A NEW ECOSYSTEM FOR THE MANUFACTURING INDUSTRY PRESENTED BY THE CIRCULAR ECONOMY

- LCA IS A KEY TO ITS FORMATION -

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SUMMARY

- In order to shift to a circular economy, the manufacturing industry must establish a "symbiotic eco-system" in which the flow of circulating goods and information is shared with other industries and new businesses are created while maintaining a balance between reducing environmental impact and achieving economic efficiency.
- In a symbiotic ecosystem, life cycle assessment (LCA) and the key players who interpret it play an important role in sharing the goal of reducing environmental impact on a common benchmark.
- Key players need to have the ability to draw out the potential of numerous stakeholders and direct co-creation. They also need to have a deep understanding of LCA and the ability to create new businesses from it or expand and promote existing businesses.

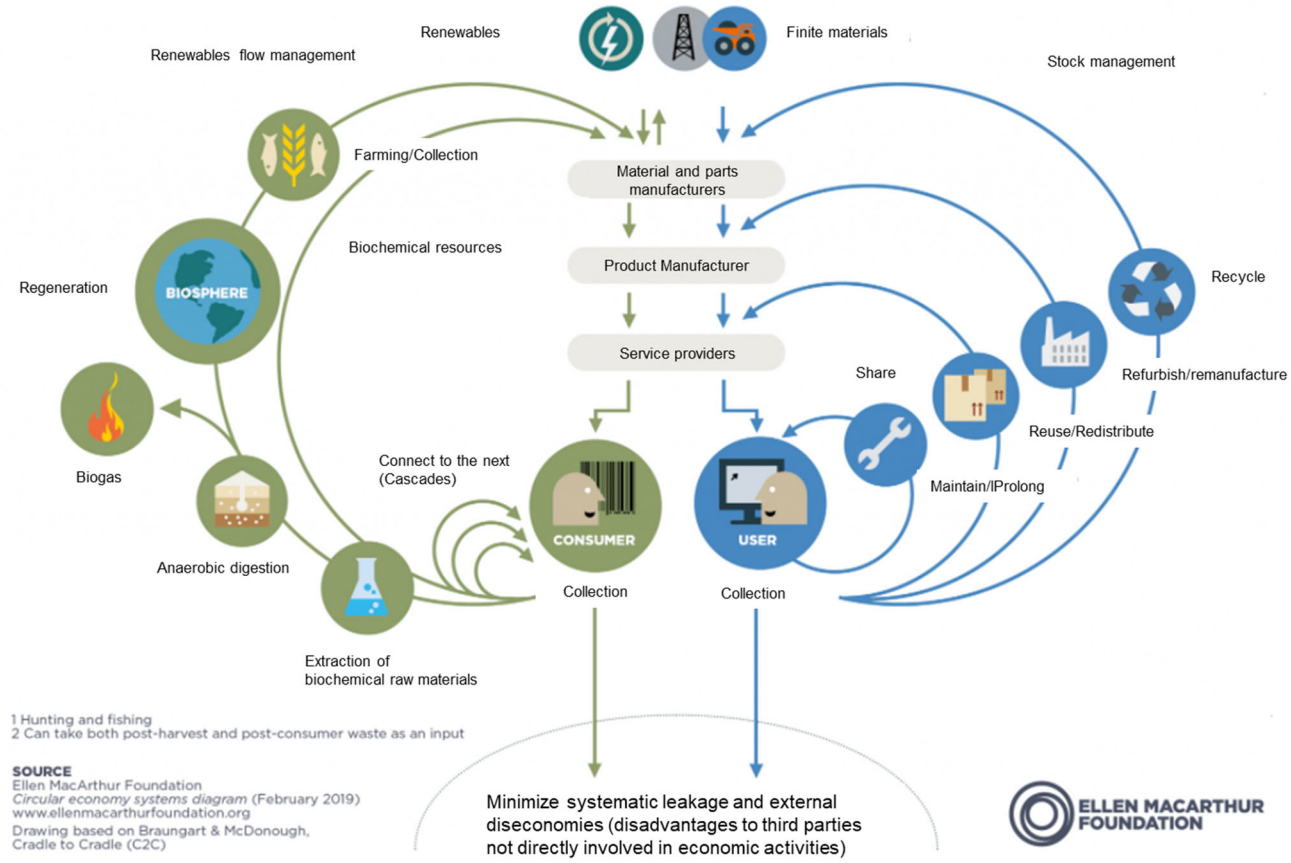
1. CREATING A SYMBIOTIC ECOSYSTEM IN THE MANUFACTURING INDUSTRY, STARTING WITH A SHIFT TO A CIRCULAR ECONOMY

