Alliance for an Energy Efficient Economy

Cold Rooms as an Enabler to Boost Farmer Incomes

Observations and Learning from Deploying Micro Cold Rooms in two FPOs

Background

Effective post-harvest management and access to multiple markets are critical to realising better value for horticulture produce, thereby improving farmers' income. The Committee for Doubling Farmers' Income, in its report *Doubling Farmers' Income – Volume III, Post-production Agri-logistics: maximising gains for farmers*, highlights the need for post-harvest infrastructure at the farm gate to "minimise handling loss and convert would-be-loss into value". For horticultural produce, the cold chain is a critical component of post-harvest infrastructure at the farm gate and the farm-to-market supply chain. However, there are still significant gaps in cold chain infrastructure, which result in

- post-harvest losses
- distress selling, as farmers are unable to store excess produce
- limitations in storing seasonal produce for a year-round supply at good prices
- restricted access to distant market

The government has launched schemes, such as the Mission for Integrated Development of Horticulture (MIDH), which include support for cold chain infrastructure, including cold rooms, packhouses, pre-cooling facilities, ripening chambers, and reefer transport. Building out cold chain infrastructure is critical to increasing the value of horticulture produce and farmer incomes, while also providing an opportunity to incorporate energy-efficient and low-GWP technologies powered by renewable energy. The India Cooling Action Plan (ICAP) estimates that an energy-efficient cold chain could result in 30% energy savings and an 11% reduction in refrigerant demand, reducing energy-related operating costs and emissions.

AEEE supported a Farmer Produce Company (FPC), Sahaja Samrudha Organic Produce Company Limited (SSOPCL), in Karnataka, and a farmer cooperative, Singhwara Primary Vegetable Cooperative Society (PVCS), in Bihar, to deploy energy-efficient, renewable energy-powered cold rooms to enhance their business operations. SSOPCL has been operating for 14 years, whereas Singhwara PVCS is a relatively new cooperative, founded in February 2021. AEEE's role spanned needs assessment, evaluation and procurement of cold rooms, installation, commissioning and testing, as well as post-deployment support, monitoring, and impact analysis. AEEE conducted comprehensive on-site assessments to understand their business operations and identify use cases for cold rooms. To select and deploy optimal cold rooms, AEEE evaluated energy-efficient, renewable energy-powered cold room models from nine suppliers based on the following principles:

Sufficiency: Ensure that the cold room is optimally sized to meet the FPC's needs, neither too large nor too small, and is designed for optimal storage conditions for the intended produce type(s).

Energy Efficiency: Incorporate energy-efficient technologies to reduce energy consumption, energy costs, and energy-related GHG emissions

Renewable Energy: Utilise renewable energy to further reduce energy expenses and energy-related GHG emissions, and provide an alternate power source in weak-grid rural areas..

This study on the deployment of cold rooms at SSOPCL and Singhwara PVCS presents the outcomes and lessons learned based on 6-12 months of field observations.

Observations at Sahaja Samrudha Organic Producer Company Limited (SSOPCL)

SSOPCL was incorporated in 2010 and currently has 1,200 farmer shareholders. As of 31 March 2024, the paid-up capital was INR 57.7 lakhs. SSOPCL has its own distribution centre and a dedicated operations team of 40-45 staff and contract workers led by the CEO. SSOPCL has well-established backward and forward linkages, procuring organic fruits and vegetables (F&V) from its farmer shareholders and selling fresh organic produce and food products to a network of 800-900 buyers comprising general traders and modern retail. Daily sales of fresh fruits and vegetables (F&V) are 5-6 metric tons (MT).

Use case

During AEEE's field visit to SSOPCL, they indicated the need to store seasonal produce, especially potatoes. SSOPCL indicated that the storage would also be used in a "trader model" to procure and store organic produce from other states for retail sales to its network of buyers.

Cold room deployment: 10 MT dual-chamber energy-efficient solar cold room

SSOPCL, in collaboration with AEEE, deployed a 10 MT dual-chamber energy-efficient solar cold room in March 2024. The cold room has Thermal Energy Storage (TES) and remote monitoring of key parameters. Per the use case outlined above, the cold room is primarily used for storing potatoes from local farmers and produce procured from other states for sale in SSOPCL's franchisee retail outlet and B2B channels. AEEE monitored the cold room operations for potato storage and sales to assess the impact on the beneficiaries.

