Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 2, Number 13; April-June, 2015 pp. 1149-1152

http://www.krishisanskriti.org/jbaer.html

# Renewable Refrigeration Technique: A Theoretical Perspective for Food Preservation

**Md Iqbal Ahmad[1], Subhro Chakraborty[2], Surajit Sur[3], Anish Chakraborti[4]**
**Prasun Das[5], Pulak Mandal[6], Tandrima Ganguly[7] and Sandip Dutta[8]**

*[1]Mechanical Engineering Department, University Of Engineering &Management, Jaipur, India)*
*[2]Civil Engineering Department, University Of Engineering & Management, Jaipur, India)*
*[3]Electronics Engineering Department, University Of Engineering &Management, Jaipur, India)*
*[4](4th Year B.Tech, Mechanical Engineering Undergraduate Student, University Of Engineering & Management, Jaipur, India)*
*[5,6](3rd Year B.Tech, Mechanical Engineering Undergraduate Student, University Of Engineering & Management, Jaipur, India)*
*[7,8](3rdYear B.Tech, Civil Engineering Undergraduate Student, University Of Engineering & Management, Jaipur, India)*

**Abstract—***Food and energy is a basic requirement for the existence and development of human life. All the foods that are consumed by the human being are obtained from the plants & animal kingdoms. The variety of foods grow in the different season and many of them are required for whole year by the human being in different parts of country. Therefore it become crucial to preserve the foods, bycost-effective and energy efficient techniques. Thedemand for energy is growing at an alarming rate every year. Therefore solar-powered cooling is one of the technologies which allows to obtain, by using the renewable solar source, an important energy saving compared to conventional refrigeration technique.India stands as one of the major food producer in the world. The green revolution & white revolution refer to the rapid increase in food grain and milk productivity respectively and changed India`s position from being a net importerto becoming self-sufficient with regard to food production.Over half of its population is involved in agriculture associated activities. Estimates indicate that post-harvest food wastage due to inadequate cold storage at 40% for fruit and vegetables alone without including dairy produce and food grains. Therefore, it is essential to develop a moderate capacity solar refrigeration system which can be operated independent of the electrical grid. This study is an investigation into the methods of solar refrigeration that can be adopted for the purpose of reducing food spoilage in rural parts of India.*

**Keywords:** *Renewable, Solar Energy, Refrigeration Technique, Food Preservation.*

## 1. INTRODUCTION

### The Indian Food Preservation & Cold StorageScenario:

- **A brief summary**

This paper is an investigation into an efficient solar powered refrigeration system for food preservation basically to support the agricultural base products (specifically fruits and vegetables) in rural and remote parts of India where significant wastage or spoilage of food or produce take place and consequent loss occurs due to the lack of refrigeration. Rising energy costs and peak demand are generating new interest in solar-thermal energy based refrigeration systems. These can compete with electrical or conventional energy based refrigeration system.

- **Why solar refrigeration technique for food preservation relevant to India**

1. Ambient temperatures are high throughout the year in the most parts of the country. Higher ambient temperature provides more energy input.
2. There is huge potential demand for refrigeration in rural areas, which are best suited for solar energy based refrigeration system.
3. Solar cooling appears to be an attractive technique due to fact that when the cooling demand is more, the sunshine is strongest.

- **Renewable energy scenarios**

World developments in the field of energy supply, after the oil crises of the 1970s and the oil crisis of 2004, are showing the way to more serious steps towards sustainability in strategic energy planning, the improvement of energy efficiency and rational use of energy. Renewable energy sources are increasingly becoming a key factor in this line of thought.

Using fossil fuel as the primary energy source has led to a serious energy crisis and environmental pollution on a global level. Renewable energy is a promising alternative solution because it is clean environment friendly. Approximately half of the global energy supply will come from renewable in 2040 according to European Renewable Energy Council (EREC) (2006).

