

Closed-cycle economy as a resource-saving model of nature management

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Abstract. The article discusses the interconnection of production and consumption patterns in the interests of sustainable development and responsible use of resources. In order to achieve sustainable development, many countries are implementing business models of the circular economy. The application of circular economy models in practice directly affects the ecological state of the country. An overview of business models of the closed-cycle economy is given: resource recovery models; closed-cycle supply models; sharing models; product life extension models; product service models. The problem of ecological and economic development of the system in the context of globalisation is topical. The aim of the study is to compare the application of business models of closed-cycle economy by leading countries. The analysis of the international practice of applying closed-type business models has been carried out, which made it possible to group countries according to the same indicators: "flagships of the closed-cycle economy concept"; "rationalizers of the closed-cycle economy concept"; "prospectors of the closed-cycle economy concept"; "reformers of the closed-loop economy concept"; "conservatives of the closed-loop economy concept". The conclusion is made about the existing links of technological, organizational and social innovations in the system of production and consumption.

1 Introduction

Closed-loop economies are generally seen as an additional source of costs in the commercial sector, so the transition to the concept of a closed-loop economy requires a profound transformation of business. The transition to a low-carbon development trajectory in the global economy dictates new conditions not only for the financial sector and regulators, but also for the public, requiring transparency in all business processes. Businesses are forced to adopt a responsible attitude to the environment and careful use of resources, and to switch to new ways of producing and consuming resources. Meanwhile, for business, the transition to a closed-cycle economy does not always have to be conditioned by additional costs; there are opportunities for profit creation.

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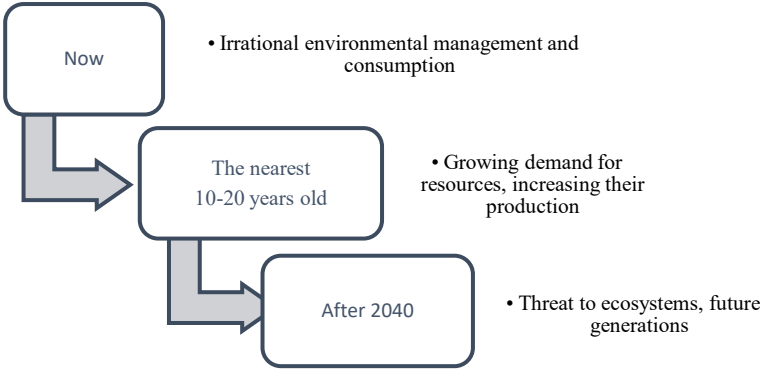


Fig. 1. Forecast scenario of the current production and consumption model.

Preserving the value of things, materials and resources in the economy for as long as possible is the main goal of the circular economy. There are only three ways to achieve this goal: to close the production cycle completely; to narrow the production cycle as much as possible; or to slow down the production cycle. The concept of the circular economy implies a fundamentally new approach to production, consumption and economic activity [1].

2 Methods and materials

Based on the main objective of the circular economy - to preserve the value of things, materials and resources in the economy for as long as possible - it is possible to consider what is now a waste product to be a resource in a circular economy.

This can be achieved in the following ways:

- 1. By recycling materials and recovering goods as much as possible, to completely close production cycles.
- 2. Reduction of the share of materials in production.
- 3. Popularizing the sharing, renting and repairing of things in order to slow down consumption.

These closed-loop economics approaches contribute to achieving the following Sustainable Development Goals [2]:

- sustainable cities and human settlements;
- responsible consumption and production;
- combating climate change;
- conservation of marine ecosystems;
- conservation of terrestrial ecosystems.

Throughout the value chain, the closed-loop economy contributes to the reorientation of the company's business model towards the application of technological, social and organizational innovations [3,4]. The application of new business models involves the replacement of traditional technologies in favor of reducing environmental impact by intensive use of resources and reducing waste generation, Figure 2.

