preservatives ✔ Dehydrated food contains 45% more nutritional value than open sun drying giving 50%-200% higher market value
Technical Specifications ✔ Setup cost is INR 40,000* after discount ✔ Measures 6ft x 6 ft ✔ Can dry 12-16 Kg per day and 3 tonnes per year ✔ Easily assembled and dismantled ✔ No electric supply and maintenance required	 **Solar Dryer**
*Market price is INR 80,000/-	

Source: Case Study developed by KPMG in India

ROADMAP 2032

Solarizing Irrigation Systems in Bihar

50% of the electricity demand for irrigation can be met through distributed solar – leading to a savings of INR 9,900 cr. for the state as against business as usual scenario.

The proposed roadmap shows a long-term transition from diesel and electric pumps to solar based pumps for irrigation in Bihar. There is a strong preference for feeder solarization to achieve clean energy transition at a larger scale for agriculture in Bihar. The roadmap also identifies potential for replacing existing diesel pumps with off-grid solar pumps/ solarization of on-grid pumps in regions where feeder level solarization is not feasible.

Feeder solarization assist in avoiding investments in the T&D infrastructure

The average cost of supply in Bihar is INR 6.84/kWh for 2019-20, and the State Govt. has announced a subsidized tariff of INR 0.75/kWh for agricultural consumers. Thus, the State Govt. is providing a subsidy of INR 6.09/kWh for each unit of power supplied to agricultural consumers. Considering the BERC approved agricultural consumption for the period 2019-20 to 2021-22 and growth rate from 19th EPS Report, projected agricultural consumption and the Govt. subsidy till 2031-32 is as below:

Table 6: Projected Agricultural Consumption Along with Assumed Parameters

Years	Projected AGL Consumption (MU)	Projected Average Cost of Supply (INR/kWh)[9]	Projected AGL Tariff (INR/kWh)	Projected Govt. Subsidy for AGL (INR Cr.)
2019-20	1,033	6.84[10]	0.75	629
2020-21	1,551	7.08	0.75	982
2021-22	2,217	7.33	0.75	1,458
2022-23	2,429	7.58	0.75	1,660
2023-24	2,662	7.85	0.75	1,890
2024-25	2,917	8.12	0.75	2,151
2025-26	3,196	8.41	0.75	2,448
2026-27	3,503	8.70	0.75	2,785
2027-28	3,838	9.01	0.75	3,169
2028-29	4,206	9.32	0.75	3,605
2029-30	4,609	9.65	0.75	4,101
2030-31	5,050	9.99	0.75	4,664
2031-32	5,534	10.34	0.75	5,305

Source: BERC, CEA 19th EPS Report & KPMG in India Analysis

[9] A nominal escalation of 3.50% per annum is considered based on the past trends in ACOS and PP cost escalation in Bihar.
[10] BERC approved ACOS for FY 2019-20 (https://berc.co.in/orders/tariff/distribution/sbpdcl/1965-tariff-order-of-sbpdcl-for-fy-2019-20)

While the average cost of supply is likely to increase owing to underlying escalation in fixed and variable costs, however feeder solarization (distributed solar generation at agricultural feeders) could provide a hedge against the cost increases by allowing the DISCOMs to procure solar power at feeder level at a lower cost, potentially around INR 3.50-4.00/kWh for 25 years, considering the feed-in-tariff approved by BERC for FY 2019-20 and the tariff discovered by BREDA in the recent solar tenders. Thus, DISCOMs will be able to save Govt. Subsidy of at least INR 2.84-3.34/kWh for the energy procured from distributed solar projects. The future implied savings will be higher as the ACOS increases over the years. However, the actual tariff discovered will be dependent on the prevailing cost of solar modules and other equipment, cost of debt, risk perception and return expectations of the developers, etc. For example, Maharashtra has discovered a tariff of INR 2.94-3.15/kWh under its agricultural feeder solarization program.

Further, feeder solarization will assist DISCOMs in saving the investments required for upgrading and strengthening of existing transmission and distribution infrastructure, avoid transmission losses and reduce subsidy burden on the State. DISCOMs are also eligible for Procurement Based Incentive (PBI) from MNRE under KUSUM scheme for the energy procured from distributed solar projects.

Bihar Government is providing a subsidy of INR 6.09/kWh for each unit of power supplied to agricultural consumers.

DISCOMs will save Bihar Government subsidy of at least INR 2.84-3.34/kWh for the energy procured from distributed solar projects.

Table 7: llustrative Economics of Feeder End Solar Plant Model for 25 years – 20 MW size feeder level plant equivalent energizing 3500 pumps (1000 3 Hp pumps, 2000 5Hp pumps & 500 7.5 Hp pumps) in the first year

