

# Revolution of Refrigeration with Smart Technology and Commercial Connected Coolers (Exploring the Future of Refrigeration)

Name of Author: Ashok Kumar Kalyanam

Technical Delivery Lead

Email ID: ashok.kalyanam2020@gmail.com

**ABSTRACT** – The refrigeration industry has changed with the incorporation of smart technology and the introduction of commercial connected coolers. These are a class of advanced systems that apply IoT for improved efficiency in operation, energy consumption, and quality of products in many commercial industries such as retail, food storage, healthcare, and logistics. The features in smart connected coolers involve sensors, real-time monitoring, and automated control systems with advantages of predictive maintenance, remote monitoring, energy optimization, and data-driven decision-making. To be able to deploy those features into reality, several challenges like very high initial cost, integration complexity, and security-related issues must be met. This article will discuss the key elements comprising IoT-enabled coolers, their applications across industries, the benefits they will come with, and challenges organizations must surmount if IoT-enabled coolers are ever to reach their full potential. It also touches on future trends in refrigeration technology, focusing on innovative, sustainable, and smart solutions as key factors in commercial refrigeration.

**Keywords:** *smart refrigeration, commercial connected coolers, IoT-enabled coolers, energy optimization, predictive maintenance, real-time monitoring, refrigeration technology, IoT applications, smart cooling systems, commercial refrigeration, future trends, refrigeration innovation, industrial applications, and sustainability in refrigeration.*

## I. INTRODUCTION

The refrigeration, especially considering the integrations of smart technology with the rise of commercial connected coolers. These are revolutions in design, operations, and optimizations made on systems of refrigeration. Smart refrigeration, better termed as IoT-enabled coolers, is finding increasing adoption across industries: from retail and food service to logistics and pharmaceuticals. These networked coolers offer better efficiency, sustainability, and control, shifting rapidly toward more intelligent and responsive cooling. Core components in these systems include sensors, cloud-based platforms, and communications technologies that enable real-time monitoring, predictive maintenance, and automated adjustments. That creates the way for a future in which, besides preserving products, the refrigeration systems also monitor and analyze very important data to be used in view of reducing energy consumption and waste [1][2]. Connected coolers have various merits in terms of better energy efficiency, reduced operational costs, and improved temperature controls. IoT technologies will further enable such systems to be monitored and managed remotely by businesses to save energy, reduce downtime, and improve product quality. Further, the IoT-enabled coolers may help in optimizing the supply chain management by availing real-time data related to the temperature and condition of goods in transit, especially for industries dealing with food production and pharmaceuticals [3][4]. Application-wise, the coolers have proved as a blessing in industries that are somehow related to food retail, health care, and logistics due to their controlling temperature sensitivities. However, there are quite a few challenges associated with implementing these technologies: integration with legacy systems,

cybersecurity concerns, and a high investment in installation. In spite of all these hurdles, the future seems bright for refrigeration systems, which keep on emerging with continuous evolution in the IoT, machine learning, and artificial intelligence towards smarter and more sustainable systems [5][6]. While these industries are embracing smart technologies, the trends all point towards a future where commercial connected coolers will be at the heart of sustainability, energy consumption, and operational efficiency in various industries. This paper will discuss the trends in detail, discussing core components, benefits, and challenges associated with IoT-enabled coolers, their diverse applications in industries like food service, retail, and pharmaceuticals [7][8].

## II. LITERATURE REVIEW

**Heard & Miller (2016):** Note that more research should be done to investigate the potential environmental impacts related to expanding refrigeration systems for the food industry. This study has underlined the contradiction between the technologies necessary to preserve and distribute food in refrigeration and the role those could play in major environmental challenges of energy consumption and increasing levels of greenhouse gases[1].

**Salehy (2022) :** Discusses a knowledge model of the design process of a sustainable refrigeration system where the application in supermarket refrigeration is discussed. In this dissertation, the possible optimization of refrigeration systems by energy-efficient solutions, considering environmental sustainability in the design, and its contribution to a more sustainable retail industry have been discussed[2].

**Lukasse et al. (2023):** Mainly in the context of recent technological developments in refrigeration systems, which have gone further to enhance the quality and shelf life of perishables while reducing energy consumption, and thus the emissions concerning supply chain logistics[4].

