May - June 2020

AIR CONDITIONING AND REFRIGERATION JOURNAL

The magazine of the Indian Society of Heating, Refrigerating and Air Conditioning Engineers

COLD CHAIN

Volume 11 Number 2

Supplement to Air Conditioning and Refrigeration Journal

HOW COVID-19 WILL CHANGE THE COLD CHAIN SCENARIO

INSIDE:

- Long Term Impact of COVID-19 on the Indian Cold Chain
- How COVID-19 will Change the Cold Chain Landscape for Ever
- Kitchen Equipment Start-up after a Long Shut Down
- Driving Clean Cold

www.ishrae.in

ISHRAE

Organiser

ISHRAE

Co-organiser

NÜRNBERG MESSE

International Exhibition and Conference
on Cold-Chain, Industrial Refrigeration
& Reefer Transportation

REFCOLD INDIA

October 29 - 31, 2020

India Expo Mart (IEML), Greater Noida, U.P.

THE BIGGEST SHOW FOR
REFRIGERATION AND COLD-CHAIN INDUSTRY

COMES TO DELHI NCR

HIGHLIGHTS OF REFCOLD INDIA 2019

- Over 200 Exhibitors
- 8,000+ Visitors
- Total Area - 10,500 Sq.m.

For space booking, please contact:

NürnbergMesse India Pvt. Ltd. | **Rohan Chopra**: T: +91 11 47168806 | E: rohan.chopra@nm-india.com

www.refcoldindia.com

Contents

COLD CHAIN

Index to Advertisers

Domestic mini coolers using earthen pots

Typical cold chain logistics

Cover design by Fezisons

Registration Numbers:
MAH/ENG/06690/13/1/97/TC
70346/98

From the managing editor

ISHRAE AIR CONDITIONING AND REFRIGERATION Journal
The magazine of the Indian Society of Heating, Refrigerating and Air Conditioning Engineers

COLD CHAIN
Supplement to
Air Conditioning and Refrigeration Journal

Published by Gautham Baliga
on behalf of Indian Society of Heating, Refrigerating and Air Conditioning Engineers.

Published at ISHRAE Mumbai Chapter
102, 1st Floor, Sunil Enclave,
Pereira Hill Road, Off M.V. Road,
Next to WEH Metro Station Gate #7,
Chakala, Andheri (East), Mumbai - 400 099.

How to Reach Us

LETTERS TO THE EDITOR
Please include your full name, address and telephone/e-mail. May be edited for purposes of clarity or space. Should be addressed to:
ISHRAE MUMBAI CHAPTER
102, 1st Floor, Sunil Enclave,
Pereira Hill Road, Off M.V. Road,
Next to WEH Metro Station Gate #7,
Chakala, Andheri (East), Mumbai - 400 099.
Tel.: 022-28390018/19
Email: journal.editor@ishrae.in

Amidst the ruins of the economy laid low by COVID-19, the agricultural sector stands as a beacon of hope. The country is expecting record food-grain production of 298 million tonnes in the current fiscal year. It would be a challenge for the government to ensure that all food grains produced by the farmers are available for use with minimal wastage across the food value chain. This is vitally important. Though the agricultural sector contributes only around 15% to the India's GDP, it provides employment to around 58% of the nation's workforce. In the near future, this sector will also have to support millions of migrant workers who have flocked back to their villages as a result of closure of industries due to issues related to the pandemic. It augurs well for the villagers that the pandemic is largely an urban phenomenon, leaving the rural areas relatively unscathed and the agricultural economy in a healthy glow.

It goes without saying that minimal wastage of agricultural produce is closely related to the development of a robust cold chain. Right at the time of the first lockdown that started on March 25, cold storages were declared to be one of the essential services that were exempt from closure.

Food processing is another industry that works to ensure minimal wastage of agricultural produce. As a part of the Rs 20 lakh crore package announced by the government to prime the economy, there is a scheme to help micro food enterprises, farmer producer's organisations, self-help groups and cooperatives. The scheme, worth Rs 10,000 crore, will help two lakh micro food enterprises (MFEs). Technical upgradation to FSSAI health and safety standards, integration with retail markets, and brand building to realise improved incomes will be key focus areas. Another scheme announced as a part of the package earmarks Rs 20,000 crore towards fisheries for building the foundation to reduce post-harvest losses and help achieve the target to double marine produce exports to Rs 1,00,000 crores by 2025 and to buoy up the country's blue economy.

The pandemic is poised to speed up India's race towards a healthy and viable cold chain industry. The cover theme of this issue is *How COVID-19 will Change the Cold Chain Scenario*. It carries articles by leading cold chain experts on how they visualise the pandemic to impact the cold chain industry in India. It also carries an article by a leading manufacturer of kitchen equipment on how to restart business after a prolonged shut down. And there are the regular departments to keep you abreast of happenings in the industry.

***Rakesh Kumar**, Managing Editor*

Cold Chain under Lock-down

By Harshal Surange and Arvind Surange

The effects of the pandemic have been seen far and wide and across all sectors including the cold chain industry. While cold storages *per se* have been operational, the incoming product has seen a decline. Further, demand has also seen a drop due to multiple user industries not being in action in the same period of time.

We do hope that the human race is able to come out from this test and continue living our lives. However, the change in patterns of living would be fairly evident as we move ahead.

This has been one of the industries that has seen the biggest spike in interest generated as a '*field to get into*' during the pandemic period. This interest has been generated mainly among people who are not related to the industry. One of the main reasons, we believe, is the fact that the cold chain has been declared as an essential service, and the entire industry has been functional. And this is something that was observed keenly by people from other industries. At the same time, other industries were not operational. Then came the announcement from the Government regarding incentives to the industry amounting to around Rs 1 lakh crore. This includes various facets of the industry, with the cold chain being one of the facets. However, the fact of the matter is that there is still a genuine need for the right people to get into the fray and do all the right things.

Now that is easier said than done. For one, the farmer who is growing the crops is often clueless about what the market demands. Especially now, when online markets are a big factor. Secondly, the farmer is typically a small entity, so for any individual to sell directly is a difficult task. Ordinarily, this needs to be done through an aggregator. Previously, these aggregators were the commission agents at the APMCs. However, now there is a demand for a completely new set of people who have to perform the role of the aggregators. Many have risen to the occasion and have started business models different from the existing ones.

The cold storage industry is still challenging to get into for a newcomer for the following reasons:

- High capital investment requirement.
- Relatively low incomes in terms of rentals.
- High number of years needed for the bank loan to be fully closed.
- It is a high electricity consumption industry, thereby making efficient design a key factor.
- An observed phenomenon in many cases is that execution agencies are given the work of designing and executing the works and in a bid to save initial costs, they end up achieving a low capex but hand over a higher power consuming plant to the end user.

The above challenges can be addressed, to some extent, in the following ways:

- Going in for multi-product multi-temperature cold warehouses, so that there can be a variety in the produce that comes into the store, and premium products fetch a higher rental.
- Subsidies, incentives and grants are available from multiple sources like the National Horticulture Board (NHB), National Horticulture Mission (NHM), Ministry of Food Processing Industries (MoFPI), Agricultural and Processed Foods Export Development Authority (APEDA) and many others. They result in reducing the load on the promoter and the burden of capital investment.
- Ensuring that the design of the system is done by a qualified design consulting firm and the erection is carried out by the execution firm as per the design. This ensures that the party designing the work also oversees the work of the execution agency and there is a separate party certifying the bills.
- Going in for alternate energy options like solar energy (works well if state has a net-metering policy), good thermal insulation, high efficiency equipment, and the like.

The times are critical and it is important that the right systems get into place.

The New 'Epidemic'

One of the countless webinars organized by ISHRAE

As you are well aware, webinars are the new epidemic, so to say (or let us call them a posi-demic, since there is a positive side to it). A large number of webinars have been taking place throughout all industries, and the cold chain industry is no exception.

continued on page 28

About the Authors

Harshal Surange is a consultant and handles Cold Chain and HVAC projects. He is a past president of ISHRAE Pune chapter and founder president of IIAR Western India Chapter. He was the winner of Bry-Air Award in 'Excellence in System Design' category in 2009. He was a part of the 15-member Indian delegation for the US Cold Chain Study Tour sponsored by USTDA, and can be contacted at *acr.consultants@gmail.com*

Arvind Surange is a consultant in Cold Chain and HVAC projects for over 40 years. He is a Fellow, ASHRAE and is past president of ISHRAE HQ and ASHRAE WIC. He is the author of '*Cold Storage Basics*' published by ISHRAE, and is a member of the technical committee of NHB. He was conferred Lifetime Service Award by ISHRAE.

Finance Minister Announces Rs.10,000 Crore Scheme for Food Processing Sector

Finance Minister (FM) Nirmala Sitharaman has rolled out a scheme to help micro food enterprises, farmer producer's organisations, self-help groups and cooperatives. The scheme, worth Rs.10,000 crore, will be implemented on the lines of Prime Minister's vision of 'vocal for local with global outreach', to help two lakh micro food enterprises (MFEs). Improved health and safety standards, integration with retail markets and improved incomes will be key focus areas, said the minister. Unorganised MFE units need technical upgradation to attain FSSAI food standards, build brands and marketing.

There are about 25 lakh unregistered food processing enterprises, which constitute 98% of the sector and are unorganized and informal. Nearly 66% of these units are located in rural areas, and about 80% of them are family-based enterprises.

FM said that it will be a cluster based approach with focus on perishables like *makhana* cluster in Bihar, mango in Uttar Pradesh, *kesar* in Jammu and Kashmir, bamboo shoots in the north-east, chili in Andhra Pradesh and tapioca in Tamil Nadu. This initiative will lead to reduction in wastage and creation of off-farm job opportunities, and aid in achieving the overarching Government objective of doubling farmers' income.

The cost of the scheme will be shared by the centre and states in 60:40 ratio, said a government official. The micro-enterprises will be assisted with credit-linked subsidy and the scheme will be implemented over a five year period from 2020-21 to 2024-25. The micro enterprises, with investment in plant and machinery up to Rs.25 lakh, will get credit linked subsidy at 35% of the project cost with ceiling of Rs.10 lakh. The beneficiary contribution will be minimum 10%, and the balance will come from the loan.

(*Source: The Economic Times, May 15, 2020*)

Industry Welcomes Scheme for Food Processing Sector

The industry has welcomed the scheme for the food processing sector announced by the Finance Minister. Ravichandran Purushothaman, President of Danfoss India, said, "The new agri-infrastructure fund is set to be a gamechanger and will create a positive roadmap towards addressing the challenges across the food industry – from value creation to better supply chain... With due focus on minimising gaps and strengthening the farm-gate infrastructure, the upliftment of the sector will open the door to increased productivity and employment opportunities, truly making India an agricultural power to reckon with. But execution is the key here!

"Additionally, the allotment of Rs.20,000 crore towards fisheries will help build the foundation to reduce post-harvest losses and aid the department's vision to double exports to Rs.1,00,000 crores by 2025. With increased economic returns, this would also facilitate the upliftment of India's blue economy."

India's Push for Milk Production

In a major push to India's dairy industry, the cabinet has approved the allocation of Rs 4,458 crore to boost the dairy sector. This will benefit 95 lakh farmers of the country. Prakash Javadekar, minister for Information and Broadcasting, informed in a press briefing. Under the scheme, 28,000 bulk milk coolers and capacity for chilling 140 lakh litre additional milk per day will be added. The government has also decided to increase interest subvention from the earlier 2% to 2.5%. (Interest subvention is a subsidy provided to farmers on the interest rates on loans through the Kisan Credit Card scheme.)

The government has been focusing on the dairy sector and recently, Finance Minister Nirmala Sitharaman had said that the government will double the country's milk processing capacity by 2025. Presenting the Union Budget 2020, she had also announced a special rail and flight project for easy transportation of perishable farmer goods such as milk.

Recently, the Department of Animal Husbandry and Dairying said that it has been the continuous endeavour of the government to increase milk productivity. This will be done via genetic improvement and reduction of input cost, the department said.

The government has also launched special programmes for enhancing the quality of milk in the country. "It is proposed to further intensify the Quality Milk Programme for both cooperative and private sectors on fund sharing basis," the statement added.

India is a highly milk-dependent country and the government aims to attract private investment in the sector to aid the dairy industry. This is expected to enhance productivity and quality of milk and milk products. The department also aims to increase competitiveness and profitability in the dairy sector with private investments, so that it also supports rural income and jobs.

(*Source: The Financial Express, February 19, 2020*)

continued on page 6

The Green Box

SIMPLY EFFICIENT & SMART

A division of Rockwell® Industries Ltd.

Since 1986

The Green Box PRESENTS

THE MOST EFFICIENT AND SMART RANGE OF COLD ROOMS

Rockwell was the first in the country to develop and introduce an ultra efficient range of freezers called GFR = Green Freezer Range. As a natural extension of capacity range and on the same lines of our GFR range of freezers we now introduce the "The Green Box" range of cold rooms that have been designed from the ground up to be SIMPLY EFFICIENT AND SMART.