Recently, there has been growing concern about environmental pollution and adverse health effects caused by the disposal of products, including the marine plastic pollution. To solve these problems, there is a need to shift from the conventional supply chain where products are disposed of after use to a new supply chain in which products are not disposed of. In other words, there needs to be a circular economy (CE)[1] (Figure 1) that returns the flow of goods to each stage of the supply chain. Moreover, it is becoming widely recognized that forming a new ecosystem in which each player creates mutual relationships with many other players through logistics, information, energy, and the like is necessary for this transformation to take place. Recently, in May 2021, Kao, Unilever Japan, and Higashiyamato City in Tokyo launched a project[2] to collect and recycle daily necessities. In this project, competing companies have formed an unprecedented eco-system, sharing information on the raw materials used in their products and building new collection routes in cooperation with the government, which is responsible for waste collection, to carry out joint recycling.

As an extension of this attempt, there is a need to create a system that covers every player involved in CE. In the system, the players share the flow of circulating goods and information related to them and create businesses while balancing the reduction of environmental impact with economic efficiency. This report calls such a system a “symbiotic ecosystem” and describes its ideal form and the Life Cycle Assessment (LCA) that is the key to its formation.

[1] A circular economy spans over sharing, reusing, refurbishing, as well as using renewable resources. It covers stopping the outflow of waste to protect the environment and creating a new sustainable business model.
[2] News Release “Unilever Japan and Kao Launch a Collaborative Plastic Recycling Program”

Figure 1: Circular economy diagram



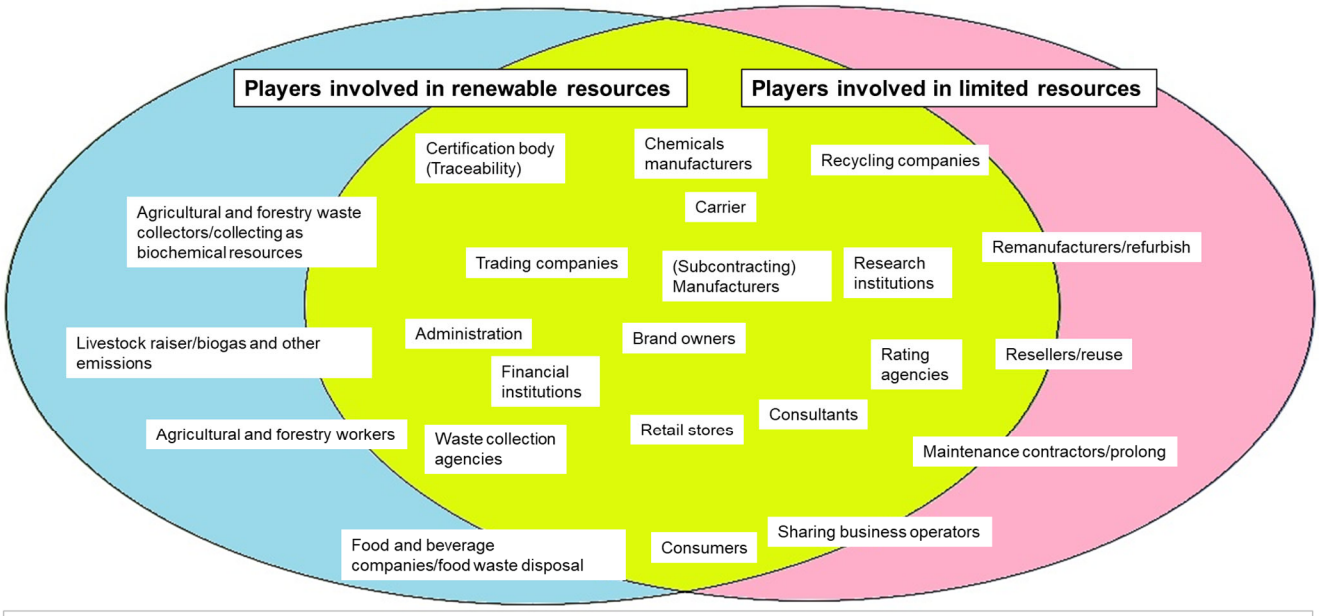
Source: Website of the Ellen Mac Arthur Foundation website (last accessed on August 19, 2021)
https://ellenmacarthurfoundation.org/circular-economy-diagram