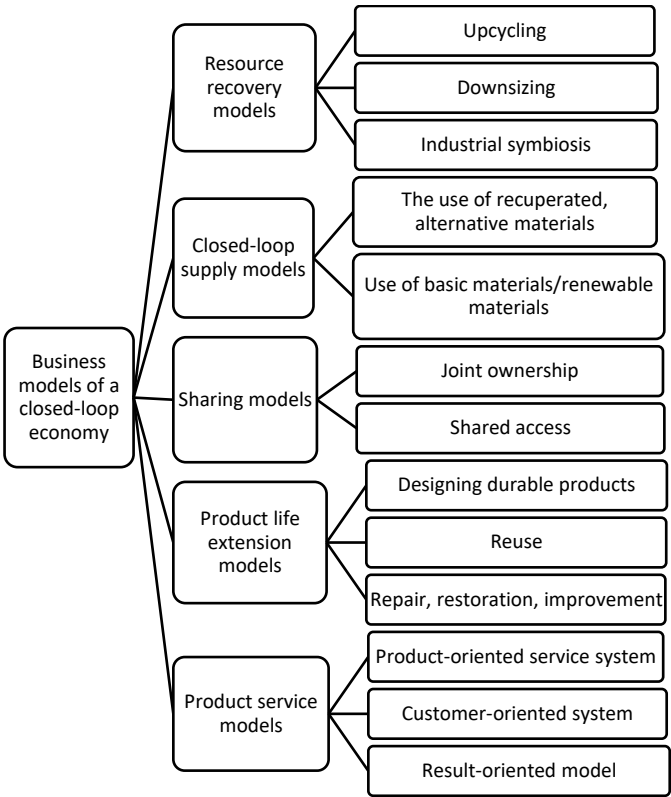


Fig. 2. Business models of a closed-loop economy

In world practice, the following business models of a closed-cycle economy are distinguished:

- resource recovery models;
- closed-loop supply models;
- sharing models;
- models for extending the service life of products;
- product service models.

3 Results and discussion

Let's consider separately each business model of the closed-loop economy, which already have practical application in the international community.

3.1 Resource recovery (recovery) models.

The model of resource recovery or recovery is based on the production of secondary raw materials from waste, which results in lower-grade raw materials compared to the original or, conversely, higher quality. From an economic point of view, benefits are derived from waste, since waste is available for free or inexpensive. At the same time, ready-made secondary raw materials are available for purchase on commodity markets, but at the same time have a higher cost [5,6].

Resource recovery models have several types of production process: downcycling, upcycling, industrial symbiosis.

Downcycling is a recycling process, instead of conventional disposal, waste is converted into secondary raw materials, but with lower quality and therefore limited in use.

Upcycling - a recycling process whereby secondary raw materials are not considered to have lost quality and can be used in the production of a higher value product.

Industrial symbiosis - the use of by-products from one production process are utilised as inputs in another production process. Within this type of production process it is appropriate to talk about large volumes of industrial waste.[7]. Let's look at which countries use resource recovery models, table 1.

Table 1. International practice of using resource recovery models

A country	Industry of production	Company	Description of the production
Upcycling			
Switzerland	The fashion industry	Freitag	Manufacture of bags from seat belts, used airbags and awnings from trucks
Brazil	The music industry	Boomera	Making musical instruments from recycled waste
Singapore	Aviation industry Furniture production The fashion industry	Singapore Airlines	Transfer of parts and materials from decommissioned aircraft to various Singapore companies for processing and use in the production of retail goods (furniture, clothing and accessories, bags)
Downsizing			
Russia	Building materials	Bor Polymer Company	Production of polymer-sand products based on plastic processing technologies (polymer-sand tiles, tiles, sidewalk curb)
United The States of America	Building materials	Veolia North America	Processing (grinding) of wind turbine blades and using them to replace raw materials in cement production
Industrial symbiosis			
India	Building materials	KK Plastic Management Ltd	A provider of plastic waste disposal services, recycles plastic into flakes that are used for road construction.
Russia	Pharmaceuticals	Ecobelok LLC	A provider of services for processing food waste into protein using the larvae of the Black Lion fly. The larvae grow quickly and are used as food for fish, cattle, and pets.
Great Britain	Alcohol industry	ToastAle	Processing of stale bread provided by bakeries for beer production.
Norway	Aquaculture	Leroy sea food (company Oceanfish)	Recycling of fish farm waste for the cultivation of kelp and mussels

3.2 Closed-loop supply models

The basis of closed-loop supply business models is the replacement of traditional primary resources with recovered, renewable or bio-based materials. Closed-loop supply models are based on the concept of ‘Cradle to Cradle’ (C2C), whereby the materials that make up the

original products at the end of their life cycle become the raw materials for the production of new products.

With the introduction of closed-loop supply business models, new opportunities are opening up: selling products at a higher price as ‘green and sustainable’ products to consumers who are willing to support sustainable production and care about the environment. The use of domestic production facilities in the production of recycled materials reduces the risks of sourcing, as a possible supplier may be located in politically unstable countries [8,9]. Figure 3 shows the countries that use closed-loop supply models in their economies.