- **India and its Socio-Agricultural Scenario**

India with diverse soil and climate condition comprising several agro-ecological regions, provide ample opportunity to

grow variety of crops. The recent Indian union budget (2012-13, p.179) places the contribution of agriculture to the GDP of India at 14.5%. India transformed from being a net importer of food since independence to becoming self-sufficient in its food produce through the green revolution for food grains and produce and through the white revolution for dairy products.

Ample sunshine, diverse agro-climatic conditions and rich soil types support the production of various food and commercial crops.

- **The Indian Food Industry**

India has experienced a considerable degree of crop diversification in terms of change in the area under various crops, since the green revolution which was largely oriented toward increasing grain production to meet the objective of self-sufficiency and resolve the country food security problems. Horticultural crops form a significant part of total agricultural produce in the country comprising of fruits, vegetables, flowers, medicinal, aromatic plants and mushroom are the key drivers of the economy development of the country. Therefore, there is an urgent need to develop such technique which is most suitable and practically efficient in rural areas of the country. As horticultural crops (vegetables and fruits) play a significant role in India economy, improving the food preservation technology with solar refrigeration may be a great contribution in Indian economy and in energy security.

- **The demand forecast scenario**

Based on data from the central statistics organization of India, an analysis of the food and agri-business industry in India by Business Monitor International identified that the Indian food market consumption was registering growth at a phenomenal 5.32% compound annual growth rate (CAGR).

This would place the market in 2020 at twice the value of 2010 levels. This is shown in the trend graph below. The industry has however exceeded this growth rate as can be seen in figure.

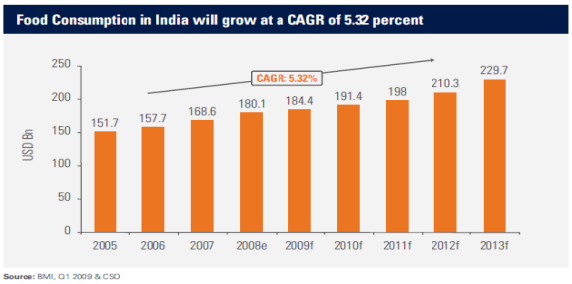


**Fig. 1: Food Consumption Trend in India**

- **Growth Forecast in Processed Food Industry and Organized Retail**

The food processing industry is expected to see growth at 7% CAGR driven primarily by urbanisation and sustained economic growth which opens the market to products at premiums.

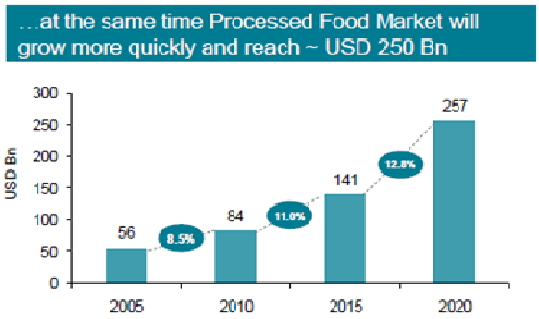


**Fig. 2: Processed Food Market Trends.**

- **Growth Drivers of the food Industry**

A strategic plan by the Ministry of Food Processing Industries in India identified the following drivers for the growth trend in the food industry the excerpt of which is given below

- **Food and grocery dominates total retail spend**

While rural consumers spend around 53%5 of their total consumption expenditure on food, urban India spends 40% of their retail spend on food items thus offering huge opportunity for processed food products.

- **Shift in demographic profile**

The median age of Indian population is 24 years and approximately 65% of Indian population is below 35 years of age. The large population of working age group forms a wider consumer base for processed products.

- **Increasing number of working women**

The number of working women, as a percentage of the total female population, has grown from 12% in 1961 to close to over 25% resulting in demand for convenience food.

NABARD is the acronym for National Bank for Agriculture and Rural Development which is the apex development bank in India responsible for facilitating credit flow for agricultural and non - farm rural uplift and sustained development.

- **The Fruit and Vegetable [F&V] sector**

This paper focuses on the applicability of solar refrigeration to highly perishable items with very low shelf lives.