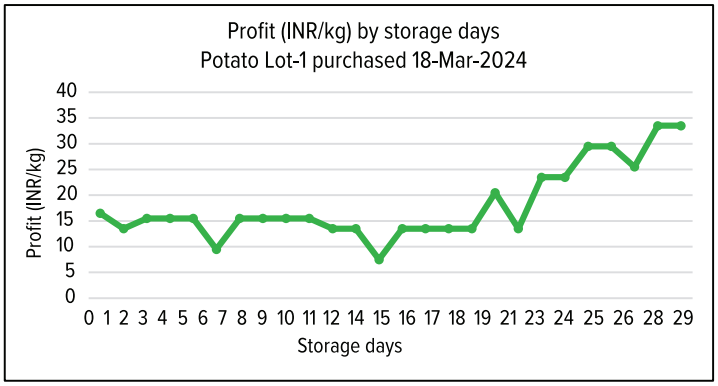
Figure 1. 10 MT dual-chamber cold room at SSOPCL

SSOPCL Business performance and beneficiary impact

SSOPCL purchased two lots of potatoes in March and April 2024. The cold room enabled SSOPCL to store potatoes and sell them based on demand, thereby taking advantage of positive price fluctuation, as seen in Figure 2. SSOPCL achieved sales of INR 7.89 lakhs and a gross profit of INR 3.39 lakhs for the two lots of organic potato purchased in March and April 2024. Farmers get a higher price for their potatoes from SSOPCL than from the mandi, as indicated in Figure 3. The price/kg indicated in Figure 3 is what the farmer receives, of which the farmer gives INR 0.50-1.00 to their producer group. Further, farmers are also shareholders in SSOPCL.

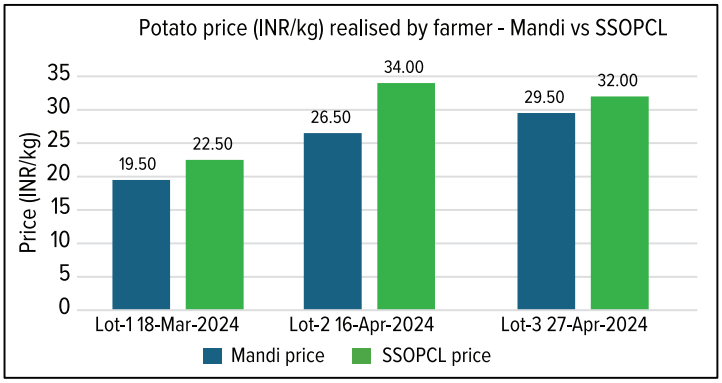
Following the storage and sale of potatoes, SSOPCL used the cold room to store organic apples. Afterwards, SSOPCL stored horse gram and cowpeas to retain the freshness of this organic produce without the need for fumigation. Figure 4 indicates that SSOPCL fully utilised both chambers of the cold room during the monitoring period; however, the cold room was overloaded from May 2024 onwards while storing horse gram and cow pea. The effectiveness of storing horse gram and cowpea, i.e., reduced spoilage, was not analysed during the monitoring period.

Figure 2. SSOPCL potato trade - gross profit (INR/kg) based on storage days



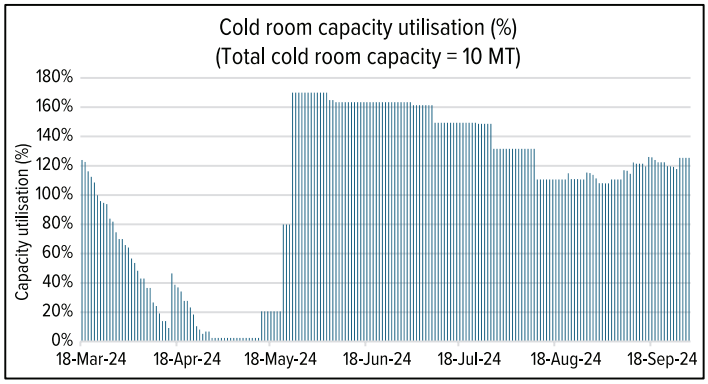
Source: SSOPCL

Figure 3. Price paid to farmers



Source: AgMark, SSOPCL

Figure 4. SSOPCL cold room capacity utilisation



Source: SSOPCL

Observations at Singhwara Primary Vegetable Cooperative Society (PVCS)

