FOOD CONSERVATION AND ENERGY EFFICIENCY IN THE COLD CHAIN AND UNIDO'S RELATED PROJECTS

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Refrigeration impacts the global warming through the emission of refrigerants that account for around 20% of total CO2-equivalent emissions from refrigeration and impacts through energy consumption of around 80% of CO2-equivalent emissions. Simply put, an impact reduction on CO2-equivalent emissions from refrigeration is therefore possible and ideal by improving energy efficiency of the systems and the overall cold chain and by adopting refrigerants with 0 or low climate impact, such as natural refrigerants.

Worldwide it is estimated that 40% of all foods require refrigeration, and that 15% of the electricity consumed throughout the world is used for refrigeration . With the rising concern over climate change, global warming as well as the insecurity in development and fluctuations in energy costs there is increasing pressure to make significant reductions in carbon emissions and energy use. Furthermore, the inappropriate management of the cold chain in the food industry is widespread, especially in developing countries, due to severe issues related mainly to technical, knowledge and investment challenges. These issues can lead to serious problems such as waste of electricity to feed the cold chain, release of powerful greenhouse gases into the atmosphere and post-harvest losses. Already in 2008 Coulomb estimated that post-harvest losses currently account for 30% of total production. Recent projections show an increase in the inefficiency of the overall food systems, causing an increase in post-harvest losses. The production of food involves a significant carbon investment that is squandered if the food is unutilized.

As illustrated in the following table there is a direct link between food losses in developed and developing countries and the availability of cold chain equipment. It emphasizes that food losses in developing countries are considerably higher than in developed countries which can be related to the number of refrigerating equipment available. These heavy losses and the impact of incorrect conservation of products affect the alimentary security and rural and urban economy, increasing prices variation and making products less available to consumers. Losses reduce the producer's incomes discouraging the alimentary production and limiting the modernization capacities of the several players. These losses of about hundred million tons of food involve also the exploitation of non-renewable and rare sources and contribute to global warming.

	World	"Developed" countries	"Developing" countries
Population			
Population in 2017 (billions of inhabitants)	7,6	2	5,60
Cold Chain equipment rate			
Volume of frigorific storage (m3/1000inhabitants)	52	200	19
No of controlled-temperature transport equipment (million)	4	2,73	1,27
No of transport engines under directed temperature (no inh./engine)	1708	450	4421
No of domestic refrigerators (/1000inh)	172	627	70
Loss rate			
Food losses (all products)	25%	10%	28%
Fruit and vegetable losses	35%	15%	40%
Losses of food not suitable for cold chain	20%	9%	23%

Improperly designed cold chain systems cause food losses and energy waste to produce this food. Hence, there is the need to also strengthen existing food systems. Successful implementation of cold chain systems requires the coordination and cooperation of multiple stakeholders at different stages of transfer. It also requires financial intervention and support for system participants at strategic stages in the system and with different economic interests and capacity to absorb catalytic capital. Cold chain systems have common elements but each system needs to be uniquely designed based on product, local economic, geographic, regulatory, and financial considerations. Therefore, it includes a variety of stakeholders along the entire food cold chain, who are not connected or brought together in the existing industrial environment of a majority of (developing) countries. A common platform, community, center or similar to enhance cooperation could be crucial for effectively improving the cold chain in the country.

Moreover, a recent review of cold chain development points out that "even in many regions or sites where adequate infrastructure is available, overall knowledge of proper cold chain practices, maintenance (including availability of spare parts), and applications are weak in most of the developing world, and it is generally worst in facilities owned or operated by government than in facilities owned or operated privately". This is of particular concern to climate change because lack of proper maintenance and knowledge very often translates into an inadequate management of the lifecycle of refrigerant gases. More refrigerant leakage means less efficient equipment and higher emission of high-GWP gases into the atmosphere.

Case study: UNIDO's food cold chain project in the Phillipines

Fresh and safe food is critical especially in the Philippines. It is home to 100 million people and is the seventh most populated nation in Asia and the twelfth most populated in the world. While the Philippines may be regarded as a newly industrialized country that is transitioning from an agricultural economy to one based more on services and manufacturing, an adequate cold chain is critical to feed such a large population and sustain its export/import potential. The cold chain industry in the Philippines, which currently has a holding capacity of approximately 300,000 metric tons, is at a delicate equilibrium between capacity and demand. At this point, there is strong potential for the industry to grow, given that consumption levels are currently low and that economic development will enhance purchasing power.

The cold chain is not a unique and defined process. It covers every produce that needs cooling from the field to the fork (including transport, storage, transformation, packaging) and it does not exist a unique cold chain applicable for all produces. Therefore the interventions to improve the energy efficiency along the cold supply chain are similarly complex.

The pillar of cold chain is based on "a golden rule" defined by Alexandre Monvoisin which describes the three main principles known as Monvoisin Tripod (1925):

a. A high-quality product, clean and healthy: because cold cannot increase the initial quality of the product
b. Early refrigeration: it is essential to applicate cold as soon as possible, after the harvest or the transformation
c. Continuous refrigeration to maintain to the end life of the product: it is this last criterion which introduces the notion of cold chain.

As every produce is different, it is not possible to define a unique cold chain with specific equipment and competences. However, general rules and approached can be applied by keeping in mind the Monvoisin Tripod as general objective.

Energy efficiency in the Cold Chain – Practices & Equipment

During project preparation, UNIDO conducted a study to assess all possible options and areas of intervention to increase the efficiency of cold chains in developing countries beside the refrigerant. In summary the analysis points out the energy efficiency and reliability of the cold chain depends on the quality of the involved stakeholders. The first level of stakeholders includes the players directly operating the cold chain, such as the decision maker, the installer, the service technician, the controller and the user.

The assessment also showed that the choice of equipment and set up, the installation, the maintenance, the control of equipment, the use of equipment as well as the produce

handling by the consumer have been identified as areas of necessary intervention to insure reliability and increase energy efficiency. In many scenarios, each of these areas involves different people that need adequate awareness raising, capacity building and/or technical training.

The obvious (and most effective) interventions fall in the area of financial support for the replacement of equipment, adoption of greener refrigerants and up-to-date technology promotion through technical training. These will not be, however, the only one area of focus in the project. The room for improvement with high impact at only small costs identified by the study is remarkable and will be integrated into the project as well. For example, it was highlighted that proper and regular maintenance of existing systems in general saves minimum 5-10%. As concrete example, it was mentioned that heat exchanger fouling conduces automatically to the decrease of the energy efficiency (by -12 to -25% according to P. Smekens, energy consultant at CCI Hainaut), the increase of consumption and the accelerated wear of compressors. Furthermore, incorrect use of equipment can have an impact on the energy consumed. This includes simple practices changes, such as closing the doors of cold rooms during operation, switching-off mobile refrigeration units while opening doors of refrigerated trucks, parking refrigerated trucks in the shade, piling the pallets in different ways, regular controls of all equipment parameters etc.

The presentation will give insights into the general importance of energy efficency and the food cold chain and showcase related projects from various regions in the world.