Project Particulars	Units	Values	
Total Project Cost	INR Crore	80	
MNRE capital subsidy	%	0	
MNRE OPEX Subsidy (Minimum of 1 & 2 below)			
1. Per unit PBI (Procurement Based Incentive)	INR/kWh	0.4	
2. Per MW PBI	INR/MW	660,000	
3. Duration of PBI (Procurement Based Incentive)	Years	5	
DISCOM /State Contribution	Rs	0	
Farmer Contribution	Rs	0	
DISCOM Savings	**Units**	**First Year**	**NPV (25 Years)**
Savings: Total cost to supply power to pumps including loss	INR Crore	19.7	228.0
Savings: Difference earned by DISCOM for buying cheap power	INR Crore	0.3	2.4
Pay-out by DISCOM to the Developer	INR Crore	12.2	104.6
MNRE Subsidy to the DISCOM	INR Crore	1.3	5.0
Net savings by DISCOM under this scheme	INR Crore	9.1	130.8
Environmental benefits		**First Year**	**Total (25 Years)**
Total CO_2 emissions avoided	Tonnes CO_2	47,602	1,121,307

Source: *KPMG in India Analysis*

Roadmap for feeder solarization and the benefits to Bihar

In order to meet 50% of the agricultural demand in 2031–32 from distributed solar projects, DISCOMs may start procuring power from distributed solar projects from 2020–21 onwards. Solarization of agricultural feeders may be aligned with the feeder separation program undertaken by the DISCOMs.

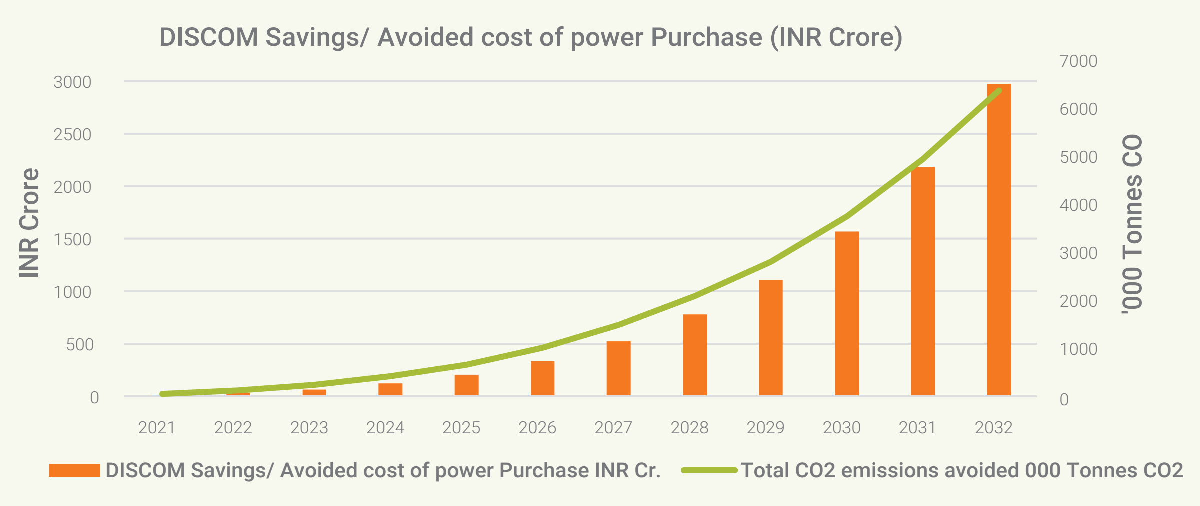
Table 8: Feeder Solarization Roadmap

Year	Projected Govt. Subsidy for AGL (INR Cr.)	Subsidy used for solar procurement (%)	Solar energy procured (MU)	Incremental Solar capacity procured (MW)	Cost of Supply (INR Cr.)	Cost of solar power (INR Cr.)	Net savings to the DISCOMs (INR Cr.)	CO_2 Emissions Avoided ('000 Tonnes)
2020–21	982	1%	33	20	24	12	11	48
2021–22	1,458	2%	83	30	61	30	31	119
2022–23	1,660	4%	166	50	126	61	65	238
2023–24	1,890	6%	291	75	229	107	122	417
2024–25	2,151	8%	458	100	372	168	204	655
2025–26	2,448	11%	707	150	595	259	336	1,012
2026–27	2,785	14%	1,040	200	905	381	525	1,488
2027–28	3,169	17%	1,456	250	1,312	533	779	2,083
2028–29	3,605	20%	1,956	300	1,823	716	1,107	2,797
2029–30	4,101	23%	2,621	400	2,529	959	1,570	3,749
2030–31	4,664	27%	3,454	500	3,449	1,264	2,185	4,939
2031–32	5,305	31%	4,452	600	4,602	1,630	2,972	6,367
Total	**34,218**	**18%**	**16,719**	**2,675**	**16,026**	**6,119**	**9,907**	**23,908**

Source: KPMG in India Analysis

To start with, DISCOMs may use 1% of the electricity subsidy for agriculture in 2020–21 to procure power from distributed solar projects and may increase this to 31% in 2031–32. By solarizing agricultural feeders in this manner, DISCOMs will be able to meet around 50% of the electricity demand for irrigation from distributed solar projects and the State Govt. will be able to save around INR 9,900 Cr. towards subsidy to agricultural consumers.

Figure 15: Estimated DISCOM Savings & CO_2 Emissions Avoided: Feeder Solarization



Source: KPMG in India Analysis

By adopting the proposed roadmap, DISCOMs are likely to meet around 65% of their solar RPO targets with the power procured from distributed solar projects, avoiding procurement of REC certificates from power exchanges. This is likely to also result in avoided CO_2 emissions of 23.91 Million Tonnes for the period 2020–21 to 2031–32. Further, the avoided CO_2 emissions over the life of project will be much higher than this.