Singhwara PVCS, under Mithila Vegetable Processing and Marketing Cooperative Union Ltd, Darbhanga, Bihar, was incorporated in January 2021. As of March 31, 2023, Singhwara PVCS had 238 shareholders and a share capital of INR 20,800. In the fiscal year 2022-23, Singhwara PVCS achieved a turnover of INR 17.36 lakhs from marketing green vegetables. However, PVCS members highlighted that marketing green vegetables in FY 2022-23 resulted in an estimated financial loss of INR 30,000.

Use case

The PVCS faces significant challenges in marketing the farmers' produce and developing new market linkages. The PVCS identified three objectives, as given below:

- Manage daily fluctuations in local supply and demand of F&V to avoid produce loss and distress sales.
- Develop market linkage to premium markets (aggregation of produce).
- Develop a "trader model" – buy produce from other markets for sale in the local market, especially during festivals.

Cold room deployment: 10 MT single-chamber energy-efficient solar cold room

AEEE collaborated with Singhwara PVCS and Mithila Union to deploy a 10 MT energy-efficient solar-powered cold room at Singhwara PVCS in September 2023. The cold room has Thermal Energy Storage (TES) and remote monitoring of key parameters. Since Singhwara PVCS is a nascent FPC, AEEE conducted a workshop on post-harvest management and cold room operations for farmers in Singhwara. Furthermore, AEEE and Mithila Union provided technical assistance during the first year of the cold room's operations.

Figure 5. 10 MT cold room at Singhwara PVCS

Figure 6. Training on post-harvest management and cold room operations for farmers at Singhwara PVCS

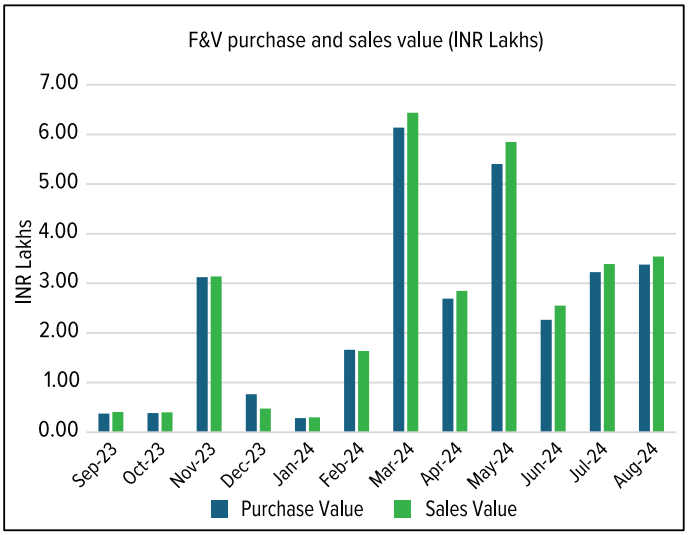
Singhwara PVCS business performance

Since deployment, Singhwara PVCS's annual turnover and profit have increased in the F&V segment. The cold room has enabled the PVCS to explore the *Trader Model*, i.e., procuring produce from distant markets for sale to local consumers, yielding gross profit margins of up to 12% from the sale of F&V. The operations took some time to stabilise since the first six months were primarily a learning phase for the PVCS. For example, incorrect storage conditions caused overripening, leading to net losses in three out of five batches of bananas sold in October–December 2023. Despite significant losses in the first six months, the business saw a turnaround from March 2024 onwards, as indicated in Figures 7 and 8.

From March 2024 onwards, sales and profits increased. Additionally, as the PVCS gained experience in using the cold room, they ventured into marketing higher-value crops, as evident from the increasing trend in the average unit price (INR/kg) in Figure 10. They also continuously utilised the cold room from February 2024 onwards once the winter season was over, as indicated in Figure 11. Overall, from September 2023 to August 2024, Singhwara PVCS sold 66.45 MT of F&V produce, generating INR 30.98 lakhs in revenue and achieving a gross profit of INR 1.27 lakhs.

