National Centre for Cold-chain Development

List of Contents

by **Pawanexh Kohli**
CEO - NCCD

Integrated cold-chain development

Preamble

Cold-chain serves as a link between production centres and market. The following sectoral components typically require developing for an effective chain:

- Static Infrastructure - as initiators of the cold-chain, for term based storage, and as cross dock distribution hubs.
- Mobile Infrastructure - as links for post production and pre-market stages. These are designed to cater to logistical load factors (small volume transit and long haul transits). Additionally cold-chain extends to last mile retail or point of sale involving merchandising infrastructure.
- Standards & Protocols - as to define and for procedural processes for safety, designing, handling and for the operations of a wide array of finished products and raw produce, largely food or health related items.
- Skilled Resources - human resources to implement all above aspects in a cold-chain.

It is a given, that both source and markets exist as do national imperatives in developing effective and sustainable cold-chains.

The success of any cold-chain relies on how efficiently it can serve as a conduit for products that are sensitive to their holding environment (air composition, temperature, microbial load, etc), from the place of origin to their destination with full integrity. *Different products require different controls and practises.*

Static Infrastructure (Cold stores, Pack-house, Pre-coolers)

1. Change of Land Use

CLU from agricultural use to industrial use is required for setting up cold-chain centres and the procedure is long drawn out. While some centres serve as distribution hubs adjoining large density population centres, the initiating centres of cold chain such as pack houses with pre-coolers are mostly intended closer to farm-gate or at source farm level.

Cold-chain intrinsically serves as a marketing supply link for agricultural produce and hence directly impacts sustainability of producer/originator of the chain. Unlike most industries, it involves minimal industrial effluent and other industrial waste.

The delays and processes in acquiring CLU have a negative impact on cold-chain development.

2. Other Sanctions and Permits

Permits from TCP (Town and Country Planning), Pollution Control Board, Fire Departments, etc are treated at par with other projects.

There is no fast-track or priority processing system for permits issued to cold-chain infrastructure; slows down development initiatives.

3. Financing Options

Banks and other funding institutes do not provide priority funding to cold-chain projects as industry is considered nascent in meeting its operational challenges. Neither has NABARD been allowed to refinance banks or directly fund private sector entities. NABARD is effectively limited in their funding operations to State Governments and Government sponsored organisations only.

There are no preferential options or interest rates for funding cold-chain; no priority lending status.

4. Regulatory Construal Service tax

Under Finance Act, chapter 5 on service tax defines storage and warehousing service as "services for goods including liquids and gases but does not include any service provided for storage of agricultural produce or any service provided by a cold storage[1]".

Yet service tax is applied to various services provided at cold storages especially in correlation to the definition of agricultural produce. Furthermore, the definition of 'agricultural produce' is exclusive to activities intrinsic to an integrated cold-chain.

Effectively, the cold-chain is deprived of perceived benefits, with service tax exemption only being extended to limited single commodity storage, This is contradictory to the agenda of integrated cold-chain development.

Service tax exemption benefit is not applicable to modern cold-chain services; should include cold-chain activities and not cold warehousing alone.

5. Regulatory Construal Custom Duty

Government exempts cold-storage projects from basic custom duty as part of cold-chain development initiative. Yet, there are post project components that are necessary for optimisation of cold storage operations, namely: energy optimisation and automation systems, data recorders and other sensors. Lack of incentive detracts utility of such systems & induces low intake of new technologies. These monitoring components are also used in mobile refrigerated trucks.

[1] Finance Act, Ch-V, Section 65 (102), 66D(d)(v)

Custom duty is applied on post project technology options that are necessary for energy monitoring & modernisation; lack of promotion of energy efficient tools.

6. Technology Availability

Domestic manufacturers have been limited in developing wide array of indigenous refrigeration and associated control systems. As such, most modern industrial equipment and technology is imported from foreign suppliers or their marketing offices in India. These importer/sellers store limited quantity in the territory of India (DTA), to avoid cash flow concerns due domestic tariff implications.

'Lead time' in sourcing equipment adds to the delays in procurement and development; need to develop capacity of local equipment manufacturers.

7. Energy Options

Cold-chain intrinsically requires energy source for maintaining compliance to product specific environmental parameters. Availability of energy is random or minimal at farm-gate or cold-chain initiation level. Back-up systems are generally diesel fuel driven with associated costs.

While rising energy cost impacts all aspects of modern living, for cold-chain development specific policy focus on R&D and promoting use of alternate technology is required. Systems that use magnetic levitation, salt-based cooling, solar thermal energy banks as well as intelligent energy monitors need investigation and promotion.

Acute energy dependency and lack thereof impact cold-chain development; need to promote non-conventional or hybrid energy systems for cold-chain use.

8. General

Cold-chain development efforts were earlier largely focussed on building storage capacity basis hypothesis of cross seasonal carry-through of produce. This resulted in single commodity bulk storage development. This did not allow mass scale promotion of back-end pre-cooling or pack-house development. The large majority of fresh produce items require urgent farm-gate activities including pre-cooling to initiate cold-chain as a conduit to market. Modern pack-house as aggregators of farm produce need developing.

Government enablement through subsidy schemes allowed for development of cold storages, non-integrated, in isolation. Cold storages were therefore easily developed irrespective of the integration agenda.

Further as a result of subsidy policies, cold storages developed in clusters, irrespective of business model validation, or of impact on demand gap or viability in location considered. Example, excess capacity developed in regions for potato resulting in less

utility of cold storages. Cold storages should also be developed as distribution nodes and aligned to last mile consumer demographics.

Lack of business model parameters in subsidy support impacts future development trends; capacity building in market assessment required.

Mobile Infrastructure (Reefer Vans/Trucks, Carriers, Merchandising carts)

9. Availability

Cold-chain is ineffective without temperature controlled distribution connectivity between source point and market. Whilst we notionally have ~31 mill MT of cold storage[2] infrastructure, the capacity in reefer transport is estimated at ~7000 vehicles[3]. At an average of 10MT per vehicle with estimated turn-around of 1 week, this fleet translates into 3.6 mill MT only, or transport availability for only 12-15% of storage capacity.