SIMPLY EFFICIENT

- The range of cold rooms come with the option of using higher thickness of insulation, that pays for itself many times over, over the life of the cold room.
- The use of efficient refrigeration system design and & high-quality efficient components enables reduction of power consumption by 10 to 15%

SIMPLY SMART

- The Green Box products come fitted with an App temperature controller that logs door openings, cold room temperature and critical refrigeration system temperatures as a standard feature at no additional cost to the customer.
- This data can be used by the user and The Green Box team to pro-actively trigger maintenance alerts for predictive, preventive and breakdown maintenance more accurately.

Mobile: +91 7799271228 | Email: sales.thegreenbox@rockwell.co.in | ashish@rockwell.co.in

continued from page 4

Mumbai Airport Launches Exclusive Terminal for Agro and Pharma Products

The Chhatrapati Shivaji International Airport in Mumbai, run by Mumbai International Airport Ltd. (MIAL) – a joint venture between Airports Authority of India and GVK – has announced the launch of an exclusive terminal for processing and storage of agro and pharma products. Touted as the world's largest airport-based temperature-controlled facility, the 'Export Cold Zone' can hold over 700 tonnes of such cargo at one time with a combined annual capacity of 5.25 lakh tonnes, MIAL said in a release. The facility will be operated by cargo handling service provider and MIAL's business partner, Cargo Service Centre.

Mumbai airport is the largest gateway for movement of pharma and agro products in the country, MIAL said, adding that the fully automated infrastructure caters to the rapidly growing demand for pharma and agri goods. It connects to over 500 cargo destinations across 175 countries through 60 airlines.

The export cold zone is equipped with 12 truck docks with dock levellers, spacious acceptance and examination area, automated workstations, X-Ray machines, unit load device storage, ballmat system for Unit Load Device (ULD) transfer and cold rooms.

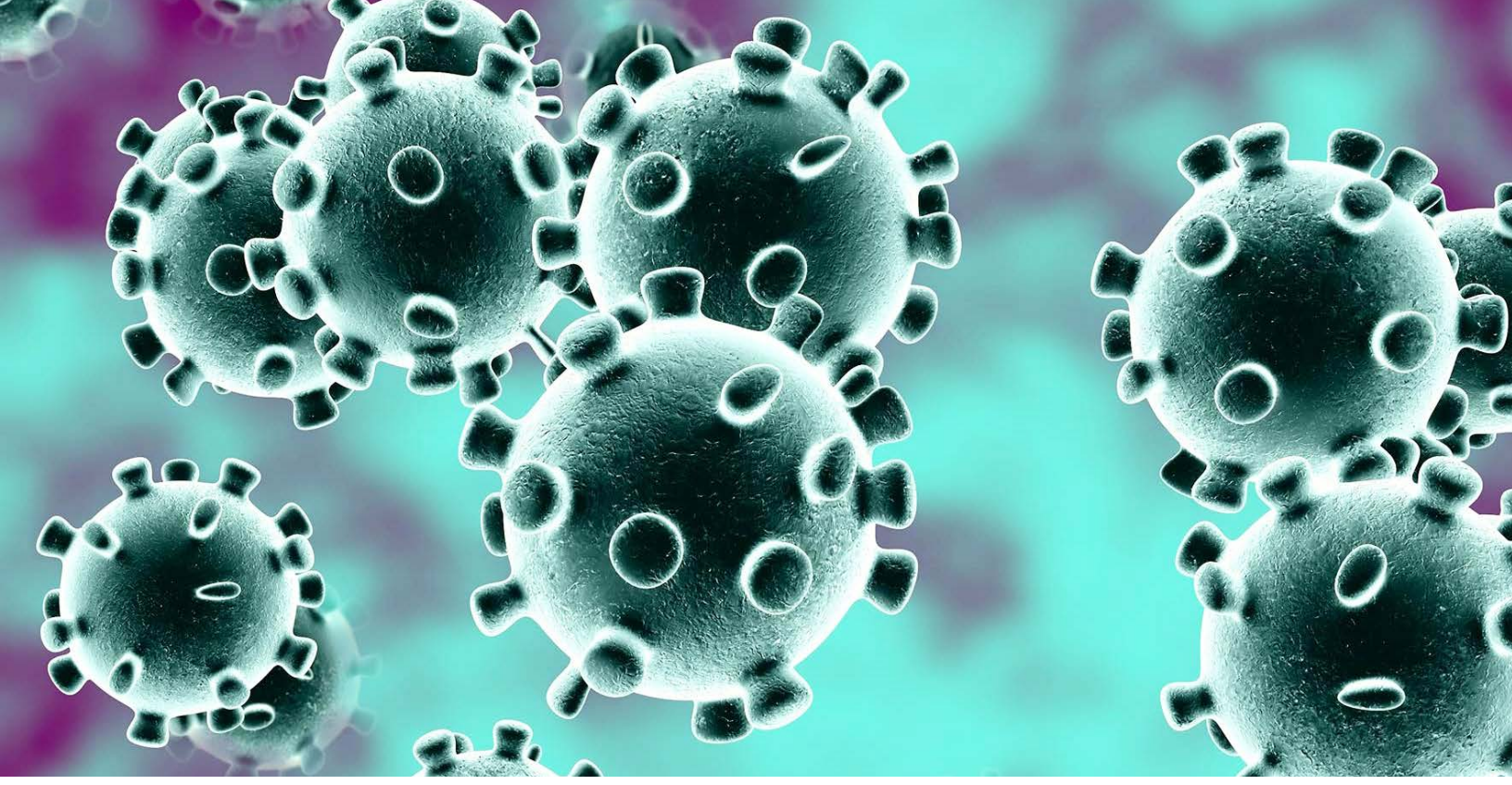
Spread over an operational area of 6,000 square metres, the facility is equipped with 10 ULD build-up workstations and as many as 172 ULD storage positions. The pharma terminal itself can hold 140 ULD positions, while the agro terminal can hold 32 ULD positions.

Mumbai airport is the first airport in the country and the third in Asia to obtain 'IATA CEIV Pharma' accreditation, a global industry recognition supporting the air transport industry, and is in full compliance with pharmaceutical manufacturers' requirements.

MIAL aims to cement Mumbai airport's foothold further in air freight supply chain capitalizing on all the business opportunities. The airport operator is creating a comprehensive digital and temperature corridor between Mumbai and CEIV certified airports powered by air cargo community portal, GMAX.

(*Source: bloombergquint, February 26, 2020*)

continued on page 27



Long Term Impact of COVID-19 on the Indian Cold Chain

By Arvind Surange
Fellow ASHRAE, PP ISHRAE
CMD, ACR Project Consultants Pvt. Ltd., Pune

COVID-19 and its Impact on India

At the end of 2019, the world was hit by an unknown virus – the novel coronavirus, with the medical name COVID-19. The virus was detected in Wuhan, China and then started spreading rapidly in China, South Korea, Italy, Spain, other parts of Europe and soon it made its presence felt in more than 40 countries.

The infection spread rate and mortality rate forced countries to go into lockdown state. Businesses, factories, services and offices were closed, working from home became the new norm, social gatherings were stopped. In India, people were prohibited from getting out of the house. Home deliveries of essential items like food and medicines were the only services allowed.

As we write this article, the situation is not very different. We are in the third phase of the lockdown and only essential services are working, and only essential items are being delivered home. Food is the most essential item and all possible measures are being taken by the government to make sure food reaches people.

India is one of the top-ranking producers of perishable foods. It is No. 1 in terms of milk production, No. 2 in terms of fruits and vegetables production and also a huge producer of fish, meat and poultry. However, the major challenge in this lockdown is ensuring food availability and food security. The central and state governments are doing their best in terms of sanitising the food storage spaces, taking care of the hygiene of people working in the food supply chains and making sure movement of food from farms to consumers is facilitated.

In this time of global outbreak, wastage of food can prove to be another disaster we cannot afford. Making sure food loss in every step of the food supply chain is minimal is important and hopefully this will pave the way for newer techniques and a newer outlook towards food supply, cold chain and distribution.

This wastage and loss of food can be minimised with enhancement of the cold chain market and infrastructure in the country and ensuring that continuity in the cold chain is maintained from the farm to the consumer.

About the Author

Arvind Surange is a consultant in Cold Chain and HVAC projects for over 40 years. He is a Fellow, ASHRAE and is past president of ISHRAE HQ and ASHRAE WIC. He is the author of 'Cold Storage Basics' published by ISHRAE, and is a member of the technical committee of NHB. He was conferred Lifetime Service Award by ISHRAE.

Indian Cold Chain and Logistics Sector

Cold chain is an integral part of modern human life. Perishable food is a major part of the human food intake and the cold chain with associated logistics services enables the distribution of food right up to the end consumer.

Cold chain is already well established in the developed world and is making strong inroads in most of the developing countries. Cold chain helps maintain quality, enhances life and facilitates delivery of foods from the centre of production to the consumer. Cold chain is operated in various food and other verticals as under:

- Dairy sector – milk and milk products
- Fisheries – with a large variety of marine, sweet water fish and fish products
- Meat and meat products
- Poultry products
- Fruits and vegetables sector with a large variety of raw and processed products
- Ready-to-eat foods
- Pharmaceutical sector for medicines, vaccines, etc.

In India, cold chain is a seen as a sunrise sector. Rightly so, considering the huge production of a variety of perishable foods. Growing at a very high pace due to the shift in focus from increasing the production to better storage and transportation facilities for commodities, the cold chain industry has now become an integral part of the supply chain industry comprising of several components from pack houses, processing plants, cold storages, refrigerated transport, distribution centres and retail.

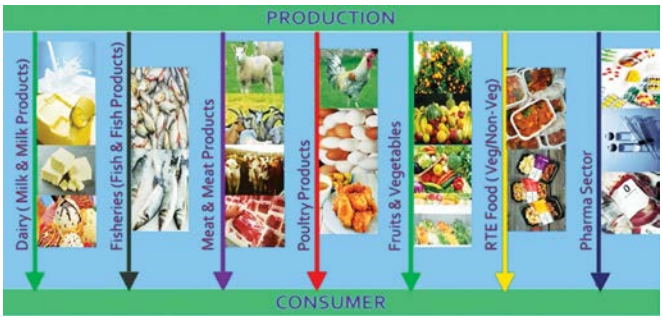


Figure 1: The entire gamut of the cold chain – lifeline of the modern world

Owing to the rising need of infrastructure and to reduce wastage, according to a market research report, the cold chain industry in India is forecasted to grow at a CAGR of 19% during the period 2017-2022. The global cold chain market will be worth USD 448 billion by 2025, based on a growth rate of nearly 15% over the next decade. The world population is also growing and will cross 8 billion in the next decade. Increasing population and fast changing lifestyles will demand more and more food, needing more cold chain infrastructure. Apart from food, the pharma cold chain is also growing at a very high rate, with pharma cold chain logistics growing at 5-6%. The global pharmaceutical industry is worth USD 1.2 trillion today, and is projected to rise by 41% by 2021.

These are several factors that justify the growth in the cold chain and logistics sector:

- Rising need for cold chain facilities to reduce the cold chain infrastructure gap as stated above.
- Need for reducing food wastage across various stages of food supply chain.
- Growing middle class, changing demographics, changing lifestyle patterns and food consumption patterns in urban areas with nuclear family setup.
- Growth of domestic and foreign based food chains with associated growth of logistics, transport and retail sector.
- Increasing demand for packaged, canned, frozen and ready-to-eat products *(frozen is fresher than fresh!)*.
- Realization about the need for a large number of pack houses, irradiation facilities, ripening units, etc.
- Increasing cold chain demand in the pharma sector.
- Government's initiative of doubling farmers' income (cold chain will play a vital role in this).
- Government's objective to increase agri-produce exports substantially from USD 38.5 billion to USD 60 billion.
- Current share of India is just 2.4% as compared to 6.7% of the Netherlands and 9.8% of the USA.
- Increasing private sector investments by both domestic and foreign players.
- Increasing interest in the Indian food market and investments by international players like food chains and logistic players.

Role of Cold Chain in the Era of COVID-19

Cold chain and logistics services are parts of essential services that must be kept operational to maintain food distribution during the lockdown and other situations with restrictions imposed on normal public activity, including commerce, trade and transport.

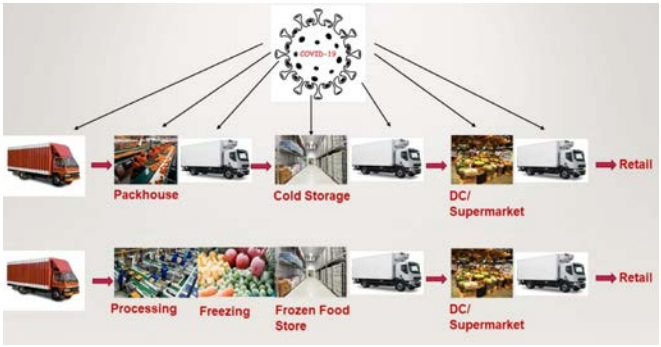


Figure 2: Coronavirus does not spare anyone – it can impact any part of the cold chain

COVID-19 gives an opportunity to rethink pharma logistics and supply chain. Nearly 70% of the country's pharma exports are carried out through GMR Hyderabad Air Cargo and during COVID-19 it has remained operational 24x7 for import as well as export operations.