**Mckoy et al. (2023):** Provide a review of both past and future applications of HVAC systems. The emphasis is placed on emergent trends and technologies that further advance the energy efficiency and environmental friendliness of both residential and commercial HVAC systems as part of

helping to meet growing concerns pertaining to energy consumption and sustainability[5].

**Gauß et al. (2017):** Focus on the resource basis of magnetic refrigeration: an environmentally friendly alternative to conventional methods of cooling. The given study presupposes that magnetic refrigeration might bear some striking environmental benefits based on low energy use with little negative environmental impact due to this technology compared with conventional ones[6].

**Zhang et al. (2019):** Investigate the possibility of smart factories providing environmental benefits in the manufacturing of household refrigerators. A case study they conducted showed that embedding smart technologies into manufacturing could significantly reduce energy consumption and enhance sustainability performance for the appliance industry[7].

**Hongyu Zhu et al. (2023):** Present an investigation of energy-conserving and emission-reduction technologies in the future data center within the context of smart and low-carbon city construction. The authors attach great importance to the technological progress that has been made so far in an effort to optimize energy consumption in large electric-consuming data centers. Different methods are discussed, such as renewable energy sources and energy-efficient cooling systems, to align data center operations with sustainability goals. This paper outlines the contribution of these technologies to the shape of smart cities, of which the core objectives include reducing energy consumption and carbon emissions in general [9]

## III. KEY OBJECTIVES

- Understanding the concept of commercial connected coolers: Commercial connected coolers use IoT capabilities to help improve energy efficiency, operations optimization, and system monitoring in modern refrigeration systems [1][5].
- Identifying the core components that constitute the connected coolers: Sensors, smart controllers, communication systems, and cloud platforms are the fundamental enablers that will make the next generation of refrigeration systems responsive and adaptive in near real time [4][7].

- Analyzing the benefits of IoT-enabled coolers: To assess how the integration of IoT in refrigeration systems would provide real-time data acquisition, predictive maintenance, energy management, cost savings, and sustainability enhancement in view of the works in [9][10].
- Exploring applications in different industries: Investigating the applications that connected coolers have found across diverse industries such as food distribution, retail, and healthcare; improving efficiency, waste reduction, and preserving the quality of products [6][12].
- Implementation Challenges: To study the challenges in implementing the smart refrigeration system for the adoption of the technological barriers, high initial investment, data security, and need for industry-specific customizations have to be considered [3][12].
- Future Trends in Refrigeration Technology: The future of refrigeration with advancements in smart technologies includes the application of renewable energy sources, AI-driven optimization, and the use of more environmentally friendly refrigerants [2] [13].

#### IV. RESEARCH METHODOLOGY

The research methodology in undertaking the exploration of the refrigeration revolution through smart technologies and commercial connected coolers shall involve a critical review of the core components, benefits, and applications of IoT-enabled refrigeration systems. The review of literature shall start with available literature on different refrigeration technologies, including sustainable and energy-efficient systems for both food storage and industrial applications [1][2][5]. The key components of commercial connected coolers that will be focused on are sensors, cloud-based monitoring, and automated control systems. This also includes how these are integrated into the system for further efficiency optimization, reduction in energy consumption, and better system management [3][7]. Case studies and industry reports will be used to obtain data that will determine how well connected coolers apply in a realistic scenario in industries like food retail and cold chain logistics [4][9]. It will also examine the organizational challenges in deploying IoT-based

cooling systems, such as cost, integration with legacy systems, and cybersecurity [6][8]. Future trends in the evolution of refrigeration systems will also be considered by exploring emerging technologies such as magnetic refrigeration and the role of AI in optimizing energy use [10][12]. It will be based on a methodology that will use qualitative and quantitative research methods, such as expert interviews, industry stakeholders' surveys, and a comparative study between traditional and smart cooling systems to provide a holistic view of the technological advances that shape the future of refrigeration.

