SMALL AND MEDIUM ENTERPRISES: ENERGY EFFICIENCY KNOWLEDGE SHARING

VOLUME 16 | ISSUE 1 | MARCH 2025

SAMEEEKSHA NEWSLETTER

www.sameeeksha.org

Inside...

- Cold storages: opportunities for improving energy efficiency
- Solar-powered cold storage system: a sustainable technological solution
- Energy efficient technologies among cold storages in West Bengal
- Demand-side management opportunities among cold storages

Promoting Energy Efficiency in SMEs
SAMEEEKSHA

VISION

SAMEEEKSHA envisages a robust and competitive SME sector built on strong foundations of knowledge and capabilities in the development, application, and promotion of energy-efficient and environment-friendly technologies.

Bureau of Energy Efficiency

SHAKTI SUSTAINABLE ENERGY FOUNDATION

teri THE ENERGY AND RESOURCES INSTITUTE
Creating Innovative Solutions for a Sustainable Future

MSME
MICRO, SMALL & MEDIUM ENTERPRISES

A PLATFORM FOR PROMOTING ENERGY EFFICIENCY IN SMEs

IN THIS ISSUE...

The focus of this issue remains on the cold storage sector, which occupies a unique and critical place in India's MSME sector as well as in the overall Indian economy. As described in the previous issue of this newsletter, there are significant gaps in the network and coverage of cold storages and associated infrastructure (i.e., cold chains) in the country, as well as scope for upgrading the low-efficiency technologies and practices that are currently deployed. The earlier issue summarized some of the major policies and initiatives being undertaken by the government to address these gaps and needs. The theme article provides an overview of the primary technologies and processes used in cold storages, and the scope for introducing energy-efficient (EE) technologies including renewable energy (RE) options.

A case study is presented on a solar cold room implemented by TERI in the village of Sadali in Karnataka through a participatory model that focused on involvement and empowerment of women members of the local community. The project worked closely with the local Farmer Producer Oragnization (FPO) and the Department of Horticulture to install a 5 kWp solar cold room for the local farmers to store their horticultural produce, and also trained local community members in operation and maintenance of the system.

The issue concludes with brief account of two sets of energy assessment studies undertaken by TERI in cold storages in West Bengal (under a project supported by SSEF) and cold storages spread across Delhi, Ajmer, and Mumbai in partnership with Tata Power (under a project supported by the MacArthur Foundation).

SAMEEEKSHA Secretariat

COLD STORAGES: OPPORTUNITIES FOR IMPROVING ENERGY EFFICIENCY

Cold storages occupy a unique and critical place in India's MSME sector as well as in the overall Indian economy, as described in the previous issue of this newsletter.[1] To recap: cold storages are a vital component of the agricultural supply chain from farmer/producer to consumer, enabling the storage of perishable produce like fruits and vegetables for long periods of time and in good condition so that they can be sold to markets across the country and overseas throughout the year. However, there are significant gaps in the network and coverage of cold storages and associated infrastructure (i.e., cold chains) in the country, as well as scope for upgrading the low-efficiency technologies and practices that are currently deployed.

The earlier issue summarized some of the major policies and initiatives being undertaken by the government to address these gaps and needs. This article provides an overview of the primary technologies and processes used in cold storages, and the scope for introducing energy-efficient (EE) technologies including renewable energy (RE) options. The articles that follow outline a few projects implemented by TERI in recent years in this direction.

Technology and processes

Cold storage units are usually multi-commodity facilities, with each having a number of cold chambers to store produce. The capacities of cold storages can vary widely: for instance, the capacities of units in the Hooghly cold storage cluster in West Bengal range from below 5000 tonnes to above 20,000 tonnes. In addition to cold chambers, a cold storage may have anterooms, docking/grading/sorting areas, crates/pallet storage areas, machine room, electrical room, etc. The major energy-intensive processes and systems are summarized below.

Refrigeration system

The primary process is refrigeration, i.e., cooling the produce in the cold chambers to low temperatures that are determined by the nature of produce being stored in them. The refrigeration system consists of refrigeration compressors, atmospheric/evaporative condensers or cooling towers, and fan coil units.