As a result of COVID-19, the pharma sector and the associated cold chain and logistics will have to play a bigger role in the distribution of the vaccine, once it is ready.

Government's Role in Cold Chain

Government incentives through various nodal agencies have proved to be a boon for growth in various cold chain verticals. Several new projects had been under implementation, starting from designing, planning, civil construction, MEP and processing

services, transport, etc. when COVID-19 struck major parts of the world including India.

The onslaught of COVID-19 came as a rude shock, as the lockdown that followed affected the entire execution of projects, some of which were nearing the stage of completion and commissioning. The projects included pack houses, frozen food plants, bulk and multipurpose cold stores, and reefer transport vehicles.

It is difficult to estimate the impact that promoters will face in terms of project delays, unemployment resulting from stoppage of work, financial losses affecting the project's economic viability and the efforts needed to restart the activity when lockdown conditions are eased. It is certainly a setback to this upcoming sector.

Apart from the setback suffered in terms of infrastructure development, one must also consider the losses that would occur due to spoilage of produce as a result of the non-availability of cold chain facilities as visualized by the promoters and possible users and support service providers. An assessment of such impact is possible only after collection of data is done for projects under implementation.

Challenges for Operating Cold Chain During Lockdown

The current lockdown conditions have imposed major challenges for the food chain and supply chain.

A majority of cold storages in India are potato cold storages. According to a news item in *The Economic Times*, potato prices have fallen up to 12% in the past month. Due to malls, pubs and bars being closed down, potato and groundnut consumption has crashed. French fries and peanuts, standard munchies with drinks, *alu tikki* and *samosas*, and street snacks are not being sold and prices of their basic ingredients are falling. This is affecting some categories of cooking oil and sugar as well. Frozen potato-based snacks include burger patties and wedges; major customers of these being chains like Burger King and KFC. These chains are doing much lesser business than usual, affecting the entire supply chain right up to the farmer. This is only one example of the potato supply chain. The same applies to other food supply chains as well.

The major challenges faced by the cold chain industry include:

- Unreliable supply of raw materials due to restrictions on transport vehicle movement.
- Fortunately, activity in logistics and horticulture sectors is not restricted during the lockdown. However, it is heavily dependent on various support services.
- Working with lesser number of staff and workmen.
- Poor availability of reefer transport for product delivery.
- Sealing of district and state borders under certain situations, causing transport delays.
- Malls, food stores and restaurants not functioning, causing reduction in regular demand. However, high short-term demand for some fruits and vegetables surges to meet requirements of voluntary organizations serving food in big quantities.
- Distribution of chilled and frozen food poses challenges as the specified temperature conditions have to be maintained throughout the chain. Any stoppages, failure of vehicles, or problems with refrigeration units could upset the whole delivery schedule and loss of cargo due to interruption in the cold chain. This could be a genuine problem as the maintenance and service workshops for the vehicles and cooling units would not be available easily on the roads and highways.
- Even last mile deliveries are affected due to restricted hours of working of shops, and more in restricted zones.

Impact on Exports

India's food exports have been growing over the years. Development of a modern cold chain has been playing a very positive role in this. However, COVID-19 has made a negative impact both on exports and imports.

Various Chambers of Commerce have forwarded their suggestions to the government to protect exports as an immediate measure. CII has suggested that exports be classified as essential services so that they can operate with free movement of cargo in the country. FICCI has recommended uninterrupted operation of all APMCs and other organized markets, permissions for sale of perishable produce even outside APMCs, distribution of fruits and vegetables to be facilitated for holding weekly markets and deliveries to main housing societies.

Mahratta Chamber of Commerce has expressed concern about the closure of all industrial activity except essential services. India has a large number of MSMEs that are handicapped due to funds shortage, continuity of business, recovery of payment dues, etc. They are hoping that the government will come forward with some concrete schemes to help the industry, including the cold chain sector.

India is one of the top-ranking countries in terms of perishable food production. With a sound and efficient cold chain and logistics sector, it deserves to be a global food hub. With proper vision, policies, incentives, strengthening of infrastructure and training to fight challenges such as COVID-19, such a target can be certainly realized.

Guidelines for Restarting Business

Frankly there are no restrictions on the operation of cold stores, distribution centres and reefer transport during the lockdown. These are, in fact, parts of the essential services that must be kept operational fully. However, there are issues about the operation of pack houses and frozen food production due to shortage of workers and logistics problems.

Fortunately, no power supply issues have emerged as ample energy supply was available due to the closure of most other industries. Where operation of the plants had to be discontinued for some valid reason, their restarting needs to be done carefully, following guidelines published by ISHRAE and other relevant societies and government institutions. Extreme care has to be taken about sanitisation, cleaning and servicing of plant and machinery and making the workers aware of hygiene and safety requirements.

The National Disaster Management Authority (NDMA) has also issued detailed guidelines for restarting of industrial activities.

Some Positive Features

- As a result of lockdown conditions in major parts of the world, carbon emission is expected to reduce by nearly 5%, according to an estimate given by the Global Carbon Project at Stanford University. It is for the first time after the Second World War that such a reduction is expected.
- According to a UNO report, the reduction in carbon emission will begin with this phase and can touch a figure of 7.6%, thus limiting the global temperature rise up to 1.5°C.
- There is a noticeable change in family lives. Improved personal hygiene, avoiding of junk food, practicing healthy exercises, e.g. *Yoga*, are some of the positive outcomes.
- People have realized the need to preserve food and minimize wastage. Stocking chilled and frozen food has been the choice of many families.
- To organise the sale, distribution and delivery of various essential products is a challenging task during such testing times. However, a welcome feature has been the enforcement of social distancing for customers as well as service personnel. A typical example is shown in *Figure 3*.

Figure 3: Well managed temporary vegetable buying place with buyers following social distancing

The Way Forward: Lessons for the Future

COVID-19 has given us a bitter experience affecting the very existence of human beings. The world has, however, faced many testing times in the past also, although not so severe in magnitude. The fight has to be won. One must also learn important lessons with a positive mind set and be prepared to meet any such challenges in the future.

Some new ideas and new practices may emerge, as a result of the issues faced in the current situation, for operating the cold chain and logistics:

1. Sanitisation needs to be ensured right from:
   a) Collections centres
   b) Pack houses
   c) Transport vehicles
   d) Processing, freezing and storages
   e) Distribution centres
   f) Food malls
   g) Transport for last mile deliveries

   This must include sanitisation of buildings and structures, doors, dock door systems, electrical switches, etc. Equally important will be facilities for regular sanitisation of workers, staff, operators and visitors.
2. Regular health check-ups to be mandatory for all workers, staff and management members. Proper medical insurance for all the above-mentioned people, including temporary workers, to be ensured. Apart from the insurance of buildings and structures, plant and machinery and accidents, fire, etc., losses caused due to the occurrence of COVID-19 like situations also to be seriously considered.
3. In view of the serious threats of closing down the plant and processing operations due to the absence of workers, it would be advisable to provide residences for a minimum or a larger number of staff and workers in all new projects (as also in existing plants where possible).
4. Experience shows that despite no restrictions on the production of agri-horticulture, dairy, fisheries and other perishables, food losses occur due to the lack of normal and reefer transport, road blockages, closure of markets and restricted shopping hours, etc. Thus, farmers are forced to resort to distress sale, as they do not have the facility even for a short-term cool storage that could save fruits and vegetables for a few days. Solar energy operated mobile pre-cooler and a small storage could be an ideal solution, but an expensive one. Perhaps, such facilities created by a group of farmers would have better economic viability.
5. A more economical and practical solution, even on a short term, could be the use of evaporative type water cooled stores located near farms. Generally, these short-term stores could keep the produce nearly fresh for 3 to 4 days, thus helping the farmers to avoid distress sales at the market place.

   Similar short-term mobile storage can also be provided in APMCs and other *mandis* to help the sellers use them as overnight stores. The cost of these stores would be just 25-35% of the conventional cold stores, and their energy consumption would be very low. Solar energy operated units are also feasible for such applications.

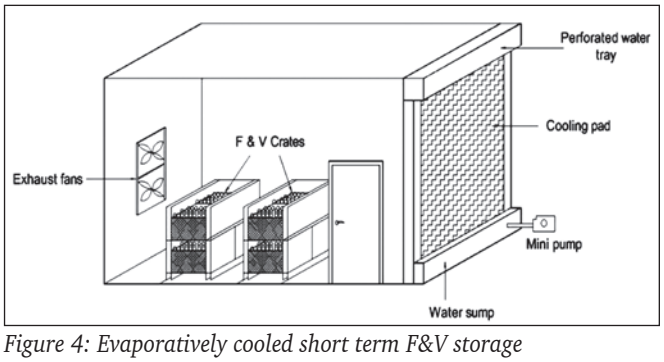


Figure 4: Evaporatively cooled short term F&V storage

5. Some most sustainable models of simple mini coolers have been developed, which need no power for operation. These simple domestic coolers work on the principle of evaporative cooling and can be constructed with just two earthen pots. The author has assembled one and tried it for up to 3 days of fruit and vegetable storage.

Figure 5: Domestic mini coolers – short term storage using earthen pots

6. In order to meet the requirements of higher sanitisation levels and health check-up of workers and staff, several gadgets can be used, some of which are:
   - UV light germicidal air curtains for sterilisation of air. DRDO has developed a UV blaster for disinfection of some specified areas.
   - Infrared images for body temperature check with gadgets like laser thermometers.
7. Some other gadgets for plant operation and control are:
   - Portable data loggers for data collection from various operations.
   - Web-based controls for plant operation.
8. Logistics services with reefer transport are also affected during the lockdown. Even post lockdown, these services need to be strengthened for efficient cold chain operation. Some ideas have emerged to meet the critical situation during the lockdown, like:
   - Rail transport can be used effectively as an alternative to road transport.
   - AC buses, which mostly remain idle during a lockdown, can be used for short-term storage and delivery of some perishable products as a temporary measure.

Figure 6: Non-contact forehead infrared thermometer

It is interesting to learn that Boeing 747F is doing a great service in transporting medicines and other essential goods in many countries. The aircraft has three compartments with the provision to maintain the temperature from 4°C to 29°C, to facilitate transportation of perishable goods along with other commodities. The service is now getting popular.

Lots of new ideas and technologies will have to be incorporated while designing, engineering and implementing cold chain projects now onwards. Green and sustainable design concepts can enhance the quality and performance of projects coming up in the future. These concepts can also be beneficial for existing and ongoing projects.

Figure 7: AC buses adapted for food deliveries for short distances

Postscript

Just as this article was written, the Government of India announced a huge financial package of Rs. 20 lakh crore to push the country's economy, which is under stress due to the outbreak of COVID-19. The package includes provision of Rs. 1 lakh crore for building agricultural infrastructure including the cold chain, raising productivity and making the sector globally competitive. The existing TOP scheme covering Tomato, Onion and Potato will be allocated additional funds of Rs. 500 crore and will include other fruits and vegetables also. Provision of Rs. 9,000 crore has also been made for the cold chain facility for the fisheries sector.

In brief, the cold chain sector can look forward to better days in the near future.