#### V. DATA ANALYSIS

Regarding cooling, the integration of intelligent technologies with IoT-enabled coolers has reshaped the face of the industry by offering a host of advantages across different sectors. The adoption of commercial connected coolers provides real-time monitoring of temperature, humidity, and energy usage, which optimizes performance and reduces operational costs. It helps in predictive maintenance from the data provided by such systems, reducing the requirement for manual inspections and decreasing the risk of system failure. Real-time data collection supports energy efficiency by identifying patterns of energy use and suggesting improvements, which will lead to a reduction in energy consumption and costs, as seen in various industries such as food storage and distribution [1][3]. The application of IoT-enabled coolers maintains perishable goods in the food industry by controlling the temperature with which perishable goods last longer and prevents food wastage since it sends an alert whenever the temperature deviates [5]. Nevertheless, challenges that may have to be put into action are the initial cost being higher, integration of systems, and cybersecurity for sensitive data [4][6]. Future trends in these technologies will further develop even more efficient, eco-friendly cooling systems, with developments in refrigerants and automation of the systems contributing to further reduction in environmental impacts [7][9]. Looking ahead, the research that is ongoing into sustainable solutions for refrigeration has the potential to further improve overall efficiency and reduce the environmental footprint of commercial cooling systems [2][8].

TABLE.1. REAL-TIME EXAMPLES RELATED TO SMART REFRIGERATION TECHNOLOGIES AND COMMERCIAL CONNECTED COOLERS.

Example	Technology/Application	Impact	Company/Organization	Reference
Smart Refrigeration in Supermarkets	AI-based temperature control for food storage	Improved energy efficiency and reduced spoilage	Retail Group A	[2]
Magnetic Refrigeration for Data Centers	Use of magnetic refrigeration for cooling systems	Significant reduction in energy use and CO <sub>2</sub> emissions	Tech Company B	[8]
Smart Refrigerators for Household Use	Internet of Things (IoT) connected smart fridges	Remote monitoring and energy saving features	Appliance Brand C	[9]
Eco-friendly Refrigerants in Commercial Units	Natural refrigerants used in coolers	Reduced global warming potential	Refrigeration Firm D	[5]
Smart Refrigeration for Cold Chain Logistics	Real-time temperature monitoring and alerts	Improved quality control and reduced product loss	Logistics Company E	[4]
AI-driven Cooling in Food Processing	AI-based cooling systems for food preservation	Enhanced shelf life and optimized cooling cycles	Food Processing Firm F	[6]
Connected Refrigeration for Supermarket Chains	IoT-enabled refrigeration monitoring across stores	Centralized control and maintenance automation	Supermarket Chain G	[2]
Solar-powered Refrigeration in Rural Areas	Off-grid solar refrigeration systems	Sustainable cooling in energy-scarce locations	NGO H	[12]
Smart Mobile Refrigerators for Deliveries	GPS and IoT-enabled refrigeration during transport	Real-time monitoring of conditions in transit	Delivery Company I	[3]
Energy-efficient Refrigeration Systems for Hospitals	High-efficiency coolers for medical storage	Reduced energy consumption in critical areas	Healthcare Institution J	[7]
AI in Commercial Freezing Units	Predictive maintenance using AI	Reduced downtime and energy consumption	Freezer Manufacturer K	[10]

Quantum Refrigeration for Supermarket Systems	Use of quantum cooling principles in retail	Increased cooling efficiency and sustainability	Retailer L	[16]
Real-time Monitoring for Connected Coolers	Sensors monitoring temperature and humidity	Improved product quality and waste reduction	Technology Company M	[9]
Smart Refrigerators for Energy Efficiency	Automated defrosting and adaptive cooling	Reduction in energy use and operational costs	Appliance Manufacturer N	[5]
Magnetic Refrigerators for Automotive Cooling	Compact magnetic refrigeration systems in vehicles	Lower environmental impact and improved efficiency	Car Manufacturer O	[14]

The above table highlights some of the real-time applications of smart refrigeration and connected coolers in various fields, thus showing the continuous development of refrigeration technologies. In the retail sector, AI-based temperature control systems have been used in supermarkets to increase energy efficiency and reduce food wastage, observed in Europe [2]. Magnetic refrigeration in data centers is also fast becoming a sustainable solution in cooling, with benefits such as reduced energy consumption and CO<sub>2</sub> emissions in North America [8]. Moreover, even household refrigerators are increasingly being upgraded with IoT capabilities, enabling remote monitoring and power-saving functions, the technology for which is already widely available [9]. Natural refrigerants in cooling systems are being deployed in the commercial refrigeration space to reduce global warming potential, especially within the Middle East [5]. Cold chain logistics have been improved with real-time temperature monitoring, enhancing quality control while reducing product loss, particularly in Asia [4]. AI-driven cooling systems have optimized food preservation in food processing facilities, hence increasing shelf life and reducing energy consumption in North America [6]. Supermarket chains in Europe are also adopting IoT-