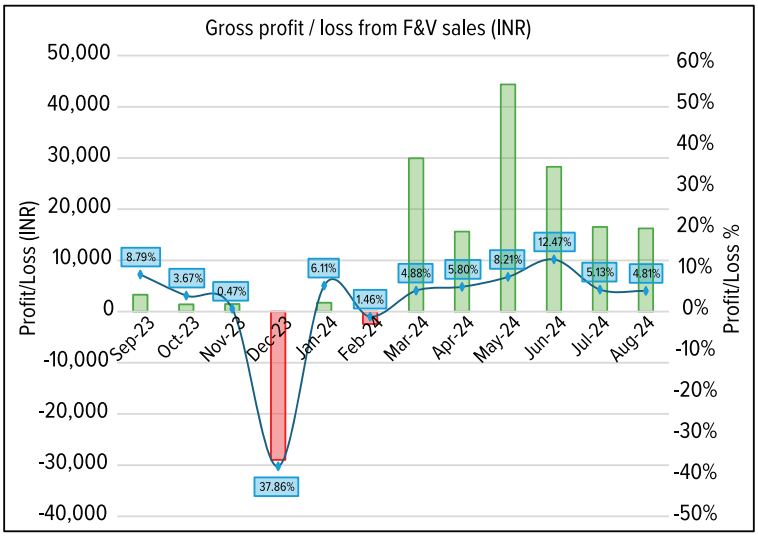
Summarising the outcomes from the first year of cold room operations, while the absolute value of sales and gross profit in the first year of cold room operation is modest, the real value was the know-how and confidence gained by the PVCS members in using the cold room effectively. Now that the PVCS is confident in operating the cold room, they can focus on aggressively building market linkages, especially for aggregating and marketing produce from the PVCS farmer members and other local farmers to premium markets.

Figure 7. F&V purchase and sales



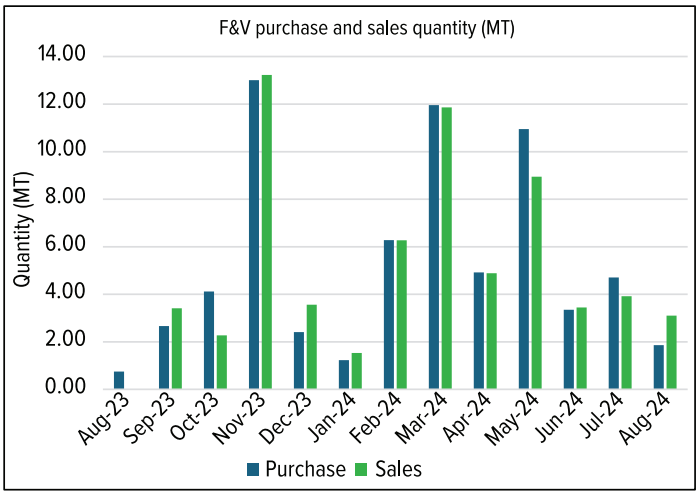
Source: Singhwara PVCS, Mithila Union

Figure 8. Gross profit/loss from F&V sale



Source: Singhwara PVCS, Mithila Union

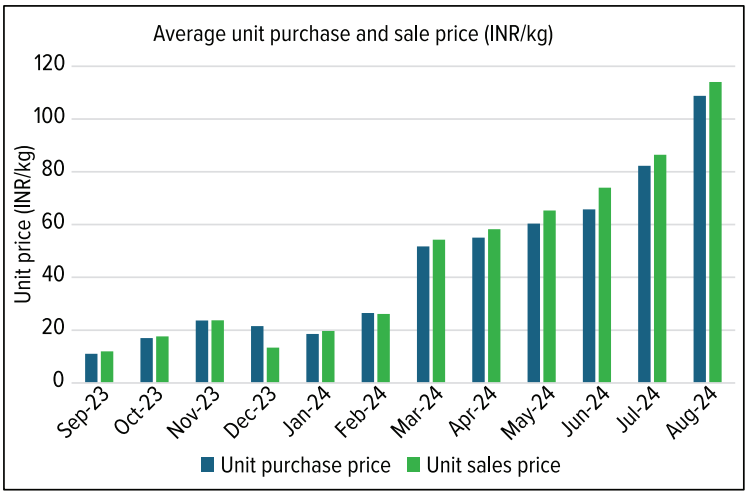
Figure 9. F&V purchase and sales quantity



