Task Force 3:
LiFE, Resilience, and Values for Wellbeing

INTEGRATING CIRCULARITY IN GLOBAL VALUE CHAINS TO ANCHOR SUSTAINABILITY IN PRODUCTION SYSTEMS

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Tulika Gupta, Research Analyst, Council on Energy, Environment and Water (CEEW)

Shuva Raha, Head - New Initiatives, CEEW

Ankur Rawal, Programme Associate, CEEW

Vanesa Rodriguez Osuna, Senior Technical Adviser, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH | German Agency for International Cooperation

Hemant Mallya, Fellow, CEEW

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Abstract

The current global linear economy, wherein more than 90 percent of materials are wasted, lost or unavailable for reuse, urgently needs to shift to a circular economy. Circularity must go beyond end-of-life product management to focus on extending the life of input materials and enhancing resource efficiency by streamlining product design, manufacturing processes, packaging, transportation, distribution and disposal, repair or recycling into the same or other value chains. Integrating circularity in product value chains needs a fundamental shift in how products are conceived and managed by designers, producers, consumers and policymakers. This Policy Brief uses a common appliance—the refrigerator—to explore the steps needed to embed circularity in its global value chain (GVC). It explores how the G20 countries can drive industrial and governance collaboration to embed circularity in GVCs to improve resource efficiency and promote sustainable production and consumption, thus lowering environmental footprint.

The Challenge

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Currently, only 7.2 percent of the world economy is circular; over 90 percent of materials do not return to the economy and are wasted, lost or unavailable for reuse.[1] In the past 50 years, the global consumption of raw materials has almost quadrupled to over 100 billion tonnes.[2] The volume of extraction and use of materials over the past six years is nearly as much as that of the entire twentieth century.[3] The linear economy depletes the earth's finite materials and emits a large share of the world's greenhouse gas (GHG) emissions and waste.[4] These factors have made a rapid transformation into a low-carbon, circular economy (CE), with sustainable production and consumption patterns, a multilateral imperative.

Redesigning value chains to integrate circularity involves 1) modifying product design; 2) ensuring sustainable extraction, processing and production of input materials – raw, processed or manufactured in other value chains; 3) deploying affordable and reliable clean energy and low-carbon transport systems to enhance energy and resource efficiency of logistical processes without disrupting value chains; 4) providing after-sales services for maintenance, refurbishment and repair; 5) coordinating end-of-life handling, including disposal or recycling; and 6) offering producer and consumer incentives to drive the adoption of these changes.

Global value chains (GVCs) are lengthy and complex, covering multiple jurisdictions, and are influenced by factors such as policies and regulations; innovation and technology; design, standards and specifications; and economics, markets, competition and trading mechanisms. About two-thirds of cross-border trade use GVCs[5] and modifying any part of these value chains needs concerted action from several actors across jurisdictions. The active buy-in of G20 economies, which drive 80 percent of the global trade, is therefore critical to embedding circularity in GVCs.

This Policy Brief uses the example of refrigerators to explore the steps needed to embed circularity in GVCs. It explores how G20 countries can drive industrial and governance collaboration to embed circularity in GVCs to improve resource efficiency and promote sustainable production and consumption, thus lowering environmental footprint.

Invented in 1913, the home electric refrigerators evolved into their modern compressor-based counterparts in the 1940s.[6] Today, around 2 billion refrigeration units are in use; this common appliance is the 70th most traded product globally.[7] In 2022, five G20 countries (China, Mexico, Italy, South Korea and Germany) accounted for about 55 percent of the refrigerator export value.[8] With the industry employing 15 million people globally, redesigning this mature GVC to deploy clean energy, drive resource efficiency and embed circularity has several implications.

At its core, a refrigerator comprises the cooling system (the condenser, the compressor and the evaporator) and two types of casing (the inner cabinetry and the outer body). The cooling system uses copper, steel and chemical coolants. The inner casing is made of sheet metal, plastic, glass and polyurethane or polystyrene-based insulation while the outer body uses aluminium or steel. Each component has well-consolidated, diverse and interconnected value chains spread across geographies.