Lack of reefer transport deters overall development of cold-chain; focus on transport including multi-modal options is needed.

10. Supply constraint

Reefer trucks are typically not sold off the shelf as in case of other vehicles. Very limited OEM manufacturers are supplying fully built refrigerated vehicles (reefers).

Normally, the OEM manufacturer supplies the base chassis. The same is retrofitted with its insulated body at a different premise by the insulated body manufacturer. Finally the refrigeration equipment supplier installs and commissions the reefer equipment. This arrangement has procedural, financial, warranty and cost repercussions.

Supply side constraints limit faster growth in reefer vehicle market; priority facilitation of reefer builders could be taken up or options to use existing trailers developed.

11. Financing Options

Vehicle procurement loans are available at low cost or through bank hypothecation route. Yet in case of reefers, the component chassis, insulated body and refrigeration are subject to differing financing norms.

The base chassis is financed at preferential market rates (8-13% interest for 80-100% cost), whereas the cold-chain components (insulated body and refrigeration unit) are financed at higher costs (10-15% interest for only 50-75% of their cost).

[2] Existing estimates and pending confirmation from NHB cold storage survey.
[3] Trade Estimates, no definite count available

In effect, a reefer vehicle has a higher cost impact than ordinary commercial vehicles or other vehicle types. No priority given towards this development.

Lack of domain understanding detracts from existing focus to ease financing options, instead there exists a higher financing cost to reefer vehicles.

12. Procedural Impediment

Reefer vehicles are subject to excise duty exemption. Yet, as they are supplied in disassembled components, the industry is effectively deprived from availing this fiscal benefit in a cost effective manner. Currently Central Excise authorities hold the view that the "Cab Chassis" itself is a finished product and as such cannot be moved for further job work.

Hence per Central Excise Rules, moving the cab-chassis for job work to complete the final reefer vehicle (fitment of cold-chain equipment), is subject to payment of excise duty (14% plus cess).

Alternately, the core utility components - reefer body comprising insulated container and refrigeration unit - are required to be transported to the truck chassis manufacturer's facility after paying excise duty. Thereafter, the aggregate vehicle is returned to originating plant for final inspection, integration and testing prior delivery. Finally, the tested vehicle has to be returned to the chassis OEM factory to comply with procedural (CENVAT[4]) requirements.

These activities to avail benefit involve extra to/fro transportation. This multiple movement adds to fuel wastage & costs, driver cost, delay in delivery to cold-chain users and increase to none-earning period of the asset owner.

Advantageous Regulations do not account for the production process and have adverse impact on cold-chain development.

13. National Permits

Reefer trucks are subject to National Permit to travel between states. This permit is applied annually and is not issued after 8th year, thereafter the vehicles are allowed to move intra-state only.

There is no specific consideration or rules for reefer vehicles under MVA 1988, reefer vehicles also being subject to colour coding for ordinary vehicles.

The process and the fees for such permits are at par with other ordinary vehicles (INR 16500/-). While some special utility commercial vehicles can be issued permits for larger periods of upto 25 years, reefer vehicles are not considered for same.

[4] CENVAT Credit Rule 4-5a (Subcontracting or Job work challan)

An important resource for cold-chain development is restricted in area of operation after its 8th year and this raises cost of utility.

Regulations limit the operating and earning life of Reefer vehicles; an extension to offset the shortage can be permitted.

14. Monitoring and Traceability

Limited promotion of monitoring of reefer parameters in vehicles. This allows for spoilage and excursions in cold-chain effecting trade. The same applies to cold storages.

There is no incentive for optimising operational controls on reefer transport. Tacking and monitoring systems can be promoted.

15. Regulatory Construal

Existing regulation exempt excise duty on components intended for installation in cold storage or refrigerated vehicles. Yet additional countervailing duty on the same components is regularly imposed when imported; even where safeguard or anti-dumping duty is not applicable.

16. Merchandising Infrastructure

Front end retail that completes the cold-chain includes street vending carts, retail shelves, display cabinets and retail side storage.

These have met little promotional focus and are causes for last mile loss in value including physical wastage. This also applies to non-F&V cold-chain in case of vaccines, ice-cream and meats & fish.

Recently set-up NMFP has agenda to focus on marketing and merchandising infrastructure. Similar developmental agenda to upgrade F&V retail establishments could be taken up. This will also help in promoting modernisation of F&V retail.

Cold-chain development focus misses out on development of retail infrastructure.

Standards and Protocols

17. Handling Protocols

Protocols as guided by regulatory authorities like FSSAI, WDRA, BEE etc must serve as a guide to the final standards to be implemented. As such, compliance protocols (safety, environment, energy) require development first to then serve as the primary driver for physical standards.

Product specific Protocols as linked to regulatory compliance are required.

18. Design Standards

Current 'Standards' are mainly focused on specifying infrastructure design and equipment and developed largely to facilitate the process of project appraisal for subsidy. This attention to engineering design aspects, limits innovation or induction of new technologies.

Standards require developing which focus across the entire activity chain with compliance to food safety and other safety regulations & environmental safeguards.

Specific standards about alternate technologies could also be developed to strategically focus attention pilot projects for innovation incubation.

Current standards focus on subsidy components and do not extend across other aspects of cold-chain.

19. Recommendations Vs Standards

Recommendations as part of knowledge dissemination should not be confused with Standards by both end users and subsidy appraisers.

Currently Recommendations are linked to regulatory Standards causing confusion among stakeholders.

20. Cold-chain Vs Cold Storage

Critical aspect of cold-chain is first stage pre-coolers and last mile delivery.

Standards, protocols or guidelines must include these components which are important to developing trade in the cold chain. Special design standards for delivery transport and product specific design for pack-house and pre-coolers are yet to be developed.

Cold-chain also requires extensive monitoring when serving as conduit to consumer. This requires localised and remote monitoring controls critical to its efficacy. Standards must be used to promote use of such equipment.

Current standards largely focus on storage development instead of integrating aspects of the source and market links.