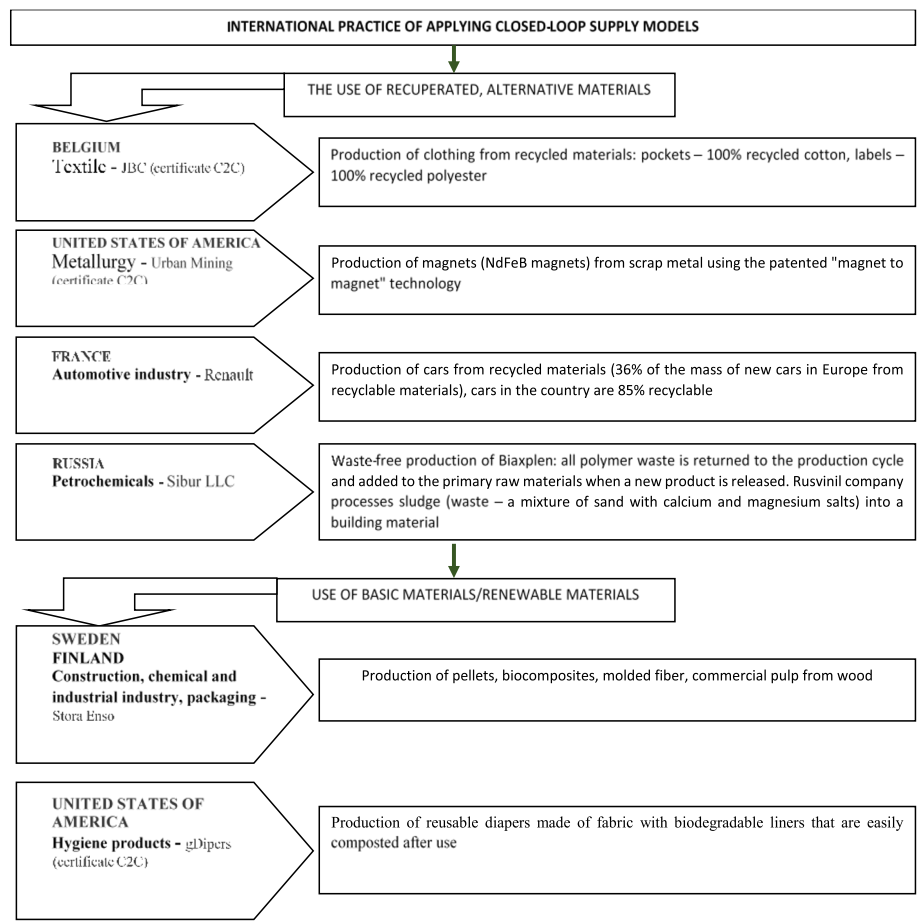


Fig. 3. International practice of applying closed-loop supply models

3.3 Sharing models

The basis of the sharing models is the intensive use of consumer assets of various types by leasing or by sharing. Sharing models include two subtypes: "shared ownership" and "shared access". Recently, due to the development of IT technologies and artificial intelligence in various fields, there has been an active growth in the trend of "sharing by strangers" consumer assets [10,11]. Online platforms, online platforms and online services act as integral elements of the sharing market, contribute to the creation of peer-to-peer communities on the Internet in order to get the right thing for temporary use. Moreover, all participants in sharing models benefit: the online platform (service or platform) is responsible for organising the online

space; the owner of the assets is responsible for renting or providing the assets; the user, in turn, saves money on purchasing the necessary asset by purchasing it for temporary use for a certain period of time. In table 3, we present data on countries that use sharing models in their economies.