2. SYMBIOTIC ECOSYSTEM AND LCA

2.1. Involvement of new players

The symbiotic ecosystem will include many players who have not been part of the traditional manufacturing supply chain (Figure 2). The concept of CE consists of both the flow of renewable resources and the stock management of limited resources. As shown in Figure 1, suppliers of renewable resources, such as agriculture, forestry, livestock, and food and beverage companies, those involved in their recovery and regeneration, and those that recover and process limited resources for reuse will be added to the traditional players in the manufacturing supply chain. It can be likened to an orchestra created by adding new members to a small chamber orchestra. While the increase in the number of stakeholders is expected to make coordination more complicated, it can also be seen as a way to involve more players and expand the range of repertoire of the orchestra, which would increase the possibility of new businesses.

Figure 2: Players necessary for a symbiotic ecosystem



Blue: players involved in renewable resources, pink: players involved in finite resources, lime: players involved in both renewable and finite resources

Source: Prepared by MGSSI

2.2. Determining the state of the symbiotic ecosystem through Life Cycle Assessment (LCA)

LCA is a method for quantitatively assessing the environmental impact of products from the extraction of raw materials to manufacturing, use, and disposal. It is a tool for sharing environmental goals for the entire ecosystem on a common benchmark when creating a symbiotic ecosystem. In an orchestra, each player has his or her own music score. If the musical note in a musical score is like the specification of the product to be handled in a symbiotic ecosystem, LCA is like the symbol that is added around it to define the expression and mood of the music.

International standardization of LCA has progressed in recent years[3], and there is a growing understanding that it is useful as a technical indicator for promoting CE. The United Nations Environment Programme (UNEP)[4] and the European Commission Directorate-General for Environment[5] are conducting LCA to compare the environmental impact of recycled and renewable (bio)plastics with that of fossil fuel-derived plastics. The results of the LCA of take-away food packages by UNEP are shown here as an example (Figure 3). Conducting LCA helps us understand that simply changing all fossil fuel-derived plastics to bioplastics could in fact increase the environmental impact of the planet as a whole. Depending on the plants used as raw materials and their cultivation methods, some cases have been reported to have a higher environmental impact than fossil fuel-derived plastics, not only in terms of ecological impact but also in terms of the impact assessment for climate change.

[3] In addition to the ISO international standard, there is also a corresponding Japanese standard (JIS).
ISO 14040 (JIS Q14040): Principles and framework
ISO 14041 (JIS Q14041): Goal and scope definition and inventory analysis
ISO14042 (JIS Q14042): Life cycle impact assessment
ISO14043 (JIS Q14043): Life cycle interpretation
[4] UNED Life Cycle Initiative website
https://www.lifecycleinitiative.org/about/our-mission-vision-and-impact/
[5] Life Cycle Assessment (LCA) of alternative feedstocks for plastics production, EC's website
https://publications.jrc.ec.europa.eu/repository/handle/JRC125046

Figure 3: Comparison of LCA results (impact indicators) for take-away food packages

		Impact indicators					
		Climate change		(Ocean) Acidification		(Oceans, rivers, lakes, etc.) Eutrophication	
A case study revalidated by the United Nations Environment Programme: Source stated in [ ]		Best	Worst	Best	Worst	Best	Worst
Comparison between single-use plastic take-away food packaging	Thermoforming boxes made of PS, PLA (corn), and PLA (cassava starch) [Suwanmanee et al, 2013]	PS	PLA (cassava starch)	PS	PLA (corn)	None	None
	Thermoformed clamshell containers made of PLA, PET and PS for strawberry packaging [Madival et al, 2009]	PLA (corn), PS	PET	PET、PS	PLA (corn)	PLA (corn), PS	PET
Comparison of single-use take-away food packaging made of plastic and materials other than plastic	Bio-based thermoformable paper food trays vs. existing plastic packages: a comparison of APET/PE and EPS [Johansson et al, 2020]	Bio-based thermoformed paper and lids made of multilayer film	APET/PE and lids made of multilayer film	Bio-based thermoformed paper and lids made of multilayer film	APET/PE and lids made of multilayer film	Bio-based thermoformed paper and lids made of multilayer film	APET/PE and lids made of multilayer film
	Comparison of fruit and vegetable packaging in six different types of plastics and recycled moulded pulp [Belley, 2011]	XPS, Recycling molded pulp	OPS、PET、PLA、PP	XPS, Recycling molded pulp	PLA、PP	XPS, Recycling moluded pulp, OPS, PET	PLA
Comparison of single-use plastic take-away food packaging and reusable packagging	Comparison of single-use and reusable plastic packaging with single-use aluminum [Gallego-Schmid et al, 2019]	XPS reusable PP (if used more than 18 times)	Disposable PP	XPS reusable PP (ifused more than 29 times)	Disposable PP	XPS reusable PP (if used more than 18 times)	Disposable PP
	Comparison of reusable plastic containers and glass containers［Gallego-Schmid et al, 2018］	Reusable PP	Reusable glass	Reusable PP	Reusable glass	Reusable PP	Reusable glass

