SINGAPOREAN JOURNAL OF BUSINESS ECONOMICS, AND MANAGEMENT STUDIES (SJBEM)

www.singaporeanjbem.com Research Paper

ICEHOUSE TO PERSONAL REFRIGERATION: REFRIGERATION INDUSTRY AND THE GREEN INNOVATION

Ajith Shanmuganathan
Doctoral Student, University of Kelaniya, Sri Lanka
Corresponding Author Email: kksajith@icloud.com

Abstract

Food is a critical commodity for human survival, and the availability of the food impacted by preserving the surplus food. The humankind has used several ways of protecting perishable foods, and cooling is one of the most convenient and widely used methods to store and transport the food. While industrial, commercial and domestic refrigerators play a significant role in the preservation, the impact on energy and environmental factors are also critical factors to be taken into consideration. This article tries to reveal the antiquity and necessity of the cooling industry worldwide in the context of green innovation and try to explore the future need for such studies.

Keywords – Cooler, Food, Innovation, Refrigeration, Sri Lanka
JEL Code – N25, N65, O00

Introduction

It was a dream for the humankind to save and preserve food for a long time for their survival in winter. In the early days of civilisations, The man used several ways of preserving food such as curing, cooling, freezing, boiling, sugaring, Pickling, lye, canning, jellying, Jugging, Burial, Fermentation. In the modern world Pasteurization, Vacuum packing, artificial food additives, Irradiation, Pulsed electric field electroporation, Modified atmosphere, Non-thermal plasma, High-pressure food preservation, Biopreservation, and Hurdle technologies added to the traditional food preservation techniques. Nevertheless, the easiest and convenient ways of preserving the food from the early days to date are cooling & freezing. Asper the IIR estimation in 2015 there were 1.5 billion Refrigerators and freezers categorised under Domestic refrigeration and 90 million Commercial refrigeration equipment classified under Commercial refrigeration are equipped worldwide which directly contribute to the Refrigeration of food. IIR estimate based on an analysis of fragmentary data about the sectorial electricity consumptions, the refrigeration sector consumes about 17% of the total electricity used worldwide.

Table 1: Refrigeration systems in operation worldwide per application

Applications	Sectors	Equipment	Number of units in operation
Refrigeration and food	Domestic refrigeration	Refrigerators and freezers	1.5 billion
	Commercial refrigeration	Commercial chilling equipment (including condensing units, stand-alone equipment and centralised systems)	90 million
	Refrigerated transport	Refrigerated vehicles (vans, trucks, semi-trailers or trailers)	4 million
		Refrigerated containers (« reefers »)	1.2 million
Air conditioning	Air conditioners	Air-cooled systems	600 million
		Water chillers	2.8 million
	Mobile air-conditioning systems	Air-conditioned vehicles (passenger cars, commercial vehicles and buses)	700 million
Refrigeration and health	Medicine	Magnetic Resonance Imaging (MRI) machines	25,000
Refrigeration	Liquefied Natural Gas (LNG)	LNG receiving terminals	110
		Liquefaction trains	92
		LNG tanker fleet (vessels)	421
Heat pump		Heat pumps (residential, commercial and industrial equipment, including reversible air-to-air air conditioners)	160 million
Leisure and sports		Ice Rinks	13,500

Source - (*The Role of Refrigeration in the Global Economy*, n.d.)

From the ancient time, man preserves food by keeping it in low temperatures. Before mechanical refrigeration systems introduced, people cooled their food with ice and snow, either found locally or brought down from the mountains. Icehouse is the first human-made cold storage using natural means. During the winter the ice houses are made naturally near the freshwater lakes or using snow and ice in the western countries. Icehouses were used to cool the drinks and store the fresh meat for a particular period using mountainside runoff from melting snow. Later humanity realised the requirement of storing food in summer and the term refrigerator introduced in the 17th century. William Cullen demonstrated the first known artificial form of refrigeration at the University of Glasgow in the year 1748. However, he did not practice his discovery for any applied purpose. The Scottish inventor William Cullen designed a machine in 1977 which creates a small amount of cooling.

