International Journal of Advanced Science and Technology
Vol. 29, No. 6, (2020), pp. 6106 - 6115

Effect of Electricity Consumption on the Financial Viability of Cold Storage Units: Recommendations for Reducing Energy Cost

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Abstract

Energy is a major cost element for cooling and preservation of fresh agricultural produce in cold storage units. Cold storage units are equipped with refrigeration systems to cool the agri-produce and maintain them at low temperatures. Fruits, vegetables, dry fruits, nuts and spices are the most common products preserved in the cold stores. Farmer's produce is protected by the cold store operators to reduce the national waste in terms of post-harvest losses. Both farmer and consumer are benefitted if the post harvest losses are minimized, which will improve the food security of the nation. The present study is conducted to investigate the financial expenditure of cold store units through a survey conducted in the Kundli and Rai area of Sonepat District of Haryana, which is a major supply and storage point for the Azadpur market, the largest fruit and vegetable market of Asia. It is found that the electricity expenditure is the most affecting source of expenditure of running cold stores. Based on the factors like energy availability, tariff charged by electricity distribution companies, recommendations are made to support the cold storage operators in terms of reducing burden on energy tariff. Recommendations are also given on techniques and methods on which training to be given to the cold storage unit entrepreneurs and technical people working in cold stores.

Key words: *Cold Storage Unit, Energy consumption, Electricity tariff, Financial viability, Food security, Post harvest losses.*

1. Introduction

Cold stores, controlled atmosphere storage units, pre-cooling and ripening centers contribute to the preservation of perishable agri-produce. These units are equipped with refrigeration systems to cool the produce and maintain at low temperature than ambient. Refrigeration units contain large capacity compressors run by electrical motors, pumps, electrical systems for operation and control of various accessories. The accessories include evaporator fans, cooling towers, condenser water pumps, chiller units, chilled water pumps, etc. All these equipment consume energy and is the major contributor for the operational expenditure. The other expenditure will be made for administration, loading and unloading labor cost, maintenance cost, etc.

ISSN: 2005-4238 IJAST

Diesel purchase is another important cost element which is needed during power fail. Fresh produce may spoil or deteriorate due to non-maintenance of cool temperatures in case of power fail from external source, i. e. electricity Distribution Company concerned. The major contributor for the overall operation of cold store is from energy through electricity bill and diesel procurement to run the Diesel Generator set in case of power failure. The major energy consuming equipment are the refrigeration units contributes 89 to 95% of total electricity used by a cold store [1].

The present study was conducted to find the cost aspects of cold stores and awareness among cold stores on electricity tariff and possible relief measures on electricity tariff. The study was conducted in Kundli area of Haryana. The average capacity of cold stores in Kundli cluster is 2833 Metric Tons (MT) [1]. The present unit rate for electricity is Rs. 8.00 to 8.35/- for HT power supply to industries including cold stores. State of Haryana is going to implement the decision of charging Rs. 4.50 to the cold stores with effect from 1st April 2020, almost 50% of existing tariff. This is definitely going to encourage the cold storage of agriculture produce and allied sectors. Rs. 2.50 per unit will be charged from pack houses and ripening chambers [2]. State of Maharashtra issued orders to DISCOMS to charge @3.50/- from the cold stores at par with the agriculture sector, which a good move for boosting the cold store sector.

2. Literature Overview

Foster et al (2018) presented two strategies for using LAES (Liquid Air Energy Storage) at Cold storage warehouses, firstly to shift the import of energy from peak to off peak tariffs and secondly to store on site renewable energy when there is a surplus and use when not. The financial viability of these strategies is then investigated taking into account the capital cost of the LAES and the money that can be saved due to the differences in tariffs at different times. They found that using LAES to load shift between peak and off-peak electricity tariffs were not economically viable for the CSWs, because the ratio between off-peak and peak tariffs was higher than round trip efficiency. But the cost of the liquefaction system by using it for cryogenic cooling, transport or sharing with other sites makes LAES more financially viable [3].

Robin Singhal & Shalini Saksena (2017) studied non refrigerated and refrigerated industry storage and warehousing performance in India during 2005-06 and 2009-10. They found that whole output and resource use efficiency in the S&W industry and its divisions has shown growth from the study period. They also studied zonal wise found differences among zones due to difference efficiency, labor efficiency and capital, cost of labor and use of electricity etc [4].