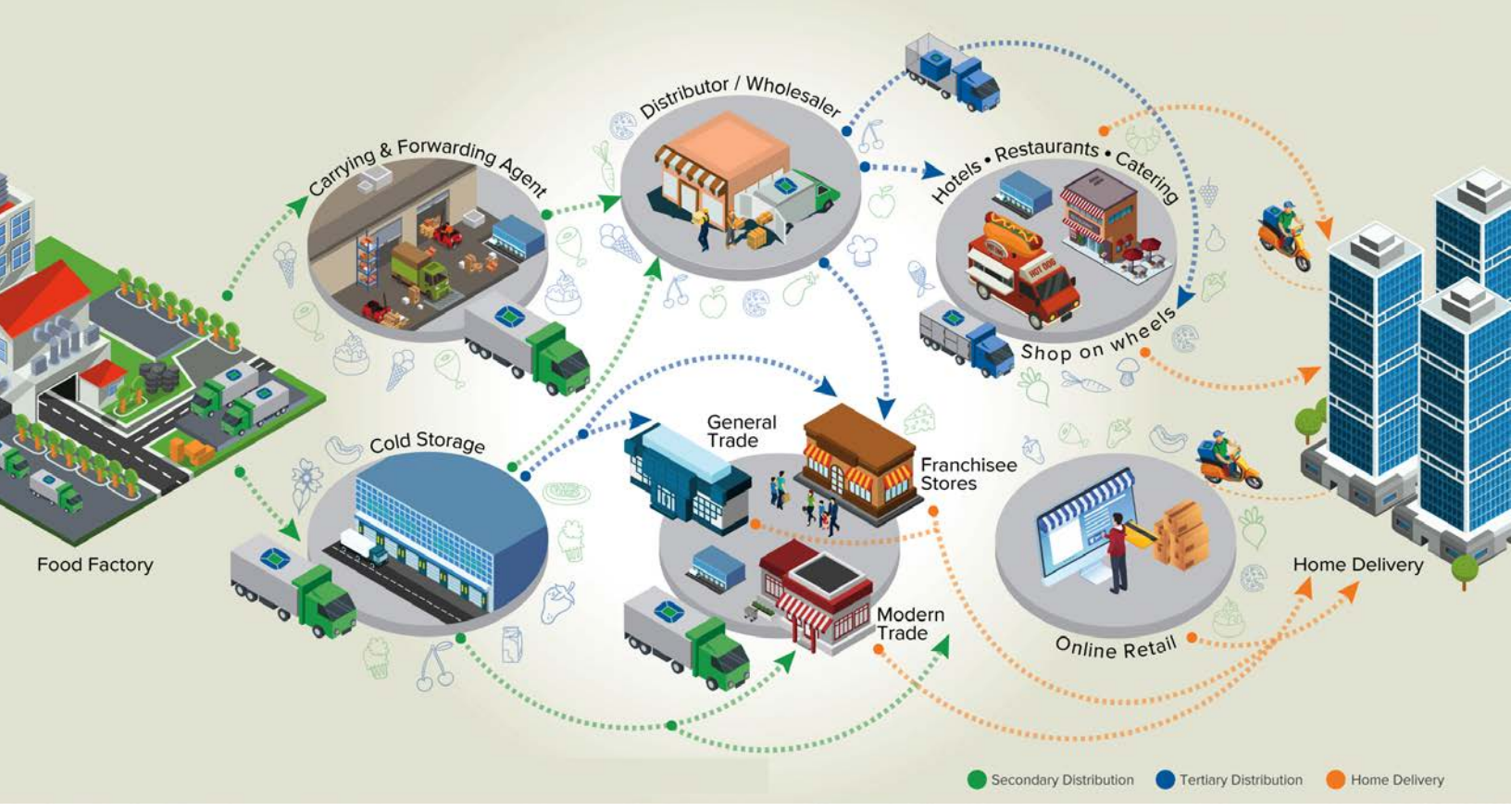
Conclusion

The COVID-19 pandemic is one of the biggest challenges faced by the whole world. It has affected most countries, both developed and developing, resulting in closure of large, medium and small industries across the world. It has created enormous challenges for the economy, food security and supply, business continuity and livelihood of billions of people.

The virus has affected even the food processing sector, although the cold chain for food and pharma sectors has been treated as an essential service by the government. Food processing and cold chain operations are also dependant on several supporting industries like packaging, normal and reefer transport, etc.

The industry is trying to fulfil the needs of the society for most perishable foods, but faces the threat of serious functional and economic challenges in the coming years. The Indian government has many arms like NHB, NHM, MOFPI, APEDA and others that can offer support to the sector by creating special incentive packages. NCCD can also play its role in promoting sustainable technology. Such positive support can only help the country realise its dream of becoming a global food hub. ❄

The author acknowledges the efforts of Aditi Surange (Technology Expert, ACR PCPL) for putting together this article.



How COVID-19 will Change the Cold Chain Landscape for Ever

By Rajat Gupta
Founder CEO
Thermal Energy Services Solutions Pvt. Ltd. (TESSOL), Mumbai

Introduction

COVID-19 has been one of most baffling problems facing the world today and has created some of the most striking disruptions that may define the coming times. This 'once in a century' (hopefully) kind of an event has clearly changed the paradigms and unfairly created potential winners and losers and forced all of us to rethink the basics on which we all operate.

Globally, *pundits* have been predicting the impact of this event, forecasting the future of the world health and economy – some of which has already fallen flat several times. In this article, I would like to propose a few thoughts (hypotheses) based on actual data from India and a couple of other countries, conversation with Industry colleagues, customers and thought leaders filtered through my sensibilities.

Impact of COVID-19 on Users of Cold Chain

Before talking about the impact on cold chain businesses, it is relevant to evaluate the impact on user segments of the cold chain components. The impact on cold chain businesses – whether equipment or services – will be a derivative of that.

I will look at some of the primary user businesses, the near term and medium-term impact, followed by the respective implications on the cold chain demand.

High Impact and Long Recovery	Short Term Impact and Faster Recovery	Positive Impact and Long term Gain
• HORECA • Ice cream • Seafood	• Dairy and Dairy Products • Poultry • Frozen Food	• Grocery e-Commerce and Kiranas • Cloud Kitchens • Processed Food

About the Author

Rajat Gupta is the Founder CEO at TESSOL, a venture capital backed cold chain technology start-up in Mumbai. He is passionate about building solutions for a farm to fork affordable and sustainable cold supply chain in the country. He has worked across continents, with a large conglomerate like Robert Bosch and several early stage start-ups like 3Tier, Flodesign, and Promethean Power. An avid reader and a music enthusiast, he holds a mechanical engineering degree from IIT Delhi and an MBA from Harvard Business School.

Hotels, Restaurant and Catering (HoReCa)

HoReCa has been the hardest hit amongst all F&B businesses with little clarity for the future. With the business closed for more than 70 days, companies are reeling under tremendous cost pressures from salaries and rentals while still uncertain on when and how they may be able to operate. K. S. Narayanan, one of the prominent thought leaders in the food services space, outlined the challenges for restaurants in the coming future in his blog: *https://ksfoodinsights.wordpress.com/2020/03/29/foodservice-the-restaurant-sector-in-a-post-covid-19-world/*

The health concerns have also reflected on the reduction in orders on food platforms like Swiggy and Zomato, which were down by 60% in the initial days of the pandemic. Post the Delhi incident of a pizza delivery boy testing positive, there was a sudden and precipitous drop in online and delivery-based ordering, albeit only for a week or so. With the uncertainty around the containment outcome, these variations are likely in the future as well.

However, in the medium term, this sector, which contributes around 3% to the GDP of India and is its single largest employer with more than 73 lakh people on its payrolls, will need to innovate and build models around the new normal. Some of the potential changes that the industry may see are:

1. Given the new shift towards home cooked food, some restaurants have evaluated launching delivery kits, which are essentially family meals where everything is all ready to be cooked. Work from home will necessitate the nuclear families to resort to such services in the future.
2. Home delivery will pick up once the Indian consumer is able to come out of the initial subsistence mode and partnerships with delivery companies will be an essential evil for all restaurants.
3. Packaging could be a huge differentiator – something sterilized against any bacteria and viruses will be highly acceptable. Single portions not to be shared may become more popular.
4. Many actual restaurants may start servicing as central kitchens for other dark kitchens, which will need an increase in the backend compared to the customer facing front end.
5. Increase in central kitchens, since 'outlet level cooking' will become highly prone to people handling especially when there will be a smaller number of people allowed in the premises.
6. There may be a larger influence of FSSAI, and restaurants will differentiate on safety and hygiene vs. price.
7. There may be uptake in the consumption of health foods and immunity builders like extensive use of herbs and spices and nutrition supplements in the recipes.

For the cold chain industry, this will imply:

a. Due to an increase in home delivery and cloud kitchens, more consolidation of central kitchens may happen – requiring larger distributed cold storage facility in restaurants.
b. More transport of chilled and frozen food to cloud kitchens will necessitate the use of blast freezing or chilling capability to ensure the quality of food.
c. Large cloud kitchens will also require frozen and chilled storage equipment. More value priced, cheaper equipment rather than fancy display counters or visi-coolers may be desirable.
d. Milk run transport between central and cloud kitchen will see an uptake that will necessitate secondary and tertiary cold chain transport equipment.
e. Lot of innovation on cold chain packaging solutions clubbed with home delivery to ensure hygiene and quality. People will be more ready to pay for such solutions now than they did before.
f. Businesses focusing on under-table counters, bar and front-end equipment may need to realign themselves to the new demand growth areas.
g. With food safety and hygiene being the paramount consideration, the need to maintain the discipline of a cold chain and ensure its adherence will go up. There could also be a likely FSSAI intervention on food safety related issues.

Poultry and Seafood

The non-vegetarian and frozen food industry in different parts of the country has been hit hard amid rumours that the novel coronavirus can be transmitted through consumption of chicken, the prices of which have fallen considerably as a result. People

were avoiding consumption of meat, fish, chicken, eggs, etc. Due to the fall in demand, the wholesale price of chicken had dropped by as much as 70 per cent. Poultrymen were getting just Rs 20 per bird in the market, whereas the cost of production was Rs 80. As a result, many cold storages are filled with tons of poultry, which may be released in the market as prices stabilize.

In contrast, seafood in India – especially exports – were hit hard due to the customer nations halting orders and many containers being stuck at ports. The economic slowdown due to the pandemic in major export destinations including the USA, EU, the UK and China shall dampen India's export performance, and this could further affect Indian aquaculture in the back end.

While going through this turbulence, there have been some short-term changes in perception, which may impact consumer behavior in the long term and present opportunities for the industry.

Almost 90% of the poultry is sold in wet markets in India and only 10% is processed compared to 90% in the USA and EU and 50% in China and other Asian countries. The coronavirus has made people sensitive to the hygiene factor related to meats, and this may benefit the organized poultry industry substantially. Established companies like Godrej Tyson and Venky's, and startups like Licious, FreshtoHome and Meatigo kept the supply lines running and serviced the customers processed hygienic chicken related products. Some cloud kitchens also started selling meat products just to fill the gap created by the lack of unorganized demand. While the overall poultry market may see a shrinking of 4-5% in meat revenues, there may be an additional investment in the processing capacity for chilled and frozen chicken for domestic use and international sales. There could also be compulsory rating of roadside butchers by FSSAI.

Due to the huge glut of seafood products in cold storages, several exporters started selling these products in the local markets. While the realization will be low, both the consumer and the processor have got a taste of each other. Going forward, the processors may want to hedge their bets between the domestic and export markets (even with lower domestic price realization), while at the same time the Indian consumer will realize the taste of frozen, hygienically processed seafood. With increased home cooking, they may be able to build a captive consumer in Indian homes through e-commerce or home delivery. However, this is a much slower process and therefore the impact may last much longer.

For the cold chain industry, this will imply:

a. Investments in processing and storage for newer facilities.
b. Investments in distribution level cold storages.
c. Secondary and tertiary delivery solutions including home delivery of fresh and frozen products.

Dairy and Ice Cream

The Rs 100,000 crore Indian dairy industry suffered an initial 25-30 per cent dip in demand post COVID-19 lockdown. A large portion of the dip in demand is due to out-of-home consumption, which contributes 15 per cent of milk consumption, coming to a grinding halt. With reduced sales but similar procurement volumes, prices of raw milk and milk powder have fallen by ~10% and ~30% respectively.

At the same time, ice cream demand has completely tanked. Almost 50-60 per cent of the annual turnover of ice cream comes during the months of March, April, May and June, and this year it is virtually absent. Consumers are not buying ice creams as they fear infection. In addition to the demand slowdown during the peak season, the financial burden of the lockdown has been near fatal for this category. As sales have come to a halt, stock inventories have piled up in cold storages. Given the current sentiment, it is highly unlikely that this industry will be making any investments in FY2020-21 in any part of the cold chain.

However, some interesting trends have started emerging. Several dairy companies have started selling products in housing societies directly to customers. This model of pooled delivery has received good traction in the lockdown period, and this may continue to work even in the future. It was also noted that while out-of-home consumption is near zero now, consumers are buying products such as paneer, ghee and cheese in huge quantities from retail stores. Therefore, total reduction in value terms is not significant.

Therefore, the estimate is that value-added dairy products may see an increase in the coming months and there may be investments in their cold chain infrastructure – from plant level to all along the chain. This will imply larger cold warehousing space, trucking, and secondary and tertiary delivery. As per my belief, ice cream may remain low on investment in the near term. One may see an increased investment in cold chain home delivery solutions to capitalize on that demand.

Retail and e-Commerce

One of the online retailers with home delivery infrastructure said that *COVID-19 to home delivery is what demonetization was to*

wallet companies – there suddenly seems to be infinite demand. Hari Menon from BigBasket commented that the increase in demand was three to six times the planned volume over a few days breaching several process limits – and he does not foresee the demand going down in the future. Online retail formed 3% of the organized grocery retail market (currently at USD 82 billion) in India in 2018 and was expected to grow to 7% (of the estimated USD 204 billion) in 5 years. But with recent developments, online sale of perishables and essential goods may go up from current levels to even around 25% of modern retail in 5 years – which implies a twofold increase in growth rate for an industry that was already growing at over 40% per annum.

Another interesting phenomenon has been the resurgence of the local *kirana* stores. With initiatives like JioMart, Grofers and Amazon co-branded stores, J24, there will be more standardization of these stores and increased sophistication to serve wider customer requirements.

Based on these observations, I think the following trends may become more dominant for the cold chain in the short to medium term:

a. The popularity of hyper format grocery markets may take a backseat and therefore businesses specializing in these may take a hit. However, a parallel opportunity could open for building the backend infrastructure for distribution and fulfillment centers for upcoming brands. Cold rooms, blast freezing equipment, packing areas, etc. will be required at these locations.
b. Compact cold chain freezers capable of holding chilled and frozen products at these delivery centers (DCs) and super format stores will largely become delivery centers for the neighborhood.
c. There should be a huge increase in the cold chain distribution network, especially intracity. With the incoming supply chain to branded *kirana* stores being managed by retail brands, cold chain compliance will improve. This will be an interesting challenge and tremendous opportunity for transport refrigeration companies to innovate and bring more flexible models in the market.
d. Home delivery and packaging solutions could become the flavour of the coming times with huge demand jumps.
e. Pooled delivery models where a full truck is taken to a housing society for sale of products will also become more desirable since the number of bikers for home delivery may reduce. In such cases, flexible single or multi temperature units may be used for retailing.