The device was known as the first invention of the refrigerator, which has no practical application due to its complicated design and lower cooling. Later in 1805, Olive Evans and 1820 Michael Faraday further developed the system using vapour-compression refrigeration & liquefied ammonia respectively. James Harrison in 1856 patent, commercial ice-making a machine which was commercially successful(Pearson, 2005). Elkins patented an improved refrigerator design on November 4, 1879. Elkins designed the device to help people have a way of preserving perishable foods. At that time, the conventional method of keeping food cold was to place items in a large vessel and surround them with large chunks of ice. Unfortunately, the ice generally melted very quickly and the food soon perished. It also intended to freezing human corpses to make the body getting decomposed. Elkins' patent for an insulated cabinet into which ice is placed to cool the interior. Elkins accredited in his patent that, "I am aware that chilling substances enclosed within a

porous box by wetting its outer surface are an old and well-known process."Up to this period, the commercial refrigerators were successful, and in 1918 a company called Kelvinator introduced the automatic control refrigerators to the market.

World Trends

General Electric introduced the commercialised version of the refrigerator in 1927, and over a million units were produced after that. Artificial refrigeration was introduced in the mid-1750s, and significant evaluations happen in early 1800s. Commercial refrigerators were in use for the last 40 years using the gas system ammonia or sulfur dioxide. The commercial refrigerators equipped with glass-fronted, which the product is visible to the customers. This is a very valuable breakthrough in marketing where the customers visualise the chilled products. This has initiated a more massive throughput of beverages and changed the whole beverage industry. Nowadays, refrigeration plays a significant role in the beverage industry, Food processing & preservation, medical and process industries. Home refrigerators and freezers for foodstuff storages are manufactured in a variety of sizes. Amongst smallest is a 4 L Peltier refrigerator promoted as being able to accommodate six cans. A domestic refrigerator stands as tall as a person, and about 1 m wide with a capacity of 600 to 1500 L. Some models are for small homes fit under kitchen tops, usually about 86 cm high. Refrigerators may be joint with freezers, either stacked with freezer above, below, or side by side. A fridge without a cold storage compartment may have a small section to make ice chunks.

Cooling Industry and Sri Lanka

"Traditional Sri Lankans grew plenty to consume and to share. The surplus was conserved to be used in the future. Food conservation was done for two reasons. Firstly, to ensure future food security, then to make available during the leaner periods." — Professor Nimal F. Perera, Department of Agriculture, University of Peradeniya.

During the times when Ceylon was under the rule of British, ice cubes were imported and auctioned at the dock and buyers used to fold them into thick blankets and hurry home as soon as their horse carriages would take the ice. These white pieces of ice created tremendous interest amongst the social elite of the day and were available only at functions and houses of the socially privileged. With an initial capital of £1,600, two steam engines of 8 & 9 horsepower and a total of 22 staffs, the Colombo Ice Company initiated producing ice on a commercial scale for a growing market under the leadership of the manager of the firm who is a German Engineer Arthur Von Possner. In those times, The Colombo Ice Company premise was in Glenie Street was popularly called 'Ice Kompaniya'. After that, the entire district officially converted known as 'Kompaniveediya'. The Colombo Ice Company was similarly in the business of making 'aerated waters', formally known as 'carbonated beverages' Mr Von Possner introduced the elephant trademark to Sri Lanka which continued a popular household brand to this date.

Mr Tom Walker, a proprietor of a competing business in the aerated water manufacturing at the time acquired The Colombo Ice Company and was combined and retitled as the New Colombo Ice Company Limited on 8th of May, 1894. Mr Tom Walker was the managing director of the New Colombo Ice Company Limited. By 1925, the company moved on to build cold storage for frozen products of all kinds, opening new cold stores in Colombo on 1 December 1928, the same year the company purchased another smaller rival, the Pure Ice and Aerated Waters Manufactory. In 1932, Ceylon Creameries Limited was acquired to produce and distribute reconstituted fresh milk and ice cream. In 1934 the New Colombo Ice Company Limited swallowed the Ceylon Ice and Cold Storage Company which established the import of frozen foods to Ceylon. A carbonic acid gas plant was installed in 1935 to produce carbon dioxide and dry ice. Later on, the Colombo Ice Company Limited altered its name to the Ceylon Cold Stores in 1941. Elephant House owes its roots to 'The Colombo Ice Company' which was formed in 1866.