Madhu Sivaraman (2016) in his working paper Government's role in India's ailing cold storage sector, he focused on various problems facing cold storages in India like high taxes on processed fruits and vegetables and variations in taxes across states. Services tax exemption is given to only single commodity storages, not for integrated cold storages. Apart from the above, he stated that there are other barriers like high investments, rising real estate prices, high operating costs and low awareness among farmers about post-harvest management that haunt the industry [5].

Sanyasi Naidu S.S (2016) conducted a study and reported that the establishment of cold storages involves high amount of initial capital investment and maintenance thereby resulting in high charges of storage from the farmers. It is also found that the constraints of the farmers and traders are high cost of storage, price fluctuations of the produce, delay in getting cold storage space, risk of damage which can be mitigated by the increase in the cold storages capacity with innovation technology, proper forecast of the market situation and arrivals of the product [6].

Vijay Paul and Rakesh Pandey (2016) found that inadequate availability of cold storage space one of the major concern, around 61 million tonnes of cold storage capacity is presently required for food products (fruits and vegetables), but the actual available facilities can accommodate only about 26.85 million tonnes. They also found that unequal distribution of cold stores in India that is 75%of the total storage capacity exist in only five states, high cost of cold storage, poor management of cold

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stores, no net working of cold stores because majority of them operative as standalone unit and most of the cold stores are outdated in term of technological point of view [7].

Shruthi Nair and Seema (2015) conducted a study on estimation of investment cost, cost and returns financial feasibility of cold storage units using capital budgeting techniques called Net Present Value method, Cost-Benefit Ratio and Internal Rate of Return (IRR) Method. It is found that there is lot of scope for investment for small, medium and large size cold storage units in the study area, i. e. Telangana State. It is also found that the storage pattern was mostly multipurpose in nature with 57.5% of cold storages, followed by fruits and vegetables with 27.5%, mild and milk products with 10% and meat and fish cold storage with 5%. Study is also focused on problems encountered by the cold storages which are maintenance cost, heavy capital investment, high storage cost and heavy competition [8].

Mukhopadhyay and Raj Gopal Nanda (2015) measured energy consumption of a cold storage for different storage temperatures. Suction temperature and pressure temperature of the compressor and working time of the compressor were determined to reach evaporator set up temperatures. It has been observed that the actual energy consumption of a cold storage by a compressor for one chamber is 55 kW per hour and theoretical energy consumption is 50 kW per hour. So, a gap of 5 kW per hour is found between the theoretical and actual energy consumption by a compressor. It is suggested that replacing three compressors for three chambers with a single equivalent compressor will deliver the same amount of load, and then maximum energy will be saved [9].

Ramkishore Singh et al (2014) conducted a survey of the10 potato cold storages to explore the energy saving potentials. They found that the specific energy consumption in the cold storages vary between 9 kWh/tone and 15 kWh/tone. They found that variation in the specific energy consumption is significant and could be a result of unlike and poor operation of the refrigeration system, and variation in building aspect ratios, orientation and other parameters [10].

Brito et al. (2014) developed an energy consumption technique simulation and optimization in cold chambers by making better operative and constructive parameters like external temperature, enclosure insulation, door opening time etc. which contribute to the infiltration of heat energy. It is also found that parameters that influence in energy consumption were directly associated with the thermal insulation of enclosure and entry warm air within. The entire contribution of these two parameters was about 95% of total consumption [11].

Gabor Hilton (2013) discussed about Airah, one of the largest cold store in Australia, how it could improve its efficiency from 53.5kWh/m³ to 37.6kWh/m³ and storage capacity from 106,270 to 142,970 pallets during the year 2009 to 2012. The reasons were constructions of new buildings and refrigeration plants to high energy-efficiency standards, retrofitting VFD (Variable frequency drives) to existing screw compressors, freezer and condenser fans, LED lights to replace High Pressure Sodium chamber lights, over sizing evaporative condensers and improved monitoring and controlling. They also found that total energy consumption did not change during the period [12].

