

GERMANY'S INDUSTRIAL TRANSFORMATION: ADVANCING THE CIRCULAR ECONOMY

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ABSTRACT

The industrial circular economy has become a key strategy for achieving sustainable development by reducing waste, extending product life cycles and improving resource efficiency. Germany is recognized as one of the leading countries in implementing circular economy principles through advanced recycling systems, industrial innovation and environmental legislation. However, the practice of planned obsolescence remains a significant examines the relationship between the circular economy and planned obsolescence in Germany. It analyses German industrial policies, examples of product durability issues and growing “right to repair” movement. This study highlights both the achievements and limitations of Germany’s sustainability transition. The findings demonstrate that although considerable progress has been made in waste management and industrial recycling in Germany, stronger regulations and repair-oriented product designs are necessary to fully support a circular economic model.

Keywords: circular economy, planned obsolescence, sustainability, Germany, Right to Repair, recycling, e-waste.

INTRODUCTION

The increasing depletion of natural resources, rising level of industrial waste and climate change concerns have encouraged governments and industries to search for more sustainable economic systems [1]. One of the most important solutions is the circular economy, which aims to replace the traditional linear model based on production, consumption and disposal [2].

Germany has become a major example of industrial sustainability because of its strong environmental regulations, recycling infrastructure and industrial innovation [3]. The German Circular Economy Act (“Kreislaufwirtschaftsgesetz”) encourages waste prevention, recycling and resource recovery across industrial sectors [4]. Industries such as automotive manufacturing, packaging and electronics increasing integrate production methods into their operations [5].

Despite these developments, planned obsolescence continues to create obstacles for sustainable efforts [6].

Planned obsolescence refers to the intentional reduction of a product’s useful life to encourage consumers to replace products more frequently [7]. Such practices increase electronic waste, resource consumption and environmental pollution.

This article investigates the relationship between the industrial circular economy and planned obsolescence in Germany. It discusses the main concepts of circular manufacturing, analyzes example of planned obsolescence in German markets and evaluates the role of repair-oriented policies in promoting sustainability.

EXPERIMENTAL

This study is based on a qualitative review of an academic literature, European Union policy documents, German environmental legislation and reports from consumer protection organizations. The research methodology includes the following:

- Analysis of circular economy policies

implemented in Germany.

- Review of scientific publications regarding planned obsolescence.
- Examination of examples from the electronics and household appliance industries.
- Evaluation of European Union “right to repair” initiatives and German sustainability programs.

The research materials were collected from official governmental publications, international organizations and peer-reviewed academic studies related to environmental economics and industrial sustainability.

RESULTS AND DISCUSSION

Germany’s circular economy model

Germany is recognized as one of the Europe’s leaders in recycling and industrial resource management [3]. The country’s waste management infrastructure enables high recycling rates for packaging materials, metals, plastics and glass [8].

One important example is the German bottle deposit system (“Pfandsystem”), where consumers return bottles and cans in exchange for refunds [9]. This system significantly increases material recovery and reduces landfill waste.

The automotive industry also contributes to circular manufacturing through vehicle recycling and material recovery processes [10]. German manufactures increasingly reuse metals, plastics and batteries from end-of-life vehicle to reduce raw material consumption.

Furthermore, Germany’s “Energiewende” policy supports renewable energy and industrial energy efficiency, contributing to broader environmental sustainability goals [11].

Planned obsolescence in Germany

Although Germany promotes sustainability, planned obsolescence present in several industrial sectors [6]. Consumer organizations have criticized manufacturers for producing household appliances and electronic devices that are difficult to repair [12].

For example, some washing machine and coffee machines contain sealed components that cannot easily be replaced [12]. In many cases, repair costs are nearly equal to purchasing a new product, encouraging consumers to discard functioning devices prematurely.

Smartphones represent another major issue. Many devices sold in Germany use glued batteries and nonremovable components, limiting repairability [13]. Additionally, software updates for older devices are often discontinued after only a few years, reducing product functionality despite operational hardware.

These practices directly contradict circular economy principles because they shorten product lifespans and increase electronic waste generation [14].

Right to repair and sustainability policies

Germany strongly supports the European Union’s “right to repair” initiatives [15]. These policies aim to improve product durability and ensure that consumers have access to spare parts, technical manuals and independent repair services.

The right to repair movement focuses on the following:

- Extending product lifespan,
- Reducing electronic waste,
- Supporting independent repair businesses,
- Improving resource efficiency.

Repair cafes have become increasingly popular throughout Germany [16]. These community workshops allow individuals to repair electronics and household items instead of discarding them. Such initiatives encourage sustainable consumption and public awareness regarding waste reduction.

The findings indicate that repairability and product durability are essential components of a successful circular economy.

SWOT Analysis of Germany’s circular economy model

A SWOT analysis helps evaluate the strengths, weaknesses, opportunities and threats associated with Germany’s industrial circular economy and its efforts to address planned obsolescence.

Strengths

Germany possesses one of the most advanced recycling and waste management systems in Europe. Strong environmental legislation, including the Circular Economy Act (“Kreislaufwirtschaftsgesetz”), supports resource efficiency and waste reduction. The country also benefits from high levels of industrial innovation, particularly in the automotive, packaging and renewable energy sectors. Public awareness

regarding environmental sustainability and recycling practices is relatively high compared to many other countries.

Weaknesses

Despite strong sustainability policies, planned obsolescence remains a major issue in the electronics and household appliance industries. Many products are designed with limited repairability, non-removable components and short software support periods. Repair services are often expensive, encouraging consumers to replace products instead of repairing them. Additionally, some industries still rely heavily on resource-intensive manufacturing processes.

Opportunities

The European Union's "Right to Repair" initiatives create significant opportunities for improving product durability and reducing electronic waste. Expansion of repair-oriented businesses, recycling technologies and eco-design practices could further strengthen Germany's circular economy. Growing consumer demand for sustainable and durable products may also encourage manufacturers to adopt longer-lasting and repairable product designs.

Threats

Rapid technological development and increasing consumer demand for new electronic devices continue to accelerate waste generation. Global supply chain disruptions and rising raw material costs may create additional economic pressure on sustainable manufacturing systems. Furthermore, resistance from manufacturers that benefit economically from frequent product replacement could slow the implementation of stricter repairability regulations.

Overall, the SWOT analysis demonstrates that Germany has strong institutional and industrial foundations for a successful circular economy. However, long-term success will depend on reducing planned obsolescence and promoting repair-oriented production and consumption models.

CONCLUSIONS

Germany has demonstrated significant progress in implementing industrial circular economy principles

through advanced recycling systems, sustainable manufacturing policies and environmental legislation. The country's bottle deposit system, vehicle recycling programs and renewable energy transition provide important examples of industrial sustainability.

However, planned obsolescence continues to undermine these efforts, particularly in the electronics and household appliance sectors. Limited repairability, short software support periods and expensive maintenance practices contribute to increasing electronic waste and resource consumption.

The study concludes that achieving a fully functional circular economy requires stronger regulations regarding product durability and repair access. Policies such as the European Union Right to Repair initiative represent important steps toward reducing waste and extending product life cycles.

Future industrial development in Germany will depend on balancing economic growth with sustainable production, responsible product design and long-term resource management.

Authors' contributions

All data are collected and analysed by P.R.

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