Some reasons for this focus is because of the volume of the market that India can stand to cater and the trending towards agricultural cropping which is seen as producing better value for the cultivators. This notable shift towards agricultural crops is studied in a paper by Sharma & Jain (2011). Following is an excerpt of the same:

"The findings of the study reveal a structural shift in consumption pattern away from cereals to high value

agricultural commodities, both in rural and urban areas, in the last two decades. This shift in dietary patterns across states and income classes is also observed. The results reveal a relatively strong and growing demand for livestock products and fruits and vegetables in both rural and urban areas. The average expenditure as well as share of beverages has increased by about six times in both rural and urban areas.

Due to shift in demand pattern towards high-value crops, the farmers have also responded to market signals and gradually shifting production-mix to meet the growing demand for high-value commodities. This is reflected in the changing share of high value crops in total value of output from agriculture.

Overall, fresh fruits and vegetables exports represent a very small share of domestic production and agricultural exports but have increased significantly."

India currently accounts for 13% of vegetable and 12% of fruit global annual production. While this is the case, India's global market share for produce trade in this sector is very low.

However, poor processing facilities and weak infrastructure for post-harvest processes, storage and transportation lead to wastage of nearly 30% of this produce resulting in a very low share of the global trade at only 1.38% despite the strength of its supply base. It aims to increase the food share from this level to 3% by 2015. Horticulture contributes to 28% of the agricultural gross domestic product of the nation with the sector seeing rapid growth (Economic Times Bureau, 2012).

- **The Indian Cold Chain Scenario**

A cold chain is supply chain which requires the control of temperature to protect the value of the perishable products within the chain.This temperature control is required in many types of agricultural crops to enhance the shelf life of the produce and is required right from the moment the harvest occurs till it reaches the consumer.

The impact of cold storage on the shelf life of some of the fruit and vegetable produce is indicatedas shown in theFigure The extra time would allow goods transfers across greater distances while maintaining quality and is thus indicative of the value that a strong cold chain can create.

Exhibit 11 **Impact of Cold Supply Chain on Shelf Life**

| Commodity | Shelf life w'out storage | Shelf life with Cold Store |
|---|---|---|
| Apples | 2-3 weeks | 3 months |
| Mango | 5-7 days | 2 weeks |
| Grapes | 4-6 days | 3 -6 weeks |
| Litchi | 7-8 days | 3-4 weeks |
| Potato | 4-6 weeks | 3-8 months |
| Onion | 15-30 days | 5-6 months |
| Tomato | 2-4 days | 2 weeks |

Source: Task-force report on Cold Chain by National Horticulture Board

**Renewable refrigeration techniques**

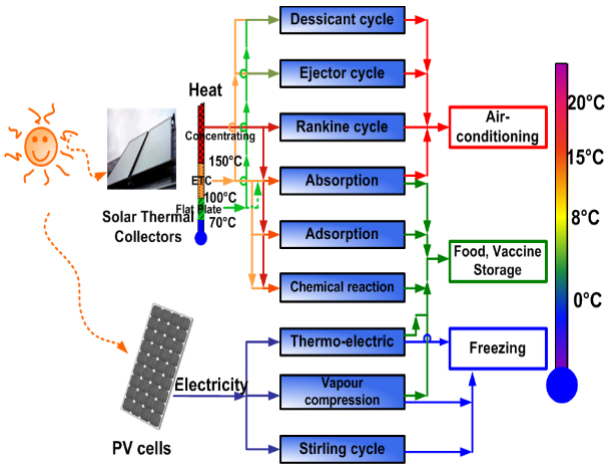


**Fig. 3: Renewable refrigeration techniques pathways**

Thesolarcoolingsystemisgenerally comprised ofthreesub-systems: the solarenergyconversionsystem,refrigeration system,andthethecooling load.Theappropriate cycleineachapplication dependsoncoolingdemand, power, and the temperaturelevelsof the refrigeratedobject,aswell astheenvironment. Anumberofpossible "paths" from solar energy to "coolingservices"areshownin Figure.