Gundewadi (2013) evaluated the role and performance of cold stores in India and revealed that the cold storage industry plays a very important role in the economy of the country and makes available a very large quantity of food products, fruits and vegetables for the people at all seasons which otherwise would not have been available. It is matter of grave concern that cold storages have not received adequate support system from the govt. Researcher stated that most of the cold stores are not financially struggling due various reasons one of them is unhealthy competition, some of them are struggling for existence, while in other part of country there has still no adequate cold storage facilities [13].

Minten et al. (2010) declared the importance of acceptable policies to stimulate the take-off of agricultural businesses within the state of the Bihar. They suggested augmented investments within the cold storage sector, however not essentially through subsidies. Further, they conjointly mentioned that these investments would accommodate process demands conjointly just like the totally different temperature needs [14].

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Preservation of fruits and vegetables can contribute for better price realization for farmers produce; else the distress sale causes losses to the producers during production season. Scientific study of pre-cooling process using numerical modeling is thoroughly reported by Narasimha Rao et al 1992,1993a, 1993b [15,16,17]. They have conducted studies on spherical foods. Preservation using low temperature through cold store/controlled atmosphere storage is one of the popular methods. (Ramesh Babu et al 2018, 2019a, 2019b, 2019c)[18-21]. Several methods and technologies for successful projects and food processing are well documented by Ram Deshmukh et al. 2020 [22], Naredla et al. 2018[23], E Ramesh et al. 2018[24] and Sammaiah et al. 2019[25]. Banana, Mango and other citrus fruits can be preserved and ripened at appropriate temperatures in artificial ripening chambers (Narasimha Rao et al. 2020a, 2020b) [26,27]

The cold storage preservation benefits in three ways:

1. Off-season benefits can be availed by farmers
2. Consumers get the fresh produce throughout the year
3. Savings to the country by avoiding imports of fresh produce

Surendar G (2018) mentioned small enterprises are playing an important role in the economic growth of the country, if they are supported by the government and equip the latest technology so that they can become a major contributor for the development of nation [28].

Surendar G et al. (2018, 2019) said business institutions should design business model to cut down their various costs in its operations and also told that they should acquire latest information technology tools which helps in doing so [29, 30].

3. Materials and methods

Data is collected through a structured questionnaire from fifty cold store units located in and around the Kundli and Rai Industrial area of district Sonepat of Haryana, where large number of cold stores are installed (about 90 units). Parameters like capacity, electricity consumption pattern, power availability during summer, tariff details on electricity, awareness on better tariff in other states, etc. are collected and analyzed using Microsoft Excel.

4. Results and discussion:

Here is data is results of the data analysis and its interpretation is presented. Data is presented in the form of bar charts and pie charts using Microsoft Excel.

From figure 1, it can be seen that the storage capacity of most of the stores are in the range of 1000 to 5000 MT, which indicate that these are moderate capacity stores. 50% of stores are in the range of 1001 to 2000 MT capacity. It is also found that below 1000 MT and above 5000 MT are less relative to 1000 to 2000 MT range. These stores consume lot of energy

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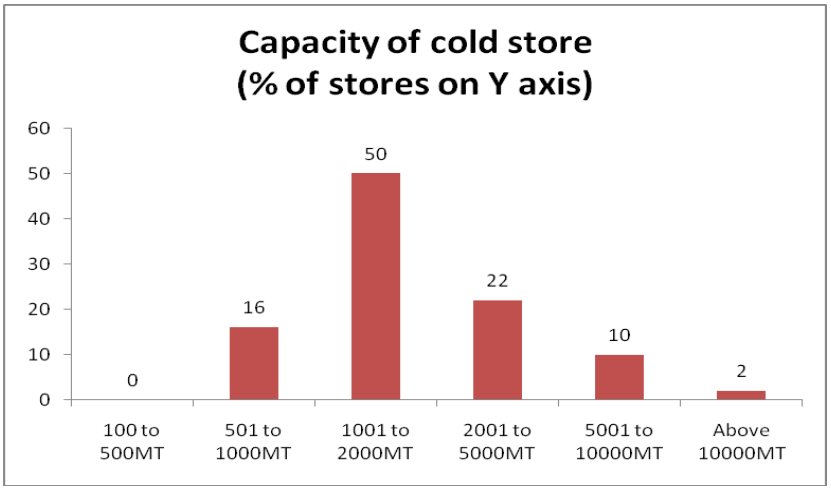