1 see SAMEEEKSHA 15(4), December 2024

Refrigeration compressors: reciprocating ammonia compressor

Refrigeration compressors: screw compressor

The majority of cold storages in India are equipped with ammonia-based refrigeration systems. Some cold storages also have refrigeration systems that operate on a category of refrigerants named hydrofluorocarbons (HFCs). Generally speaking, ammonia-based refrigeration systems can be more efficient than HFC-based systems, because of ammonia's ability to absorb and release large amounts of heat, and to liquefy easily under pressure. Also, ammonia is less expensive than HFCs. In terms of environmental impact, neither ammonia nor HFCs have any adverse effects on Earth's ozone layer; but ammonia is considered more environmentally friendly than HFCs because it has zero global warming potential (GWP), while HFCs have a high GWP (and are hence being phased out across the world).

Ammonia tanks in a cold storage facility

It is important to note that these relative advantages of ammonia over HFCs must be weighed against the toxic nature of ammonia, making it essential for safety measures to be put in place while using ammonia-based refrigeration systems.

Pre-cooling

Pre-cooling is the rapid removal of heat from produce like fruits and vegetables after harvesting. It is an essential first step in prolonging the shelf life of the produce by reducing metabolic activities. For fresh horticulture commodities, a delay by one hour at the field temperature of 35 °C between harvest and pre-cooling leads to loss of moisture and weight of the produce, and may reduce quality equivalent to 20 hours in cold storage.

There are multiple methods for pre-cooling; these depend largely on the perishability of the produce and the refrigeration equipment available at the facility. Some of the common methods used for pre-cooling are:

- Hydro-cooling
- Forced air cooling
- Evaporative room cooling
- Package ice cooling

Storage

For maximizing the life and maintaining the quality of perishable commodities in cold storages, it is essential to maintain temperature, humidity, and carbon dioxide (CO_2) levels in the cold chambers based on the parameters specified for the commodities being stored.

Ceiling fans and exhaust fans are used in cold chambers to circulate cold air. Some units also use ceiling fans for potato drying in their shed areas. The majority of the units use conventional ceiling fans.

Potato bags on racks in cold chamber

Cold chamber

The walls of the cold chambers are typically made of brick or solid concrete blocks with sand and cement plaster. The roof is typically made of reinforced cement concrete (RCC) or is a truss structure with corrugated galvanized iron (GI) sheet covers. The walls and ceilings are insulated with materials such as polyurethane foam (PUF) panels. The roofs too may have layers of PUF with other materials such as atactic polypropylene (APP) membrane blended with bitumen tar to provide insulation against heat and ageing, as well as waterproofing. The doors of the cold chambers are often fitted with strip curtains to prevent air infiltration.

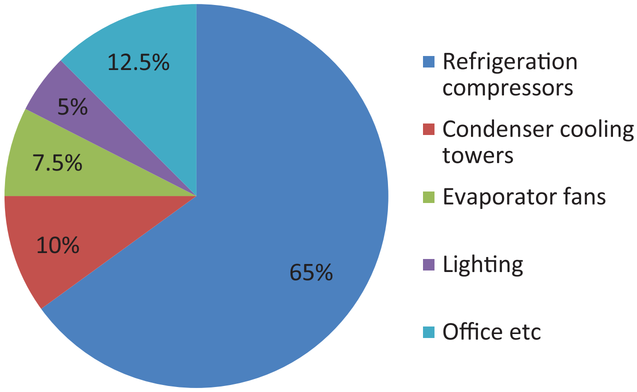
Lighting/illumination system

LEDs are commonly used in cold chambers, machine rooms and other areas. Some cold storages still use incandescent lamps and compact fluorescent lamps in cold chambers and mercury vapour lamps in the shed and common areas.

Energy usage

Cold storages depend entirely on electricity for their processes. Grid electricity is the primary source of electrical energy, with diesel generator (DG) sets providing backup power when necessary.

The electricity consumption in a cold storage varies with ambient temperature and relative humidity. The refrigeration compressors account for the maximum share of electricity consumption (65% or more), followed by other systems like condenser cooling towers, fans, lighting, etc.



Section-wise electricity consumption in typical cold storage

[Source: 'Aggregating DSM Opportunities Among Industrial Consumers at Utility Level for Low Carbon Growth'. TERI: 2021.]

Energy efficiency opportunities

The following EE technology opportunities can be considered for adoption by cold storages. The feasibility of adopting these improved technologies will vary from unit to unit and may be determined through detailed unit-level energy assessment studies.