Frozen Food and Processed Food

Frozen food has been always under-rated by the Indian consumers due to the perception that *frozen is not fresh*. However, during the current crisis, it may be a wonderful opportunity for frozen and processed food brands to dwell on the hygiene, mechanization, and preservation of flavors through the freezing process. At this time the Indian consumer is open to alternatives and trying things (s)he may have never tried before. Also, with

the reduction in helping hands at home, processed foods like batters, dips, cold pressed juices, frozen pizzas, and cut fruits and vegetables have also been gaining their share of the consumer wallet.

However, while the processing capabilities may be top notch, the cold chain integrity of frozen products, the availability of freezers at retail level, etc. have been posing huge challenges for the industry. To capitalize on the trend, the Industry will need to create more confidence in the Indian consumer about the final quality of the product.

While there is no concrete data on the growth in these markets, conversations with experts and processors seem to indicate a good push towards processed food, going forward. This may be able to offset some slack in the demand in ice cream segments in the next 12-18 months.

Pharmaceuticals

Over the last few years, the pharmaceutical cold chain has become more dominant with several large players investing in this area. From large carrying and forwarding agents (CFAs) like Parekh Integrated to large cold chain logistics plyers like Kool-ex, huge investments have been made in the pharma cold chain.

Regulations have played a major role in companies opting for cold chain logistics in India. They have also indicated a mandatory cold chain for even normal drugs to be transported at 15-25 deg C. The second dominant factor has been the mix of drugs. With large companies shifting to biologicals, the need for maintaining the cold chain has increased and correspondingly the payoff has improved.

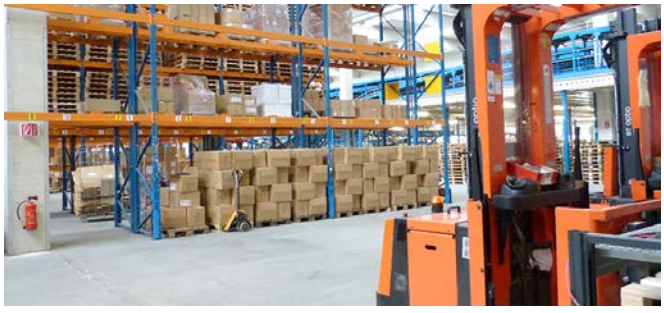
India is the largest producer of vaccines in the world. In the current situation, with any potential development on a COVID-19 vaccine, the demand could shoot through the roof. All Indian and international cold chain players are eyeing this opportunity at present.

With or without a COVID-19 vaccine, it is important to understand that Pharma is still going to remain a sector to watch out for the cold chain. Pharma e-commerce will also pick up considerably, given the change in consumers preferences. However, as per experts, it seems to be on a growth trajectory like the pre-coronavirus times.

Impact of User Industries on the Cold Chain Sector

While there are several operational changes required in all businesses including cold chain operations, I would not spend time on detailing those, but address their impact on the cold chain segments, costs, productivity and hence business decisions.

Warehousing and Storage



- Due to the lack of labor, the sector will see much more automation and lesser human touch. This in turn creates a Segway to standardization and palletization in cold chain warehousing.
- Leveling docks, tail lifts and other equipment that help reduce the amount of manual handling may gain in popularity.
- In the near- and mid-term, one will see larger stocks due to unpredictability of supplies. As someone said, the just-in-time stocking may convert into just-by-chance, to ensure better order fulfillment.
- One may see more full case sales instead of case in pack out operations at the cold store.
- Costs of operations may increase due to increased sanitation activity of incoming materials, maybe an additional per vehicle cost in addition to per kilogram or cubic meter.
- More formal and higher compliant service providers may be preferred.

Processing, Kitchen, and Retail Equipment

- Lesser counter equipment and more backend equipment.
- Kitchen equipment will increase, especially preservation using blast freezers, etc.
- Value-for-money equipment will be more in demand since lesser equipment may be customer facing.
- New under-counter equipment; serving equipment sales may get impacted.
- Vending equipment, especially based on mobile apps without touch and pre-sanitized, may be an interesting opportunity.

Refrigerated Transport and Logistics

- There will be a huge increase in the secondary and tertiary movement of goods.
- Transport to dark kitchens, stores, etc. with an increase in volumes will mean more number of smaller vehicles to be deployed (volumes from HoReCa will move into this segment).
- Home delivery solutions and safe packaging solutions will be the flavor of the season.
- Lesser number of drops per vehicle if the sanitization needs to be done at all locations before entering.
- Tracking and monitoring for traceability of the product and its temperature and condition will see an uptake from compliance and management control standpoint.

Conclusion

I believe that in the long term, the cold chain industry will get a significant boost from the current crisis. There may be some short-term losses and wins – but the medium to long term outlook looks positive across the segments. It is only a question of time for the recovery of HoReCa segment.

The *mantra* is to realign your businesses to whom you think will be the winners in this game and innovate along with them to deliver value for money. While one may see an increase in the adoption of cold chain, value driven products and cost-effective technologies that offer upfront cash relief may be preferable. People will look at much shorter returns on investment in most cases. They may prefer to take up lease options vs. investing capex upfront.

I would conclude that COVID-19 could be the biggest shake up and the largest disruptor of the century, which will catalyze certain behaviors and alter decision making variables and provide us opportunities that could be the very basis of our future business growth. ❄

Kitchen Equipment Start-up after a Long Shut Down

A walk-in cooler

By Harshal Ganjawalla
Director,
Hospitality Appliances Pvt. Ltd., Mumbai

Introduction

Cooking equipment, convection ovens, dishwashers and refrigerators are just some of the equipment used in the hotel and restaurant industry, which will be switched on for the first time in two to three months.

When a commercial kitchen is idle over a long period of time, it is crucial that each piece of equipment is restarted properly. Incorrect procedures not only lead to inefficient operation, but they also can damage the unit.

In order to help professionals in this sector, we have put together a complete commercial kitchen start-up check list for getting the equipment up and running at full strength.

Gas Main to Kitchen

1. Check that the main gas line is working.
2. Check that the ANSUL/ firefighting system is on and operating.
3. Check that the supply valve is open.
4. Check that the standing pilots are lit.

Electrical to Kitchen

1. Check that the breakers are clean, clear of water and free of rodents.
2. Check that the circuit breakers are in position and not tripped.

Convection Ovens

1. Check that the utilities are in the 'ON' position.
2. Check that the gas flow is unrestricted.
3. Check that the unit is free of gas leaks.

About the Author

Harshal Ganjawalla is Director at Hospitality Appliances Pvt. Ltd. – MGPRO, a turnkey contractor for professional kitchen, refrigeration and bar equipment and a vast range of customized equipment, with over 36 years of experience in serving the Food & Beverage Industry across India.

4. Check that the doors open and close properly.
5. Check that the pilots are lit (if applicable).
6. Run the unit in standby operation.
7. Relight the unit.

Combi Ovens

1. Check that the utility connections, including water supply, are on or open.
2. Check that steam and hot air flow are working properly.
3. Check that all modes and combi functions that use steam and hot air work together.
4. Check that the door gasket seals are clean, tight and free of cracks.
5. Delime the unit.
6. Clean the door gaskets if dirty.

Cooking Ranges

1. Check that the gas or electric power are on.
2. Check that the gas flow is unrestricted.
3. Check that the unit is free of gas leaks.
4. Check that the pilots are lit (if applicable).
5. Run the unit in standby operation.
6. Relight the unit.

Deep Fryers

1. Check that the gas or electric power are on.
2. Check that the gas flow is unrestricted.
3. Check that the pilot light works.
4. Conduct a boil-out procedure.
5. Fill the fryer with fresh oil to proper level.

Griddles and Grills

1. Check that the gas or electric power are on.
2. Check that the gas flow is unrestricted.
3. Check that the unit is free of gas leaks.
4. Check that the surface is clean and free of rust.
5. Check that the pilot light works.
6. Check that the radiant positioning and flame distribution is correct.
7. Run the unit in standby operation.
8. Relight the unit.
9. Confirm the temperature is correct with a thermometer.

Holding Cabinets

1. Check that the power supply is on.
2. Check that the lights and switches are operational.
3. Check that the door gasket seals are clean, tight and free of cracks.
4. Check that the door hardware is operational.
5. Clean the heater elements, thermostat and fans.
6. Clean the fill pan (if applicable).

Broilers

1. Check that the gas flow is unrestricted.
2. Clean any grease build-up.

Steamers

1. Check that the water and power supply are on.
2. Descale the boiler and generator if necessary.

3. Delime the unit.
4. Clean the cabinets.
5. Check that the door gasket seals are clean, tight and free of cracks.
6. Test if the steam generator is operating correctly.

Conveyor Ovens

1. Check that there is power to all the belts.
2. Check that the belts, axial fans and other moving parts are running smoothly.
3. Measure temperatures and calibrate the unit if necessary.
4. Check that the electrical display is operational.

Kettles and Braising Pans

1. Check that the power supply is on.
2. Check that the gas flow is unrestricted.
3. Sanitise the unit.
4. Fill the hydraulic fluid to proper levels.
5. Check that the water levels in the jackets are correct.

6. Check that the steam jacket is in a vacuum (if applicable).
7. Check that the temperatures are correct.

Toasters

1. Check that the power supply is on.
2. Check that the heat element works on both sides (if applicable).
3. Test the belt motor rotation for smooth operation.
4. Lubricate the conveyors and bearings (if applicable).

Hot Wells

1. Clean and sanitise the unit.
2. Check that the water levels are correct before start-up.
3. Check that the unit is operating properly.

Microwave and Rapid Cook Ovens

1. Check that the power supply is on.
2. Check that air filter is clean.
3. Check that the door seals are tight.
4. Check that the LED screen is operational.
5. Clean the oven cavity.

Walk-in Coolers and Reach-in Refrigerators

1. Check that the fan is operational.
2. Check that the coils are clean.
3. Check that the door gasket seals are clean, tight and free of cracks.

4. Check that the door hardware and inside release mechanism are operational.
5. Check that the cooling temperatures are correct.

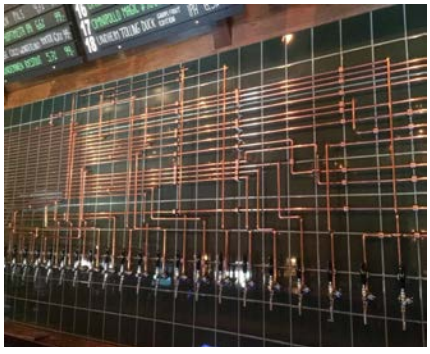
Ice Machines

1. Check that the power supply is on.
2. Clean and disinfect the machine.
3. Sanitise the bin.
4. Replace the filters.
5. Clean or replace the air intake filter.
6. Run a cycle operation to see if ice is being made properly.

Beverage Dispensers

1. Clean and disinfect the machine.

Beer Tap Lines



1. Purge and clean each tap line.

Coffee Brewers

1. Delime, clean and disinfect the unit.

Food Prep Equipment

1. Check that lubrication fluid levels on the hydraulics are correct.
2. Sanitise the units.

Hoods and Exhaust Fans

1. Check that the baffle filters are clean and in working condition.
2. Check that the belts and bearings are functioning without squeaking.
3. Empty the grease catch tray.
4. Test the make-up air operation.

Ware Washers

1. Check that the power supply is on.
2. Sanitize the belt by running it.
3. Check that machine is reaching wash, rinse and final rinse temperatures.

Conclusion

There could be more equipment in your kitchen than covered in this check list. You may avail the services of professionally trained service agents to help with thorough cleaning and start-up procedures. It is best to connect with them and get the kitchen professionally re-started. ❄

Driving Clean Cold

E. Teyssandier[(*)], F. Wagner[(*)], Z. Bengherbi[(*)], D. Strahan
[(*)]The Dearman Engine Co, 7 Henrietta Street, London, Wc2e 8Ps
etienne.teyssandier@dearman.co.uk

Abstract

Research has predicted extremely rapid growth of demand for transport refrigeration units (TRUs), with upper estimates suggesting there could be over 16 million TRUs in operation by 2025 – up from 2.1million today. This growth will largely be driven by changing demographics in the Asia Pacific region and could have major global environmental consequences if met with existing fossil fuelled technology.

This paper will evaluate the potential reductions in all forms of pollution that could arise from mass adoption of novel, zero emission, liquid air TRUs. It will be based upon original analysis of ten European markets, their demand for transport refrigeration and the pollution associated with existing TRUs. This provides a baseline to evaluate the potential environmental benefits of introducing zero emission alternatives. The paper will also consider the potential for liquid air technologies to be adopted quickly, assessing both available infrastructure and the economic viability of the technology.

