International Journal of Applied Agricultural Research
ISSN 0973-2683 Volume 12, Number 2 (2017) pp. 227-238

http://www.ripublication.com

Assess the Possibility to transform cold depots through Techno-Economic Up-gradation

Abhishek Gaikwad[1] and Abhishek Rishab Paul[2]

Department of mechanical engineering
Sam Higginbottom University of agriculture technology and sciences

Abstract

India is developing and while electrification is considered a top priority by the planning commission, there are still a great number of villages that are still to be electrified. Even the ones that are electrified have unreliable power (Gopal & Suryanarayana, 2011). This poses a challenge with regard to the energy required for refrigeration of food produce. Hence, there exists a pressing need to develop a smaller capacity refrigeration system which can be operated with similar electrical grid connection but with greater efficiency and less consumption. This research paper presents an investigation into the methods of refrigeration that can be adopted for the purpose of reducing food produce wastage. Specific focus adopting technologies from developed countries related to refrigeration and cold storage is placed due to the tropical position of the country that ensures through the year.

Keywords: Cold storage, developing, efficiency, investigation, refrigeration, etc.

I. INTRODUCTION

Competitiveness in the warehousing industry is driven by service/infrastructure providers' ability to deliver value to their clients, along with offering returns beyond the cost of capital to their shareholders. Competitiveness is not about cost but about value — recognition of this fundamental truism is central to any meaningful discussion on building or improving competitiveness in logistics, particularly in warehousing, in India.

While some players have intentionally built infrastructure much ahead of demand to be best prepared for a demand upswing, most of the players mainly suffer due to a fundamental lack of competitiveness on account of multiple factors. Some of these include:

- Lack of alignment of capacity with cargo flows
- Lack/Absence of the appropriate scale and quality of warehousing infrastructure and services required to enable value-based pricing
- Low capital and operating efficiencies (i.e., lower utilization and poor throughput/unit space)
- Limited capacity (and ability) for handling multi-modal interfaces
- Limited value addition specific to the user industry, which stems from a weak understanding of the user's supply chain
- Inappropriate level of automation
- Inappropriate measurement of "total" logistics costs by end users, creating an illusion that value can only be driven by cutting piecemeal logistics (warehousing, transport, handling) costs

Energy-efficient practices like energy recovery systems, energy-efficient designs of refrigeration equipment and automation are some of the innovative features. Present research work is designed and streamlined to achieve goals in order to address problems described in this conclusive heading. Efforts need to be made in order to introduce the concept of green technology, as also the use of renewable energy for the cold chain sector. Special emphasis needs to be laid on development of reefer infrastructure in view of India's exports thrust and potential.

II. RELATED WORK

A Cold storage technologies can be classified according to the type of a storage medium and the manner in which the storage medium is used. Previous research has provided summaries and reasonable analyses for most of the common storage media such as water and ice. Saito (2002) suggested that water storage and static-type ice, which are based on established technologies, have little need for further study. More topics have surfaced in recent years for promising phase change material (PCM) storage.

Truman and Wildin (1989) developed a model, which was found to be reasonable in predicting the tank storage performance. Other models such as an effective diffusivity model to quantify the inlet mixing effect caused by various inlet geometries were also developed (Zurigat et al., 1991; Ghajar and Zurigat, 1991; Caldwell and Bahnfleth, 1998). Later, many two dimensional studies have attempted to simulate the thermocline formation process and were able to predict it reasonably. A steady state model was developed by Stewart et al. (1992) to study the effects of a submerged, downward-impinging flow from a slot in a chilled water storage tank.