Table 2. International practice of using sharing models

A country	Industry of production	Company	Description of the production
Joint ownership			
Holland	House holdtools	Peerby	An online platform for the sharing of household tools (drills, chainsaws, grinders, etc.) For capital-intensive tools, a joint ownership model is used (machine tools, drying equipment, etc.)
Sharedaccess			
United States of America	Rental housing Rent clothes	Airbnb Tulerie	An online platform for placing and searching for private housing rentals around the world. Online clothing sharing service. Allows users to rent their clothes on the service and thus monetize their wardrobe.
France	Joint trips	Bla bla car	An online service for finding car companions

3.4 Models for extending the service life of products.

Service life extension models are based on three concepts: design of durable products; reuse of products; repair, restoration and improvement of products. The purpose of using product life extension models is to slow down the turnover of products in the economy, which allows reducing the rate of new waste generation. Reduced consumption of virgin materials can lead to a reduction in the cost of the final product and a reduction in the cost of the remanufactured product. Moreover, the manufacturer of products with a longer warranty period can set a higher price for the product, as it will be of higher quality compared to its analogues with a shorter period of use [12,13]. Also the manufacturer can provide its products not only with warranty service but also with post-warranty repair, which will affect the extension of product life. Table 3 shows the countries that use product life extension models in their economies.

Table 3. International practice of application of models for extending the service life of products

A country	Industry of production	Company	Description of the production
Designing durable products			
Holland	Electronics	Fairphone	Production of modular high-strength smartphones
Denmark	Construction	System Rexton	The construction of buildings from modular blocks, which, after dismantling the buildings, can be reused for the assembly of new buildings
Reuse			
Holland	Consumer goods	Avito (Prosus)	An online platform for placing ads for the sale of used personal items, vehicles, and secondary real estate

Russia	Resale of clothing	Chatiry Chop stores and the Second Wind Foundation	The Foundation accepts unwanted clothes and resells them in its stores, and sends the clothes for recycling in poor condition
Norway	Thefiel dofnutrition	Madsentralen	Redistributes unclaimed food from cafes and retailers to social organizations
Repair, rebuild, improve			
United States of America	Mining machinery Construction machinery Electronics	Caterpillar Backmarket	Carries out major repairs, replacement of parts, upgrade of models of equipment of its production to extend its maximum service life E-commerce of refurbished (repaired) household appliances
Russia	Design, Construction industry	Bricktiles	Restoration and sale of vintage 19th century brick masonry

3.5 Product service models

Product service models are based on three concepts: a result-oriented model; a customer-oriented service system; and a product-oriented service system. The purpose of using product service models is to provide a range of services for products, stimulating their responsible consumption [14,15].

The product-oriented service system involves various after-sales services, including the ability to bring the product to the manufacturer for disposal when its shelf life ends.

The customer-oriented service system provides time-limited access to specific products, while the supplier retains ownership of the products.

The result-oriented model assumes payment only for the actual result of the work, and not ownership of a particular product. Table 4 shows the countries that use product service models in their economies.

Table 4. International practice in the application of product service models

A country	Industry of production	Company	Description of the production
Product-oriented service system			
United States of America	Clothes	Patagonia	Provision of guarantees for the restoration of damaged clothing and other products of the company, support of an online service for the resale of used clothing of the company
Франция	Appliances	Tefal	Repair in the company's product service centers not only during its operation, but also after the end of the warranty period
Japan	Electronics	Canon	Repair of photographic equipment in service centers not only during its operation, but also after the end of the warranty period
Customer – oriented service system			

Germany	Electronics, furniture	Lendis	Office equipment and furniture rental
China	Clothes	Ms. Paris	Rent designer clothes
Russia	Packaging	«Dishesagain»	The service of delivery of dishes from restaurants and cafes in a revolving container
United States of America	Theentertainmen tindustry	Amazon, Netflix, Spotify	Access to content for the duration of a paid subscription
Result-oriented model			
Holland	Leasing of lighting services	Phillips	Providing sustainable lighting in line with the ‘pay per lux’ concept: the company commits to providing a specific amount of lighting
Egypt	Chemical leasing	Azko Nobel Powder coating SAE	Provision of painting services. The company's work is evaluated on the basis of the necessary properties of the painted equipment
Japan	Leasing of transportation services	Mitsubishi elevator	The Corporation provides elevator leasing services

Having considered and analyzed the international practice of applying standard business models of a closed-type economy, it can be summarized that not all countries in their economies apply all business models of a closed-type economy, Table 5.

Table 5. Analysis of the international practice of applying closed-type business models

A country	Resource recovery models	Closed-loop supply models	Sharing models	Product life extension models	Product service models
UnitedStates ofAmerica	+	+	+	+	+
Russia	+	+	-	+	+
France		+	+		+
Holland			+	+	+
Norway	+			+	
India	+				
GreatBritain	+				
Singapore	+				
Brazil	+				
Switzerland	+				
Sweden		+			
Finland		+			
Belgium		+			
Denmark				+	
Japan					+
Germany					+
China					+
Egypt					+

Thus, when analyzing the international practice of applying closed-type business models, we see that all the countries studied conditionally form five groups:

1. The flagships of the closed-loop economy concept.

2. Rationalizers of the closed-loop economy concept.
3. Prospectors of the concept of a closed-loop economy.
4. Reformers of the concept of a closed-loop economy.
5. Conservatives of the concept of a closed-loop economy.