DISCOMs will be eligible to meet their RPO targets with the power procured from distributed solar projects and can avoid procuring Renewable Energy Certificates.

Table 9: Solar RPO Targets to be Achieved by Feeder Solarization

Years	Projected Solar RPO Targets (%)	Projected Energy Consumption (MU)[11]	Solar capacity required to meet RPO (MW)[12]
2019–20	4.75%	27,513	785
2020–21	6.75%	30,846	1,251
2021–22	8.00%	34,567	1,661
2022–23	8.00%	37,878	1,821
2023–24	8.00%	41,506	1,995
2024–25	8.00%	45,482	2,186
2025–26	8.00%	49,839	2,396
2026–27	8.00%	54,612	2,625
2027–28	8.00%	59,843	2,876
2028–29	8.00%	65,576	3,152
2029–30	8.00%	71,857	3,454
2030–31	8.00%	78,740	3,785
2031–32	8.00%	86,282	4,147

Source: KPMG in India Analysis

[11]Considering BERC approved energy consumption for FY 2019–20 to FY 2021–22 and the CAGR from 19th EPS.
[12]Considering 19% CUF for distributed solar projects.

Benefits to farmers: This will offer continuous day time power supply to the farmers. Further, landowners can get stable source of rental income for 25 years even when the land is uncultivable by leasing their land for installation of solar projects and maintaining a minimum installation height so as to ensure that farming activities are not affected.

For solarization of grid connected pumps, a farmer has to contribute 40% of the total cost while MNRE and Bihar Government provide a subsidy of 30% each.

Solarization of Grid Connected Pumps in regions where feeder-level solarization is not feasible

State Govt. may also consider solarization of grid connected pumps instead of feeders wherever it is not possible to solarize the feeders due to unavailability of land near the substations. Solarization of grid connected pumps is eligible for MNRE subsidy under KUSUM scheme. MNRE shall provide 30% subsidy, State Govt. to provide at least 30% subsidy and farmer has to contribute the remaining 40%. Farmer can draw loan up to 30% and contribute only 10% of the cost. Under KUSUM scheme, farmer is allowed to install solar PV capacity up to two times of the pump capacity in kW. Excess energy injected into the grid shall be procured by the DISCOMs. A summary of the solar PV costs for solarization of grid connected pumps is as below:

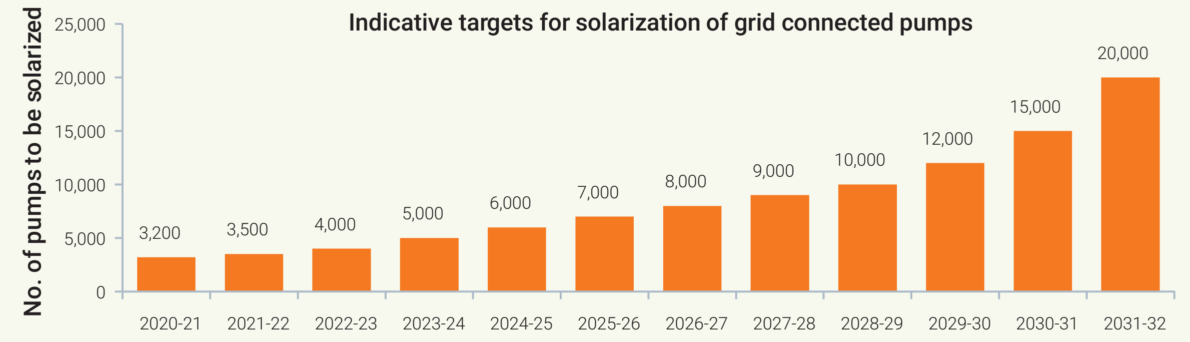
Table 10: Illustrative Financials for Solarization of Grid Connected Pumps

Particulars	Units	Values
Cost of Solar PV project for solarization of grid connected pumps	INR/kWp	40,000
MNRE Subsidy	%	30%
State Govt. Subsidy	%	30%
Farmer Contribution	%	40%
Farmer Loan	%	*30%*
Farmer Equity	%	*10%*
MNRE Subsidy	INR/kWp	12,000
State Govt. Subsidy	INR/kWp	12,000
Farmer Contribution	INR/kWp	16,000
Farmer Loan	*INR/kWp*	*12,000*
Farmer Equity	*INR/kWp*	*4,000*

Source: KPMG in India Analysis

Considering the MNRE targets under KUSUM scheme, the following targets are proposed for solarization of grid connected pumps in Bihar till 2031-32:

Figure 16: Estimated DISCOM Savings & CO_2 Emissions Avoided: Feeder Solarization



Source: KPMG in India Analysis

Based on success in the initial year pilots, targets may be gradually increased. This is likely to provide additional income to the farmers as they will be paid for excess energy injected into the grid and are encouraged to utilize the pumps in an efficient way. Further, this is likely to also reduce ground water exploitation. State Govt. is expected to save subsidy provided to agricultural farmers towards electricity consumption of the pumps. There are expected notional savings to DISCOMs due to avoided cost of power purchase for supply of power to these agricultural consumers. Further, DISCOMs will be able to meet their solar RPO targets from the power injected into the grid by these solar plants. This is likely to also result in avoided CO_2 emissions of 8.49 Million Tonnes for the period 2020-21 to 2031-32. Further, the avoided CO_2 emissions over the life of project will be much higher than this.