While some companies buy components locally or from subsidiaries for manufacturing, most rely on imports. The manufacturing of compressors is led by Japan, the US and India,[9] while the US, Ireland and Japan lead the coolant market.[10] The machinery and equipment for outer cabinets mainly comes from Japan, China, the US, Germany and South Korea.[11] Oil refiners in the Netherlands, the US and India provide virgin plastic pellets that are used to make inner cabinets and shelves.[12] Germany, China, Japan and the US lead the polyurethane market.[13]

The GVC of a refrigerator depends on several stakeholders across a range of sectors. A typical manufacturing unit needs logistics to bring locally sourced or imported raw materials and components to its site. Assembly lines then combine compressors, cabinets, coolants and electronics. The finished products travel to local retailers or are exported. Refrigerators have long operating lives – 15 years in the European Union (EU)[14] – making maintenance a crucial value-added service. Several countries have end-of-life regulations and recycling mandates for refrigerators.

GVCs depend on the environment they operate in as well as on diverse market conditions. While each manufacturer owns its design and process intellectual property rights, each country in the GVC applies its own regulatory, operational and safety standards, including those for environmental compliance, energy efficiency, extended producer responsibility (EPR) and end-of-life disposal or recycling. The trade of components and products is regulated by various trade agreements, investment rules and tariffs, such as import duties. The COVID-19 pandemic underscored the vulnerability of GVCs to geopolitical shocks and protectionist reactions, particularly in labour- and import-dependent economies.[15]

The G20's Role

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The G20 is aware of the urgent need to improve collaboration to create a circular and resource-efficient global economy. In 2017 the German G20 presidency set up the Resource Efficiency Dialogue (RED), which developed a three-year, action-oriented roadmap between 2019 and 2021. The roadmap covered topics such as sustainable production, design for circularity, sustainable and circular cities, circular fashion and textiles, food loss and waste, climate change and environmental challenges, and sustainability reporting.[16,17] During the 2022 Indonesian presidency, the G20 agreed to promote Resource Efficiency (RE) and Circular Economy (CE) to "work together on scientific knowledge-sharing… and capacity-building" to improve sustainability.[18]

The 2023 Indian presidency, in keeping with its emphasis on sustainable and climate-resilient development, has also included RE and CE in its priorities. The meetings of the Environment and Climate Sustainability Working Group have discussed RE/CE for the hard-to-abate steel sector and bioeconomy, the role of EPR and the potential of a G20 RE/CE industry platform.[19]

A key topic of the G20 RED has been the challenge of evaluating and redesigning major linear GVCs to integrate circularity without disrupting supply chains, destabilising trade balances and infringing upon the sovereignty of involved countries, including G20 members.

Such a multilateral effort will require the G20 to explore the flow of materials, services and information across global supply chains, including inputs, outputs, processes and internal and external supply chain participants, through the lens of the six types of activities mentioned earlier.

Modifying product design: Business models that prioritise sales over durability have made the product design of major household appliances (or white goods) akin to those of fast fashion, using cosmetic changes in shapes and casings to update products instead of improving core functionalities. This impedes the progress of Sustainable Development Goal (SDG) 12, which was set to encourage responsible consumption and production. Circular product design can make more durable core components and easy-to-replace, modular non-core components with standardised parts for universal repair

and technology upgrades.[20] Circularity can also improve manufacturing processes by tracking material and emission flows.[21]

Complex, circular GVCs need harmonised standards and certification systems. Lead markets need to consider that setting new design standards and specifications requires other countries in the GVC to be ready to implement them without great socioeconomic cost or the risk of falling behind if they are short of capital or certain technologies.[22]

Refrigerator design has evolved steadily in terms of materials, shapes and capacities; operations – from mechanical to electronic to 'smart' controls – and functional efficiencies, such as auto-defrost and lower energy consumption. A milestone related to the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer shows how multilateralism for common good can influence innovative and efficient product designs.