- **Optimize and/or upgrade refrigeration compressors**. EE options for optimizing the performance of compressors include proper maintenance (with complete overhaul where necessary), adoption of automation such as programmable logic controller (PLC) system, and installation of variable frequency drive (VFD).
- **Install rooftop solar power systems**. Cold storages usually have large rooftop areas on which rooftop solar photovoltaic (PV) systems can be installed to generate electricity. These solar power systems will reduce grid electricity consumption and the overall energy bill, as well as reduce the dependency on DG systems for backup power.
- **Replace the existing low-efficiency (standard and/ or rewound) motors with premium efficiency class IE3/ IE4 motors**. The standard and rewound motors that are currently used in the different equipment/ processes in cold storages can be replaced with premium efficiency class (IE3/ IE4) motors.
- **Replace conventional ceiling fans with energy efficient BLDC fans**. Cold storages commonly use conventional ceiling fans which quickly get heated up, adding to the air-conditioning load and increasing overall electricity consumption. Replacing the conventional fans with energy-efficient BLDC fans can bring an estimated 40% energy saving over baseline.
- **Re-pipe and insulate old, corroded refrigeration distribution pipe networks**. The pipes in the refrigeration distribution networks are often corroded and lacking in proper insulation, particularly in the older cold storages. Replacement of old damaged pipes, together with proper insulation, can reduce the electricity consumption by 5–8%, with quick payback period on investment (typically less than a year).
- **Improve door designs in cold chambers**. The doors to cold chambers are frequently opened for the movement of materials, reducing the efficiency of the refrigeration system because of (a) hot and humid air entering the cold chambers from outside areas, and (2) outward leakage of refrigerated air. To avoid energy losses, airlocks/ air curtains should be fitted on all access doors, and periodic checks and maintenance carried out on door seals, door self-closers, etc.
- **Create buffer zones (anterooms)**. To avoid ingress of heat into the cold chambers during loading and unloading processes of materials, anterooms can be set up to act as buffer zones between the cold chambers and ambient. This measure can yield an estimated 3–5% energy savings over baseline.
- **Replace the existing lighting system with LED lighting system**. The illumination system accounts for about 5% of total electricity consumption in a typical cold storage. Many cold storages use relatively low-efficiency lamps, which not only consume more energy but generate heat and add to the refrigeration load. Replacing the existing lighting systems with LED lamps can bring an estimated 55% energy savings in the lighting bill.

This article has drawn largely from documentation related to the following projects implemented by TERI:

- 'Promoting Green Energy Efficient Technologies and Practices among MSMEs in West Bengal ': a tripartite collaboration between TERI, Shakti Sustainable Energy Foundation (SSEF) and the Department of MSME and Textiles, Government of West Bengal (2022–23).
- 'Aggregating DSM Opportunities among Industrial Consumers at Utility Level for Low Carbon Growth': a project supported by the MacArthur Foundation (2019–21).

SOLAR-POWERED COLD STORAGE SYSTEM: A SUSTAINABLE TECHNOLOGICAL SOLUTION

In 2023–24, TERI implemented an innovative solar-powered cold storage project in Sadali village, Chikkaballapura district in Karnataka, with financial support from EKOenergy, Finland. This initiative actively involved the local women and youth, and serves as a successful, community-centred model by which renewable energy technology can be harnessed to secure the livelihoods of small horticultural farmers, minimize agricultural waste and enhance food security, and thus contribute to the sustainable development goals.

Initiative

The project village of Sadali has nearly 800 farmers of whom 35% are small and marginal farmers, possessing less than two hectares of agricultural land. The major horticulture crops grown in this region are mango, grapes, pomegranate, sapota, guava, papaya, banana, citrus, and cut flowers. However, the nearest cold storage facilities were situated about 30 kilometres from Sadali, and the storage fees were unaffordable for the majority of farmers. In these circumstances, the farmers had no option but to transport their horticultural produce to the Agricultural Produce Market Committee (APMC) yard or to private traders for immediate sale. As a consequence, they obtained low prices for their produce.

At the behest of the Sadali farming community, a local Farmer Producer Organisation (FPO) named Sadaliamma Horticulture Farmer Producer Company Ltd. (SHFP) approached TERI for assistance in developing and implementing an innovative and sustainable technological solution to the problem. As the power supply in Sadali was erratic, TERI decided to develop and install a solar-based cold storage system designed to meet the local needs and conditions, through a participatory model that involved the local community at every stage of the project, transferred ownership of the system to the community following successful demonstration, and equipped the community members with the technical and management skills needed to operate the system on their own in the long term.