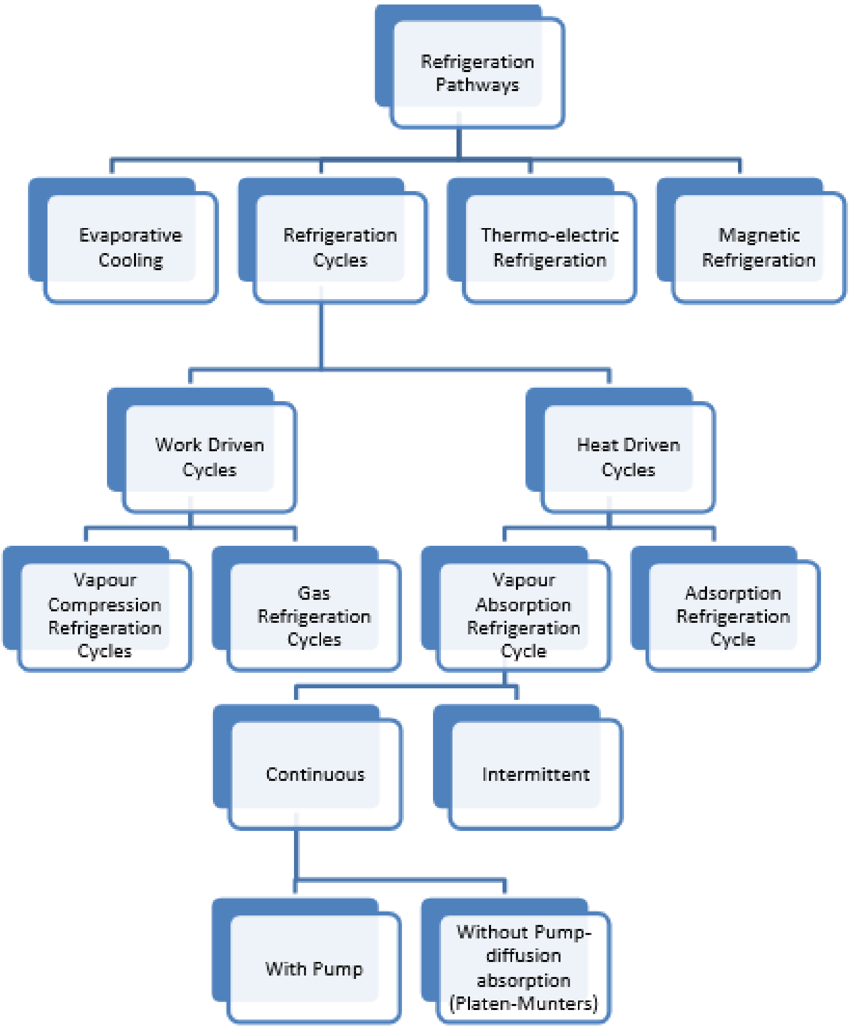


Fig: flow chart of common refrigeration cycle.

The most common freezing point depressant materials for water are glycols (Hirata et al., 2000; Inaba et al., 1998), alcohols (Ohkubo et al., 1999) and salts. Ice slurry can be made from harmless aqueous solutions such as an ethanol solution, a propylene glycol solution, and an economical aqueous solution such as ethylene glycol solution. The main purpose of using ice slurries is to take advantage of the latent heat of the ice crystals. Continuous ice slurry can usually be produced through buoyancy force (Hirata et al., 2000). Kumano et al. (2007) systemically studied the production of apparent latent heat from ice in aqueous solutions, which was defined as the effective latent heat, as shown in Figure 2.2 (combined from original figures by Kumano et al., 2007).

III. MATERIAL & METHODOLOGY

The core research material was from data gathered first hand from various cold storage depot surveys conducted Fab 2016 – September, 2016. During the surveys, depots with normal atmosphere were categorized as conventional cold depots and those with fully controlled atmospheres and also those with some storage rooms with controlled atmosphere were categorized as modern cold depots. We also made use of various research reports and statistical data, both from India and the rest of the world.

Data about the number and location of cold storage depots were obtained from the Ministry of Agriculture, GoI. From these records we found that a total of 346 568 tonnes of cold storage capacity within 87 cold storage facilities of various sizes exists within our research area (Anonymous, 2010). These facilities are almost completely used exclusively for apple storage.