DISCOMs can avoid CO_2 emissions of 23.91 Million Tonnes between 2020-21 and 2031-32 by adopting the proposed roadmap for feeder solarization.

Off-grid Solar pumps to replace existing diesel pumps in areas where grid network is not developed

Agricultural Ministry is providing diesel subsidy to the farmers in Bihar. This is expected to be around INR 400-500 Cr. per annum. Further, drought seasons aggravate the requirement of diesel subsidy leading to additional burden on the Ministry. To encourage sustainable agriculture and reduce subsidy dependence, Ministry may promote Off-grid solar pumps in areas where grid network is not appropriately developed.

Off-grid solar pumps may be promoted by the Agricultural Ministry to encourage sustainable agriculture and reduce subsidy dependence.

Agricultural Ministry may slowly phase out the diesel subsidy for wider adoption of off-grid solar pumps.

Off-grid solar pumps support both the Agricultural Ministry and the farmer by reducing subsidy and avoiding diesel costs. Further, MNRE subsidy @30% of the Off-grid solar pump cost is available under the KUSUM scheme. State Govt. must provide minimum 30% subsidy and the remaining cost has to be borne by the farmer. To increase the adoption of Off-grid solar pumps, Agricultural Ministry may provide 30% subsidy in addition to the State Govt. subsidy of 30% and farmer to contribute the remaining 10%. A summary of the prices discovered by MNRE in KUSUM and subsidy component is as below:

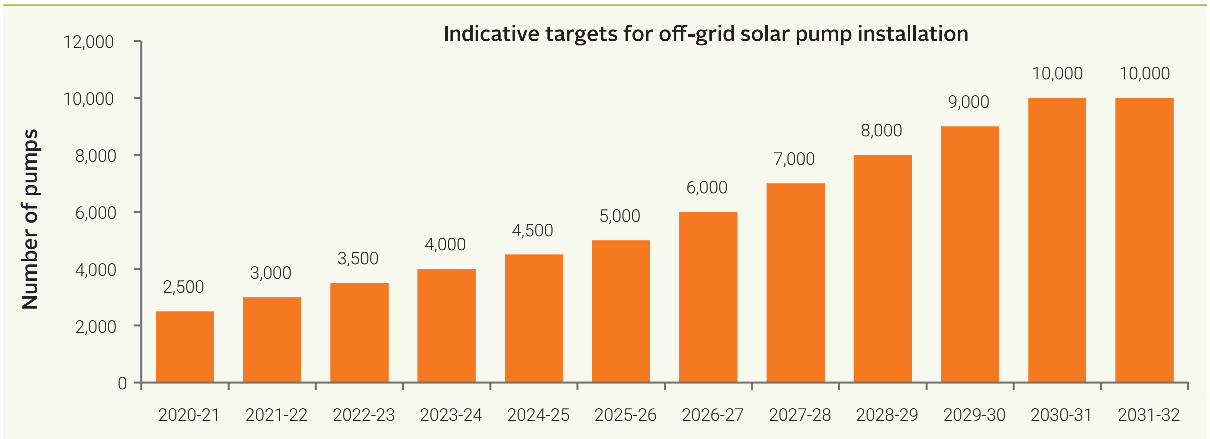
Table 11: Financials for Off- grid Solar Pumps based on Prices Discovered under KUSUM Tender

Particulars	Units	Value	Value	Value
Pump capacity	HP	3.0	5.0	7.5
Cost of pump discovered under KUSUM scheme tender (AC pumps)	INR	153,500	218,500	335,000
MNRE Subsidy	%	30%		
State Govt. Subsidy	%	30%		
Agricultural Ministry Subsidy	%	30%		
Farmer Contribution	%	10%		
MNRE Subsidy	INR	46,050	65,550	100,500
State Govt. Subsidy	INR	46,050	65,550	100,500
Agricultural Ministry Subsidy	INR	46,050	65,550	100,500
Farmer Contribution	INR	15,350	21,850	33,500

Source: KPMG in India Analysis

Considering the MNRE targets under KUSUM scheme for Off-grid solar pumps installation in Bihar, the following Off-grid solar pump installation targets are proposed for Bihar:

Figure 17: Indicative Targets for Off- Grid Solar Pumps



Source: KPMG in India Analysis

Agricultural Ministry may promote community-based pump-sets with higher capacity rating (5.0 HP and 7.5 HP) to improve pump efficiency and reduce ground water exploitation. Agricultural Ministry may slowly phase out the diesel subsidy for wider adoption of Off-grid Solar pumps. Further, switching to micro irrigation systems from flood irrigation may be encouraged through creating awareness and use of conditional subsidies. This will benefit farmers in terms of lower operating costs, the State Govt. will be able to save diesel subsidy provided to the agricultural consumers and DISCOMs will save connection costs for connecting these consumers to the grid and notional power purchase cost for providing supply to these consumers. Further, fulfillment of above targets will result in avoided CO_2 emissions of 5.12 Million Tonnes for the period FY 2020-21 to FY 2031-32. Further, the avoided CO_2 emissions over the life of project will be much higher than this. In future, when the area gets grid extension then these off-grid pumps may be connected to the grid and farmers can generate additional income by injecting surplus power into the grid.

