

TECHNOLOGY HIGHLIGHT

How the cold appliance industry can contribute to GHG emission reduction

A next-generation manufacturing technology for more energy-efficient refrigerators



Project Name: PASCAL™ Technology for home cold appliances

Project Description: The project is designed to reduce greenhouse (GHG) emissions through improved energy efficiency of home cold appliances, enabled by the next-generation manufacturing technology.

Project Start: May 2018

Crediting Period: 2018-2026

Partner: Haier



Why Beyond Business as Usual? PASCAL™ Technology utilizes a vacuum-assisted process along with specially formulated polyurethane foam systems to fill the insulating cavity of the appliance cabinet, improving its insulating performance. Reduced energy consumption at the use phase is expected to result in notable GHG emissions savings over the lifetime of the appliance.

The challenge: Reducing the energy consumption of cold appliances

Tackling climate change by reducing greenhouse gases (GHG) is an urgent societal challenge. Energy-efficient cold appliances can play a key role. The latest IEA report¹ shows that the sector remains one of the largest users of electrical energy globally. Among all home appliances, refrigerators consume approximately 30% of the total household energy consumption.²

During the past 20 years, the cold appliance industry has made significant progress in cutting energy consumption through collective efforts to develop more energy-efficient refrigerators. These efforts have been supported by market mechanisms such as labeling systems and minimum efficiency standards.³ For instance, the European A+++ model refrigerator consumes 80% less electricity today than an average refrigerator manufactured in 1990, and 50% less electricity than the currently regulated level in the European Union.⁴

However, there is still more work to be done to lessen the environmental impact of the home appliance sector. The demand for home appliances is still growing, driven by rising incomes and standard of living improvements.

This increasing demand will greatly impact overall energy intensity. At the same time, domestic appliance manufacturers want to improve their productivity while maintaining design freedom and meeting consumer demands for cost-effective appliances. The challenge: How can we partner with home appliance producers to help significantly improve energy performance without sacrificing productivity, design flexibility or cost-effectiveness?

The solution

According to industry life cycle assessments (LCA),⁵ the greatest potential to lower GHG emissions of large home appliances such as refrigerators is to improve their energy-efficiency performance during the use phase. The use phase represents more than 80% of the total environmental impact – compared to less than 10% of the embodied and direct CO₂ emitted from manufacturing.

Dow's PASCAL™ Technology is a next-generation insulation technology for refrigerators and freezers that has successfully shown to notably reduce energy consumption and GHG emissions in the use phase. The energy consumption of a refrigerator-freezer is directly related to the cabinet's internal load and thermal performance. The major factors affecting thermal performance are the thermal resistance of the insulated cabinet and air leakage.

Polyurethane rigid foam is the insulating material most widely used globally for thermal insulation of refrigerators and freezers.⁶ The patented Dow PASCAL™ Technology is a high-quality polyurethane system that greatly increases the energy-efficiency performance of refrigerators during their use phase, while improving the manufacturing process and allowing more design freedom and less weight. LCA confirms the significant total environmental impact benefits of this technology in both the manufacturing and the use phases⁷:

- **Improved manufacturing process: faster cycle time, material and energy efficiency**

In the PASCAL™ Technology process, the foaming is done under vacuum-assisted injection, which allows for enhanced foam properties (lower thermal conductivity), excellent process behaviors (faster cycle time), cost advantages (lower applied density) and easy capture of the released blowing agent.

¹<https://www.iea.org/reports/appliances-and-equipment#abstract>

²<https://www.apec.org/Publications/2018/12/Refrigerator-Freezer-Energy-Efficiency-Improvement-in-the-APEC-Region>

³https://www.aham.org/AHAM/Energy_Efficiency/AHAM/EnergyEfficiency/Energy_Efficiency.aspx?hkey=500a671c-c0f8-4f12-a9b8-577e99595583

⁴https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter9.pdf p. 691

⁵<https://www.electroluxgroup.com/en/wp-content/uploads/sites/2/2010/07/Incentive-for-Change-Electrolux-Dec-2007.pdf>

⁶<https://www.polyurethanes.org/en/where-is-it/refrigeration-and-freezers/>

⁷https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=ENERG_ICE_Public_Report.pdf

• **Reduced weight, leading to sustained design flexibility**

This technology can be used to reduce the overall insulation mass per refrigerator without compromising its energy-efficiency performance and mechanical integrity. It also allows more space for design freedom and improvements.