Implementation

TERI assumed the role of overall coordinator for project execution, which included the establishment of a solar-powered cold room and its subsequent transfer to SHFP. The Taluk-level Department of Horticulture (DoH) facilitated training and capacity building. The technology supplier was selected based on the capability of supplying a good quality system in time, and on providing good after-sales service and long-term support. SHFP provided the necessary space for the system's installation.

Solar cold room system, Sadali

The cold storage system

Through close engagement with the farmer community assisted by household surveys, data was collected and analysed on crop growing area, type of horticulture crops, and practices (harvesting, cleaning, sorting, storing, packing, marketing, etc.). Based on the analyses and interactions, TERI designed and demonstrated an off-grid solar-powered cold room system with a capacity of 5 tonnes. The system operates using a 5kWp solar photovoltaic (PV) system which charges during daylight hours and maintains a cool environment in the cold room for 24 hours without relying on batteries, diesel, or any conventional energy sources. The project covered the entire cost of the device, amounting to Rs 14 lakhs. SHFP ensures its maintenance post-installation, and offers the solar cold room for rent to farmers, with a particular emphasis on supporting women farmers.

Women-led management and capacity building

The project placed a strong emphasis on the involvement of women at every stage, from planning and execution to management. Women members of SHFP were trained to oversee the daily operation and maintenance (O&M) of the system. The EKOenergy Solar-based Cold Room Committee (EKOSCC), which includes women members, was established under the project to monitor the system and mobilize SHFP funds for O&M as needed.

Two skill training programs were organized for the members of EKOSCC and the farmer members of SHFP including both men and women: the first, on O&M; and the second, on processing, packaging, and marketing techniques for various horticultural crops. Also, an Entrepreneurship Development Programme (EDP) was organized by involving 6 entrepreneurs from different parts of Karnataka and 10 women farmers from Sadali. The EDP focused on the various business opportunities that could open up new revenue streams through utilization of the solar cold storage system—such as preservation of mushrooms, dairy products, and other perishable items.

A log book was kept at the SHFP office for regularly collecting and recording actual data such as inflow and outflow of horticulture produce, temperature, electricity consumption during cloudy days, revenue generated from renting of the system, quality of produce, and the additional profits earned due to increase in shelf life of the produce provided by the system.

A technical O&M manual was developed and shared with SHFP. The O&M requirements for the solar cold room are minimal, involving only the weekly addition of 20 litres of potable water to the storage and monthly cleaning of the solar panels. The system can be operated via a mobile application, allowing users to set the storage temperature for their produce, monitor system operations, and identify any issues that may arise. All farmers in the project area are well-connected with the FPO to access the solar cold room. The SHFP has placed a notice board at their office displaying contact numbers for renting the facility, which is available on a first-come, first-served basis.

Results

While the cost of storing produce in traditional grid-connected cold storage facilities is Rs 2/kg over a five-day period, the SHFP charges only Rs 1/kg for the same duration. During the period December 2023–24, around 60 individual farmers utilized the solar cold room to store a total of 15 tonnes of horticultural products, from which SHFP generated Rs 40,000 as rental income. The farmers have expressed satisfaction with the cold room as it prevents spoilage and prolongs the shelf life of their produce. Also, individual farmers have minimized the transportation charges for their produce. The active involvement of both male and female farmers in all phases of the project, along with the FPO and the Department of Horticulture, has fostered a sense of ownership among the community. A key outcome of this project is the heightened awareness among community members regarding solar energy and its advantages for both the society and the environment.

Strengthened by their insights into the new business opportunities emerging from the use of the solar cold room, a group of five women farmers from Sadali have identified potential for another 5-tonne solar cold room in community. Following a stakeholder workshop organized by TERI in Chikkaballapur, members of FPOs from other Talukas have approached DoH to seek subsidies, and have formulated a plan to invest 60% of the funds required to purchase solar-based cold storage units.

Produce stored in solar cold room: preserving quality, livelihoods, and the environment

ENERGY EFFICIENT TECHNOLOGIES AMONG COLD STORAGES IN WEST BENGAL

During 2022–2023, TERI undertook detailed energy audits of 15 cold storages across various locations in West Bengal under the project 'Promoting Green Energy Efficient Technologies and Practices among MSMEs in West Bengal'. This initiative was a collaborative effort between TERI, Shakti Sustainable Energy Foundation (SSEF), and the Department of MSME and Textiles, Government of West Bengal.

The primary goal of the project was to encourage the adoption of energy-efficient technologies and practices within the state's MSME sector. Through extensive on-site assessments, the TERI team successfully identified a set of common energy-saving solutions applicable across the audited cold storage facilities.