Keywords

Transport refrigeration, Pollution, Liquid Air, NOx, Particulate matter

1. Introduction

Transport refrigeration is a vital part of modern society, enabling temperature sensitive produce to be transported by road over great distances while preserving its economic and, in the case of food, nutritional value. As economies develop and societies become more affluent, lifestyles inevitably change. Reliable access to modern healthcare means that vaccines must be kept cool in order to preserve their efficacy. Diets tend to feature more meat, dairy and fresh food, all of which rely on an uninterrupted cold chain. This paper will explore how increased affluence causes the demand for cooling to increase, and so transport refrigeration becomes more prolific.

The design of transport refrigeration units has developed significantly since their mass introduction in the 1950s, and incremental improvements in refrigerant gas legislation mean that the units operating now have less impact on the environment than 60 years ago. However, the majority of these systems are still powered by burning fossil fuels. The environmental impact of one transport refrigeration unit on local air quality can be equivalent to that of almost 30 modern diesel cars. As long as diesel remains the 'business as usual' solution for powering a refrigeration cycle, airborne pollution will be emitted. If emerging economies continue to develop quickly, lifestyle changes will cause refrigeration units to become more numerous, which will dramatically impact air quality.

Fossil fuels have persisted as first choice for fuelling transport refrigeration because they are energy dense and readily available worldwide. However, growing concerns over environmental impact are putting pressure on the transport industry to move away from this polluting source of power. Any viable alternative to fossil fuels must offer both operational parity and a competitive business case. The industry has begun to trial more environmentally sound alternative fuel sources, however these suffer from particular weaknesses, which have thus far prevented them from overtaking diesel. For instance, batteries have range and temperature restrictions and take hours to charge, affecting the duty cycle of the vehicle, and evaporative cryogenic systems suffer from inefficiencies that impact their economic viability and overall business proposition.

A novel cryogenic system that offers operational parity with diesel, while being zero-emission at point of use, is now being demonstrated. Its viability in developing and developed markets will be discussed in this paper. In the context of the paper, 'novel' should be taken to mean different to that which has come before, or 'completely new'. The novel aspect of the system is a proprietary process that extracts both cooling and power from a single unit of liquid nitrogen. The term 'liquid air' is occasionally used in place of 'liquid nitrogen' with reference to this system. As the atmosphere

Paper presented at 4th IIR Conference on Sustainability and the Cold Chain, Auckland, New Zealand, 2016.

comprises 78% nitrogen, the thermodynamic properties of both liquid air (filtered, but unseparated atmosphere) and liquid nitrogen (LiN) are comparable and either can be used without impacting the efficacy of the process.

Through modelling, market analysis and a comparison of available transport refrigeration systems, this paper sets out the case not only for unprecedented market growth in emerging economies, but also for those markets to adopt environmentally sound, economically viable alternatives.

2. The Global Road Transport Refrigeration Market

2.1 Causes for market growth

Cold is a crucial element of our modern societies, as evidenced by the impact it has on our economies, energy production and the environment. The International Institute of Refrigeration estimates that the 3 billion refrigeration, air-conditioning and heat pump systems in operation worldwide account for 17% of the global electricity consumption. Refrigerated transport represents a relatively small share of the overall cold chain (4 million refrigerated vehicles, (IIR, 2011)) but is nonetheless vital as it is the only mechanism through which goods can move from producers to consumers allowing economic value to be realised. Without it the cold chain would also be broken, making investments in food processing and refrigerated storage worthless.

The global market for refrigerated transport has historically been dominated by the developed world, but growth in these territories is currently plateauing. Although it could still grow in different ways (temperature controlled transport of art pieces, tyres, etc.), these markets are considered mature enough for high growth rates not to be observed. Developing countries however are anticipated to achieve high growth rates – the cold chain in these regions is generally not as well established as it is in developed economies and refrigerated transport there tends to be particularly weak. India is a striking example – despite having recently surpassed the US to become the biggest cold-storage capacity in the world with 131 million m^3 (US Department of Commerce International Trade Administration, 2015), less than 4% of the country's fresh produce is transported under low-temperature conditions, as compared with over 90% in the UK (Subin, 2011).

Globally, although a third of the food production requires temperature control, less than 7% was in fact refrigerated during transport in 2010 (IIR, 2009). The International Institute of Refrigeration estimates that this results in wasting near 20% of the global food production – 9% in developed countries vs. 23% in developing countries (IIR, 2009). Meanwhile, rapid demographically-driven market growth in developing economies means that the growth in demand for cold chains may be stronger than previous forecasts imply, as these use projections at a fixed growth rate indexed on GDP growth. As countries develop and national income rises they progress towards a consumer society typically marked by urbanisation, declining family size and a rise in services. The FAO estimates that food production will have to increase globally by 70% (about 4,400 million tonnes) to feed an additional 2.3 billion people by 2050 and refrigeration has a vital role to play in this context (FAO, 2009). Setting up cold chains for perishable foodstuffs, which are as extensive and reliable as those in industrialized countries, would already enable developing countries to raise food supply by about 15% (i.e. about 250 million tonnes (IIR, 2009)).

2.2 Quantifying the market growth

Due to the lack of publically available registration data for refrigerated vehicles globally, proxies have been used to estimate the size of the current global refrigerated vehicle fleet. Market size analysis is available for a number of territories – amongst these Europe, the UK and California for developed countries and India and China for developing countries. Data for these territories has been used to derive estimates of the refrigerated vehicle density (relative to population) and of the ratio of refrigerated to total commercial vehicles. A refrigerated vehicle fleet of 1 million units was assumed for Europe (Strahan, 2015), and it is estimated by the California Air Resources Board that there are approximately 40,000 refrigerated vehicles operating in California. These, combined with country specific population data (UN Dept. of Economic and Social Affairs, 2015) and commercial vehicle market size (OICA, 2013) allow to estimate the number of refrigerated vehicles in operation in developed countries. Outputs are presented for three subsets – the EU 28, North America and the rest of developed countries (as per the United Nations definition). For developing countries, China and India form the basis of the calculation as more data was available than in other territories. Developing countries have been split in five subsets – Latin America and the Caribbean, India, China, the rest of Asia and the rest of developing countries (again as per the United Nations definition).

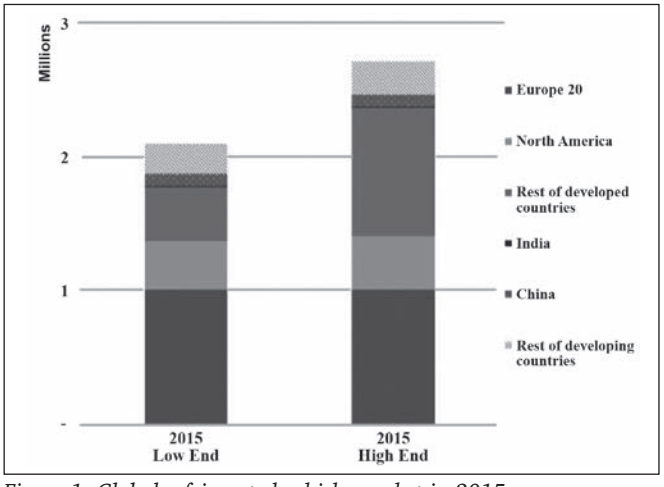


Figure 1: Global refrigerated vehicle market in 2015

Choosing one proxy or the other (refrigerated vehicle density or ratio of refrigerated to non-refrigerated vehicles) makes a difference in terms of the resulting market estimates, highlighting one of the limitations of this methodology. The analysis indicates that the global refrigerated vehicle fleet consists of somewhere

between 2.1 (density based estimate) and 2.8 million vehicles globally – numbers, which are consistent with those published in the 2010 and 2014 UNEP reports.

To estimate the likely refrigerated vehicle market in 2025, conventional analysis methods apply predicted GDP growth rates to current market sizes, which results in a 2025 global vehicle fleet of ~ 4 million vehicles. This method is appropriate for developed countries where the market is already well developed and mature, however it does not capture the fact that developing countries now need to make up for the lack of refrigerated transport equipment to satisfy their growing urban middle classes. Forecasting refrigerated transport uptake rates for these countries is a challenge – it can however be assumed that in the long-term developing countries will reach levels of refrigerated vehicle penetration of similar orders of magnitude when compared to the markets now considered mature. For the purpose of this analysis, it is assumed that this would be realised by 2025 – although potentially ambitious, it highlights the scale of the long-term challenge, whether it be realised by 2025 or a number of years later.

This analysis identifies a potential demand for 16.4 million vehicles in 2025 – 12 million more vehicles than forecasts based on GDP growth rates imply and over 13 million more compared with today.

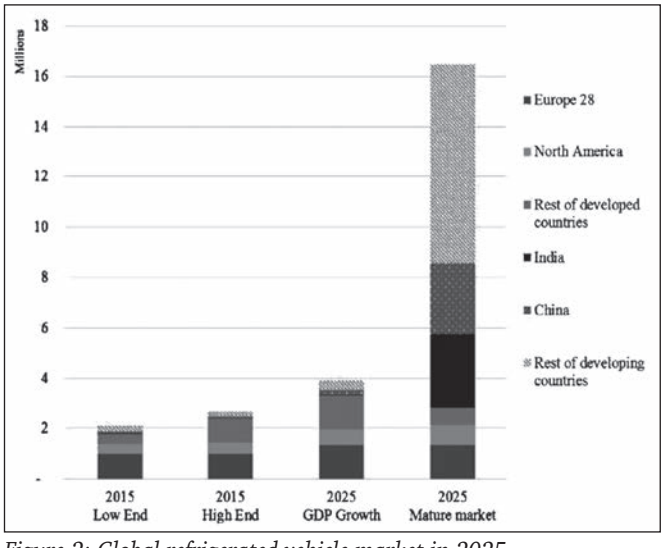


Figure 2: Global refrigerated vehicle market in 2025

3. The Challenges Facing the Transport Refrigeration Industry

As further uptake of cold chain equipment in general – and of refrigerated transport in particular – appears inevitable, the industry already recognises that current technology will not be suitable in the long-term. In fact most, if not all industry participants, are already either demonstrating or even placing on the market technologies with improved environmental credentials.

Greenhouse gas (GHG) emissions are the most significant concern at present in the transport refrigeration industry. The majority of transport refrigeration equipment in use relies on chemical refrigerant fluids referred to as F-gases, which have very high global warming potential (GWP). R404a, one of the most common refrigerants has a GWP of 3940 meaning that each kilogram of R404a released to the atmosphere has the same impact as 3.9 tons of CO_2. The EU has responded to this issue by legislating to drive the highest GWP refrigerants out of the market (by placing a series of cuts in the supply of refrigerants from an agreed baseline), forcing the industry to look at new refrigerants.

The first significant cut will take place in 2018, while by 2030 total supply will be limited to 21% of the agreed baseline. Despite being enforced in the EU only, the legislation will affect the global supply of refrigerants.

As part of the drive to reduce CO_2 emissions from transportation and logistics, the industry is also under pressure to reduce its products' fuel consumption to satisfy its customers sustainability and corporate social responsibility objectives (CSR) – in fact CO_2 emissions from F-gases alone only account for ~20% of the lifecycle CO_2 emissions attributable to transport refrigeration units (Strahan, 2015).

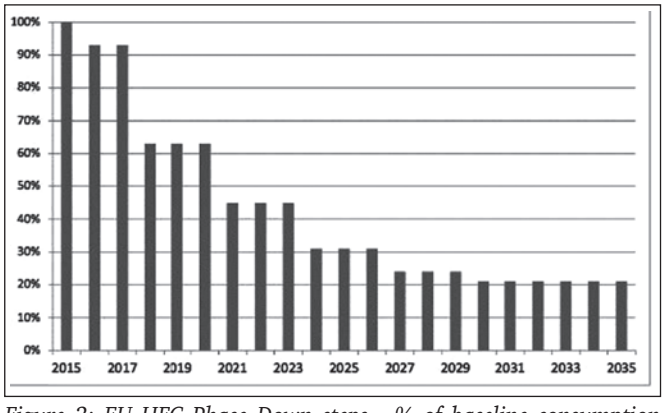


Figure 3: EU HFC Phase Down steps - % of baseline consumption allowed

Air quality is increasingly becoming an issue of public and political importance. At present TRUs are only (lightly) regulated in a limited number of territories as they are not used for vehicle propulsion (in Europe for instance they are exempted from the Non-Road Mobile Machinery (NRMM) emissions targets). Previous analysis has shown that during a normal day's operation the small auxiliary diesel engine, which powers a conventional TRU will emit as much as 6 times the NOx and 29 times the particulate matter (PM) of the much larger Euro VI tractor unit that pulls the truck (Strahan, 2014). Increasingly, local authorities and governments are beginning to understand the costs of poor air quality because of its direct impact on human health, environment and economic activity (UNECE, 2013). While poor air quality mainly increases the population morbidity and mortality it can also lead to crop loss. The European Commission commissioned an independent study (RICARDO-AEA, 2014) aiming to provide a comprehensive overview of approaches for estimating the external costs of transport and to recommend

a set of methods and default values for use when conceiving and implementing transport pricing policy and schemes. The study, which used an Impact Pathway approach to quantify the monetary impact of pollutant emissions, concluded that in Europe each tonne of NOx emitted (resp. PM) would incur between 1,957 and 22,893 EUR (resp. 9,347 and 98,132 EUR) in damage costs depending on the country considered. While these figures are not directly applicable to territories outside Europe, it gives an indication of the magnitude of the issue.