21. Commercial Protocols

There exist no guiding principles to assist transactional bottleneck in cold-chain trade. There is an enhanced risk to cold-chain operators when handling perishable products wherein the service cost is disproportionate to risk and cost of goods handled.

Protocols for commercial transactions with cold-chain specific redressal guidelines are not available.

The need for these extends from initial installation standardisation to subsidy disbursal and operational guidelines.

The fear of risk exposure negatively impacts cold-chain development.

22. Producer Owner Models

Farmer groups are risk averse to extend links to markets over long distance. Pilot projects through a programme to mitigate via minimum risk coverage can be considered. FPOs/FIGs/FPCs can serve as direct source mechanism with retail groups.

Need for guiding principles or standards for policy makers to promote alternate cold-chain models developing direct market access. PPP-IAD can become important solution.

Developmental incentives that enable Farmers or Self help Groups to directly link to retail or wholesale groups are needed to promote entrepreneurship at farm-gate.

Skilled Resources

23. Resource Integration

Cold-chain is evident and successful in segments like frozen foods, dairy, pharmaceutical products as these require minimal skill-sets. Yet, the infrastructure and resource use has commonality.

Cold-chain is identified primarily with fresh farm produce whereas processed, fresh frozen and medical cold-chain is synergistic in skill and other resource utilisation.

Incorporating various synergistic uses will aid cold-chain development by providing scope to reduce viability gap and in enhancing operational skill sets. Most critically it will promote sharing of skilled resources across segments.

Inclusive policy across segments will add viability to the developing trade. Policy development should cater to allow for the total cold-chain utility instead of differentiating between product types.

Inter-ministerial coordination required to promote resource integration of cold-chain across segments and not be perceived to focus only on term storage of F&V produce.

24. Promoting Knowledge Based Services

Agriculture extension[5] services including education and training at farmer level is exempted from Service Taxes. Yet, cold-chain which serves as an extension to market from farm, does not find mention in such waivers.

[5] Finance Act Ch-V, 65B(4), 66D(d)

The knowledge gap is most acutely felt in cold-chain, largely as this service sector has yet to develop beyond the previous infrastructure development focus.

Appropriate skill-sets are intrinsic to cold-chain since such service involves product and cargo specific inputs and continuous attention. These skill inputs are in addition to those needed in the ordinary supply chain or other generic logistics activities.

Cold-chain training, awareness initiatives and skill development services should be included in negative list as part of the national cold chain development initiative.

Knowledge dissemination as a service to cold-chain development is inadequate.

25. Knowledge Centre

Cold-chain development is disconnected from India's Farming patterns -

- Cold-chain is currently the domain of technology makers, the focus remains on equipment and machinery.
- The operational and handling practises for perishable produce do not factor in the fragmented yield lots that will be handled in Indian cold-chain establishments at farm gate stage.
- Flexible designs of cold chain infrastructure will allow added utility given diverse produce cachement and flexible work force. Yet focus remains on large rigid designs as marketed by companies.
- India would benefit from a move from mass storage to direct-access storage, yet there is minimal focus on this option – most thought is focussed on traditionally understood concepts on cold-chain.
- Disconnected from India's Human backdrop-
  - The largest disconnect exists in ignoring the awareness and training gap. Untrained application of the cold chain creates greater losses.
  - While the viability gap and the seminars addressing it focus largely on the power factor. In truth, untrained utilisation adds to power wastage.
  - Operating errors lead to shrinkage, wastage, damage and all these occur after energy application. This thereby translates into gross energy loss.
- Lack of Domain Skills or access to trained knowledge base – nascent centralised knowledge resource specific to F&V care.
- No access to trained technical skills – sustaining specific cold chain links.
- No specialized institutes for cold chain technicians – only on the job training.
- No central body of knowledge on good cold chain practices for managers.
- No Training to financing bodies – lack of domain understanding.

Require focused development of –

- Technical Cadre – Engineers and technicians, who can install, commission, maintain and maximise the various equipment required in the cold chain.
- Knowledge Cadre – a cadre who will take decisions on appropriate climate control and handling for various fruits & vegetables; to enable the farmer to extract maximum realisation from any unit of produce.

There is minimal resource allocation to promote a centralised knowledge centre.

Inputs by the Chief Advisor

CONTROLLED ATMOSPHERE STORAGE: FRESH PRODUCE

Explaining the concept

The concept "Controlling the atmosphere"

Cold stores alter the temperature inside an enclosed chamber through the use of refrigeration. To save operating costs of the refrigerating equipment, insulation as a thermal barrier is used during construction to minimise external heat ingress. Depending on the product types stored, the cooling is distributed inside the chambers using fans which circulate cool air – in case of frozen temperature goods, the cold air need only shield the cargo, to isolate it from exterior peripheral walls and other heat ingress. In the case of living fresh produce, the cold air must additionally envelope each individual piece and penetrate interstitial space in storage to evacuate other gases & heat produced due to respiration. This is ordinary storage and does not involve any change to the base atmospheric composition.

Controlled atmospheres are essentially those which deviate from the normal air composition of 21% oxygen, 78% nitrogen and 380ppm of carbon dioxide. Other gases are also present but normally in too small a concentration to have a prime effect on stored produce.

Controlled Atmosphere cold stores are understood as cold storages designed and fitted with additional equipment such as to actively control the atmospheric content inside the closed chamber.

The concept involves forcibly purging the mass of air in a closed room with other 'inert' gas, to quickly obtain a low level of oxygen inside the chamber. Low oxygen levels (in tandem with controlled temperature) have been observed to further reduce the physiological rates of living tissue stored in such an environment. Controlled atmosphere technology benefits by reducing produce respiration, slowing ethylene production, inhibiting pathogen reproduction, and killing insects.

The most common inerting gas used is natural Nitrogen (abundant in plenty in earth's air). Special generator units are employed to extract the atmospheric Nitrogen (reducing O^2 content). The resulting air mixture is then pumped into the cold store chamber, purging the existing mass of air. The atmosphere content in the chamber is controlled to preset levels (depending on produce) and CA requirements complied with.