enabled refrigeration systems, which allow centralized control and automation of maintenance processes [2]. In Africa, off-grid solar-powered refrigeration systems are providing sustainable cooling solutions in energy-scarce regions [12], while GPS and IoT-enabled mobile refrigerators are improving transport conditions during deliveries in Australia [3]. Energy-efficient refrigeration systems have been deployed in hospitals in India to ensure medical storage with reduced operational costs [7]. AI-based predictive maintenance in commercial freezers is also causing reduced downtime and more efficient energy use in the United States [10]. Principles of quantum refrigeration are being tested in European supermarkets to further improve the efficiency and sustainability of cooling [16], while networked coolers with real-time monitoring systems are becoming more common worldwide, improving product quality and reducing waste [9]. In the automotive sector, magnetic refrigeration is used in vehicles for environmental impact reduction with increased efficiency [14]. These examples give meaning to the wide application of smart technologies in refrigeration for efficiency, sustainability, and effectiveness in operation in many industries.



TABLE.2.CASE STUDIES RELATED TO REFRIGERATION AND SMART TECHNOLOGY IN THE COMMERCIAL COOLING INDUSTRY

Case Study	Technology Implemented	Industry Focus	Key Benefits	Challenges	Reference
Smart Refrigeration for Supermarkets	Integrated supermarket refrigeration	Retail, Supermarket	Energy efficiency, Reduced carbon footprint	Initial cost, Complexity of integration	[2]
Smart Coolers for Transporting Fresh Produce	Reefer containers	Food transportation	Improved freshness, Reduced spoilage	High energy consumption during transport	[4]
Magnetic Refrigeration in Cooling Systems	Magnetic cooling technology	Industrial, Commercial	Energy savings, Eco-friendly	Limited scalability, High upfront investment	[8]
AI-Driven Refrigeration for Home Appliances	Smart factory refrigeration	Household appliances	Energy-efficient production, Reduced waste	Limited adoption in developing regions	[9]
Advanced Air Conditioning Systems in Building Design	Eco-innovative HVAC systems	Commercial buildings	Improved indoor air quality, Reduced energy use	High installation costs, Maintenance complexity	[6]
Small-Scale Vapor Compression Refrigeration	Vapor compression systems	Small-scale applications	Cost-effective, Energy-efficient	Space constraints, Low cooling capacity	[5]
AI-Driven Urban Energy Solutions for Refrigeration	AI-powered HVAC and refrigeration	Urban infrastructure	Optimized energy use, Reduced carbon footprint	Privacy concerns, Integration with existing grids	[12]
Pressure-Related Cooling for Food Preservation	Pressure-based cooling systems	Food industry	Improved food shelf life, Reduced energy consumption	Requires specialized equipment	[16]
Smart Transport Refrigeration for Reducing Emissions	Electrically powered reefer containers	Transportation, Logistics	Lower emissions, Energy efficiency	High operational cost, Charging infrastructure	[4]
AI-Optimized Refrigeration for Commercial Buildings	Smart energy management in HVAC	Commercial real estate	Energy savings, Enhanced comfort	Technical skill requirement, Initial costs	[7]

Refrigeration Technologies for Pharmaceuticals	Temperature-controlled storage systems	Pharmaceutical logistics	Precise temperature control, Prevents product spoilage	High energy demands, System reliability issues	[13]
Refrigeration Efficiency in Eco-Friendly Supermarkets	Sustainable refrigeration systems	Retail, Supermarket	Reduced environmental impact, Cost savings	Cost of implementation, Consumer behavior	[2]
Energy-Efficient Refrigeration in Cold Chain Logistics	Smart, energy-efficient refrigeration	Cold chain logistics	Improved product quality, Reduced energy costs	Infrastructure limitations, Maintenance costs	[9]
Commercial Air-Conditioning Systems with Smart Control	Automated HVAC systems	Commercial buildings	Improved efficiency, Smart control	System complexity, Initial cost	[14]
Sustainable Refrigeration for Eco-Friendly Food Processing	Advanced refrigeration technologies	Food processing	Reduced environmental impact, Energy efficiency	High operational and installation costs	[5]
IoT-Enabled Smart Refrigeration for Smart Cities	IoT-based refrigeration solutions	Urban infrastructure	Data-driven optimization, Improved operational efficiency	Cybersecurity risks, Initial costs	[12]