The Montreal Protocol and the 2022 Kigali Amendment to it are multilateral environmental agreements to regulate, and eventually phase out, the production and consumption of artificial ozone-depleting substances (ODS), including chlorofluorocarbon (CFC) and hydrofluorocarbon (HFC) coolants used in refrigerators. Nuanced negotiations, which set different timelines for various groups of countries based on their economic and technological capacities, led to 197 countries signing the Montreal Protocol, making it the first United Nations (UN) treaty to achieve universal ratification. Since then, innovations in manufacturing have replaced CFCs and HFCs with isobutane, pentane or propane in several markets, resulting in 98 percent phase-out of ODS globally compared to 1990 levels. [23,24]

Ensuring sustainability in extraction, processing and production of input materials, such as aluminium, steel, plastic, copper and glass: Among metals, steel and aluminium, produced using emissions-intensive coal-fired smelters, have the highest absolute emissions. New methods of producing low-carbon aluminium, copper and steel are emerging, such as green hydrogen-fired production. However, sustainable products, made from green aluminium, copper and steel, are still scarce and very expensive, and therefore, not yet prevalent in most value chains.[25] While it is difficult to reduce emissions from iron and aluminium ore extraction, improved recycling and reuse of metals can

reduce resource use per unit of product, lowering overall resource extraction.

Some multinational companies (MNCs) are using recycled materials in home appliances, including refrigerators.[26,27] However, lower resource extraction and shrinking materials and products markets could dampen exports and trigger declines in GDP and exchange rates in resource-rich countries such as Indonesia, and manufacturing hubs such as China, South Korea and India, thereby creating resistance to embedding circularity in GVCs. Conversely, circularity can create new secondary raw material markets and export revenue for consumer countries such as the US, EU member states, Japan and Australia. The G20 in particular has to find a delicate balance between economics and sustainability in such cases.

Lowering emissions is complex but essential.[28] Many MNCs are reducing Scope 1 (direct) and Scope 2 (indirect) emissions, but these will need extensive multilateral support for credible Scope 3 (indirect upstream and downstream emissions from a company's end-to-end value chain) implementation in their GVCs. This effort requires enhanced traceability and transparency within supply chains.

Deploying affordable and reliable clean energy and low-carbon transport systems to enhance energy and resource efficiency in logistical processes without disrupting value chains: The clean energy transition has gained momentum in recent decades. However, supplying reliable, affordable, and clean energy to hard-to-abate sectors, traditional manufacturing hubs and long-distance transportation, especially air, rail and marine freight, remains a major challenge.

In 2015, 196 parties, including all G20 countries, adopted the Paris Agreement. The Nationally Determined Contributions (NDCs) of most of these parties include shifting from fossil fuels to renewable energy and emission reduction targets. To support their NDCs, countries have been urged to formulate voluntary, long-term, low-GHG emission development strategies. The UN notes that "zero-carbon solutions are becoming competitive across economic sectors representing 25 percent of emissions" and by 2030, these can cover sectors representing 70 percent of emissions, with the trend

becoming most prevalent across power and transport systems.[29]

The G20 countries, except for Mexico, have also targeted net-zero emissions by, or around mid-century. The 2022 G20 Bali Energy Transitions Roadmap includes steps to scale up such solutions as low-carbon, electric and hydrogen-powered heavy transport and green ammonia-based shipping. The G20 needs to synchronise such efforts, integrating policy, finance, technology and capacity-building to restructure GVCs at scale, without compromising on competitiveness.

Providing after-sales services – maintenance, refurbishment and repair: As value chains globalise, access to repair manuals, non-proprietary components and trained personnel can extend product life cycles. Repairing goods is not convenient for consumers or producers. On the consumer side, technologies, such as the Internet of Things (IoT) can enhance maintenance and repair services, for example, by detecting when product parts need replacement so that manufacturers can ensure timely servicing.[30] For producers, ensuring modular components in their production will help reduce inventory management and enable businesses to repair or refurbish goods.

Considering the long life cycles of refrigerators, manufacturers already have robust after-sales services. The EU's 'right to repair' rules mandate fridge makers to supply spare parts for at least seven years.[31] Similar regulations may be adopted by the G20 to synchronise the manufacture, supply and disposal of parts and services for their major GVCs.

Coordinating end-of-life handling, including disposal, repurposing or recycling: Recent research and investment in end-of-life operations across GVCs, such as plastics, clothing, automobiles, appliances, pharmaceuticals and food products, have underlined the need for customised handling of each part and process instead of adopting a one-size-fits-all approach.