The main added cost component for building a controlled atmosphere store is the nitrogen generator with controls and associated fan blowers. The equipment regularly samples air parameters inside the target chamber to stop the system and to replenish with fresh air when needed.

Modified Atmosphere

Conversely, modified atmosphere storage involves the passive inducement of atmospheric parameters inside any enclosed space or package.

This can be compared to modern office buildings where human occupancy & activity self-induces changes to atmosphere content and raising the CO^2 and humidity levels beyond optimal working levels. These levels are monitored and controlled ventilation of fresh air is accordingly undertaken.

In case of long term storage of fruits & vegetables, the goods would continually manifest their presence by creating their own atmosphere through normal respiration. All cold stores monitor such parameters and maintain a living atmosphere over extended period by vent regulation. All modern cold store designs would qualify as MA stores.

Since, Modified atmospheres are self-induced due to normal respiratory activity, advantages to shelf life is exploited through MAP (modified air packaging), where semi-permeable packaging is used to sustain a localised MA condition inside the package itself.

Globally a lot of research has been conducted in quantifying the benefits from controlling the atmosphere when storing fruits and vegetables. The most commonly beneficial products accepted for commercial storage in CA are apples, pears, kiwifruits for long term and for temporary storage or transport of strawberries, cherries, bananas and lettuce. Research has continued on various other produce types.

In either case, the intent of CA storage is to extend the shelf life of fresh produce, wherein price realisation is possible through sale in their original non-processed condition.

When used for long term storage, CA storage is deployed as farm-gate infrastructure and designed to suit batch wise dispatch as per market requirement.

It is notable that CA conditions (low oxygen contents) are harmful to living produce when delayed after harvest, cannot be tolerated by produce which is in later stage of shelf life and must be enforced within first few days of harvest. If CA conditions cannot be operationally achieved within first 36 to 96 hours of initiation, the process is annulled and normal cold storage parameters are to be maintained. Once a produce has been removed from CA environment, it reverts to normal physiological activity and reintroducing into CA is harmful and causes tissue demise.

Cold storage Status in India

The Indian government promotes the development of cold-chain infrastructure. This includes cold storage infrastructure, transport infrastructure and point of production infrastructure. Development so far has manifested in the storage space, largely stemming from earlier successes with storing potato on an annual basis. For other horticultural crops, point of production infrastructure in form of pre-coolers and packhouses are required to serve as the base initiators of cold-chain movement. It is noted that food processing units as a point of production for food items have been successfully implemented. Without such production units, the goods cannot enter the cold-chain and hence instead of domestic produce transiting through our cold storages, we have imported produce that is effectively serviced.

In case of cold storages, two primary types persist. The first is farm gate infrastructure that is deployed close to producing regions for long term storage of farm produce. These storage types are designed for single commodity bulk storage where the produce is intended for subsequent sale over an extended period over its marketable life. These stores are predominated by potato stores and those for spices and specific crops like carrots, apples, oranges, onions, etc. CA stores, due to their base intent of extending shelf life over long term, fall under this category. Produce stored in such cold storage is not intended for repetitive handling and these stores can serve as initiating points for subsequent market links.

The second type of cold stores, are more transient in their nature of service. These are the distribution hubs close to market, those that are at point of consumption (retail outlets and fridges at homes), consolidation hubs (eg. for grapes and those appended to pack-houses), etc. The integrity of the cold-chain largely depends on this transit infrastructure including logistics. The goods handled in these stores are those with shorter shelf life, those that have exited bulk storage, and those that are enroute to market or final consumption. The majority of horticultural crops have a limited shelf life even when in the cold-chain and cannot be stored across seasons. Additionally, all products towards the end of their storage life, need to transit to market through such cold-chain facilities. Such storage infrastructure has only recently been developed in India.

Amongst laymen all cold storages seem to be the same but farm gate cold storage infrastructure must not be confused with the other types of cold storage, especially when correlating with the integrated cold supply chain that links farm to markets.

As per recent reports there are approximately 6000 cold stores in India, predominantly the farm gate long term storage type, designed originally for single commodity storage. In the last decade, more of the market linked transit type storage facilities have developed. Without these facilities, the chain breaks as soon as the produce exits farm-gate production units if there is no close to market facilities.

Pack-houses with pre-coolers with appended staging stores are not sufficiently present in India. Reefer transportation that links the primary processing units to the cold-chain service facilities are present to service existing trade in the must-have category (ice-creams, dairy, meats and imports in the cold-chain).

Use of Controlled Atmosphere (CA) Cold Storage

Apples are the major commodity stored in Controlled Atmosphere (CA) cold stores worldwide. The reason for limited commercial use of CA to relatively few products, despite experimented benefits on quality of many others, is related to cost benefit ratios. Like ordinary cold stores, CA structures must not only be air tight and refrigerated, but require added investment in equipment to modify and maintain the desired atmospheres. The volumetric size of these storage rooms is also optimised to maximize the value of the added equipment. Typically, adding CA equipment can increase the cost of constructing a cold store by x1.8 to x3.0 times depending on various factors.

Therefore, the return on investment requires long lived horticultural products that are stored for months and not days or even weeks. In addition, the extension of storage life is often too small to warrant added investment. If the storage potential of a particular product is a week, for example, then adding on a few days extra, is often not commercially significant.

However, newer tent-based CA based cold storage systems, with lower cost oxygen and carbon dioxide control monitors, are now available, and maybe more useful for shorter lived products. The tents and controllers are placed in cold storage rooms and have been used successfully for local market strawberries for example. Similarly, Modified Air Packaging which allows the produce's own respiration to alter the air composition inside the package, is considered more viable in case of short storage life products. CA is also used for long term storage of dry grains. Ripening rooms are examples of short term controlled atmosphere storage – in this case ethylene and CO_2 are the parameters controlled.

Since nitrogen is the most commonly used gas in controlling the atmosphere, special human safety aspects must also be deployed in CA cold stores. These include personnel O_2 monitoring instruments to safeguard inadvertent asphyxiation and nitrogen related hazards (one whiff of pure nitrogen can cause brain death). Nitrogen is generated by separating it from normal atmospheric air (78% Nitrogen) through special equipment. Alternately, gas injection from cylinders and CO_2 generators are also used in some facilities.