Our aim was to visit cold major storage facilities situated in India where cold storage facilities are most common. Unfortunately 2 of the facilities refused to share information, while another one had just been built, thus limiting us to 59 facilities. Our research indicates that of these 59 facilities 51 of them are conventional and 8 of them are modern cold storage facilities. In our surveys of the cold storage facilities we included general information about the facilities like the year of establishment, legal status, personnel status, the education levels of managers, cold storage types (conventional or modern), cold storage capacity, capacity usage ratios, the average length of storage time for apples, storage season, storage temperature, humidity values, ventilation systems, gas compounds, losses in products caused by storage as well as common problems in storage facilities, inputs used, cost and income figures.

Comparisons between storage facilities were made using energy effeciency program independent sample t-test. The level of significance was chosen to be 0.05. The results were gathered and put into tables to be used with comparative and absolute distribution using weighted and basic average methods to obtain our final interpretation.

The total power consumption from storage, gross power input and gross power used were summed to find the total power consumption. By subtracting cost from the gross Power we found the net Power Consumption. Cold storage facilities gross power consumption values were calculated with respect to the unit storage price during the active season.

VI. CALCULATIONS

To establish values for cold storage depot depreciation expenses, we took into account the current values for capital and its components as well as the time period they could be used. This research accepts depreciation values as 2% for building capital, 6.66% for water wells, generators and weigh-bridges, 3.33% for the climate control system, 20% for plastic cases given to rent, equipment in the administrative building, pallet trucks, trucks and the rest of the permanent equipment, 14% for auxiliary equipment and hardware capital, 8.33% for batterypowered forklifts, 16.66% for scales and 25% for forklifts and trucks (Anonymous, 2012).

The value of all the equipment was determined by interviewing the managers and owners of the facilities. Enterprise costs were categorized as fixed and variable costs and analyzed accordingly. Fixed costs were determined to consist of depreciation, permanent worker fees, interest, tax and insurance. Variable costs were determined to consist of temporary worker fees, repairs, maintenance, electricity, gas, water, oil, fuel and a few more. Net income was determined by subtracting all expenses from the gross income. To determine the profit margins, we calculated the economic and financial profitability ratios.

$$\text{Economic Profitability Ratio} = \frac{\text{Net profit}}{\text{Total Active Capita}} * 100 \quad \ldots\ldots\ldots\ldots(1)$$

$$\text{Financial Profitability Ratio} = \frac{\text{Net profit} - \text{Debt Interest}}{\text{owners equity}} * 100 \quad \ldots\ldots\ldots(2)$$

By using break-even point analysis we determined the minimum capacity the facilities have to operate.

Q= FC/ (P-VC)*100 **………………………………. (3)**

Q: Minimum capacity and the break-even point

FC: Fixed cost total

P: Storage cost per unit

VC: Unit variable cost total per unit (Oluç, 1978; Beierlein et al., 1986)

Gross power consumption is the sum of all power consumption before and after the expenses incurred to achieve that Efficient cooling (Güllenoğlu, 1993). The greatest portion of the researched facilities’ power consumption is to run the cold storage service. The enterprises also reported small power losses from other auxiliaries as these were too much old.

V. DATA COLLECTION

Data is collected from 26 cold storage business establishments and documented in XL sheet.

This Data Collection was done to begun a comparative analysis of modern (controlled atmosphere) and conventional (normal atmosphere) cold storage facilities by using data gathered from 26 facilities via questionnaires. During the research we give most concern in Collection Power Consumption related data to understand efficiency of Conventional Cold Depots Technologies used in India along with reviewing the technical and economic specifications of the facilities and determined criteria like their capital structure, income, expenses, profitability and minimum capacity to run to continue profitability (break–even point) and determined which type of enterprise is more profitable.

Other than that, the quality of refrigeration must be inspected thoroughly. Application of these collected data would help in calculation of overall efficiency of conventional cold storage technologies used in India and to compare with Foreign Solar powered refrigeration technologies.

VI. OBSERVATION & RESULT

In our survey, we found that during the last 10-15 years, there is significant progress has been made in the expansion of the cold-chain industry in western UP Zone. Such development is playing a leading role in connecting more domestic markets with producing areas as well in the export and import of fruits / vegetables / meats / flowers etc.