Switching to micro-irrigation systems from flood irrigation will lower the operating costs for farmers.

Priority districts for solar pumps: The high penetration of diesel pumps across different districts can act as a potential indicator to prioritize the solarization of irrigation systems in Bihar. Figure below provides district-wise mapping for prioritization of solarization of diesel pumps based on penetration of diesel pumps.

Figure 18: District wise Mapping for Priority of Solarization of Irrigation Systems According to Penetration of Diesel Pumps

Source: Minor Irrigation Census (2013-14) & KPMG in India Analysis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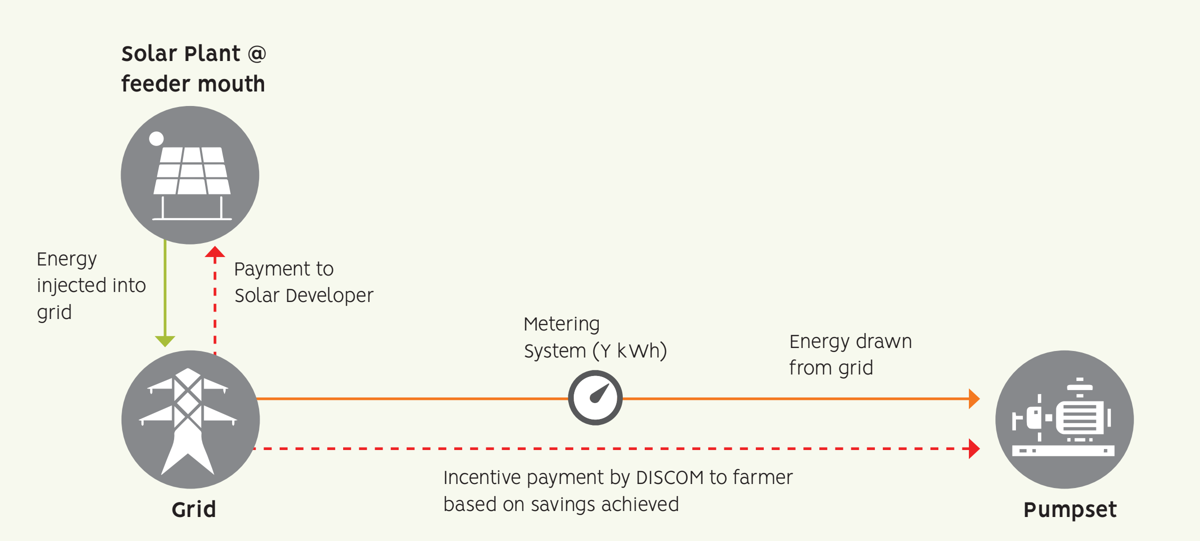
Roles and responsibilities of different stakeholders

1. Feeder Solarization (Distributed solar) model

DISCOM appoints an agency to install solar panels at the agricultural feeder mouth of an appropriate capacity as per the substation load to cater agricultural consumers primarily

DISCOM to sign a Power Purchase Agreement (PPA) for 25 years with Solar Developers

Figure 19: Schematic Representation of Feeder Level Solar Power Plant Model



State Government

- Support DISCOMs in solarization of agricutural feeders (installation of distributed solar projects). Help in identifying land for solar projects.

DISCOMs

- Aggregate the demand for distributed solar projects
- Enter into PPA with developers for 25 years at pre-fixed levelised tariff

MNRE

- Provide Procurement Based Incentive to the DISCOMs.

Developers

- Responsible for land identificaton near the sub-station
- Responsible for financing, installation, operation and maintenance of the project.

Farmers

- May lease land to the developers for installing distributed solar projects. In such cases, farmers shall be eligible for land lease from the developers.

2. On grid/Off-grid solar pump model

State Government	• Provide 30% subsidy towards Off-grid solar pumps/solarization of On-grid pumps
Agricultural Ministry	• Provide 30% subsidy towards Off-grid solar pumps • Eliminate diesel subsidies in a phased manner
MNRE	• Provide 30% subsidy towards Off-grid solar pumps/solarization of On-grid pumps
Developers/ EPC Contractors	• Responsible for installation, repair and maintenance of the Off-grid solar pumps/On-grid solar plants
Farmers/FPO/ cooperative society	• Invest 10% of the cost towards farmer contribution • Responsible for operating the Off-grid solar pumps/On-grid solar plants

Note: *In the On-grid model, subsidy is available only for solar PV component, whereas in the Off-grid model it is available for both solar PV and pump*

Solarizing Agro-processing units and cold storages in Bihar

The roadmap proposes the setting up of solar based cold storages and agro processing units in Bihar

The proposed roadmap shows a long-term transition from existing electric based cold storages and agro processing units to solar based cold storages and agro processing units in Bihar. Based on the literature review of existing models, two proposed options to achieve sustainable energy transition at a larger scale for cold storages and food processing units in Bihar are–a) rooftop solarization of the large existing and new cold storages and food processing units and; b) setting up of new micro solar based cold storages and solar dryers for processing.

Rooftop solarization of existing cold storages and Agro-processing units

Electricity costs form a major part of total operating costs for cold storages and food processing industries.