Additionally, since the internal atmosphere of a chamber is forcibly flushed, the chambers are fitted with pressure relief valves to avoid excess pressure build up inside the chamber which can cause the insulating walls to bulge outwards. CA cold stores maintain a positive internal pressure to avoid ingress of external air which is detrimental to controlled status. Monitoring equipment to record and control the CA conditions are also installed. Usually, once CA parameters are achieved – usually within 5 days of harvest – the gas generator can be switched off as natural respiration then continues to lower the oxygen level and effect CO_2 and other gases. At predetermined limits, outside air is then vented into the rooms to effectively maintain the desired levels – feed and bleed approach. Such cold stores also deploy CO_2 scrubbers and optionally ethylene scrubbers. Before sale of the stored produce, the entire chamber is flushed with fresh air with venting blowers to bring the atmosphere back to normal conditions and to make it safe for human access.

The most capital intensive component added to a cold store (with CA facility) is the Nitrogen generator with associated controls. The common N^2 generators are swing adsorption type and pressure membrane type (like reverse osmosis tubes). The capacity of the CA generator (in M^3 or litres per hour), is matched to ensure that the entire broken space in the cold store can be purged in 36 to 72 hours. If CO_2/O_2 parameters cannot be achieved in this critical initial duration, the space must be reverted to normal atmosphere condition and the produce should be maintained as in an ordinary cold store.

CA Cold Storage in India

Controlled Atmosphere storage in India has been well developed in case of apples, a model that is one of the most commercially accepted globally. In India, the single season produce, apple is selectively stored in CA cold stores with the intention to safely store the crop, while drip feeding the consuming market for the whole year, until the next harvest comes due, when the cycle is repeated.

The costs involved for building a controlled atmosphere Cold store are highly subjective and will depend on a variety of factors – source of equipment, design parameters, number of chambers under controlled atmosphere, type of utility, capacity etc. CA cold stores are used for storing of fresh produce over extended duration but in some cases, food processors may use CA stores to safeguard produce like peaches intended for canning purpose over short durations to counter canning line capacity restraints. In reference to NHB Guidelines and Standards (CS03); these take guidance from WFLO for the use of CA storage, and recommends only for Apples and Pears notably.

Components: differentiating technology of a cold storage

1. The Normal component costs applicable to a cold store, such as-
    a. Thermal structural barriers (Insulating wall, ceiling, floor, doors, air curtains)
    b. Refrigeration designed to produce type and capacity.
        i. Evaporators/Air handlers
        ii. Compressors/Condensers
    c. Humidifiers
    d. Energy efficiency controls
        i. PLC controls
        ii. Temperature monitors
        iii. RH monitors
        iv. Air Ventilation systems.
    e. Safety and structural components
        i. Emergency door release
        ii. Gas leak detectors
        iii. Fire Detection, fighting equipment
        iv. Effluent and waste treatment
    f. Handling and Storage components
        i. Docks – staging and receiving
        ii. Ante-rooms
        iii. Racking, bins, crates
        iv. Material handling equipment (Forklifts, pallet lifts, conveyor, etc.)

2. Add-on cost components specific to Controlled Atmosphere components-
    a. Gas generator – nitrogen generator – by unit capacity.
    b. Additional piping to supply gas to chambers
    c. Pressure relief valves or pressure equalisers
    d. Gas analysing/sensing instruments
    e. Added air ventilation systems
    f. CO^2 & ethylene scrubbers (where needed)
    g. Human safety – oxygen analysers
    h. Gas tightening walls etc with resin, coating/cladding
    i. Specialised Gas tight doors
    j. Storage Bins and special high reach trucks

While the CA components are an added cost to capital, the overall cost of these additional components is not a direct factor to the storable ton capacity of a cold storage. This is more so, in cases where only some compartments and chambers are designed for CA use. The remaining cold chamber space created is for use as normal temperature controlled storage.

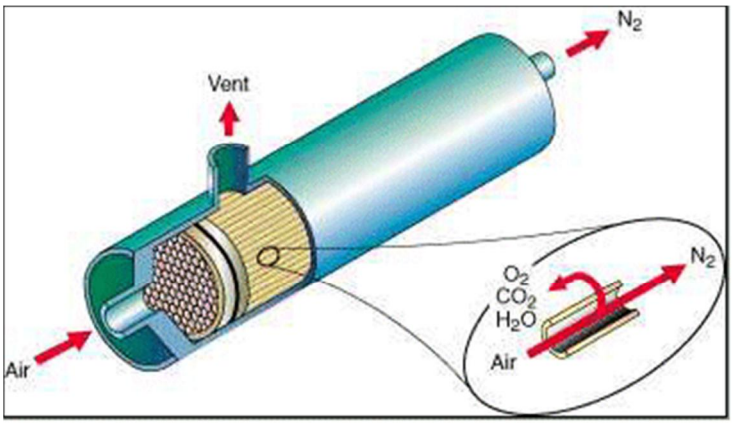
Not understanding the technology or its application, many projects are reported with nominative compliance with technical CA parameters from regions far distant from the established commercially tested norm (in desert regions, more than 8 hours distance from farms, in ports with intent to store imported produce, etc).

In such cases, where target intent is not the prevalent or commercially established norm, partial capacity for CA may be considered for trial pilot projects.