But in order to improve the cold chain sector further for the western UP in general and for rural India in particular, there is a need to understand the existing status in terms of requirement, capacity created and gaps in technologies if any, across the various infrastructure components that comprise an integrated cold-chain.

In this context the Department of Agriculture and Cooperation, Ministry of Agriculture requires an assessment to be made of the post-harvest cold chain infrastructure requirements, specific to products and linked with markets.

As per the survey some infrastructure components would specifically needed to be included in order to improve cold warehousing, packaging & distribution facilities and other cold-chain infrastructure and other operational discrepancies, so as to formulate a future strategy of intervention for development of integrated cold chain infrastructure in the country. These requirements are as such –

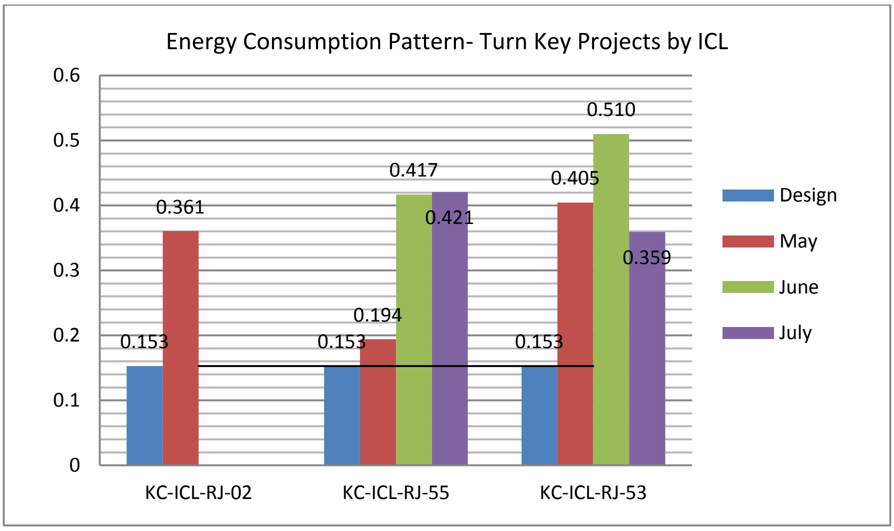
- Improve Energy Efficiency of Technologies used in Cold Storage systems,
- Capacity Enhancement without enhancing power load
- Technology upgradation
- Modernization of old cold store infrastructures in minimum cost.

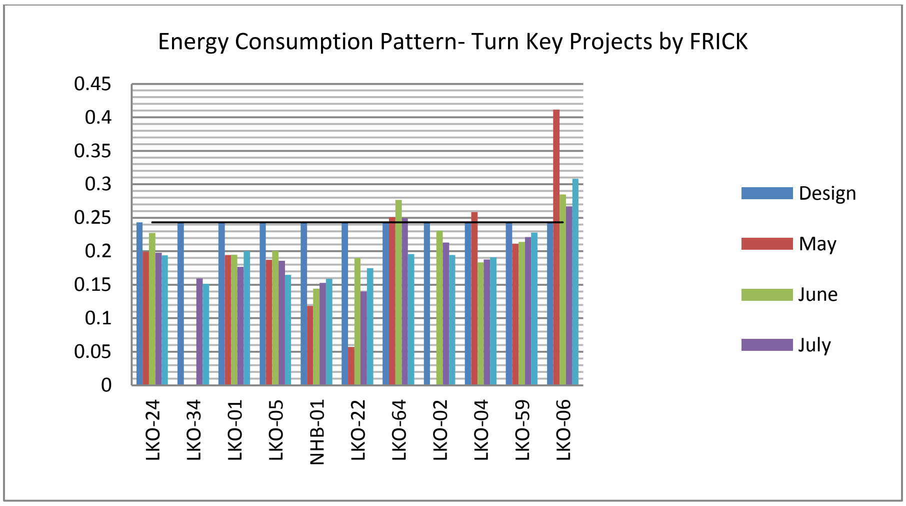
Table 1: Electricity Consumption Pattern during Holding Period- Turn Ket Projects