Analysis presented in sections 4 and 5 describes how to estimate the lifecycle CO_2, HC+NOx and PM emissions from baseline TRUs. This analysis indicates that assuming a rapid uptake of transport refrigeration technologies in developing countries and that equipment in the meantime does not evolve (aside from complying with the EU F-gas regulations driving global uptake of low-GWP gases), up to 223 million tonnes of CO_2, 880,000 tonnes of HC+NOx and 92,400 tonnes of PM could be emitted annually by TRUs alone in 2025. This would cause a considerable societal and economic burden, arising from an industry which, unlike other transport sectors, has opportunities to start pursuing cleaner technologies at affordable costs.

4. Potential Long-Term Solutions

This analysis considers a number of conventional and advanced technologies applicable to transport refrigeration systems, but does not represent the full universe of technologies. In particular eutectic technology, magnetic refrigeration and fuel cell powered vapour compression systems are not described here as there is no indication of likely significant uptake in the next 10 years. It should also be noted that transport refrigeration units' performance will depend on a number of externalities – for instance ambient temperature, refrigerated compartment temperature set-point. The efficiency in converting a unit of fuel stored on-board a refrigerated vehicle into cooling energy has been calculated as follows assuming a set-point of -20°C and ambient temperature of 30°C.

Auxiliary diesel powered vapour compression – A conventional non-road diesel engine is 25% to 30% efficient at constant load (Mader *et al.*, 2007), therefore converting the 42.91MJ/kg (11.91kWh/kg) of energy available in 1kg of diesel fuel to 3.26kWh/kg. Of this useful energy, some will be used to drive ancillary systems like an alternator to charge the batteries (and power the engine radiator fan, fans to circulate air through the compartment, condenser fans, etc.) while the rest will be used to drive the vapour compression cycle. Mader *et al.* (2007) estimated that a third of the useful work produced by the engine is consumed by ancillaries while the remaining two thirds of the useful work are used to drive the vapour compression cycle. Therefore, of the 3.26kWh/kg of useful energy produced by the engine, only 2.17kWh/kg is used to drive the refrigeration system. Assuming that a conventional R404A refrigeration unit has on average a coefficient of performance (COP) of 1 (Mader *et al.*, 2007), this means in turn that 2.17kWh of cooling energy per kg of diesel fuel can be generated using a transport refrigeration unit.

Alternator driven vapour compression – Vehicle diesel engines tend to be more efficient than non-road engines as per the more stringent regulations they are submitted to; a modern diesel engine (35% to 45% efficient at constant load, (RICARDO, 2010)) will generate 4.53kWh/kg of useful energy from 1kg of diesel fuel. Similarly to other TRUs, a third of this useful work is consumed by ancillaries while the remaining two thirds are used to drive the alternator – meaning only 3.03 kWh/kg of useful energy is used to drive the alternator. High efficiency alternators can be assumed to be on average 90% efficient, with electric motors being 92% efficient (RICARDO-AEA, 2012) – of the 3.03kWh/kg of useful energy produced by the engine, 2.51kWh/kg is available to drive the refrigeration system. Assuming that a conventional R410A refrigeration unit has on average a coefficient of performance (COP) of 1, this means in turn that 2.51kWh of cooling energy per kg of diesel fuel can be generated with these systems.

Battery electric vapour compression – Electric TRUs where power is sourced from the vehicle main engine are not considered in this analysis – primarily because a) electricity produced from the main vehicle engine tends to be significantly more expensive than grid electricity; and b) despite the main vehicle engine being more efficient and less polluting than small auxiliary diesel engines, these systems use fossil fuel as their energy source. All-electric TRUs are charged before leaving their base using grid electricity, and during daily operation the refrigeration unit then draws its energy from the batteries. The batteries' electricity is used to run an electric motor, which in turns powers the refrigeration machine – a vapour compression cycle as on diesel-powered TRUs. To quantify the system performance and operating costs, it is assumed that advanced batteries (Li-ion) have a charge/discharge efficiency of 90% (Krieger and Arnold, 2012); the electric motor has a 92% (RICARDO-AEA, 2012) efficiency on average; the refrigeration unit has on average a coefficient of performance (COP) of 1; similarly to diesel engine powered TRUs, the system consumes a third of its energy to power electrical ancillaries such as fans. Under these assumptions, every kWh of grid electricity fed to the TRU's batteries will result in 0.50 kWh of cooling.

Cold and power LiN systems – By comparison with diesel, it takes ~0.101 kWh of energy to vaporise and warm 1 kg of liquid nitrogen from -196°C up to -25°C – if the refrigerated vehicle is used to transport frozen goods at -20°C, the LiN would be vaporised and warmed to around -25°C. This translates to 0.101 kWh of heat absorbed from the refrigerated vehicle per kg of LiN. In the Dearman refrigeration unit, the warmed nitrogen is then fed to the Dearman engine where it is expanded isothermally to produce mechanical work. For every 0.101 kWh of heat absorbed by the nitrogen before entering the engine, 0.060 kWh of work can be produced by expansion of the nitrogen in the Dearman engine (Teyssandier *et al.*, 2015). Similarly to diesel engines, a third of this work is used to drive ancillaries in the refrigeration system while

the rest is used to drive a vapour compression cycle to provide additional cooling on top of the cooling provided by the LiN. In the Dearman refrigeration unit, the vapour compression cycle air-cooled condenser is replaced by a water cooled condenser, which more than doubles the efficiency of the vapour compression system (COP of 2, (Teyssandier *et al.*, 2015)). Overall the Dearman refrigeration unit recovers 0.101 kWh of cooling per kg of LiN directly from the cryogenic fluid and a further 0.040 x 2 = 0.08 kWh of cooling per kg of LiN from the Dearman engine driving the vapour compression cycle – a total of 0.175 kWh of cooling per kg of LiN after accounting for heat exchange inefficiencies.

Evaporation only cryogenic systems – Other cryogenic TRUs (LiN, liquid CO_2) exist, which are not equipped with a means to recover mechanical energy from the cryogenic fluid (like the Dearman engine). As such they can only recover up to 0.101 kWh of cooling energy per kg of LiN (resp. 0.103 per kg of liquid CO_2). In addition, these systems will require energy to drive their ancillary systems – typically this energy is taken from the main vehicle engine, which will add to the system's operating cost and also means that the system is not emissions free at point of use.

Another cryogenic refrigeration system capable of recovering both cold and power from liquid nitrogen is being introduced to the North American market – this system has not been described here due to lack of information to estimate its performance. There also exists evaporation only liquid CO_2 cryogenic systems – similar to evaporation only LiN systems – and diesel engine driven transcritical vapour compression CO_2 systems. The former is not included here because unlike liquid nitrogen, the liquid CO_2 infrastructure is not well-developed therefore the embedded carbon emissions, costs and even supply are not understood well enough to be described here. The latter is not included because it still relies on auxiliary diesel engines – therefore only addressing a fraction of the CO_2 emissions issues and none of the air quality ones.

The outputs of this comparison are summarised and combined with cost and emission factors in table 1 below.

5. The Impact of Zero-Emission Technology Deployments

Table 1 summarises the efficiency of each of the aforementioned technologies in converting energy stored on-board into cooling energy. The annual pollutant emissions from each technology – in terms of lifecycle CO_2 emissions, HC + NOx and PM emissions – and total life costs of operating such systems have been calculated to illustrate the cost effectiveness of each zero-emission technology in reducing transport refrigeration's environmental and air quality impact. For ease of understanding, the table uses current New-Zealand energy prices (road-taxed diesel and average industrial electricity cost) and carbon intensities to illustrate how technologies compare in this market.

Lifecycle CO_2 calculations include equivalent CO_2 emissions from the manufacturing and disposal of TRU equipment (RICARDO, 2011), equivalent CO_2 emissions from annual F-gas leakage (for those systems that use refrigerant gases, an annual leakage rate of 10% has been assumed except for alternator driven units for which a leakage rate of 20% has been assumed (Cemafroid and IRSTEA, 2015)) and in-use fuel related emissions. Fuel related carbon emissions include well-to-tank (fuel production and delivery to the end-user) as well as tank-to-wheels (fuel use in the application considered, here transport refrigeration) emissions to be representative of lifecycle emissions. While carbon intensity factors for diesel are publically available, they are not for cryogenic fuels such as liquid nitrogen or liquid CO_2. In this analysis, the Low Carbon Fuel Standard regulation methodology (California Air Resources Board) has been adopted to estimate the carbon intensity of LiN – with the assumptions that air separation units (ASUs) are powered exclusively from grid electricity, that road vehicles are used to deliver LiN from ASUs to customers covering an average (one-way) distance of 50 miles, and that a share of LiN will be lost to the atmosphere through evaporation during delivery, refilling and customer on-site storage.

HC + NOx and PM emissions calculations assume auxiliary/vehicle engines used in diesel powered TRUs emit at the limit of

Table 1: Transport refrigeration technologies energy efficiency and cost comparison

	Auxiliary diesel powered vapour compression	Alternator powered vapour compression	Battery-electric vapour compression	Evaporation only LiN system	Cold and power LiN system
Energy efficiency	2.17 kWh cool. / kg diesel	2.51 kWh cool. / kg diesel	0.501 kWh cool./ kWh grid elec.	0.101 kWh cool. /kg LiN	0.175 kWh cool. /kg LiN
HC + NOx emissions	11.25 g/kWh of cooling	0.72+0.23 g/kWh of cooling	0 g/ kWh of cooling	0 g/kWh of cooling	0 g/ kWh of cooling
PM emissions	0.6 g/ kWh of cooling	0.02 g/kWh of cooling	0 g/ kWh of cooling	0 g/ kWh of cooling	0 g/ kWh of cooling
Lifecycle CO_2 emissions	2.24 g/ kWh of cooling	1.70 g/ kWh of cooling	0.64 g/ kWh of cooling	1.54 g/ kWh of cooling	0.73 g/ kWh of cooling
Cost of a unit of cooling (1 kWh)	USD 0.47	USD 0.41	USD 0.27	USD 0.64	USD 0.37
Annual operating cost	USD 7067	USD 6112	USD 4099	USD 9659	USD 5573
Capital cost	USD 22800	USD 26600	USD 76000	USD 28500	USD 26600
Annual maintenance cost	USD 1824	USD 912	USD 456	USD 608	USD 1824
Add. infrastructure cost per vehicle over the TRU life	USD 0	USD 0	USD 6080	USD 1520	USD 1520
5 year total cost of ownership (TCO)	USD 67254	USD 61721	USD 104853	USD 81357	USD 65103

what the world's most stringent emission regulations allows – the non-road US Tier 4 emission standards for auxiliary engines, and Euro VI heavy-duty engines for vehicle engines.

Table 1 highlights that over the life of a TRU, a liquid nitrogen cold and power system would have a significantly positive environmental impact – both in terms of carbon reduction and air quality – while not imposing an economic burden on the end-users. It should be noted that the carbon savings likely to arise from cryogenic systems as well as battery electric systems are integrally dependent on a country's energy mix – in the case of New-Zealand where hydro power is a major source of energy, savings of up to 69% vs. a conventional fossil fuelled system are already achievable. Looking ahead, assuming the International Energy Agency's forecasted grid mix for North America and the European Union in 2025 and that liquid nitrogen cold and power transport refrigeration units were the only technology used then, a saving of 2.4 million tonnes of CO_2 in North America and 7 million tonnes of CO_2 in the European Union vs. fossil fuelled systems would be achieved. As countries' energy production are greened, CO_2 savings will become more substantial.

In addition, non-fossil fuel technologies are HC + NOx and PM emission free. In developing countries such as China and India, where HC + NOx and PM emission are known to contribute to poor air quality, deploying these technologies could prevent social disasters. For instance, by 2025, switching from diesel to zero-emission technologies would result in savings of 150,000 tonnes of HC + NOx and 16,000 tonnes of PM in China alone.

6. The Way Forward

Strahan (2015) quantifies the likely benefits of introducing liquid air transport refrigeration in the EU to replace fossil fuel technology. In light of his findings he discusses how current European energy mix and prices are favourable to liquid air TRU deployments – generating significant emission savings without imposing a financial burden on end-users. A further key argument arising from the analysis is the presence of sufficient infrastructure to support the deployment of over 70,000 liquid air TRUs before exhausting the fuel supply.