Rooftop solarization is expected to provide economic benefits to existing food processing units and cold storages by reducing input cost significantly. The electricity costs form a major part of total operating costs for cold storages and food processing industries (with current average tariff of 7 Rs). As an illustrative case, financials and benefits for setting up a unit kWp rooftop solar plant for industrial purpose in Bihar is discussed below assuming project life of 25 years and 100% consumption by the industrial consumers:

- The project will require an investment of INR 40,000 and has an NPV of INR 7,416 and IRR of 16.25%
- The industrial consumer will save electricity purchase equivalent to INR 61,806
- 60.92 Tonnes CO_2 emissions are likely to be avoided over 25 years life cycle

Table 12: Economics for Rooftop Solarization of Agro Processing Industries/ Cold Storages for Bihar

Parameter	UNIT	VALUE
Rooftop space required	Sq. meters/kWp	10–12
Investment required	INR/kWp	40,000
NPV	INR/kWp	7,416
NPV (avoided cost of power purchase)	INR/kWp	61,806
IRR	%	16.25%
Avoided CO_2 emissions	Tonnes CO_2/kWp	60.92

Source: KPMG in India Analysis

The above illustration indicates high savings for entrepreneur per kWp investment in the rooftop solarization. While the above model assumes 100% consumption by the industrial, the variant of this model can also be considered where the surplus generation can be injected in to the grid and the entrepreneur can get the net metering benefit. While the investment in solar rooftop is likely to be economically beneficial due to significant reduction in the input cost, there is a lack of awareness related to benefits of solar investments in Bihar and the state government should encourage these investments by formulating a special program for promotion and adoption of rooftop solarization.

Government of Bihar should encourage investments in rooftop solarization through a structured programme for its adoption and promotion.

In this regard, BREDA/Discoms may facilitate the installation of solar rooftop at a larger scale. In Kerala, State Electricity Board has rolled out an innovative Saura project in which they have identified various residential and commercial sites for rooftop solarization under two different models – RESCO and EPC [19]. On similar lines, Discoms of Bihar along with BREDA can play a constructive role by doing large scale aggregation of demand to reduce transaction costs, streamlining application process and taking confidence building measures through a specific program for solarization of existing cold storages and food processing units in Bihar.

The innovative Saura project in Kerala has identified various residential and commercial sites for rooftop solarization.

Department of Agriculture and Department of Industries

- Identification of cold storages and Agro-processing facilities for rooftop solarization

Bihar State Electricity Board/DISCOM/BREDA

- Tendering and Inviting bids from developers
- Supporting and easing out the process of providing sanction, approvals, permits and clearances from the appropriate authorities
- Creating awareness and gathering the consent of facility owners for the adoption of rooftop solar plant
- Making Payments to the developers
- Making any required grid modifications beyond metering point
- Installing data rooms for the selected bidders

Developer/Bidder

- Development of solar roof top plant on the selected site
- Installations of solar meters & net meters and providing data acquisition and communication facility on the site
- Bearing full cost of infrastructure and installations till the metering point and fees for connectivity

Cold storage/Food processing Owner

- Providing necessary support like facillitating consent, providing access to premises, information of the building

Priority districts for solar food processing units: The National horticulture board (NHB) provides the district wise distribution of the horticulture produce for Bihar. The production data has been used to estimate district-wise food processing potential. As indicated in the figure below, two levels of prioritization can be considered for promoting solarization of food processing units in Bihar.

Figure 20: District wise mapping for priority of solar food processing units according to Production levels

Source: District wise production of Fruits and Vegetables (NHB database, 2014-15) & KPMG in India Analysis

Priority districts for solar cold storages: Presently, the total capacity per unit of production is 0.17 against the required factor of 0.54. Total horticulture production for each district[13] is used to derive the corresponding cold storage capacity requirements assuming the district wise capacity to production factor as 0.54. Further, the potential for cold storage in a district is the gap between the required and the present capacity. These gaps indicate district wise potential for setting up cold storages in Bihar. Based on the estimated gap, districts can be prioritized. Broadly, two categories for the prioritization is proposed.

The current total capacity of solar cold storages per unit of production is 0.17 against the required factor of 0.54.

Figure 21: District wise mapping for priority of solar cold storages according to average gap between production and existing capacity

Source: Available cold storages (Directorate of Horticulture Bihar, 2017), District wise production of Fruits & Vegetables (NHB database, 2014-15) & KPMG in India Analysis

Promotion of micro solar cold storages and solar dryers

There are around 2645 markets in Bihar including rural haats, market yards and wholesale markets [2] & [20]. Establishing micro solar cold storages and solar dryers at these markets could be a viable option considering high agricultural wastage numbers for the state and a need to strengthen the agriculture value chain. BREDA can promote micro solar cold storages through a cooperative model as done by JREDA. In addition, solar dryers may also be promoted along with solar cold storages on similar lines.

In addition to strengthening the agriculture value chain, this will provide employment opportunities.

Summary – JREDA's Micro solar cold storage programme [21]

- Farmers' Cooperative has max. 30% stake in the ownership of the cold storage, this is likely to bring sense of responsibility towards the micro solar cold storage and its efficient operation
- Government of Bihar will contribute the remaining 70%
- Revenues will be shared in the proportion of 30:70 between cooperative and the government.