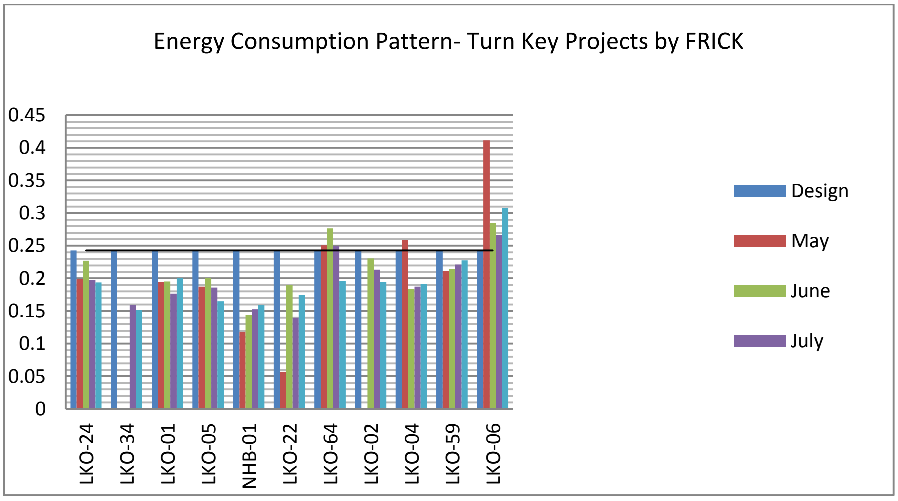
Month	LKO-24	LKO-34	LKO-01	LKO-05	NHB-01	LKO-22	LKO-64	LKO-02	LKO-04	LKO-59	LKO-06
Design	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**
May	0.199		0.194	0.187	0.119	0.057	0.251		0.259	0.211	0.412
June	0.227		0.195	0.200	0.144	0.190	0.277	0.231	0.184	0.214	0.285
July	0.198	0.159	0.177	0.186	0.153	0.140	0.249	0.213	0.188	0.221	0.267
August	0.194	0.151	0.200	0.165	0.159	0.175	0.196	0.194	0.191	0.228	0.308
average	**0.205**	**0.155**	**0.192**	**0.185**	**0.144**	**0.140**	**0.243**	**0.213**	**0.205**	**0.219**	**0.318**

Table 2: Electricity Consumption Pattern during Holding Period for Projects not Executed on Turn Key Basis

Electricity Consumption Pattern during Holding Period for Projects not Executed on Turn Key Basis											
Month	KC-AL-LKO-2	KC-AL-LKO-18	KC-AL-LKO-10	KC-AL-LKO-21	KC-AL-LKO-14	KC-AL-LKO-29	MX-ICL-LKO-17	MX-AL-LKO-33	MX-AL-LKO-35	MX-MX-LKO-76	ICE-LKO-52
Design	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**	**0.243**
May	0.307	0.272	0.363	0.439	0.403	0.436	0.22862	0.362	0.309	0.355	0.329
June	0.387	0.292	0.318	0.402	0.367	0.268	0.24692	0.314	0.344	0.311	0.205
July		0.284	0.302	0.347	0.302	0.272	0.18768	0.268	0.338	0.270	0.205
August		0.247	0.287		0.289	0.323			0.323	0.210	0.218
average	**0.347**	**0.274**	**0.317**	**0.396**	**0.340**	**0.325**	**0.221**	**0.315**	**0.329**	**0.286**	**0.239**







Graph – 1: Graphic Representation of consumption pattern.

VII. CONCLUSION

Energy consumption of all 26 Surveyed cold storage of Western UP was measured 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.

The findings are as follows –

- Average Capacity of compressor, condenser, and evaporator installed in all 26 cold depots were 10460 kJ/h, 12552 kJ/h , and 10460 kJ/h, respectively.
- Axial fan located back of the evaporator was used to distribute the cooled air into maximum cold storages.
- Electrical heater were used to defrost in maximum plants.
- Refrigerant was R22.
- Energy use in a cold storage facility is affected by the amount of heat the refrigeration equipment must remove and the efficiency of the equipment.
- The main sources of heat in a facility for long-term storage are transmission through walls, evaporator coil fans, lights, air leakage, and respiration of the stored commodity.
- The electric energy consumption of existing cold stores ranges between 30 and 50kWh/m3/year for storage. It is depends on the quality of the building, on the activities (chilled or frozen storage), room size, stock turnover, temperature of the incoming produce, outside temperatures, etc.
- The total cost of electric energy is about 10 to 15% of the total running costs of a store.
- Improving Energy Efficiency (EE) has two goals: cost reduction and environmental protection.