Source: Singhwara PVCS, Mithila Union

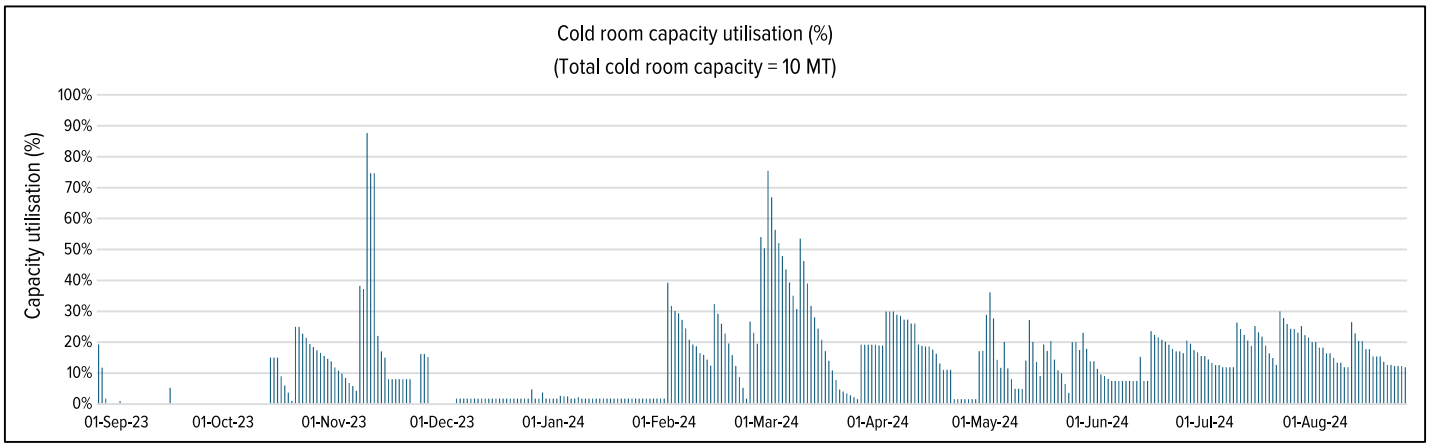
NOTE: Produce purchased in a month was not necessarily sold in the same month; produce sold in a month may have been purchased in the previous month(s)

Figure 10. Unit purchase and sale price



Source: Singhwara PVCS, Mithila Union

Figure 11. Cold room capacity utilisation



Source: Singhwara PVCS, Mithila Union

Beneficiary Impact – Individual farmers and local vendors

Singhwara PVCS is yet to scale up purchases from farmers, with just 6% of its total procurement coming from them in the first year. In interviews with PVCS farmer members, fourteen farmers reported that selling to the PVCS saves them transport costs and commissions incurred at the mandi. Some farmers said that storing tomatoes and cauliflower in the cold room extended produce shelf life by three to five days, boosting their confidence in using the cold room. However, to maximise benefits to farmer members, the PVCS must expand market linkages for their produce.

In interviews with local F&V vendors, they stated that they previously sourced produce from regional markets such as Samastipur, Muzaffarpur, and Darbhanga, but now procure most of their F&V from Singhwara PVCS. The shift has been driven by the proximity of the cold room, the superior quality and longer shelf life of the produce stored in it, and the responsive customer service from PVCS. The cold room has enabled vendors to adjust F&V procurement based on demand and store unsold inventory in the cold room, improving their profitability.

Testimonial from Mr. Sohail Akhtar, Chairman of Singhwara PVCS

"The deployed solution has proven to be a game-changer for our business. The freshness of F&V stored in the cold room has been exceptional and instrumental in our ability to consider business expansion confidently. Affordability was a key factor for us, and this solution has met our expectations with minimal operational expense. We are highly satisfied with the overall performance and cost-effectiveness of this solution."