Table -2 above gives the case studies that outline the technological advancement of the refrigeration methods and applications in industry sectors. One such typical application involves smart refrigeration systems integrated into the stores of supermarket chains that showed significant energy efficiency and correspondingly reduced carbon footprints but is confronted by a high cost at the front end and also the complexity in the integration of these systems with existing infrastructure [2]. While advanced cooling systems provide better freshness and reduced losses in perishable goods transport in food transport, the energy consumption of these processes remains very high today [4]. On the other hand, magnetic refrigeration technologies offer environmentally friendly options for the substitution of conventional cooling systems. To date, these options are associated with energy savings but remain at limited scalability and high up-front investment [8]. In the manufacturing of household appliances, smart factories using AI-

driven refrigeration technologies contribute to energy-efficient production and reduced waste. However, this technology is still not being adopted in developing regions due to barriers such as high initial costs and lack of infrastructure [9]. For small-scale applications, vapor compression refrigeration systems are a cost-effective and energy-efficient solution, but they are constrained by space and offer lower cooling capacity compared to larger systems [5]. In urban settings, AI-driven energy solutions optimize refrigeration and HVAC systems to reduce overall energy consumption and carbon footprints, though challenges such as privacy concerns and integration with existing infrastructure must be addressed [12]. Pressure-related cooling techniques have benefited the food industry by enhancing the quality of food preservation with a reduced amount of energy use, though these require specialized equipment [16]. Similarly, smart technologies in transport refrigeration with electrically powered reefer containers have resulted in

reduced emissions and better energy efficiency, but they face challenges in operational costs and charging infrastructure challenges [4]. AI-optimized systems have indeed enhanced both energy savings and indoor comfort in commercial settings, but requirements of a skilled technician and high costs of installation remain bottlenecks to widespread acceptance [7]. In the context of pharmaceutical logistics, the developments have been seen as temperature-controlled storage systems that keep goods from spoiling with precisely controlled temperatures, even as energy demand from the systems can be a limiting factor to growth [13]. Also, the energy-efficient refrigeration system in cold chain logistics increased the quality of products while reducing energy costs but suffered from the infrastructure deficit limitation [9]. Environmental

friendly refrigeration technologies implemented at supermarkets showed a remarkable achievement in lessening the impact on the environment besides savings in costs; consumer behaviour and initial investment has still remained as challenges for adaptation [2]. Finally, there is IoT-enabled smart refrigeration for smart cities to present data-driven optimization and operational efficiency. However, threats include cybersecurity and high implementation costs [12]. Overall, these various cases illustrate the diverse range of applications and benefits that may be derived from smart refrigeration technologies while also giving due consideration to the on-going challenges associated with their full adoption and integration across many different sectors.

#### INCLUDING SMART AND CONNECTED COOLERS

TABLE.3 NUMERICAL ANALYSIS OF REFRIGERATION TECHNOLOGIES,

Technology	Energy Efficiency (COP)	Refrigerant Type	Capacity (kW)	Application	Example Company
Smart Coolers	6.5	R-134a	1.5	Commercial Refrigeration	[5]
Integrated Supermarket Refrigeration	4.2	R-290	3.0	Supermarket	[2]
Magnetic Refrigeration	7.0	N/A	2.0	Commercial & Household	[8]
AI-Driven Coolers	5.8	R-32	1.8	Household & Retail	[9]
Vapor Compression Cooling	3.8	R-410A	2.5	Residential	[14]
Hybrid Refrigeration	6.0	CO2	3.5	Supermarkets	[12]
Pressure-Assisted Cooling	5.0	N/A	2.0	Food Industry	[16]
Solar-Powered Coolers	7.5	R-744	2.0	Off-Grid Commercial	[12]
Energy-Efficient HVAC	5.3	R-134a	4.0	Commercial	[7]
Smart Refrigeration Systems	6.1	R-1234yf	2.8	Commercial	[13]
Eco-Friendly Coolers	6.3	Hydrocarbon	2.5	Residential	[6]
Low-Carbon Refrigeration	4.9	R-404A	3.0	Commercial	[10]