Table 1: Common EE technologies for cold storages

EE technologies	Energy saving potential	Payback period
Replace conventional fans with BLDC fans	45-50%	2-2.7 years
Installation of strip curtains at the cold room doors	1-2%	< 1 year
Replacement of inefficient cooling water circulation pumps	20-40%	1-4 years

As part of the detailed energy audits carried out in the Hooghly and Howrah regions of West Bengal, the TERI team identified several unit-specific energy-efficient technologies and best practices. These findings are summarized below.

Drying area of a potato cold storage in West Bengal

Table 2: Unit specific EE technologies and benefits

EE technologies	Annual monetary saving (Rs. Lakhs)	Investment (Rs. Lakh)	Payback period (y)
Improvement of power factor by installation of capacitor bank	0.7	0.27	0.4
Replacement of existing fans with BLDC fan	3.96	7.86	2
Replacement of inefficient cooling water circulation pumps	1.74	2.8	1.6
Installation of strip curtains at the cold room doors	0.59	0.52	0.9
Re-piping of existing facilities	1.2	1.4	1.2

Best operating practices

1. Implementation of energy meters in cold storages to enable accurate monitoring of parameters like power, voltage, and energy consumption, allowing for real-time alerts, performance analysis (e.g., SEC, SPC, TR generation), and cloud-based remote access—ultimately improving efficiency.
2. Replacement of old inefficient and rewinded motors with high-energy-efficient motors (such as IE3/IE4).
3. Periodic test of compressor oil level, colour, and viscosity.
4. Periodic test of Total Dissolved Solids (TDS) level in cooling water.
5. Ultrasonic tests on the ammonia receiver every 2-3 years as a precautionary safety measure.
6. Periodic cleaning of condenser pipes

DEMAND-SIDE MANAGEMENT OPPORTUNITIES AMONG COLD STORAGES

TERI conducted energy assessment studies during 2019–21 on a number of cold storages spread across Delhi, Ajmer, and Mumbai in partnership with Tata Power, a major private sector power utility in these areas, as part of a project supported by the MacArthur Foundation to explore the aggregation of demand-side management (DSM) opportunities among SME industrial consumers.

Through its extensive field work, the project team was able to identify a number of common energy efficient (EE) options for all the cold storages (table 1).

Table 1: Common EE options for all cold storages[1]

EE option	Energy saving potential	Payback period
Replace existing motors with IE3 motors	5–7%	< 2 years
Replace conventional fans with BLDC fans	55–60%	< 1 year
Replace existing lighting with LED lighting	55–85%	<0.5 year

TERI also conducted detailed energy audits (DEAs) on five cold storages in the Delhi region to identify specific EE options for each unit. Table 2 summarizes a few of these unit-specific EE options as examples that highlight their benefits in terms of monetary savings and quick payback periods on investment.

1 TERI. 2021. Aggregating DSM Opportunities Among Industrial Consumers at Utility Level for Low Carbon Growth. New Delhi: TERI.

Table 2: Unit-specific EE options and benefits

EE option	Annual monetary saving (Rs lakhs)	Investment (Rs lakhs)	Payback period (y)
Replace existing compressor with new EE compressor	6.6	5.0	0.9
Overhaul compressors	10.8	6.0	0.6
Install EE lighting	1.2	0.1	0.1
Replace conventional fans with BLDC fans	0.1	0.1	1.0
Improve power factor by adding fixed capacitor banks	2.2	0.2	0.01
Reduce contract demand and use maximum demand controller	1.6	0.3	0.2

ABOUT SAMEEEKSHA

SAMEEEKSHA is a collaborative platform aimed at pooling the knowledge and synergizing the efforts of various organizations and institutions—Indian and international, public and private—that are working towards the common goal of facilitating the development of the Small and Medium Enterprise (SME) sector in India, through the promotion and adoption of clean, energy-efficient technologies and practices.

SAMEEEKSHA provides a unique forum where industry may interface with funding agencies, research and development (R&D) institutions, technology development specialists, government bodies, training institutes, and academia to facilitate this process.

For more details, please contact

SAMEEEKSHA Secretariat
Industrial Energy Efficiency Division
TERI, Darbari Seth Block
IHC Complex, Lodhi Road,
New Delhi - 110 003, India
Tel: (+91 11) 2468 2100
Fax: (+91 11) 2468 2144, 2468 2145
Email: sameeeksha@teri.res.in
Website: http://sameeeksha.org