VIII. FUTURE WORK & SUGGESTIONS

65% of Indian population is engaged in agriculture and it is a key sector with profound impact on the nation’s economy. The total agriculture output contributes nearly 40% to the national income. The country approximately produces nearly 137 million tones of fruits and vegetables annually. Since most products are perishable they require specialized environment controlled facilities for prolonged storage and transport.

Each year, India produces 63.5 million tons of fruits and 125.89 million tons of vegetables. India is also the largest producer of milk (105 million metric tons per year). India produces 6.5 million tons of meat and poultry, as well as 6.1 million tons of fish a year. The perishable products transaction volume is estimated to be around

230 million metric tons. Although India has the potential to become one of the world's major food suppliers, the countries inefficient cold chain network results in spoilage of almost 35 percent of its total agricultural production. India, therefore, has tremendous growth potential with respect to rural-based food processing. [2] Till the year 2009, the total number of cold storages in India is 5,381 with total installed capacity of 24.45 million MT. Uttar Pradesh and West Bengal accounts for more than 60 per cent of the cold storage capacity followed by Punjab, Bihar, Gujarat, Andhra Pradesh and Madhya Pradesh. Over ninety five percent of the cold storages are in the private sector.

REFERENCES

[1] Study by National Spot Exchange Ltd. in 2010 for assessing requirement of the cold storage capacity in the country.

[2] Report of the committee headed by Shri Soumitra Choudhary, Member Planning Commission on encouraging Investments in Supply Chain including provision for cold storages for more efficient distribution of farm produce.

[3] Base Line Study draft report submitted by Hansa Research Group Private Limited to NHB onAll India Cold Storage Capacity and Technology.

[4] Study by Central Institute of Post-Harvest Engineering and Technology (CIPHET), Ludhiana on Harvest and Post-Harvest Losses of Major Crops and Livestock in India.

[5] Magoo Nitin, High-temperature refrigerated warehouse operation under real-time pricing of electricity, A thesis of Master of Science, 2003, pp. 1-151.

[6] Jog K. V, Cold storage industry in India, Proceedings of Refrigerated Warehouse & Transport Association of Australia, 2004, pp. 1- 21.

[7] Matapurkar Aneesh, Sinha Arnav, Cold chain: Finally warming up to India, Infrastructure Today, 2011, pp. 22-25.

[8] ASHRAE Handbook of Fundamentals, 1993 (Section 26).

[9] National Horticulture Board Report, Technical Standards Number NHB-CS-Type 02-2010, Department of Agriculture & Cooperation, Ministry of Agriculture, Govt. of India.

[10] Patel Amit M., Patel R. I., Optimization of different parameter of cold storage for energy conservation, International Journal of Modern Engineering Research, Vol.2, Issue.3, May-June 2012 pp-1001-1005.

[11] Crawley Drury B., et al., Energy Plus: Creating a new-generation building energy simulation program, Energy and Buildings, 2001, 33, pp 319-331.

[12] Engineering Thermodynamics, P. K. Nag (Book)

[13] Willis croft PMP, NZ Rural Press Limited, Auckland, 2007

[14] ISHRAE Publications, Air conditioning and Refrigeration,

[15] Darbouret, M., Cournil, M., Herri, J.M., 2005. Rheological study of TBAB hydrate slurries as secondary two-phase refrigerants. International Journal of Refrigeration.28, 663-671

[16] Dimaano, M.N.R., Escoto, A., 1998. Preliminary assessment of a mixture of capric acid and lauric acid for low-temperature thermal energy storage. Energy. 12(5), 421-427.