Note: The best and worst materials were selected from the perspective of three impact indicators (climate change, ocean acidification, and eutrophication of oceans, rivers, lakes, etc.).
(PS: Polystyrene, PLA: Polylactic acid, PET: Polyethylene terephthalate, APET: Amorphous polyethylene, PE: Polyethylene, EPS: Expanded polystyrene, XPS: Extruded polystyrene, OPS: Oriented polystyrene, PP: Polypropylene)
Source: Prepared by MGSSI based on "Single-use plastic take-away food packaging and its alternatives" by the United Nations Environment Programme

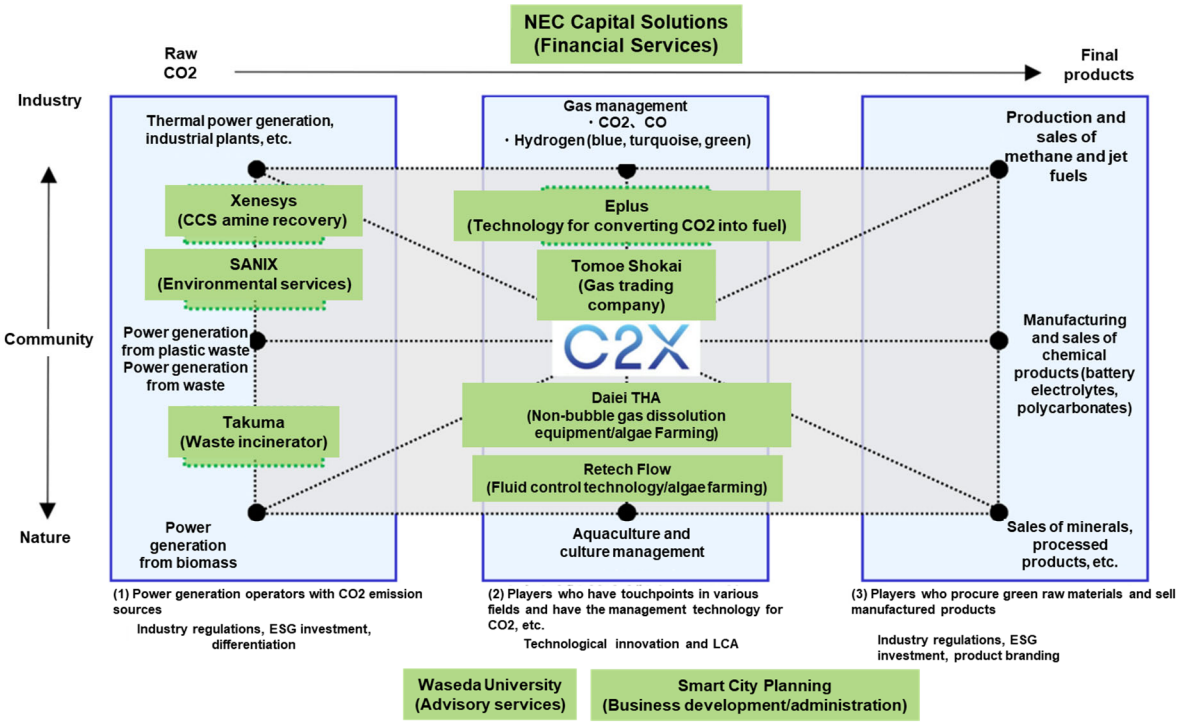
What is needed here is the presence of a conductor, as in an orchestra. Just as a conductor is responsible for creating valuable music by appropriately interpreting the musical scores of all the players for the audience, the symbiotic ecosystem also requires a role equivalent to that of a conductor, and the players who play this role will be referred to here as key players. Based on the LCA results and the LCA rules, the key players hypothesize, for example, that plant-derived waste from agriculture has a low environmental impact as a raw material for bioplastics, and that leveraging waste will be important in spreading bioplastics. The role of the key players will be to create new markets by streamlining the flow of goods and identifying and supporting the relevant players to validate the hypothesis. Even in the stock management of finite resources, LCA is essential for finding a business model that can both reduce environmental impact and achieve economic efficiency, as the options for dealing with used products diversify to include refurbishing, sharing and other methods. It also serves as the basic data for sharing the condition of the business with stakeholders in a transparent and clear manner.