For example, if recycled properly, nearly all parts of a refrigerator can be reused;[32] MNCs can foster the recycling process via company collection points in selected markets. However, with an increasing demand – China alone is projected to have over half a billion refrigerators by 2035 – corporate efforts

will be inadequate and nationwide regulations will be critical to ensuring that resource inputs are extracted and recycled properly and at scale.[33]

Many countries and companies have recognised the value of recycling materials from appliances and have instituted systems, such as the Waste from Electrical and Electronic Equipment (WEEE) mandates and recycling facilities. The EU has had WEEE regulations since 2003; 80 percent of scrapped appliances are collected for recycling by the industry or other actors.[34] However, one or more countries in a GVC imposing such regulatory mechanisms as EPR and recycling fees on materials and waste, without the consensus of all involved countries, could disrupt trade patterns and partnerships, especially among the highly competitive G20.[35] The G20 can help better structure GVCs by shaping a globally uniform taxonomy of waste, scrap and secondary raw materials to ensure that these are accurately tracked and legally traded, and not illegally dumped or marketed.

Offering producer and consumer incentives to drive the adoption of circular changes: Each step towards circularity in a GVC involves substantial costs, which requires access to finance for novel business models to onboard manufacturers and attract consumers.[36] Without consumer-friendly business models to mitigate the impact of the 'green premiums' of such sustainability-related GVC shifts, forcing consumers to absorb the costs will deter uptake of these products and relegate end-of-life disposal to inexpensive and informal disposal and recycling agencies.

There are models, supported by digital technology and artificial intelligence (AI), which have led to commercially feasible, deposit-free packaging alternatives for food take-outs, providing incentives to consumers and producers.[37]

Circular business models, such as product-as-a-service, potentially transfer the incentive to the producer as a services-based balance sheet is often more profitable than the sale of hard assets alone. For appliances, one of the strategies includes shifting from ownership to rental models, as was successfully piloted for refrigerators for low-income Belgian households.[38] In countries where ownership is a sign of prestige, service-and-use contracts or re-manufacturing to serve multiple consumer segments with one product can be an alternative.

Recommendations to the G20

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The G20 can power sustainable development by proactively leveraging the economic advantages offered by the transition from linear to circular value chains.

Industrial innovation, investment and agility must be supported by timely, coherent and consensus-led policies and fair regulations to drive producer and consumer shifts towards circular GVCs. This process is experimental, iterative and collaborative and needs conscious commitment to sustainable consumption and production; multilateral collaborations among governments, industry, academia and consumers; technology-sharing; new business and financing models; and specialised capacity-building for each interlocking process of each GVC.

An RE/CE Industry Platform (RECEIP), as being proposed by the Indian presidency, can be housed in the Business 20 (B20) Engagement Group to foster dialogue and exchange of knowledge between the G20 countries and their business sectors.

Such a platform can connect producer and supplier companies, logistics operators, financiers, technology providers and training and staffing agencies across the G20 in areas beyond their immediate supply chains and help them leverage the G20's influential economic network and interlocked GVCs. It can collate industry-wide feedback on challenges to GVC transition and help leading G20 markets in specific sectors disseminate – and other markets prepare for – emerging designs, standards and specifications.

The G20 RED should be constructively utilised to annually convene key stakeholders, including guest countries and industry experts (via the B20), to integrate political, economic and industrial discussions and debates on the transition from linear to circular GVCs. Incentive structures, implementation and enforcement are outside the ambit of the G20, but discussions on best practices, principles and protocols will allow individual countries to develop their own mechanisms and priorities.

Conclusion

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Integrating circularity in GVCs requires a fundamental shift in how products and services are perceived by designers, producers, consumers and policymakers. Piecemeal and sporadic measures, such as recycling, are inadequate to keep the global resource footprint within planetary boundaries. A G20-driven symbiosis of industrial and governance processes can help change perceptions, drive knowledge exchange, make policies more coherent and create new markets geared to circularity while accelerating a socioeconomically and politically viable transition to a circular economy that fosters sustainable production and consumption.

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