The first group of "Flagships of the closed-loop economy concept" included 1 country - the United States of America.

The second group "Rationalizers of the closed-loop economy concept" also included 1 country - Russia.

The third group of "Explorers of the closed-loop economy concept" consisted of 2 countries - France and the Netherlands.

The fourth group "Reformers of the closed-loop economy concept" included 1 country - Norway.

The fifth group of "Conservatives of the closed-loop economy concept" was formed by 13 countries - Switzerland, Brazil, Singapore, India, Great Britain, Belgium, Sweden, Finland, Denmark, Japan, Germany, China and Egypt.

4 Conclusion

Thus, the selected groups of countries clearly show us that there are different degrees of motivation for production, consumption and economic activity in the context of the projected shortage of resources and global efforts to reduce CO² emissions into the earth's atmosphere.

The first group included only one country – the United States of America. The country successfully applies all five groups of closed-type models in its economy: resource recovery models; closed-cycle supply models; sharing models; product life extension models; service models (for goods).

The second group is also formed by only one country – Russia, which so far uses four closed-type business models in its economy: resource recovery models; closed-cycle supply models; product life extension models; service models (for goods). The development of the sharing (consumption) economy in Russia lags behind developed countries. Among the problems hindering the development of the economy of shared consumption in Russia, the following can be distinguished: high level of uncertainty; low level of trust; income level; information inequality; problems of state regulation [16].

The third group was formed by countries that successfully use three of the five groups of closed-type models in their economies - France and Holland. Closed-loop supply models; sharing models and service models (for goods) France is actively using it in its economy. The Netherlands, as well as France, follows models of sharing and service models (for goods), as well as models for extending the service life of products. This group is united by common views on the state of ecology, climate, projected resource scarcity and, as a result, the threat to ecosystems and future generations [17]. Therefore, the "Prospectors of the closed-loop economy concept" are engaged in the search, analysis and development of new production surveys capable of preserving ecology, biodiversity, and natural resources for as long as possible.

The fourth group is formed by one country, Norway, which applies two of the five groups of closed-type business models: resource recovery models and product life extension models. The group "Reformers of the closed-loop Economy concept" is characterized by a steady desire to transform existing industries, applying a fundamentally new approach to production, consumption and business activities.

The fifth group includes the rest of the countries that use at least one of the group models in their economies. Switzerland, Brazil, Singapore, India and the United Kingdom have successfully applied resource recovery models (upcycling, downcycling, industrial symbiosis). Belgium, Sweden and Finland actively use closed-loop supply models (use of

recuperated, alternative materials; use of bio-based materials/renewable materials). Denmark applies the fourth group of models for extending the service life of products (design of durable products; reuse; repair, restoration, improvement). Service models (product-oriented service system; customer-oriented system; result-oriented model) have successfully found their application in countries such as Japan, Germany, China and Egypt.

Based on the results of the study, the applied closed-loop business models of the studied countries in their economies were analyzed. The interrelation of the position of each country under study in the given ratings is revealed. The research indicators were: resource recovery models; closed-loop supply models; sharing models; product life extension models; product service models. The analysis of the international practice of applying closed-type business models has been carried out and the criteria involved in determining the position of each country in the ranking have been identified.

The results obtained allow us to see the groupings of countries according to the indicators of the application of business models of the closed-cycle economy in single standard groups:

1. "The flagships of the closed-loop economy concept".
2. "Rationalizers of the concept of a closed-loop economy".
3. "Prospectors of the concept of a closed-loop economy".
4. "Reformers of the concept of a closed-loop economy".
5. "Conservatives of the concept of a closed-loop economy".

The purpose of grouping countries by indicators of the application of business models of a closed-loop economy is to form full-fledged ecological and economic chains, search for new niches for investments in technological, social and organizational innovations. The creation of certain conditions of competition within the group will facilitate the application of more business models of the closed-loop economy. Thus, the subjects of the global economy with the use of new business systems will be obliged to replace traditional technologies in favor of reducing the impact on the environment by intensive use of resources and reducing waste generation.

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