Figure1: Installed capacity of selected cold stores in Kundli area of Haryana

Figure 2 presents the data regarding business model of cold stores, it is found to be "renting out" in which the produce of farmers/ traders are preserved for some rental charges. 62% of the stores found to be operating with this business model, which can be seen in figure2. Only 24% of operators found to be storing their own produce, either purchased from farmers for selling in off-season or their own agricultural production. About 4% of stores are operating on long term lease/contract with reputed companies for storing ice-creams, pharma products, rice, etc., Ten percent of stores use combined model of keeping own produce plus rental model. On informal discussions, cold store owners conveyed that they lease-out to Mother-Dairy, Amul, LT Overseas (Daawat brand rice exporter).

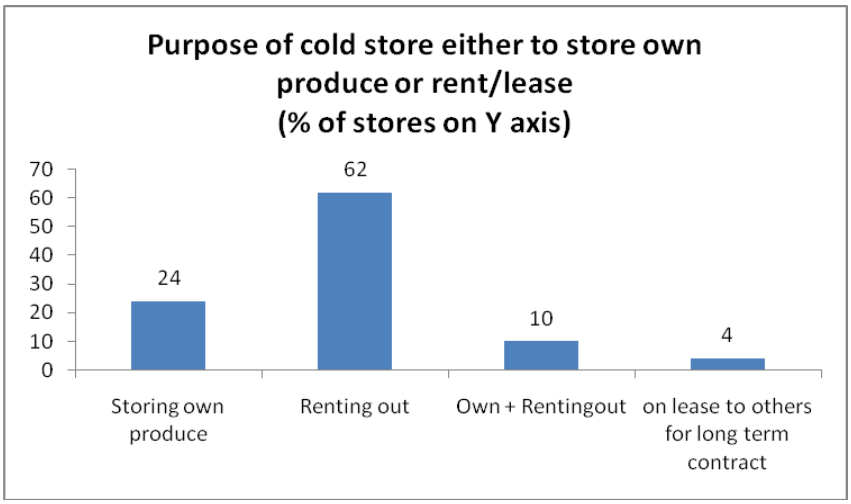

Figure 2: Business model of cold store, whether used for own produce storage or rent/lease out

Figure 3 indicates the relative costs of operation, maintenance and labor. All the respondents mentioned that major cost is for operations only. This only indicates the relative major cost

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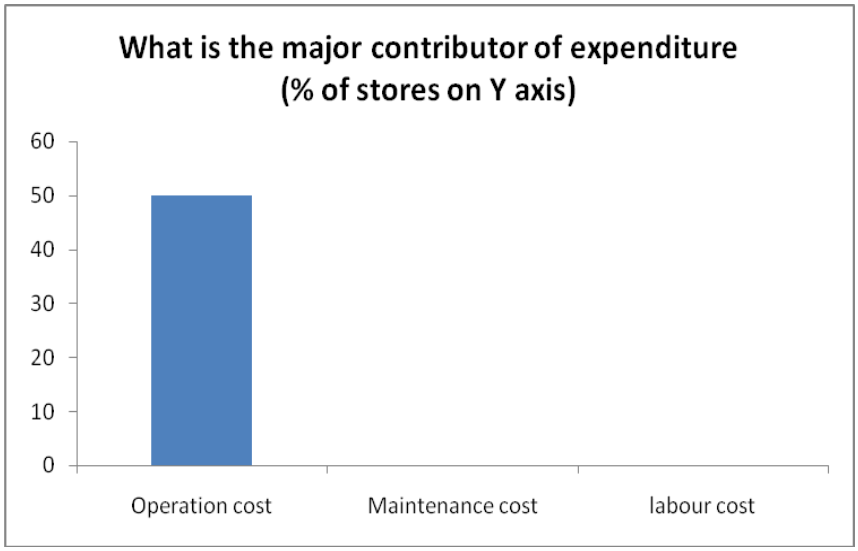

Figure3: Major contributor of expenditure of cold store unit compared to other costs

From figure4 it can be clearly seen that 72% of store owners felt that electricity is the major expenditure out of overall operations expenditure. This is an important concern need to be addressed to make cold storage units financially viable or successfully running without losses