For example, solar dryers can also be set up in rural villages and women can actively participate in food processing activities

As per primary survey, 88% farmers are interested in working for any food processing unit that can set up micro solar based dryer on a rental basis at their homes in return for dry products by which they can earn monthly income over and above the cost of the raw material.

Integrated approach for cold storage and Agro-processing units

The solar based cold storage capacity building must be integrated with food processing, packaging and branding activities to enable significant reduction in wastages. For example, Bihar State Vegetable Co-operative Society adopted four-pronged strategy to link farm gate to the retail end using the cooperative organizational structure for attaining minimum scale of investment and size of operations. In addition, Government of Bihar can bridge the void of "missing middle" by banding & certifying the localized processed food products.

Four-pronged approach of Bihar State Vegetable Co-operative Society

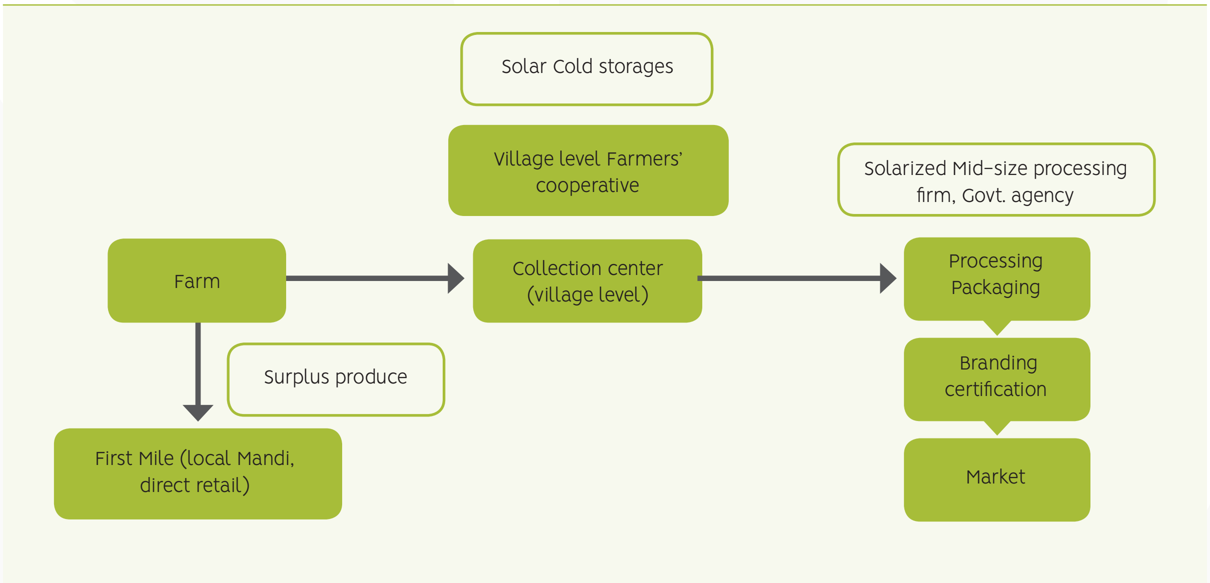
- **First line:** A fresh line of fruits & vegetables packaged and sold in the market
- **Second line:** pulp form of Agri-produce with no further processing e.g. pulped tomatoes
- **Third line:** Processed Agri-produce, e.g. Jam, pickle
- **Fourth line:** Fresh produce for further sale

Branding the local milk-Sudha Bihar [10]

Three-tier structure of Bihar State Milk Co-operative (COMFED): The Village-level Dairy Co-operative Societies (DCS) collect the surplus milk from farmer-members. District-level Milk Producing Unions collects milk from entire village DCS of its district, processes & markets it, the State-level Cooperative Milk Producing Union is responsible for overall policy-making and governance.

[13]NHB database

Figure 22: Integrated Approach for setting up Solar cold storages in tandem with Solar agro processing Units



Key levers for achieving the Roadmap

There exist sector-specific barriers such as socio-economic barriers, institutional and regulatory barriers, market and technology related barriers that may prevent government in implementing the proposed roadmap for sustainable energy transition across the agricultural value chain. Some of these barriers are listed below:

Market Barriers

a) Lack of market (supply chain) for decentralized solar products

b) Distortions in energy markets due to current policies of providing heavy subsidies on diesel/electricity for agricultural use

c) Missing middle size firms for agro-processing industry

Institutional and Regulatory Barrriers

a) Lack of a common framework for regulation and coordination amongst different departments and ministries

b) Lack of infrastructure to support market introduction of solar technologies

c) Lack of monitoring and inefficient implementation of the solar projects

Technical Barriers

a) Lack of local technology suppliers of solar panels and other spare parts

b) Lack of maintenance and support services for solar technology adopters

Economic and Financial Barriers

a) High upfront cost for solar technologies as compared to alternatives

b) Lack of credit availability for farmers and local entrepreneurs (mising middle firms)

Socio-Cultural Barriers

a) Lack of Awareness and entrepreneurial skills among farmers for solar technologies

b) Low demand for preserved food in local markets acts as a deterant for capacity enhancement of cold storages

c) Lack of willingness to adopt solar technologies due to inability of solar pump to provide reliable water supply during cloudy days and Morning/evening time of irrigation