Regardless of where they are used, liquid air TRUs will be free of NOx and PM emissions and therefore contribute to improving local air quality – but not CO_2 free. Lifecycle CO_2 emissions from liquid air TRUs rely on a country's energy mix, and only in countries with low enough grid carbon intensity (equivalent quantity of CO_2 emitted per unit of energy produced) will liquid air TRUs lead to significant CO_2 savings. Looking at the world in 2025, the International Energy Agency predicts a global average grid carbon intensity of ~0.52g CO_2/kWh (similar to the average of American countries members of the Organisation for Economic Co-operation and Development, OECD, currently). Using this average carbon intensity in the lifecycle calculation would result in liquid nitrogen TRUs saving just above 7% when compared to diesel technology. This calculation relies on the assumption that liquid nitrogen remains the energy vector used to power cryogenic cold and power TRUs, however should liquid nitrogen TRUs achieve significant penetration, the time will come when dedicated infrastructure will be required and opportunities to optimise the cryogen production will arise. As opposed to liquid nitrogen, liquid air production does not require distillation equipment to separate nitrogen, oxygen and argon – reducing production costs as well as embedded carbon. The predicted uptake of Liquefied Natural Gas (LNG) also offers opportunities to integrate liquid air/nitrogen production facilities with LNG regasification terminals, where otherwise wasted cold from LNG can be used to improve the liquefaction process – further reducing the production costs and embedded carbon footprint.

This analysis would also further benefit from more detailed and granular data on the real-world performance of transport refrigeration technologies, to quantify the likely impacts of deploying innovative solutions. Incentives should be developed to encourage the development of data-collection campaigns to collect information of sufficient quality for policy-makers to take informed decisions for the long-term. Cost sensitivity is also an issue in this industry, therefore supporting the demonstration of innovative technologies would enable technology developers to build sufficient customer acceptance and confidence – crucial to enable the uptake of clean technologies.

7. Conclusions

Available evidence and reasoned modeling shows that demographic change in emerging markets will increase demand for transport refrigeration. This has the potential to see 16.4 million vehicles operating worldwide in 2025. The fact that alternatives to conventional fossil fuelled systems, such as batteries and evaporative cryogenic systems, are already being demonstrated across the cold chain industry is indicative of the trend towards systems and products with more robust environmental credentials. There is both a socio-economic need and industrial appetite for innovative technologies. However, in order to be successfully adopted into the market, new systems must be commercially viable.

Despite the paucity of data available, strong conclusions may be drawn concerning the potential of the LiN cold and power systems to support the rapid development in emerging economies without negatively impacting on air quality. Reducing food loss and supporting the distribution of food and medicine are key to this process. The commercial viability, operational capacity and environmental credentials of the LiN cold and power system are more favorable than other alternatives currently in the market. Additionally, the lifetime and projected CO_2 savings of the system contribute to its prospect as a cleaner, cheaper system for both mature and emerging markets.

References

Cemafroid and IRSTEA. 2015. Refrigerant Containment Study. ADEME.

FAO. 2009. How to feed the world in 2050. Food and Agriculture Organization of the United Nations. http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf.

IIR. 2011. 21st Informatory Note on Refrigerating Technologies "Sustainable Refrigerated Road Transport". International Institute of Refrigeration. http://www.iifiir.org/userfiles/file/publications/notes/NoteTech_21_EN.pdf.

IIR. 2009. 5th Informatory Note on Refriegration and Food "The role of refrigeration in worldwide Nutrition". International Institute of Refrigeration. http://www.iifiir.org/userfiles/file/publications/notes/NoteFood_05_EN.pdf.

Krieger, E.M., Arnold, C.B. 2012. Effects of undercharge and internal loss on the rate dependence of battery charge storage efficiency. Journal of Power Sources 286-291.

Mader P., Kulkarni,C., Dwyer, H. A. and Brodrick, C. J. 2007. Emissions, Performance, and Duty Cycle

Measurements of Diesel Powered TRUs. SAE International.

OICA. 2013. Vehicles in use. Organisation Internationale des Constructeurs d'Automobiles. Accessed

November 2015. http://www.oica.net/category/vehicles-in-use/.

RICARDO. 2010. Heavy Goods Vehicle Simulation Tool "Model definition, build and validation". RICARDO.

RICARDO. 2011. Preparing for a Life Cycle CO2 Measure. RICARDO.

RICARDO-AEA. 2012. A review of the efficiency and cost assumptions for road transport vehicles to 2050. Committee on Climate Change.

RICARDO-AEA. 2014. Update of the Handbook on External Costs of Transport.

Strahan, D. 2015. Liquid Air on the European Highway, The economic and environmental impact of zero emission transport refrigeration. Dearman.

Strahan, D. 2014. Liquid Air on the Highway - The environmental and business case for liquid air commercial vehicles in the UK. Centre for Low Carbon Futures and Liquid Air Energy Network.

Subin, R. US Commercial Service Department of Commerce. 2011. August. https://www.academia.edu/5952490/Indias_Cold_Chain_Industry.

Teyssandier, E., Metcalf, P., Owen, N., Lawton, R., Mynott, T. and L'Heureux, Z. 2015. Development of a Novel Refrigerated Transport System using a combination of liquid nitrogen expansion and mechanical vapour compression. Proceedings of the 24th IIR International Congress of Refrigeration ICR2015, Yokohama, Japan, IIR.

UN Dept. of Economic and Social Affairs. 2015. "World population prospects." United Nations. July. Accessed November 2015. http://esa.un.org/unpd/wpp/Download/Standard/Population/.

UNECE. 2013. Pollutant Emissions in The Transportation Sector.

US Department of Commerce International Trade Administration. 2015. Top Markets Report: Cold Chain.

Did You Know?

continued from page 6

F&V Worth Rs.20,000 Crore Perish in Lockdown

Farmers may have lost at least Rs 20,000 crore during the lockdown period, as parts of fruits-and-vegetables produce perished due to transport gridlocks and labour paucity. Arrivals of fruits and vegetables have picked up since April 15 after several *mandis* were opened and the government swung into action to ease movement of trucks, including inter-state ones. While the *mandi* arrivals were down by a half (year-on-year) till April 10, the average drop has now narrowed down to a third.

"Unless the situation is completely normalised, farmers will not be able to sell their produce in a seamless fashion. The demand has also slumped due to the closure of eateries," said V. M. Singh, convenor of All India Kisan Sangharsh Samiti. He also asked the government to procure all crops including fruits and vegetables at minimum support prices, as an emergency measure.

There is technology available to keep the vegetables under cold stores, which is very capital-intensive and only high value crops can be put there, said B. B. Patnaik, former chairman of Central Warehousing Corporation (CWC). Besides, vegetables like cauliflower, cabbage and brinjal used to be consumed within days after harvesting, so there was never any need to develop cold storage facilities earlier, he said.

Logistics is another factor that contributed to the overall drop in *mandi* arrivals. Amid reports that inter-state movement of trucks was not smooth due to local authorities insisting on separate passes other than national permit licences, the Centre had written to the state governments asking them to ensure this practice is stopped forthwith and its April 15 guidelines in this regard are truly complied with.

As many as 3.6 lakh national-permit trucks plied on Indian roads on April 30, up from 1.5 lakh on April 20 and 1.2 lakh on April 12, in what indicates a gradual improvement in inter-state commerce. However, it would be a long road ahead before the plying rate returns to over 10 lakh vehicles or 70% of the NP-registered vehicles that plied before the outbreak of COVID-19 pandemic.

"Farm-gate prices of perishables have fallen as the supply chain has been disrupted with trucks not plying. Also, all shops are closed, so there is no demand for products like milk, poultry and egg. The major problem is while farmers are unable to get value for their crops, prices have not declined at consumers' end," noted economist Ashok Gulati said.

The value of fruit and vegetables produced in the country – at prices realised by farmers – was Rs 5 lakh crore in 2019-20. Production of fruit in the last fiscal was estimated at 95.74 million tonnes and that of vegetables at 188 million tonnes.

(*Source: The Financial Express, May 13, 2020*)

What's happening?

IOR Celebrates World Refrigeration Day

World Refrigeration Day was observed on June 26. The Institute of Refrigeration (IOR) is launching four initiatives over the next two weeks to celebrate it:

- An IOR membership campaign with a reduced £20 joining fee and instant access to the IOR's online resources.
- The Service Engineers Section becoming the IOR RACHP Engineering Technician Section to reflect the broader appeal of the section, which covers technical roles across the whole spectrum of cooling activities.
- RACHP Heroes – a social media campaign celebrating the work of everyone in this sector who has helped to support essential services during the COVID-19 pandemic.
- IOR Climate Change Plan for Cooling and a challenge for the industry to work together towards its net-zero future.

ASHRAE Supports World Refrigeration Day

ASHRAE joined with associations and societies around the world in supporting World Refrigeration Day 2020 on June 26. Called the 'Coolest Day of the Year,' World Refrigeration Day is an international awareness campaign created to raise the profile of the refrigeration, air-conditioning and heat-pump sector and focuses attention on the significant role that the industry and its technology play in modern life and society. This year's theme is *Cold Chain 4 Life*.

"Since 1904, ASHRAE's contributions to refrigeration research and technology continue to advance the cold chain industry and benefit the public in profound ways", said 2019-20 ASHRAE President Darryl K. Boyce, P.Eng. "We are proud to partner with other global organizations to support World Refrigeration Day, in this its second year, as we celebrate refrigeration's vital role to the modern world."

Prominent industry associations and societies in dozens of countries participated in a series of refrigeration-related activities to support the day. Governmental officials also joined in recognizing the event, including issuing letters and statements of commendation.

"Refrigeration and the cold chain are part of a growing, worldwide industry," said Rajan Rajendran, chair of ASHRAE's Refrigeration Committee. "ASHRAE's resources and the work of our members will continue to make a difference in improving the quality of life for people throughout the world."

Visit *ashrae.org/refrigeration* for resources, information and publications concerning refrigeration and refrigerants such as standards, design guides and ASHRAE courses.

The Cold Chain Federation Marks Cold Chain Energy Week

The Cold Chain Federation will be holding a series of three webinars over three days, as part of an online Energy Summit. The webinars will detail the current energy landscape in the UK as well as what this means for cold chain businesses, and showcase the latest innovations for energy efficiency. The CCF Cold Chain Energy Week will culminate with a preview of the November Energy Summit event.

Cold Chain CORNER

continued from page 3

We have been involved in many webinars organised by ISHRAE Chapters such as Pune and Indore. A noteworthy webinar was held under the name of 'Frozen is the new Fresh', in which Harshal Surange was a speaker. It was organised by i2i Consulting in association with the US Soya Exporters Council along with the Global Cold Chain Alliance (GCCA) as a supporting organization. (GCCA is also a supporting organization of ISHRAE.) This webinar was large in terms of registrations (over 2,000), and crossed 1,400 actual attendees. This goes on to show the kind of interest investors have in the cold chain.

While things have slowly started to move in the direction of normalcy, we can see that there are many challenges to overcome, not just in terms of the pandemic but also on the economic front, not to mention the border. We need to be strong physically and mentally and support our Government in whatever way possible. One important thing we can and, in our opinion, *must* do is to support Indian (*Swadeshi*) products and equipment, even if they come at a slightly higher price. We, on our part are taking this up very seriously and would try to do our bit for *Atmanirbhar Bharat*.

Jai Hind.

LU-VE GROUP
leadership with passion






- RELIABLE PERFORMANCE
- REDUCED FOOT PRINT
- LOWER REFRIGERANT CHARGE
- LOWER ENERGY CONSUMPTION

CO_2 - NH_3 - GLYCOL - HFC

www.luve.it www.luvegroup.com

BLUE STAR

INTERFACE 10424039

DIVERSE REFRIGERATION NEEDS. ONE REFRIGERATION EXPERT.

Different food products have different refrigeration needs. Blue Star understands this and offers expert solutions that suit all these needs. From Water Coolers and Visi Coolers to Chest Freezers and Ice Machines to Modular Cold Rooms, all Blue Star products are specially designed to suit the unique requirements of your food business. And are backed by a reliable nationwide service network. Making them ideal for your hotels, restaurants and cafés.


Hard Top Chest Freezers


Glass Top Chest Freezers


Bottled Water Dispensers


Water Coolers


Ice Machines


Visi Coolers


Modular Cold Rooms

For more information, contact Blue Star Limited •AHMEDABAD: Tel: (079) 40224000 • BENGALURU: Tel: (080) 41854000 • BHOPAL: Tel: (0755) 4273378 • BHUBANESWAR: Tel: (0674) 2572403 • CHANDIGARH: Tel: (0172) 5024000 • CHENNAI: Tel: (044) 42444000 • GOA: Tel: (0832) 2438171/2437287 • GURGAON: Tel: (0124) 4094100 • GUWAHATI: Tel: (0361) 2468496 • JAIPUR: Tel: (0141) 2744033/35 • KOCHI: Tel: (0484) 4499000 • KOLKATA: Tel: (033) 22134000 • LUCKNOW: Tel: (0522) 4034000 • MUMBAI: Tel: (022) 66684000 • NAGPUR: Tel: (0712) 6624000 • PUNE: Tel: (020) 41044000 • SECUNDERABAD: Tel: (040) 44004000 • THIRUVANANTHAPURAM: Tel: (0471) 2720065 • VADODARA: Tel: (0265) 2330334/6614100 • VISAKHAPATNAM: Tel: (0891) 2748405 • VIJAYAWADA: Tel: (0866) 2484004 • Email: coolingsolutions@bluestarindia.com, visit us at www.bluestarindia.com or **SMS 'COOL' to 57575.**