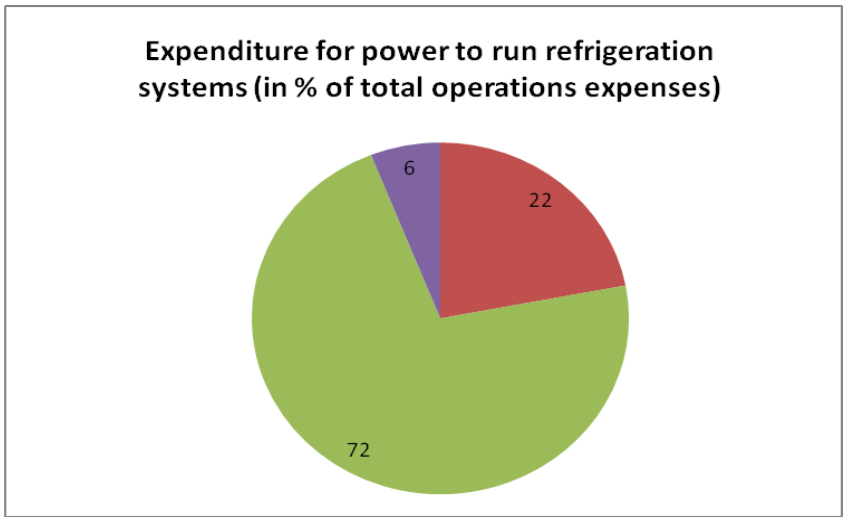

Figure4: Expenditure made on electricity out of total operations expenses

Figure 5 shows the view of the cold store entrepreneurs on "reduction in electricity charges leads to reduction in operations cost". Majority (84%) felt that electricity charges per unit can drastically reduce the operations cost. All the remaining felt that "It may be", indicating the poor awareness of entrepreneurs on costing contributors.

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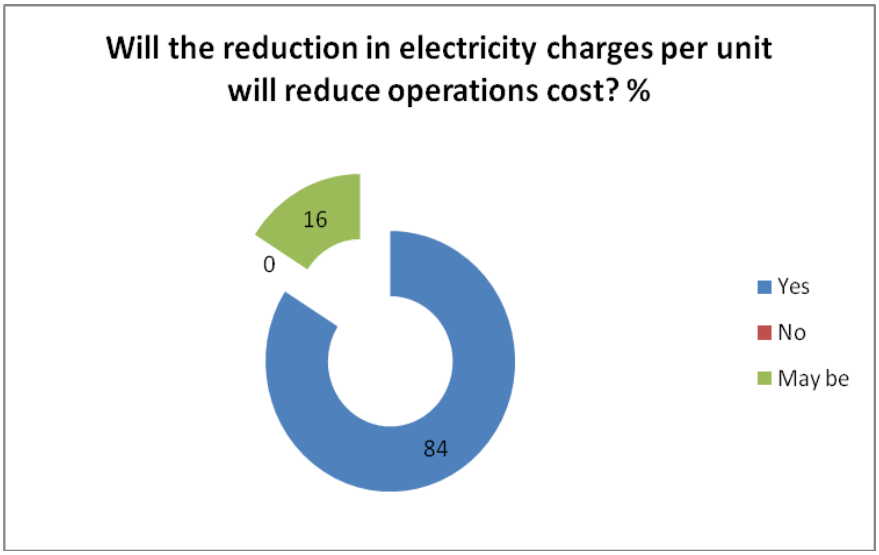

Figure5: Entrepreneurs response on reduction in electricity charges on financial viability

Summers are the tough times for cold storage units in terms of power supply availability from the Electricity distribution companies. Cooling need to be maintained round the clock to preserve the fresh produce. The survey results showed in figure 6 indicates that 72% of stores are receiving electricity only for 16-20 hours per day. About 24% stores indicated that they get power supply only for 12-16 hours, for them the energy cost through diesel generators will burden financially.