Environmental Barriers

a) Over exploitation of ground water resources

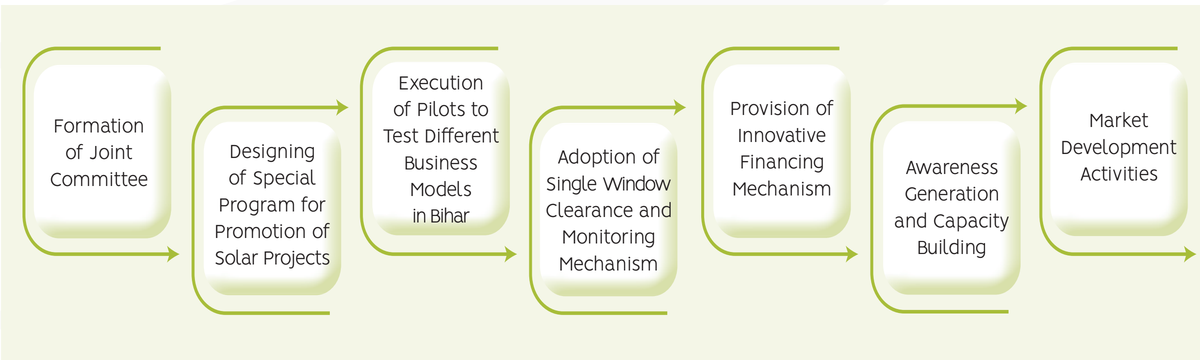
b) Land competition and diversion of agricultural land for setting up solar

However, the below provided recommendations will help in achieving the vision of the roadmap by addressing the above barriers

Barriers	Recommendations	Responsible Entity
1. Market Barriers	a) Incentives to solar technology users and entrepreneurs (subsidies, tax rebates) b) A policy to divest subsidy provision for agricultural consumers and invest the same in improving the infrastructure towards agricultural services. c) Branding & certifying the localized processed food products with existing govt brands such as Sudha. Promoting Integrated approach of setting up Solar cold storage & agro processing units through cooperative model.	a) Ministry of Energy b) Ministry of Agriculture, Ministry of Energy c) Ministry of Agriculture, Ministry of Industries
2. Institutional and Regulatory Barriers	a) Adopt Single window approach to streamline application process for farmers and to make business environment conducive to investors and developers. Design special program/ policy for promotion of solar projects as done by KSEB and JREDA. b) Promote specialized institutes for financing, capacity building, marketing and commercialization. c) Form a joint committee to regulate and monitor efficient implementation of key activities such as metering, billing collection and prompt payment to developers etc. An active role of the joint committee can build confidence of developers and streamline the processes.	a) Joint committee of Agriculture Department, Energy Department & Water Department b) Banks, NGO's & FPO's c) Joint committee of Agriculture Department, Energy Department & Water Department
3. Technical Barriers	a) Provide policy incentives (tax rebates) to promote local entrepreneurs for setting up solar technology businesses. b) Develop relevant skills of local people to strengthen solar energy supply chain for training, demonstration, setting up a solar technology related business and maintenance of solar technologies.	a) Ministry of Energy & Ministry of Industries b) Ministry of Skills & Development, Ministry of Energy
4. Economic and Financial Barriers	a) Promote community solar pumps for better utilization and economies of scale. Provide targeted subsidies to marginal farmers through direct benefit transfers. b) Design innovative financing mechanism to increase liquidity of marginal farmers and small entrepreneurs and to enable them to adopt solar technologies through models such as pump sharing agreements through cooperatives/FPOs, warehouse receipt scheme – for cold storage in Tanzania reduced time-based price risk of storage owner in an event of price crash when famers don't claim their stored produces [10].	a) Ministry of Agriculture, Ministry of Energy b) Local Financial Institutions along with Agriculture & Energy Department

5. Socio-Cultural Barriers	a) Organizing sensitization workshops and awareness campaigns for farmers, FPOs and all stakeholder's officials b) Detailed assessment of the perceived needs of consumers for processed and preserved foods. c) Promotion of water storage tanks for morning /evening irrigation	a) Ministry of Agriculture through regional Krishi Vigyan Kendra's, Ministry of Energy b) Ministry of Industries c) Irrigation Department
6. Environmental Barriers	**a) Water** – Promote drip and mini sprinklers along solar pumps. Subsidies provided by irrigation department could be linked to solar pump adoption. – Installation of water meters and use of new technologies such as Internet of things (IOT) for remote monitoring and management. – Farmers can be incentivized to restrict water consumption below a threshold level by introducing a differential electricity pricing in feeder solarization model. – Mapping of optimal pump size as per regional ground water level, cropping pattern and land size **b) Land** – Pilots of Agri-Photovoltaics where agricultural activities are carried below high mounted solar panels	a) Irrigation Department b) Energy Department & Agricultural Department

A few of the key steps which could be undertaken to keep the energy roadmap vision relevant and effective are:



Despite the imminent barriers in implementing the roadmap, one would require a different lens to look at these issues which would involve critical thinking, keeping farmer's interest in consideration and most importantly bringing various departments that work tirelessly to improve the lives of people together to cohesively work and make this transition real and sustainable.

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