2.3. Symbiotic ecosystem-oriented case study: C2X

This section introduces the Carbon to X Project (C2X) as an example of how different industries are working together to form a symbiotic ecosystem (Figure 4). The project was launched on June 10, 2021, with the aim to achieve a decarbonized society and with an emphasis on promoting co-creation among small and medium-sized enterprises with high technological capabilities in Japan. In C2X, Smart City Planning, an incubator for new businesses to realize environmental cities, plays the role of a key player in formation and development. According to a source at Smart City Planning, the impetus for the C2X consideration came from a dialogue with two long-standing partner companies, Takuma, a manufacturer of incinerators, and Xenesys, a company that possesses CO2 capture technology, regarding next-generation incineration plants. Specifically, the theme of CO2 capture, storage, and utilization is being discussed as the ideal form of an incineration plant based on the recent transition toward decarbonization. In order to delve deeper into this field, Smart City Planning has concluded a joint research agreement with Professor Hiroshi Onoda of Waseda University, who has a wide experience in this field, ranging from research to commercialization and providing advice to the government. Under the joint research agreement, the company conducted a careful study of the direction and technology to be considered for commercialization, in light of the advice received, and has made proposals for individual projects. Since then, the number of players has continued to increase with the addition of Eplus, which has CO2 fuel conversion technology, Tomoe Shokai, which has the knowledge of gas distribution, and Daiei THA and

Retech Flow, which have technologies related to algae cultivation. Fuel consumers and chemical manufacturers are also likely to join in the future.

Figure 4: Necessary elements and players for C2X (turning CO2 into new value) (as of August 2021)



Source: C2X website （https://c2x.jp/index.html#a01） The green boxes (player name and business/business outline) have been added by MGSSI based on interviews with the companies.

In addition to appropriately connecting companies that emit CO2, those that collect and transport it, and those that use the collected CO2 to make products, Smart City Planning have been making efforts to create an environment to drive commercialization. First, C2X was made an incorporated association in order to ensure neutrality. To ensure that the corporation to be able to focus more on commercialization activities rather than activities as an incorporated association, no annual membership fee is collected. The corporation will receive a success fee when the business is successful. Additionally, when it is necessary to make policy recommendations or obtain a government budget for promoting commercialization, the corporation expects to flexibly collaborate with other incorporated associations that specialize in these areas. To promote co-creation, it has also established a rule that it will not prevent competitors from joining C2X. At the start of C2X, almost all new individual project proposals were made by Smart City Planning, but as the company has been presenting specific individual projects and providing appropriate additional information, the number of proposals from member companies is gradually increasing.

The company says that it has started recognizing that the future challenge would be to quantify the CO2 reduction effect of C2X through LCA. It plans to ask Professor Onoda to conduct the LCA itself, but Smart City Planning has several ideas for businesses based on LCA. Specifically, the concept is to develop LCA tracking technology by incubating startups as a new individual project of C2X, and to propose LCA tracking as a social system to the government in cooperation with other incorporated associations. In the future, the development of technologies and the formation of rules for LCA to quantify CO2 emissions are expected to keep pace with the study of carbon pricing and other issues in Japan and overseas. These technologies and rules are expected to have a significant impact on the success or failure of C2X commercialization.

Although C2X is still in the process of growth and many hypotheses are still waiting to be verified, there is a lot to learn from it as an ecosystem that is gradually growing by involving new players based on the networks of existing businesses and as a reference for business concepts based on LCA.

3. CREATING AND DEVELOPING A SYMBIOTIC ECOSYSTEM

The role of key players is important in making symbiotic ecosystems a widespread development model for manufacturing. Key players are required to have (1) the ability to involve a large number of stakeholders, draw out their potential, and direct co-creation, and (2) the ability to master LCA.

(1) requires the ability to understand the potential of producers of renewable resources and players who collect, process, and supply various types of wastes as new resources, as well as the constraints of new resources as raw materials for certain products, and then to derive and direct the realization of the optimal path to achieve both quality and economic efficiency.

For (2), the company must be able to make decisions based on a deep understanding of LCA by comparing its results with economic sustainability, and then launch new businesses or expand and promote existing businesses while sharing the results with stakeholders in a transparent and easy-to-understand manner.