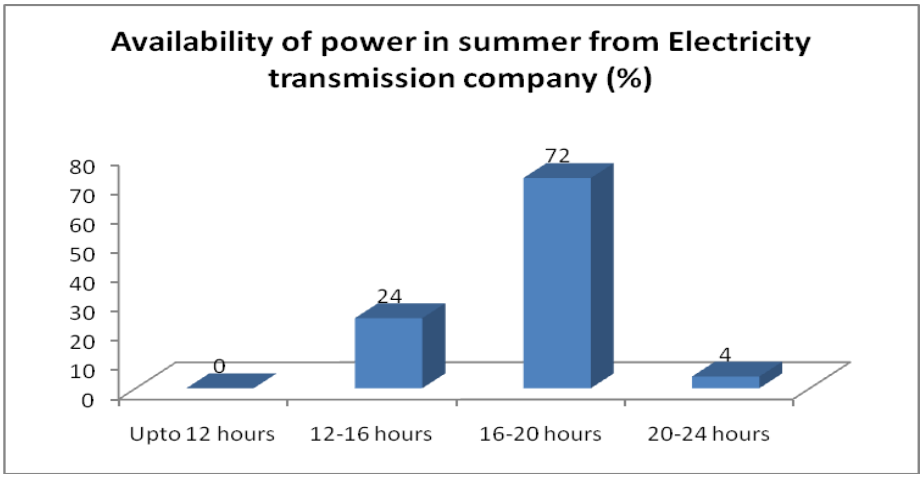

Figure 6: Response of the cold store operator on availability of electricity in summer

72% of the entrepreneurs running cold stores doesn't know that better tariff is offered to the cold store units in the state of Maharashtra @ equivalent to the subsidized agriculture sector power supply tariff.

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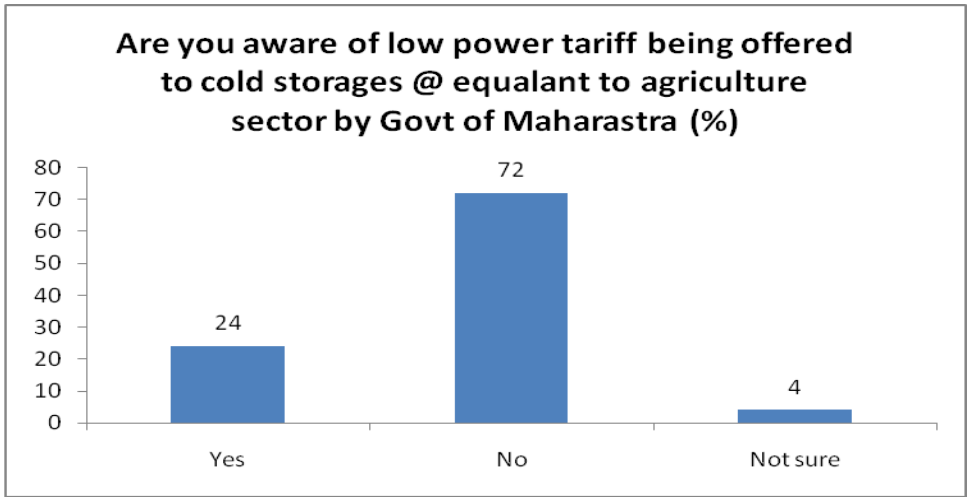

Figure 7: Awareness about low tariff charged to cold stores in Maharashtra

Most of the times, the entrepreneurs operating cold stores are little aware of new technologies and better business models. Creating awareness and training to the cold store owners/ entrepreneurs can only be the way to help them run their units successfully specifically financial viability.

NCCD 2014 reported about power availability from grid is in the range of 16 to 17 hours per day only. However cold stores needs power availability round the clock, which makes more expenditure on running DG Set to support the power shortage. Typical cost of power generation through DG Set is Rs. 12 to 14 per unit, which makes the situation worse for the cold store operation from expenditure point of view.

5. Conclusions and Recommendations

From the above study, it can be clearly seen that all the entrepreneurs running the cold storage business found facing issues with expenditure on energy consumption. It is necessary to support the cold store business, which are directly reducing the national wastage of agricultural produce.

Considering the requirements of food security to the nation, it is required to motivate and strengthen the business of cold storage /post harvest storage of fruits and vegetables. Keeping in mind the contribution of cold store operators to reduce the post-harvest losses, the following recommendations made to reduce the burden on the cold store entrepreneurs:

1. Implementing the reduced tariff in all the states of India with a tariff equal or less than the tariff of agricultural and cold store power tariff of Rs. 4.5 per unit and Rs. 3.5/- per unit by Haryana (to be implemented w. e. f. 01-04-2020) and Maharashtra respectively.
2. Special feeders to be provided to cold storage units from the nearest 133 kV power grid substations to make the uninterrupted power supply to all cold stores in the country. This will reduce the burden of DG Set running expenditure.
3. Implementing power saving methods in each and every cold store. Use of VFDs for all motors and fans of condenser and evaporator cooling fans.
4. Training of cold store technical persons on energy saving practices.
5. Imparting training to technicians and technical operators to use automatic systems for putting off the electricity consuming devices based on necessity.
6. Installing energy efficient lighting systems
7. Installing solar based lighting system wherever possible.