In 1941, New Colombo Ice Company transformed its name to Ceylon Cold Stores Limited. In 1964 Mallory Wijesinghe became its first Ceylonese chairman. In January 1970 the company listed on the Colombo Stock Exchange. Ceylon Cold Stores came under the umbrella of John Keells Holdings Limited with the acquisition of the Whittalls Group in 1991. John Keells Holdings holds the 54% majority shareholding in the company. Sri Lanka has a population of nearly 22 M and 35.1% of the people are equipped with refrigerators. As in the current context of Sri Lanka, the depreciation of rupee value is more venerable to currency crisis which is a significant factor affecting the country's economy rapidly. Central Bank Governor Dr Indrajit Coomaraswamy declared the rupee was under pressure more due to exogenous factors("Crux of currency crisis! | FT Online," n.d.). He further states that for Sri Lanka the best buffer and resilience is

develop exports to boost reserves and attracting Foreign Direct Investment The factor in our hand, which can be controlled to sustain the economy, is to reduce the import and increase the exports.

Innovation

In the international market, the Sri Lankan products need to confront and compete with the revels to have considerable growth in the exports and to attract the investors to Sri Lanka. In a competitive business, the atmosphere will survive and succeed only those enterprises that can come up with new ideas and unique products or applications (Ali Taha, Sirkova, & Ferencova, 2016). There are two significant changes in the business environment happening in these days which will change the business environment rapidly, and those two are One Belt, One Road (OBOR) and the Fourth Industrial Revolution (4IR) in the world (Shanmuganathan, 2018). Although technological innovation and its role in the economic growth of advanced countries has been studied in-depth, a detailed reading of the literature shows that there has been little examination of the determinants of technological innovation and the essential factors for successful industrial innovation in developing countries (DCs) in general and Middle Eastern countries in particular (Bagherinejad, 2006). (Efrat, 2014) state, Cross-border knowledge spillovers and the race between nations for increased innovativeness only underscore the importance of innovation.

One of the recent development in the industry in terms of innovation is the reinvention of the refrigeration system to use Carbon dioxide as the refrigerant. Carbon dioxide has been used as a refrigerant in vapour compression systems of many types for over 130 years, but it is only in the last decade that inventive minds and modern techniques have found new ways to exploit the unique beneficial properties of this remarkable substance(Pearson, 2005). The limiting aspect for most carbon dioxide systems is currently pressure, and this increases the expenses of accessories of the refrigeration system. In such a case, is this development is financially suitable for developing countries? This area needs an in-depth study to have a balance in-between the green innovation and the technology adopted in developing countries.

Green Innovation

Green Innovation fundamentally change the way we do business, and the manufacturers need to push the innovative boundaries from the platform what is currently believed possible. GI is directly linked to the Green Economy (GE), especially in the refrigeration industry. Some scholars classify the green innovation into green technology innovation (GTI) and green management innovation (GMI) while some others as proactive green innovation (PGI) than the reactive green innovation (RGI). It is also essential to have new technologies to manage green innovations. Tesco cut its annual refrigeration cooling costs by 20% across the UK and Ireland by analysing gigabytes of refrigeration data(Wang, 2018). Big data analysis bringing hidden information to light and pave a path to make business decisions and innovative and choices prolong to green initiatives.

Table 2: summary of Definition

Reference	Definition
(OECD, 2009)	The creation or implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organisational structures and institutional arrangements which – with or without intent – lead to environmental improvements compared to relevant alternatives

(Arundel & Kemp, 2009)	A new concept of great importance to business and policymakers. It is about innovations with a lower environmental impact than relevant alternatives. The innovations may be technological or non-technological (organisational, institutional or marketing-based). Economic or environmental considerations can motivate Eco-innovations. The former includes objectives to reduce resource, pollution control, or waste management costs, or to sell into the world market for eco-products
(Oltra & Saint Jean, 2009)	as innovations that consist of new or modified processes, practices, systems and products which benefit the environment and so contribute to environmental sustainability
(Reid & Miedzinski, 2008)	the creation of novel and competitively priced goods, processes, systems, services, and procedures that can satisfy human needs and bring the quality of life to all people with life-cycle-wide minimal use of natural resources (material including energy carriers, and surface area) per unit output, and a minimum release of toxic substances
(Andersen, 2008)	as innovations which can attract green rents on the market. (. . .) The concept is closely related to competitiveness and does not claim the "greenness" of various innovations. The focus of eco-innovation research should be on the degree to which environmental issues are becoming integrated into the economic process
(Kemp and Pearson, 2007)	the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives
(Chen, Lai, & Wen, 2006)	hardware or software innovation that is related to green products or processes, including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs, or corporate environmental management
(Driessen & Hillebrand, 2002)	Does not have to be developed with the goal of reducing the environmental burden. (. . .) It does, however, yield significant environmental benefits
(Fussler & James, 1996)	new products and processes which provide customer and business value but significantly decrease environmental impacts