Nitrogen Generators

for Reference

What is MEMBRANE TECHNOLOGY



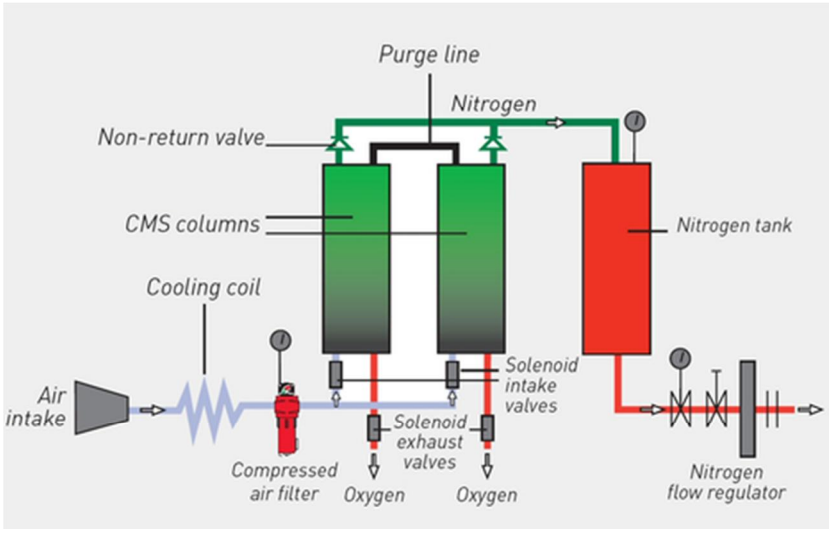
Compressed air enters one end of a permeable membrane. The membrane is comprised of many hollow fibres. The N^2 travels the length of the fibres and exits at the other end of the membrane. The O^2 in the air passes through the sidewall of the fibres and exits the side of the membrane.

Prior this basic process, the air mixture is treated to remove contaminants, moisture, etc. Nitrogen generated on demand and is directly pumped into enclosed chambers.

This technology is more modular for expansion, is mobile and similar to membrane sieve technology used in water purification (reverse osmosis) designs. It has a much reduced foot-print (a 10 feet by 20 feet container can house capacity to serve 15000MT of produce).

What is PSA TECHNOLOGY

Compressed air enters one end of two absorber tubes . . . filled with carbon molecular sieve (CMS). While the smaller oxygen molecules are absorbed by the CMS, the larger nitrogen molecules pass through and are stored. Upon saturation, the first adsorber releases the oxygen, which the second adsorber repeats the process over again for further purification for N2 levels.



After about one minute adsorption in one adsorption tower the process controller is switching over to the second tower and the first one is regenerated. Nitrogen generated is stored in tanks for subsequent use.

This technology is more commonly used in India and requires larger area to install.

Other methods involve stored nitrogen in cylinders (usually used for air transport) or in case of small storage options.

IMPORTANCE OF CONTROLLING THE ATMOSPHERE

CA storage has been the subject of an enormous number of biochemical, physiological and technological studies, in spite of which it is still not known precisely why it works. The actual effects that varying the levels of O2 and CO2 in the atmosphere have on crops varies with such factors as:

a. The species of crop
b. The cultivars of crop
c. The concentration of the gases in the store
d. The crop temperature
e. The state of maturity of the crop at harvest
f. The degree of ripeness of the climacteric fruit
g. The growing conditions before harvest
h. The presence of ethylene in the store

There are also interactive effects of the two gases, so that the effects of the CO^2 and O^2 in extending the storage life of a crop may be increased when they are combined. The practical advantages of storage under CA can be summarized as follows:

1. A considerable decrease in respiration rate, with a reduction in climacteric maximum, accompanied by an expansion of both pre-climacteric and post-climacteric periods
2. A reduction in the effect of ethylene on metabolism due to the interaction of O2 with ethylene, with a consequent delay of appearance of senescence symptoms
3. An extension in storage life, which can even be doubled, in as much as the over ripening is delayed
4. The preservation of an excellent firmness of flesh, due to effect of CO2 concentration on the enzymes acting on cellular membranes
5. A high turgidity is achieved, such that fruits are more juicy and crisp
6. A smaller loss of acidity, sugars and vitamin C, so that the nutritional and sensory quality is higher
7. A limited degradation of chlorophyll, with a consequent higher stability of color.
8. CA is also used for long term grain storage where it reduces wastage due to infestation by pests, insects, etc.

These benefits manifest commercially when storage span is longer than 3 months or where quality benefits are similarly realised in consumption markets. Partial in-transit benefits are also targeted as in case of cross continent ocean transport where an added week in special CA transport containers allows for longer times to new markets at added distances.

Commercial viability from controlling the atmosphere, either actively or passively ranges from product to product. In storage it is mostly used for long term storage at production end. For produce with short term storage it is used in transportation in specially designed refrigerated modes and by use of Modified Air packaging.

Dangers associated with Controlled Atmosphere applications

Safety of Life is prime concern since the environment maintained is not only oxygen deficient but has high levels of nitrogen. Nitrogen is highly dangerous for human life and one whiff of oxygen free nitrogen can cause brain death tissue. Minor leaks can cause irreparable damage. Inert gas asphyxiation becomes a major concern.

Prioritising Equipments

1. **Safety of Life.**
2. **Atmosphere Proof.**
3. **Positive Pressure.**
4. **Humidity Control.**
5. **Temperature Control.**
6. **Exhaust, Venting.**

Since positive pressure is maintained inside CA cold stores, to counter any inadvertent leakages developing, the structural integrity of the chambers requires better controls during installation. Appropriate pressure relief valves are deployed to counter high pressures that can cause bulging or more to cold room walls. A layer of resin is usually applied to its inside joints to maintain an atmosphere proof environment.

Since re-entry into an enclosed chamber is not possible once inerted (without compromising the intent of inerting), humidity and temperature controls must be well designed and automated. Of course, all this should typically be done for normal cold stores too, if truly building a modern facility. Finally, prior man-entry into an innerted chamber, it must be well exhausted and oxygenated to make it safe for human access.

Symptoms of Asphyxia

- 21% oxygen: Breathing normal, all functions normal.
- 17% oxygen: Candle is extinguished.
- 12 - 16 % O^2: Breathing and pulse rate accelerated. Ability to think clearly is diminished. Muscular co-ordination for finer skilled movement is disturbed.
- 10 - 14% O^2: Judgement becomes faulty. Severe injuries (burns, bruises, broken bones) may cause no pain. Muscular efforts lead to fatigue, may permanently injure the heart, and induce fainting.
- 6 - 10% O^2: Nausea and vomiting may occur. Legs give way. This is often the first and only warning and it comes to late. The person may realise he is dying, but he does not greatly care. It is all quite painless.
- < 6% O^2: Loss of consciousness in 10-45 seconds. Convulsive movements, then breathing stops. Heart may continue beating for a few minutes, then it stops.