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References:

1. TERI, "Energy Profile: Kundli Cold Storage Cluster, Kundli (Haryana)", New Delhi: The Energy and Resources Institute, 24 pp. **(2016),** [Project Report No. 2015IE18]
2. United News of India Report, Posted on December 30, 2019, available at http://www.uniindia.com/haryana-to-subsidize-electricity-rates-for-horticulture-based-industries-cold-supply-chains/north/news/1838280.html
3. Foster A, D Negro, L Varga, Y Hu, K Fikiin and J Evans, "Financial Viability of Liquid Air Energy Storage Applied to Cold Storage Warehouses", 5th IIR Conference on Sustainability and the Cold Chain, China, **(2018)** April 6-8.
4. Robin Singhal and Shalini Saksena, "Performance Assessment of the Storage and Warehousing Industry in India", The Journal of Industrial Statistics **(2017)**, vol 6, no.1, pp. 15-40.
5. Madhu Sivaraman, "Government's role in India's ailing cold storage sector", Working Paper, **(2016)** December. DOI: 10.13140/RG.2.2.36370.45765
6. Sanyasi Naidu S.S, "An Economic Analysis of cold Storage Units in Guntur District of Andhra Pradesh", Report submitted to Acharya N. G. Ranga Agricultural University, Andhra Pradesh, **(2016).**
7. Vijay Paul and Rakesh Pandey, "Cold storage in India: Present Scenario and Future Directions", Processed Food Industry, **(2016),** May, pp. 25-29.
8. Shruthi Nair & Seema, "Investment Viability of Cold Storage Infrastructure for Agriculture Produce in Telangana State", Report published by Professor Jayashankar Telangana State Agriculture University, Hyderabad, **(2015).**
9. Mukopadhyay N. and Raj Gopal Nanda, "A Study on Energy Audit of a Cold Storage", Dr. N. Mukhopadhyay Int. Journal of Engineering Research and Applications, **(2015),** April. vol.5, no.7 (part-7), pp.6-10.
10. Ramkishore Singh, SP Singh and I J Lazarus, "Energy Performance Improvements in Indian Potato Cold Storages", J. Bas ic. Appl. Sci. Res., **(2014)**, vol.4, no.7, pp. 44-50.
11. Brito, P., Lopes, P. and Reis, P, "Simulation and optimization of energy consumption in cold storage chambers from the horticultural industry", Int J Energy Environ Eng, **(2014**), vol.5, no.88.
12. Gabor Hilton, "Reducing energy use in the cold storage industry – A case study", ECOLIBRIUM, **(2013)**, April, pp. 44-50.
13. Gundewadi, B.B., "Role and Performance of Cold Storages in Indian Agriculture", International Journal of Scientific Research, vol.2, no.11, **(2013)**, November, pp. 323-324.
14. Minten, Bart and Reardon, Thomas and Singh, K.M. and Sutradhar, Rajib, "The benefit of cold storages: Evidence from Bihar, MPRA Paper No. 54345, **(2010)**, posted on 13th March 2014 available at https://mpra.ub.uni-muenchen.de/54345/
15. Narasimha Rao, K. V., Narasimham, G. S. V. L. and Krishna Murthy, M. V., " Analysis of Co-Current Hydraircooling of Food Products in Bulk", Int. J. of Heat and Fluid Flow, **(1992),** vol.13, no.3, pp.300–310.
16. Narasimha Rao, K. V., Narasimham, G. S. V. L. and Krishna Murthy, M. V., "Parametric Study on the Bulk Hydraircooling of Spherical Food Products", AIChE Journal, **(1993a)**, vol.39, no.11, pp.1870–1884.
17. Narasimha Rao, K. V., Narasimham, G. S. V. L. and Krishna Murthy, M. V., "Analysis of heat and mass transfer during bulk hydraircooling of spherical food products", Int. J. of Heat and Mass Transfer, **(1993b**), vol.36, no.3, pp. 809–822.
18. Ramesh Babu, D., Narasimha Rao, K. V., Satish Kumar, M. V. and Satish Kumar, B., "Handling of Apples During Sorting-grading Operation and Measuring the Mechanical Properties Firmness after Controlled Atmosphere Storage", International Journal of Mechanical and Production Engineering Research and Development, **(2018)**, vol. 8, no.6, pp. 617-634.
19. Ramesh Babu, D., Narasimha Rao, K. V. and Syam Kolati., "The Design of Refrigeration, Thermal Insulation and an Equipment for Healthy Ripening of Mango and Banana Without Using Harmful Chemicals", International Journal of Mechanical and Production Engineering Research and Development, **(2019),** vol. 09, no 1, pp.423-434.
20. D Ramesh Babu, Sireesha Koneru, K V Narasimha Rao, B Satish Kumar, Syam Kolati, N Suman Kumar, "Identifying Opportunities to start Industries on the Food Production Potential in Telangana and Andhra Pradesh, India", International Journal of Engineering and Advanced Technology**, (2019),** vol.8, no.5, pp.2189-2193.
21. D Ramesh Babu, Ram Deshmukh, K V Narasimha Rao, M Rajya Laxmi, Kafila and T Sabita, "Awareness on Calcium Carbide Ripened Fruits and Recommendations for Toxic Free Artificial Ripening of Fruits", International Journal of Engineering and Advanced Technology, **(2019**), vol.9, no.2.pp.2779-2782.
22. Ram Deshmukh, D Ramesh Babu and K V Narasimha Rao., "Pressure Testing Results (As A Decision Tool For Deciding Low Oxygen Or Ultra-Low Oxygen Or High Oxygen Storage) Of Semi- Hermetically Sealed Controlled Atmosphere Storage Insulated Chambers". IJMPERD, **(2020)**, vol.10, no.1, pp. 531-540.
23. Naredla, S. K., Shekar, P. R., Babu, D. R., and Condoor, S., "Uniquely Addressing Customer Pain Points-the Case Study of Agritech", App. International Journal of Mechanical Engineering and Technology, **(2018)**, vol.9, no.11, pp. 2306-2314.
24. E. Ramesh, D. Ramesh Babu and P. Ramchandar Rao, "The Impact of Project Management in Achieving Project Success- Empirical Study", International Journal of Mechanical Engineering and Technology**,(2018)**, vol.9, no.13, pp. 237–247.
25. P Sammaiah, D Ramesh Babu, L Radhakrishna, and P Rajendar, "Kinetics of Moisture Loss during Dehydration of Drum Stick Leaves (Moringa Oliefera) In a Bio-Mass Tray Dryer", International Journal of Engineering and Advanced Technology**,(2019),** August, vol,8, no.6, pp.2937-2941.