Starting from the inflow of solar energy there are obviously two significant paths to follow; solar thermal collectors to heat or PV cells to electricity. For solar thermal collectors, different collector types produce different temperature levels. This indicates that the temperature level can be matched to various cycle demands. For example, the Rankine cycle requires a rather high driving temperature whereas the absorption cycle manages at a lower temperature level of heat supply.

The same type of temperature matching is important for the cold side of the solar cooling path, i.e in the cold object. Since several cycles typically operates with water as a working fluid, it is impossible to achieve temperatures below 0°C for some cycles. The solar thermal driven air-conditioning cycles can be based on absorption cycles, adsorption cycles duplex Rankine, desiccant cooling cycles, or ejector refrigeration cycles.

- **Performance analysis**

With the help of two hypothetical solar refrigeration system one of the most economic and efficient can be can analyzed by considering two different such as *system 1,* which is a solar thermal (heat) driven refrigeration system and *system 2,* is PV's driven refrigeration system.

*Now considering System1*,aheatdrivencycle with acycle COPof0.7receivesitsheatfrom asolarcollectorwith80%efficiency.*System2*,avapourcompression refrigeration cyclewitha COPof4receivesit selectricity from a PV array withan efficiency of 15%.

Whichonegivethehighestoverallefficiency? Inthis paper, efficiencyisdenotedSTR, System Thermal Ratio.

Thecalculationissimpleandstraightforward, whereastheresultismore difficulttointerpret.Apparently, thereareatleasttwopathstothesame overallefficiency. Thereisalsoanecessity tobetterdefinethevariousefficienciesneededfortheanalysis.

$STR_1 = \eta_{collector} * COP_{cycle} = 0.7*0.8 = 0.56$

$STR_2 = \eta_{pv} * COP_{cycle} = 0.15*4 = 0.6$

Thecalculationissimpleandstraightforward, whereastheresultismore difficulttointerpret.

- **Solar Refrigeration Applications**

1. Fresh FruitsAnd Vegetables
2. Preventive medicine(mainlyvaccines)
3. Icecream and dairy products
4. Chemicals
5. Marine products
6. Processedmeat &poultry etc

## 2. CONCLUSION

Whenusinglowtemperature applicationsforfoodstorageat0to-8°C, various cyclescanbeapplied,i.e.thevapour compressioncycle,thermo-electriccycle (Peltier) and vapour absorptioncycle.Asuitable cycleforthis application hasprovedtobethePV-drivenvapourcompressioncycle.Thedoubleeffectabsorptioncycle,adsorption cycleandchemical reactioncyclecanalsobeused, especially forl arger cold storage for the preservation of food.

Typically forthecyclesin above Figureisthat,theefficiency oftheelectricity-drivenrefrigeration cyclesarequitehighbuttheyrequirephotovoltaic panels andbatteries, whichareexpensive. Heatdriven cyclesontheother hand,arelessefficient,butthethermalsolarcollectors mayreachmuch higherconversion efficiencies thanthePV's eventhoughtheoutputis heat,notelectricity.

However there are number of advantages in using thermal solar collector absorption cycle as follows:

1. It very economical as compared to PV operated refrigeration system.
2. It requires less amount of mechanical work input.
3. Smooth in operation and maintenance cost is low.
4. It can provide very large capacity more than 1000 Tonnes.
5. It works efficiently under fluctuating load etc.

Therefore, now it clear from the above discussion that I have to go for thermal solar collector absorption refrigeration system for efficient operation and better performance etc.

## REFERENCES

[1] http://agriexchange.apeda.gov.in/homepage.aspx
[2] http//:www.sciencedirect.com
[3] http//:www.mnre.gov.in
[4] Solar Energy by H P Garg & J Prakash
[5] Non-conventional energy sources by G.D. Rai
[6] Solar energy utilization by G.D. Rai
[7] Solar energy by Sukhatme
[8] Thermodynamics an engineering approach by Cengel & Boles