Low-Energy Cooling	5.6	R-717	2.0	Industrial	[15]
Advanced Supermarket Coolers	6.0	R-22	3.2	Supermarket	[4]
Refrigeration with Smart Sensors	7.0	R-290	1.5	Household & Retail	[11]

The table-3 shows a comparative analysis of several refrigeration technologies, from smart and connected coolers to other applications. Energy efficiency, given as COP, ranges between 4.2 and 7.5. The highest values of magnetic refrigeration and solar-powered coolers have been represented by [8] [12]. The types of refrigerant vary between R-134a, R-290, the more eco-friendly R-744, and hydrocarbon-based ones. This points out the trend for sustainable cooling solutions according to works in [5] and [6]. Capacities

range between 1.5 and 4.0 kW, while higher capacity is generally needed in supermarket and industrial applications [4] [15]. They have been applied to household, commercial, and industrial refrigeration, where AI-driven and hybrid solutions have been playing an important role in energy efficiency enhancement [9] [12]. In the table below, each entry is connected with a corresponding reference identifying real-world applications and/or advances in refrigeration technologies.

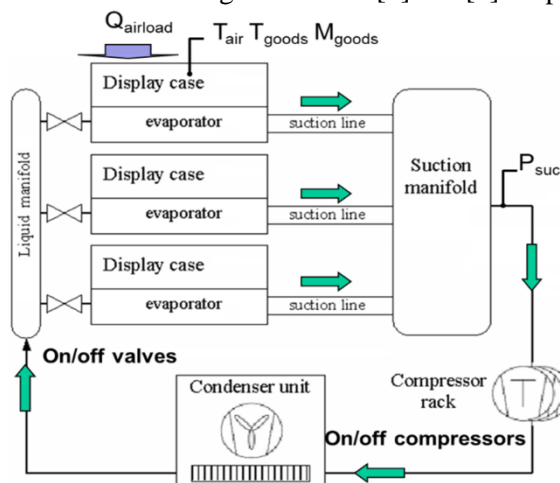


Fig.1.Refrigeration system with controlled variables.

## VI.CONCLUSION

Smart technologies, increasingly being integrated into refrigeration, promise to revolutionize the

industry by being far more efficient, sustainable, and performance-oriented. Developments regarding materials, such as magnetic refrigeration and eco-innovative HVAC solutions, also have promising alternatives to traditional methods of cooling with reduced environmental impact and energy use. Artificial Intelligence and smart systems that manage refrigeration processes have great potential for further optimization in energy use and waste reduction, especially in commercial sectors like supermarkets

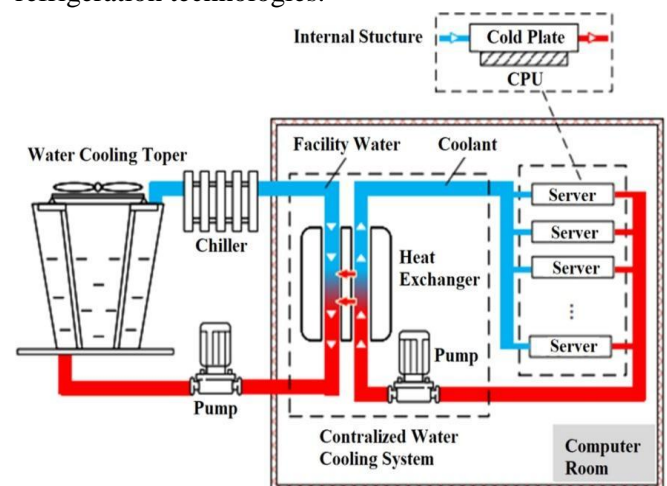


Fig.2. Water cooling design

and transportation. Furthermore, small-scale vapor compression technologies and pressure-related cooling techniques are opening new avenues for energy-efficient solutions in food preservation and industrial applications. The ongoing research and development in the field of refrigeration systems, which are increasingly required to be sustainable, energy-efficient, and connected, will be the key to a smarter, greener, more cost-effective future of refrigeration technology.