ISSN: 2005-4238 IJAST

26. Narasimha Rao K V, Shareef Shaik and Ramesh Babu. D, "Mathematical Modeling of Cooling Rates of Mango Fruits During Unsteady State Cooling in An Artificial Ripening Chamber", Test Engineering and Management, **(2020),** March-April, vol 83, pp.6862-6871.
27. Narasimha Rao K V, Sasank Devarakonda and Ramesh Babu D, "Mathematical Modeling of Cooling Rates of Mango Fruits During Unsteady State Cooling in An Artificial Ripening Chamber", Test Engineering and Management, **(2020),** March-April, vol 83, pp.6872-6879.
28. Surendar G, "MSMEs' Role in Economic Growth – a Study on India's Perspective", International Journal of Pure and Applied Mathematics, **(2018),** Vol.18, no.18, pp.1727-1741.
29. Rathnakar. G. and Surendar. G., "Innovative Fin Tech Business Models the Role of Financial Institutions", Jour of Adv Research in Dynamical & Control Systems, **(2019),** vol. 11, no. 5, pp.122-125.
30. Surendar. G and Rathnakar. G. "Accounting Profession-Role of Information Technology", International Trends of Advanced Trends in Computer Science and Engineering**, (2019),** vol.8, no.10, pp154-160.

ISSN: 2005-4238 IJAST