[17] Dimaano, M.N.R., Watanabe, T., 2002a. The capric–lauric acid and pentadecane combination as phase change material for cooling applications. Applied Thermal Engineering. 22(4), 365-377.

[18] Energy Information Administration, U.S. Department of Energy, 2011. Annual Energy Review 2011, Primary Energy Production by Source, Selected Years, 1949-2011.

[19] Eun, T.H., Song, H.K., Han, J.H., Lee, K.H., Kim, J.N., 2000. Enhancement of heat and mass transfer in silica-expanded graphite composite blocks for adsorption heat pumps. Part II. Cooling system using the composite blocks. International Journal of Refrigeration. 23, 74-81.

[20] Farrell, A.J., Norton, B., Kennedy, D.M., 2006. Corrosive effects of salt hydrate phase change materials used with aluminum and copper. Journal of Materials Processing Technology. 175, 198-205.

[21] Grandum, S., Yabe, A., Nakagomi, K., Tanaka, M., Takemura, F., Kobayashi, Y., Frivik, P.E., 1999. Analysis of ice crystal growth for a crystal surface containing absorbed antifreeze proteins. Journal of Crystal Growth. 205, 382-390.

[22] Hasnain, S.M., 1998. Review on sustainable thermal energy storage Technologies, part II; Cool thermal storage. Energy Conversion and Management. 24 (11), 1139 -1153.

[23] He, B., Setteerwall, F., 2002. Technical grade paraffin waxes as phase change materials for cool thermal storage and cool storage systems capital cost estimation. Energy Conversion and Management. 43(9), 1709-1723.

[24] Jegadheeswaran, S., Pohekar, S.D., Kousksou, T., 2010. Exergy based performance evaluation of latent heat thermal storage system: A review. Renewable and Sustainable Energy Reviews.14(9),2580-2595

[25] Kozawa, Y., Aizawa, N., Tanino, M., 2005. Study on ice storing characteristics in dynamic-type ice storage system by using supercooled water. Effects of the supplying conditions of ice-slurry at deployment to district heating and cooling system. International Journal of Refrigeration. 28(1), 73-82.

[26] Lin, K., Zhang, Y., Xu, X., Di, H., Yang, R., Qin, P., 2005. Experimental study of underfloor electric heating system with shape-stabilized PCM plates. Energy and Buildings. 37, 215-220.

[27] Ma, Z.W., Zhang, P., Wang, R.Z., Furui,S., Xi, G.N., 2010. Forced flow and convective melting heat transfer of clathrate hydrate slurry in tubes. International Journal of Heat and Mass Transfer. 53(19-20), 3745-3757.

[28] McCormack, R.A., 1990. Use of clathrates for 'off-peak' thermal energy storage. Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, pp. 300-305.

[29] Nakayama, H., 1987. Hydrates of organic compounds. VI. Heats of fusion and of solution of quaternary ammonium halide clathrate hydrates. Bulletin of the Chemical Society of Japan. 55, 389-393; Hydrates of organic compounds. XI: Determination of the melting point and hydration numbers of the clathrate-like hydrate of tetrabutylammonium chloride by differential scanning calorimetry. Bulletin of the Chemical Society of Japan. 60, 839-843.

[30] Ohkubo, H., Matsumoto, N., Fukuchi, M., Chandratillelke, R., 1999. Development of fluid latent heat storage material using ethanol water solution. Proceedings of the 20th International Congress of Refrigeration, IIR/IIF, Sydney, Vol.1, Paper No. 488.

[31] P. Tatsidjodoung, N. Le-Pierrès, L. Luo. 2013. A review of potential materials for thermal energy storage in building applications, Renewable and Sustainable Energy Reviews. 18, 327-349

[32] Porisini, F.C., 1988. Salt hydrates used for latent heat storage: corrosion of metals and reliability of thermal performance. Solar Energy. 41(2), 193-197.

[33] Rivera, C.O., Rivera, W., 2003. Modeling of an intermittent solar absorption refrigeration system operating with ammonia/lithium nitrate mixture. Solar Energy Materials and Solar Cells. 76,417–427.