¡ Remember CA Chambers CONTAIN LESS THAN 5% OXYGEN.

¡ Do not approach a relief (PV) valve even within 50 cm. Possibility of brain damage arises if even one breath of CA gas is taken.

High Carbon Dioxide

¡ The upper limit for CO2 in rooms for human occupation are:
- Continuous occupation (8 Hours) 0.5% CO^2
- 15 minutes exposure 1.5% CO^2

¡ In cold chambers containing respiring fruit or ripening rooms, the CO^2 levels can build up to dangerous levels (exceeding 5% possible).

Modified Air Packing

Modified Atmosphere Packaging is a way of extending the shelf life of fresh and other food products. The technology allows modification to the atmospheric air inside a package.

The simplest form of this technology is the application of a wax coat to the surface of the fruit. Similarly, selectively permeable plastics can be used to package fresh produce. In effect, the packaging serves like a molecular sieve and allows for normal respiratory process of fruit to alter the atmosphere inside the packaging within specified limits.

In some cases including meat, fish and processed foods, forcible flushing of the package with gas can be used to counter microbial build up and preserve the product longer. CO^2 in carbonated drinks is the most common example.

References:

- *Proc. Fla. State Hort. Soc. USDA, Agriculture Research Service Subtropical Horticulture Research Station*
- *Controlled Atmosphere Storage, Prof Kadel, University of California, Davis, CA*
- *Controlled Atmosphere and Modified Atmosphere Guidelines, ICCT*
- *Controlled Atmosphere Reefer vessels, CrossTree techno-visors*
- *NYS IPM Publication No. 10, Cornell University*
- *FAO Corporate Document Repository*
- *UNIDO Documents repository*
- *Inputs from stakeholder and user industry*

Costing of Project components for Cold Chains Date: 17-Nov-2012

Recommendation - NCCD

Cold Chain projects are eligible for support from the government for subsidies under various schemes. Currently, these subsidies largely apply towards-

a. Equipment and installation cost of cold warehouses.
b. Cost of Refrigerated vehicles.

The costs eligible for consideration are based on budgetary quotes received from suppliers as submitted by project promoters. The selected equipment to be procured and installed is basis the design and layout which is derived from standardised heat load calculations and base utility intended.

The specifications of the installation is to concur with minimal standards (guidelines) as currently adopted by Govt of India, leaving scope to the promoters to deploy higher standards in design and equipment in their project.

It is noted, that in presenting the costing and financials when applying for subsidy, there is frequent occasion where the budgetary costs are sourced from both Foreign and Indian suppliers.

NCCD's task is to promote holistic development of cold chain, both as a service industry and as a technology dependant & refrigeration based industry. In doing so, we propose that the subsidy provided by government of India, be judiciously applied to aid development of the industry base within the country and support the development of Indian companies.

It is therefore being recommended that all project costs be assessed for subsidy as follows-

1. Where equipment source is proposed from foreign entities, it should be ascertained that the same technology or quality standard is not available from Indian suppliers.
    a. *Case in example, insulation panels - These have standards and fitments that are available from Indian manufacturers. Similar for energy monitoring or control systems.*
    b. *Case in example, various CA or refrigeration equipment – these are not readily available by domestic manufacturers and hence need to be imported.*
2. Where equipment costs are to be imported at higher cost than available locally (using foreign exchange), a justification note should be included in project report exemplifying the contingent reason.
    a. *In case there are extended lead times from Indian suppliers, effecting project completion.*
    b. *In case the Indian suppliers are not able to meet standard criteria or quality norms.*
    c. *In case technology is not available in India.*
3. Indian cold chain equipment suppliers to be registered under NCCD and provide standard specifications and price lists on regular basis. Additionally they be open to tests and quality audits.
    a. *Cost standards can be drafted on a regular basis from all listed suppliers for ease in assessing subsidy considerations. This list can be provided to all appraisal committees.*
    b. *New technology imports and standards not available in India can be shared as business opportunity to equipment manufacturers promoting manufacturing in the country.*
    c. *Looking ahead at partnership with Cemafroid, various standards & certifications authorities (BIS, WDRA, BEE, etc) can be supported on revisions to appropriate standards, verification mechanism basis new developments.*

4. Provide incentive for indigenous innovation and to promote upgrading of technology component manufacturing and research within India, both by industrial suppliers and by technology institutes.
    a. *Import of technology and benefits of same will be categorised and highlighted. These will be announced as unavailable within India, providing important information to industry and research institutes.*

Recommendation:

1. Revision to costing of cold chain project components in line with those adopted for subsidies for Micro Irrigation projects with record of approved vendors/supplier list and price lists.
2. Import of technology where necessary to be documented with justification parameters.
3. Where technology goods are imported, a performance monitoring mechanism be established to document advantages to share with industry at large.
4. Quarterly list of imported technology be published to make Indian manufacturing industry aware of opportunity.

Benefits of such revision:

- Cold-chain Project promoters shall find ease in selection of standardised equipment and in preparation and submission of standardised project proposals.
- Appraisals of projects will be simplified having established base comparators for industrial equipments used. This will assist both financing institutions and technical appraisal teams.
- Subsidy spends to cover forex transactions shall be minimal. Revision will not infringe upon choice of promoter to source from foreign partners but shall mitigate subsidy component from unnecessary forex spend, unless there is a value-add is confirmed in terms of technology or business contingency.
- Industrial equipment manufacturers and Technology providers once registered shall require complying with standards or guidelines as they are further developed. Standards accreditation bodies will thereby have itemised components to assess and accredit.
- Structuring subsidy spend will allow developing of greater collaboration and associated technology transfer with foreign technology providers who seek long term association with Indian cold chain market. It will help drive and promote setting up of units by foreign providers in India.
- Subsidies granted will thereby serve dual purpose of developing cold chain in India both for service / project owners and equipment providers.
- Will aid in formulating a redressal mechanism with registered suppliers on user's quality concerns that may otherwise negatively impact cold chain development. Will also facilitate organising of institutional maintenance and domestic R&D initiatives.
- Indian cold chain equipment supplier industry shall see this as a positive and inclusive move and can take future direction for business development from this initiative.