"तैनात किया गया समाधान हमारे व्यवसाय के लिए एक क्रांतिकारी बदलाव साबित हुआ है। कोल्ड रूम में संग्रहीत फलों और सब्जियों की उत्कृष्ट ताजगी ने हमारे व्यवसाय को आत्मविश्वास के साथ विस्तार करने में महत्वपूर्ण भूमिका निभाई है। हमारे लिए लागत-सामर्थ्य एक महत्वपूर्ण पहलू था, और यह समाधान न्यूनतम संचालन व्यय के साथ हमारी अपेक्षाओं पर पूरी तरह खरा उतरा है। हम इसके प्रदर्शन और लागत-प्रभावशीलता से अत्यधिक संतुष्ट हैं।"

Testimonial from Mr. Vinod Mahto, Farmer Member Singhwara PVCS

“My name is Vinod Mahato, and I'm a proud member of the Singhwara PVCS. I've been growing cauliflower for years. In November 2023, when prices were really low, I decided to store some of my cauliflower in the cooperative's cold room. I kept it there for about five days. When I finally sold it, the prices had gone up, and I got a much better price for it. I'm really grateful for the cold room; it's been a huge help to me and other farmers."

Testimonial from Mr.Mrityunjay Kumar, Farmer Member Singhwara PVCS

“My name is Mrityunjay Kumar, and I recently used the cold storage facility to store 50 kilograms of tomatoes for three days. It was a great decision! I was able to sell my tomatoes at a much better price in the market because they were fresh and in good condition. The cold storage really helped me out."

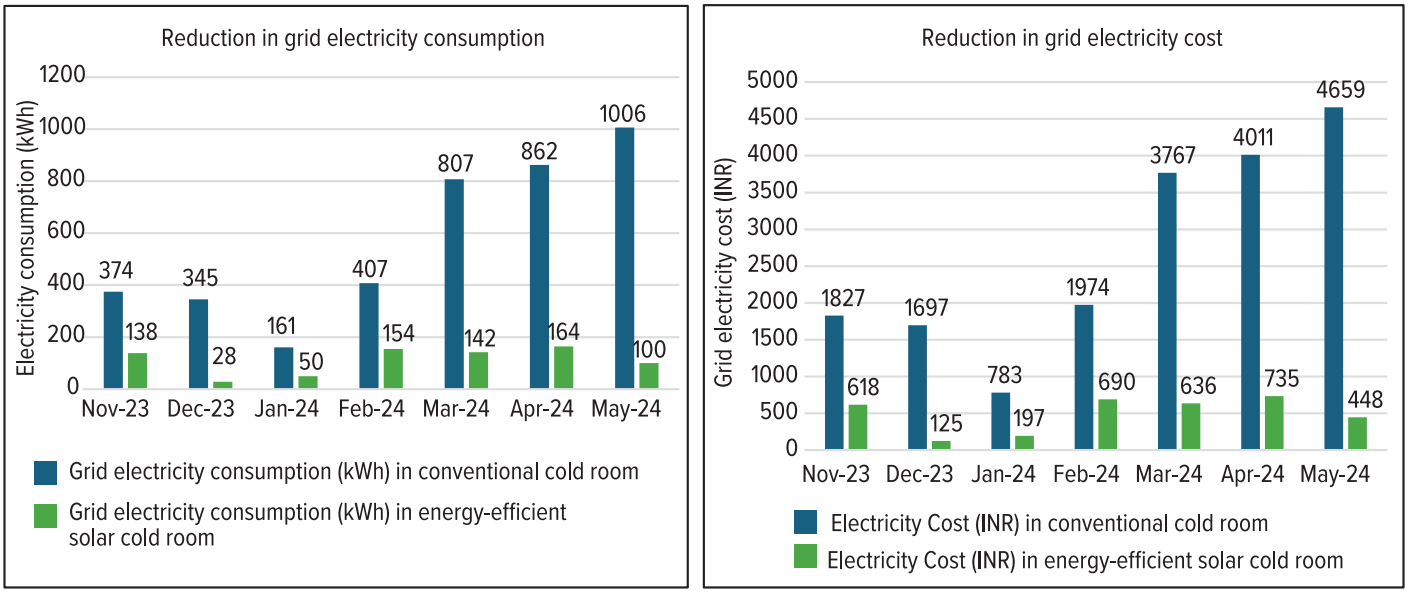
Cold room energy consumption and associated emissions