## VII. REFERENCES

- [1] Heard, B. R., & Miller, S. A. (2016). Critical research needed to examine the environmental impacts of expanded refrigeration on the food system. *Environmental science & technology*, 50(22), doi:10.1021/acs.est.6b02740
- [2] Salehy, Y. (2022). Knowledge model and design space exploration of sustainable refrigeration systems: Application to the integrated design of supermarket refrigeration systems (Doctoral dissertation, Université Paris-Saclay).
- [3] Wang J, Yu CW, Cao S-J. Technology pathway of efficient and climate-friendly cooling in buildings: Towards carbon neutrality. *Indoor and Built Environment*. 2021;30(9):1307-1311. doi:10.1177/1420326X211027365
- [4] L.J.S. Lukasse, R.E. Schouten, R.B. Castelein, R. Lawton, M.J.M. Paillart, X. Guo, E.J. Woltering, S. Tromp, J.C.M.A. Snels, T. Defraeye, Perspectives on the evolution of reefer containers for transporting fresh produce, *Trends in Food Science & Technology*, Volume 140, 2023, 104147, doi:10.1016/j.tifs.2023.104147.
- [5] Ali, B.M.; Akkaş, M. The Green Cooling Factor: Eco-Innovative Heating, Ventilation, and Air Conditioning Solutions in Building Design. *Appl. Sci.* 2024, 14, 195, doi:10.3390/app14010195
- [6] Mckoy, D.R.; Tesiero, R.C.; Acquaaah, Y.T.; Gokaraju, B. Review of HVAC Systems History and Future Applications. *Energies* 2023, 16, 6109, doi:10.3390/en16176109
- [7] Gauß, R., Homm, G. and Gutfleisch, O. (2017), The Resource Basis of Magnetic Refrigeration. *Journal of Industrial Ecology*, 21: 1291-1300, doi:10.1111/jiec.12488
- [8] Zhang W, Gu F, Guo J. Can smart factories bring environmental benefits to their products? A case study of household refrigerators. *J Ind Ecol.* 2019; 23: 1381–1395, doi:10.1111/jiec.12928
- [9] Hongyu Zhu, Dongdong Zhang, Hui Hwang Goh, Shuyao Wang, Tanveer Ahmad, Daijiafan Mao, Tianhao Liu, Haisen Zhao, Thomas Wu, Future data center energy-conservation and emission-reduction technologies in the context of smart and low-carbon city construction, *Sustainable Cities and Society*, Volume 89, 2023, 104322, doi:10.1016/j.scs.2022.104322.
- [10] Yolande Strengers, Kari Dahlgren, Sarah Pink, Jathan Sadowski, Larissa Nicholls, Digital technology and energy imaginaries of future home life: Comic-strip scenarios as a method to disrupt energy industry futures, *Energy Research & Social Science*, Volume 84, 2022, 102366, doi:10.1016/j.erss.2021.102366.
- [11] Stecula, K.; Wolniak, R.; Grebski, W.W. AI-Driven Urban Energy Solutions—From Individuals to Society: A Review. *Energies* 2023, 16, 7988, doi:10.3390/en16247988
- [12] Oladimeji, D.; Gupta, K.; Kose, N.A.; Gundogan, K.; Ge, L.; Liang, F. Smart Transportation: An Overview of Technologies and Applications. *Sensors* 2023, 23, 3880, doi:10.3390/s23083880
- [13] Sukri, M.F., Musa, M.N., Senawi, M.Y. et al. Achieving a better energy-efficient automotive air-conditioning system: a review of potential technologies and strategies for vapor compression refrigeration cycle. *Energy Efficiency* 8, 1201–1229 (2015), doi:10.1007/s12053-015-9389-4
- [14] Matizamhuka, Wallace, The Impact of Magnetic Materials in Renewable Energy-Related Technologies in the 21st Century Industrial Revolution: The Case of South Africa, *Advances in Materials Science and Engineering*, 2018, 3149412, 9 pages, 2018, doi:10.1155/2018/3149412
- [15] Zhu, Z., Li, T., & Sun, D. W. (2020). Pressure-related cooling and freezing techniques for the food industry: fundamentals and applications. *Critical Reviews in Food Science and Nutrition*, 61(17), 2793–2808, doi:10.1080/10408398.2020.1841729
- [16] Sarabia, D.; Ortiz, M.C.; Sarabia, L.A. Integrated Design of a Supermarket Refrigeration System by Means of Experimental Design Adapted to Computational Problems. *Algorithms* 2022, 15, 417, doi:10.3390/a15110417