Cold-chain Investments in India

A Projection

2012 – 2017

National Centre for Cold-chain Development

E: Contact-NCCD@gov.in / NCCD.India@gmail.com

T: 011 – 2306 1595

Office: 645A, Nirman Bhawan, New Delhi 110001
Director: Krishi Bhawan, New Delhi 110001

Total investment projected in cold chains over the next 5/10 years

As per estimates by the National Centre for Cold-chain Development (NCCD), the total investment expected in India's cold chain in the next 5 to 10 years is approximately USD 6 to 10 billion. These estimates are based on the following, basis current costing norms. This investment estimate does not include cost of land and added cold-chain ancillary requirements-

- Current gap in cold storage infrastructure estimated about 40 million metric tonnes
- Estimated investment of $ 5 billion in storage infrastructure alone; at average cost of $ 127 per ton capacity for multi-product storage other ancillary infrastructure. The land and other infrastructure would require further $ 5 billion investment.
- Specialised storage systems like Controlled Atmosphere cold stores would involve a higher investment cost of $ 580 per ton capacity.
- Further investment would be needed for upgrading technology of existing cold storages, which is estimated at $ 27 per ton capacity. Such upgradation involves thermal integrity, refrigeration installation, handling systems, etc.
- These cost estimates are linked to norms for minimum design standards as established by the government.
- In refrigerated transport, the capacity is required to grow 3 fold to fully service the existing and more for growing storage capacity. Current estimate of refrigerated transport indicates an available on road capacity of only 3.6 million MT.
- An estimated $ 1 billion investment will be required for long haul refrigerated transportation. A refrigerated vehicle of 10 ton capacity currently costs $ 44,000/.
- Each cold storage on an average employs 10 direct employees and approximately 50-100 handlers. Currently we have 6488 cold storages (30.4mill MT), and this is expected to double in capacity in next 5/10 years. This requires added investment for training approximately one million skilled and semi-skilled employees in this sector. An investment of approximately $ 300 million is projected for this.
- Similar investment will be needed to train refrigerated transport operators and technicians (road and rail). Each road transport employs two drivers, one helper and shared maintenance technical staff.
- Investment will additionally be required in developing farm-gate level packhouses with precoolers as initiators of cold-chain, specifically for horticulture produce. Infrastructure cost for such packhouses with precooling capacity of 15 MT per is about $ 50,000 per unit. Currently there is negligible capacity available in the country.
- To complete the cold-chain, there is front-end investment required at retail end, both for walk-in buffer storage and vending platforms or shelf space.
- The other investment needs are in testing and certification labs, research and protocol development centres, specialised training centres, transaction based IT network, handling and packaging equipment.

Plans/Strategies of achieving these targets

- Easing of import rules for cold-chain equipment including refrigerated vans.
- Developing FPOs and FIGs and enabling them to develop direct market links.
- Developing improved business models by promoting producer owned supply chains.
- Amendments to APMC aimed at enabling direct market driven supply chains and opening options through alternate market channels.
- Continue extant grants and subsidy schemes for cold-chain infrastructure development and extend the schemes to include the logistics and transport sector.
- Develop multi-modal cold-chain links through rail and highways, aimed at a fast track green corridor for perishables.
- Promote use of Negotiable Warehouse Receipts for notified perishable goods stored in WDRA accredited cold storages.
- Exemption of all cold-chain activities including knowledge dissemination in cold-chain from service tax.
- Promote HRD for all levels of cold-chain; farm-gate aggregation and pre-cooling, storage, transport, handling, packaging.
- Establish produce specific protocols linked with domestic FSSAI and ATP Legislation for the export markets.
- Promote energy efficiency and low carbon imprint technologies and operational processes in the cold-chain.
- Promote development of a national virtual network or grid of cold warehousing and transport available to public lease.
- Establish National Centre for Cold-chain Development (NCCD) as centre of excellence to promote an integrated approach to cold-chain development, spanning agricultural and non-agricultural products.
- Implement recommendations of Dr Saumitra Chaudhari Committee (DSCC) Report, for strengthening supply chains, in XIIth Plan.

The status of tax reliefs and financial incentives

- Basic Custom duty at a nominal 5% for imports specified for cold-chain projects.
- Basic Custom duty Nil for import of Reefer vans and containers.
- 100% FDI through automatic route open for cold-chain.
- ECB route open for cold-chain infrastructure.
- Investment subsidy of 40% for cold chain projects is available.
- Service tax is exempted for storage of agricultural produce in cold storages and warehouses.

- Service tax is exempted for erection, installation or commissioning of cold storage equipment; transport; technical testing and analysis service by state or central certification agencies.
- Deduction of 150% of Capital expenditure incurred for setting up and operating a cold chain facility (for computing taxable income).
- Excise duty is fully exempt for specified equipment for cold storages or transport.

Status of PPPs in this area

- NCCD has been setup as an autonomous organisation in PPP mode with Govt and industry participation. The mandate of NCCD is to provide enabling environment through developing standards & protocols, HRD and applied research for integrated cold-chain.
- Govt participation is through credit linked subsidy schemes to strengthen the equity base of the cold chain projects. Since 2009-12, government has participated by disbursing INR 739 crore as subsidy to cold-chain projects.

The work being done with other Governments

- Cooperation in the field of agriculture which includes development of cold chain is being implemented through work plans with Israel, Netherlands and France. The focus is on developing produce specific Centres of Excellence to showcase technologies in specific states, applied research and implementation, knowledge exchange through subject matter experts, capacity building programs, promotion of PPP including exchange of business delegations. The implementation of projects in the participating states under these cooperation programmes is monitored by Joint Working Groups (JWG).