The cold rooms deployed at SSOPCL and Singhwara PVCS are energy-efficient and powered by solar PV, and most importantly, are designed to meet the requirements of both organisations in terms of capacity and storage conditions. The cold rooms include 100 mm insulation for the walls and roof and 80 mm insulation for the floor, thereby reducing heat ingress and cooling demand. Both cold rooms have Thermal Energy Storage (TES) to enable cooling at night without drawing electricity from the grid, thus avoiding or reducing electricity costs. Further, using TES has broader positive impacts, such as avoiding drawing from the grid during peak time (evening/night). Both cold rooms also have remote monitoring systems.

AEEE assessed the technical performance of the energy-efficient solar cold room deployed in Singhwara PVCS from November 2023 to May 2024. The data suggests that integrating energy efficiency and solar power in cold rooms has led to substantial energy cost savings for the user and lower grid-based emissions, as depicted in Figures 12 and 13. This is particularly significant considering the energy-intensive nature of refrigeration systems.

The grid-based electricity consumption and cost for the energy-efficient solar cold room are 80% lower than for a conventional cold room.

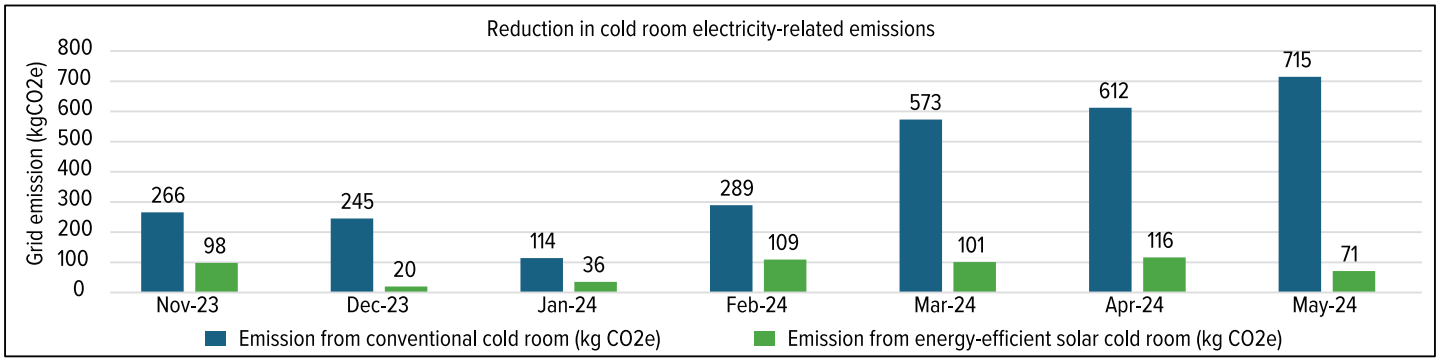
Figure 12. Grid electricity consumption and cost - conventional vs energy-efficient solar cold room



Source: AEEE monitoring data, Singhwara PVCS electricity bills

The CO_2 emissions for the energy-efficient solar cold room are 80% lower than those for a conventional cold room.

Figure 13. Grid electricity emissions – conventional vs energy-efficient solar cold room



Source: AEEE monitoring data, Singhwara PVCS electricity bills, CEA grid emission factor

Lessons Learned and Recommendations

The deployment of energy-efficient solar cold rooms at SSOPCL and Singhwara PVCS has demonstrated that FPCs and farmer cooperatives can improve market access and enhance income with the proper infrastructure. We present key learnings and recommendations to improve the effectiveness and impact for farmers when scaling sustainable cold room deployment.

Business operations

Staffing, systems and protocols

A cold room can only maintain the quality and freshness of produce that is already in good condition. Effective post-harvest management, including proper handling, sorting, grading, packaging and storage protocols, is crucial for maximising the benefits of storing produce in the cold room. SSOPCL, a well-established FPC with trained staff, could more effectively utilise and benefit from the cold room, while Singhwara PVCS, a nascent farmer cooperative, initially faced losses due to lack of expertise. This setback led to a valuable learning opportunity, emphasising the importance of procuring produce at the correct stage and setting optimal storage conditions to retain produce quality and freshness. The PVCS was able to improve operations within a year with technical assistance from AEEE and Mithila Union. Being part of the Mithila Union of Vegfed Bihar, Singhwara PVCS can get support in developing a dedicated and trained operations team.