Conclusion

It is essential to understand the future of the cooling industry of Sri Lanka, where the food and beverage industries majorly depend on the cooling industry. The general perception was that, due to steady economic growth in the last decade, the purchasing power of refrigeration units and air conditioners of middle income and lower-middle-income groups had substantially increased. One of the dominant power consuming industry is cooling. Hence there should be a balance to be managed between two sectors to develop the green innovation keeping in mind, the developing countries economic status and the current depreciation of rupee value against us dollars. There is the technological improvement in the data collected from the commercial refrigeration units such as energy control modules, data collection elements etc. Nowadays, the units are directly or indirectly connected to the internet of things (IoT). Therefore it is straightforward to collect data from the units intended to be monitored and controlled. In such case, the raw data to be analysed in a big data environment for a decision making and the artificial intelligence (AI) can be used to predict and forecast the green innovation to be developed in the future. There are many studied carried out in the western countries, and there are very few studies carried out in the Sri Lankan context. There is a potential for analysing this subject further, and research needs to be carried out to understand and to choose the correct innovation model by the Sri Lankan refrigeration industry to sustain in the competitive international markets.

References

Ali Taha, V., Sirkova, M., & Ferencova, M. (2016). the Impact of Organizational Culture on Creativity and Innovation. Polish Journal of Management Studies, 14(1), 7–17. https://doi.org/10.17512/pjms.2016.14.1.01

Andersen, M. M. (2008). Eco-Innovation-Towards A Taxonomy And A Theory Entrepreneurship And Innovation-Organizations, Institutions, Systems And Regions Eco-Innovation-Towards A Taxonomy And A Theory Eco-Innovation-Towards A Taxonomy And A Theory. In JEL-codes: L. Retrieved from https://www.researchgate.net/publication/228666208

Arundel, A., & Kemp, R. (2009). Measuring eco-innovation. UNU - MERIT. https://doi.org/10.1111/j.1467-629X.1980.tb00220.x

Bagherinejad, J. (2006). Cultivating technological innovations in Middle Eastern countries. Cross Cultural Management: An International Journal, 13(4), 361–380. https://doi.org/10.1108/13527600610713440

Chen, Y.-S., Lai, S.-B., & Wen, C.-T. (2006). The Influence of Green Innovation Performance on Corporate Advantage in Taiwan. Journal of Business Ethics, 67(4), 331–339. https://doi.org/10.1007/s10551-006-9025-5

Crux of currency crisis! | FT Online. (n.d.). Retrieved September 27, 2018, from http://www.ft.lk/top-story/Crux-of-currency-crisis-/26-663273

Driessen, P., & Hillebrand, B. (2002). Adoption and diffusion of green innovations. In Marketing for Sustainability: Towards Transactional Policy-Making. https://doi.org/10.1007/s13398-014-0173-7.2

Efrat, K. (2014). The direct and indirect impact of culture on innovation. Technovation, 34(1), 12–20. https://doi.org/10.1016/j.technovation.2013.08.003

Fussler, C., & James, P. (1996). Driving eco-innovation : a breakthrough discipline for innovation and sustainability. Pitman Pub.

OECD. (2009). Sustainable Manufacturing and Eco-innovation: Towards a Green Economy. Retrieved from https://www.oecd.org/env/consumption-innovation/42957785.pdf

Oltra, V., & Saint Jean, M. (2009). Sectoral systems of environmental innovation: An application to the French automotive industry. Technological Forecasting and Social Change, 76(4), 567–583. https://doi.org/10.1016/J.TECHFORE.2008.03.025

Pearson, A. (2005). Carbon dioxide - New uses for an old refrigerant. International Journal of Refrigeration, 28(8), 1140–1148. https://doi.org/10.1016/j.ijrefrig.2005.09.005

Reid, A., & Miedzinski, M. (2008). Eco-Innovation. Final Report for Sectoral Innovation Watch. https://doi.org/10.13140/RG.2.1.1748.0089

Shanmuganathan, A. (2018). Product Innovation: Impact of Organizational Culture in Product Innovation. International Journal of Advancements in Research and Technology, 7(7), 83–89. https://doi.org/10.14299/ijoart.07.07.002

The Role of Refrigeration in the Global Economy. (n.d.). Retrieved from www.iifiir.org

Wang, G. A. (2018). Analytics and Data Science. https://doi.org/10.1007/978-3-319-58097-5