• **Advanced energy efficiency and reduced carbon footprint in the use phase**

The carbon footprint of a typical residential refrigerator depends on its age, energy performance and the local electricity grid. Improved insulating performance contributes to reduced energy consumption over the lifetime of an appliance. PASCAL™ Technology improves the energy efficiency of refrigerators compared to conventional polyurethane insulating systems by reducing their annual GHG emissions in the use phase by 6 kg of CO₂ per refrigerator in China (based on conservative assumptions), according to the LCA conducted by Dow and validated by a third party in 2020.

The results

Dow's PASCAL™ Technology was industrially validated and implemented at one of the world's leading household manufacturers of refrigerators and freezers, Qingdao Haier Co. Ltd.

Dow and Haier have been working together to create significant GHG emission reductions by driving adoption and utilization of PASCAL™ Technology for energy-efficient refrigerator production in China. China has become one of the world's largest producers and consumers of household appliances as ownership rates have increased considerably over the last decades.⁸

Together with an independent third-party auditor, Dow and Haier are verifying GHG reductions achieved through the adoption of PASCAL™ Technology. GHG emission reductions are calculated based on the decreased energy consumption of new refrigerators built with PASCAL™ Technology in comparison with those using conventional technology. The validated GHG emission reductions forecast in China for the project period of 2018-2026 exceed 900,000 tonnes. This is equivalent to GHGs sequestered by more than 15 million tree seedlings grown for 10 years.⁹

This initiative is in line with Dow's new carbon reduction target, which includes a commitment to innovating and advancing technologies that contribute to a low-carbon society.



Dow's solutions for advanced home appliance manufacturing

PASCAL™ Technology is one of many innovative products and technologies from Dow that improve energy efficiency. Dow has been a world leader in insulation technology and energy efficiency in a wide variety of industries and applications. We bring more than just an industry-leading portfolio of advanced materials. As your dedicated innovation leader, we bring proven process and application expertise, a reliable global supply base and world-class customer service.

For more information on Dow's solutions for advanced home appliance manufacturing and how it can benefit your business, visit:

<https://www.dow.com/en-us/market/mkt-consumer-goods-appliances/sub-consumer-cold-chain/app-consumer-coldchain-domestic-app-ins.html>

About Dow

Dow (NYSE: DOW) combines global breadth, asset integration and scale, focused innovation and leading business positions to achieve profitable growth. The Company's ambition is to become the most innovative, customer centric, inclusive and sustainable materials science company, with a purpose to deliver a sustainable future for the world through our materials science expertise and collaboration with our partners. Dow's portfolio of plastics, industrial intermediates, coatings and silicones businesses delivers a broad range of differentiated science-based products and solutions for its customers in high-growth market segments, such as packaging, infrastructure, mobility and consumer care. Dow operates 106 manufacturing sites in 31 countries and employs approximately 35,700 people. Dow delivered sales of approximately \$39 billion in 2020.

Dow	US	dow.com
2211 H.H. Dow Way	Toll Free	800 441 4DOW
Midland, MI 48674 USA		989 832 1542
	International	
	Europe / Middle East	+ 800 36 94 63 67
	Italy	+ 800 783 825
	Asia / Pacific	+ 800 77 76 77 76
		+ 60 37 958 3392
	South Africa	+ 800 99 5078

NOTICE: No freedom from infringement of any patent owned by Dow or others is to be inferred. Because use conditions and applicable laws may differ from one location to another and may change with time, Customer is responsible for determining whether products and the information in this document are appropriate for Customer's use and for ensuring that Customer's workplace and disposal practices are in compliance with applicable laws and other government enactments. The product shown in this literature may not be available for sale and/or available in all geographies where Dow is represented. The claims made may not have been approved for use in all countries. Dow assumes no obligation or liability for the information in this document. References to "Dow" or the "Company" mean the Dow legal entity selling the products to Customer unless otherwise expressly noted. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

⁸National Bureau of Statistics of China, table 6-5 Main durable goods owned per 100 households nationwide <http://www.stats.gov.cn/tjsj/ndsj/2019/html/E0605.jpg>

⁹<https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

®™Trademark of The Dow Chemical Company ('Dow') or an affiliated company of Dow.