Recommendation: All FPCs and farmer cooperatives using a cold room should receive comprehensive training and onsite technical assistance in post-harvest management, cold room operations, marketing, and finance. They should appoint dedicated staff for operations. Furthermore, they should receive training periodically as they diversify into new produce types.

Market access – forward and backward linkages

SSOPCL has well-established market channels and a reliable supply of produce from its farmer members. Although Singhwara PVCS was established only in February 2021, it utilised the cold room to develop the *Trader Model*, i.e., procuring produce from distant markets for sale to local consumers. However, to truly benefit its farmer members, the PVCS could use the organisational strength and capacity of Mithila Union and Vegfed to develop market channels, fed by a reliable supply of produce from its farmer members.

Recommendation: FPCs and farmer cooperatives need expert support to establish market linkages. This requires a comprehensive programme, possibly led by state departments, agri-marketing boards, and the private sector, to support FPCs and farmer cooperatives. Without market linkages, cold rooms will remain underutilised.

Cold room utilisation

Single-chamber designs can be restrictive for storing diverse F&V, which require different temperature and humidity conditions.

Recommendation: FPCs and farmer cooperatives should understand the type, seasonality and volume of produce likely to be stored in the cold room, and accordingly opt for single- or multi-chamber cold rooms.

Energy-efficient solar cold room performance

Energy-efficient solar cold rooms with thermal energy storage (TES) significantly reduce electricity costs and reliance on grid power, while effectively preserving the quality and freshness of horticultural produce. Considering the energy-intensive nature of typical refrigeration systems, this solution offers a sustainable and economically viable solution.

Recommendations:

- NCCD guidelines 2024 stress the importance of incorporating energy efficiency and renewable energy in cold chain solutions. This should be taken further by developing and mandating standards for energy efficiency, renewable energy, and low-GWP/natural refrigerants for micro cold rooms. Notifying standards will improve the awareness and credibility of energy-efficient RE-powered micro cold rooms.
- Additionally, interventions are required to bring the initial cost of energy-efficient RE-powered cold rooms on par with conventional cold rooms to make them more affordable.

Other observations on the cold room

- Even energy-efficient solar cold rooms require grid backup to manage intermittent RE supply. Though the cold room grid backup was initially designed for 3-phase supply, it was observed that 3-phase supply is unreliable in rural areas and costly for the PVCS. The manufacturer provided a backup solution using single-phase supply; this was effective and should be the norm for smaller energy-efficient solar cold rooms (up to 10 MT).
- Multiple technical challenges were encountered during the implementation phase, particularly the repeated failure of the solar Maximum Power Point Tracking (MPPT) system due to high-voltage surges in the grid backup. A 500-volt stabiliser was installed to resolve this issue.
- The remote monitoring system was helpful for checking the cold room operating conditions, including temperature, humidity, compressor status, power consumption, and energy usage. Adding alarms for critical parameters would enable users to address issues proactively.

AEEE collaborated with the Mithila Union team (Mr Madhawendra Thakur, Md. Reyazuddin Ashraf) and Singhwara PVCS Chairman Mr Sohail Akhtar to collect and analyse data for Singhwara PVCS, and with Mr Somesh and Anand to collect and analyse data for SSOPCL. The AEEE team extends its gratitude to Dr Nitin Goel, CEO of Inficold, for his consistent technical support throughout the monitoring period.

Alliance for an Energy Efficient Economy (AEEE) supports policy implementation and enables the energy efficiency market with a not-for-profit motive. AEEE promotes energy efficiency as a resource and collaborates with industry and government to transform the market for energy-efficient products and services, thereby contributing toward meeting India's goals on energy security, clean energy, and climate change.

Alliance for an Energy Efficient Economy
37 Link Road, Ground Floor,
Lajpat Nagar III, New Delhi, 110 024
+91-11-4123 5600
info@aeee.in
www.aeee.in