

The Impact of Resource-Based Circular Economic Models in Japan

*Bianca Yamaguchi**

Toru Takahashi

Cristian Iulian Vlad

Hiroaki Kaneko

Ana Damaschin

Abstract

This paper illustrates the impact of education and digital technology adoption within the local community in Nagaoka (Japan) while proposing a business model focused on an increase in the creation of social value based on services, as opposed to incumbent models based on increasing the manufacturing and selling of physical products. The authors analyze the supply chains network common to local businesses to help them establish an active exchange of waste and bi-products for a more effective recycling and a more sustainable remanufacturing system.

By taking into consideration all 17 of the United Nations' Global Sustainable Goals (SDGs), this research work individually on the achievement of Goal 12 (Responsible production and consumption) on the one side, to establish the essential steps for a more viable resource-based circular economic model, with an application on manufacturing businesses, from the other hands, to create a sustainable, waste-free, closed-loop supply chain system in rural Japan.

The methodological and conceptual-theoretical and practical architecture of this analysis is built to provide insights on the current state of affairs regarding essential resources. The focus is naturally on a centralized system for collecting and analyzing data on the availability of global resources (both raw and recyclable) to help small/medium enterprises and public organizations make more sustainable decisions.

Keywords: Education, digital technology, circular economy, sustainable decisions, Nagaoka

JEL Classification: O13.

* Bianca Yamaguchi is a Nagaoka Review Senior Editor, Japan. E-mail: yamaguchi.bianca@gmail.com; Toru Takahashi is a PhD. student at Bucharest University of Economic Studies, Romania, and Managing Director at Globis International Education, Japan E-mail: t-takahashi@globis.co.jp

Cristian Iulian Vlad is a PhD. student at Bucharest University of Economic Studies, Romania, Founder & CEO at JCE Japan Creative Enterprise, and Talent & Transformation Associate Partner, Global Business Services at IBM Japan. E-mail: cristian@japancreativeenterprise.jp

Hiroaki Kaneko is a PhD. student at Bucharest University of Economic Studies, Romania, and Senior Director at Globis University, Japan E-mail: h-kaneko@globis.co.jp.

Ana Damaschin is a PhD. Student in International Relations and European Studies at Babeş-Bolyai University, Faculty of European Studies, Romania, and Associate Professor at Nagaoka University of Technology, Japan. E-mail: damaschinana1@gmail.com;

Introduction

In recent years, in Japan have been lively discussions surrounding resource efficiency and circular economy. In the context of constructing a sustainable global society, the high national interest for the topic was made even more evident than before, and the Japanese government has taken significant steps to develop a circular economy policy framework. As such discussions go beyond the traditional scope of recycling and focus on increases in the product, it's became clear that the topic is influencing not only the recycling industry but manufacturers as well as service providers, and the industry as a whole.

In this paper, the authors explore how the representatives of the three social sectors: Governmental, Educational, and Entrepreneurial have cooperated to lead the rural area of Niigata, specifically around Nagaoka city, Japan, towards becoming more sustainable, while simultaneously boosting the local economy. To better understand the current situation and to be able to monitor progress, the authors explain how the circular economic model has improved the local infrastructure and how the concept of closed-loop systems has been adapted to local needs by improving efficiency and reducing waste.

The circular economic model has two cycles: a biological one and a technical one. This paper illustrates the natural cycle by providing evidence of an efficient farm-to-table and organic waste reduction system, using the example of a local conglomerate called SUZU Group.

Starting with the assessment of how locals have adapted by producing and consuming mostly local products through farm-to-table practices. But also, their slow and steady shift from reliance on production for most of their income to reliance on services and a sharing economy instead. The authors then investigated the social transition towards sustainability by examining supply chains and initiatives from local corporations that supply other raw materials, such as gas and oil. Also, providing information on local initiatives regarding efficient management of waste and byproducts, such as the use of biomass and microbial genetics.

In the case of cooperation between the education sector and the government, this paper illustrates an initiative done by the city hall together with the local technological university. Through practical examples, the authors of this paper show how technological innovations developed locally, the RPA and robots have helped efficient both the city hall's bureaucratic processes and how the local manufacturing companies have benefited from innovation.

The main goal of this paper is to propose a centralized network, an online and easily accessible platform that connects local governmental bodies, educational institutions, local businesses, and local producers to minimize the loss of waste and byproducts and to create a more sustainable, circular, ethical, locally fueled region, and allow a smooth transition towards the achievement of the SDGs, with focus on goal nr. 12 "Responsible production and consumption."

1. Theoretical conceptual framework

According to the Ellen MacArthur Foundation, a Circular Economy (also called circular economic model, closed-loop model, donut model, or doughnut economics), is a

cyclical, sustainable system that is opposed to the Linear Economic Model of “take-make-sell-use-waste” industrial model.

The circular economic model focuses on a cyclical model of make-use-remake, focusing on positive society-wide benefits. It entails gradually transitioning from the consumption of finite resources to designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles:

- ❑ Design out waste and any toxic chemicals or pollutants
- ❑ Continue to keep products and materials in use
- ❑ Regenerate natural systems (Ellen MacArthur Foundation, 2017).

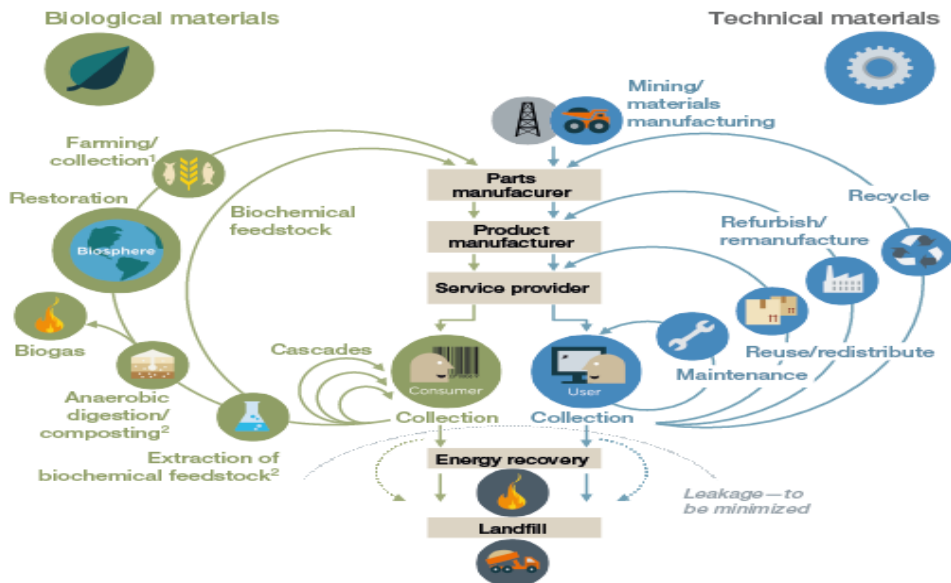


Fig. 1. Butterfly Diagram

Source: Ellen MacArthur Foundation, 2017. What is the circular economy concept?
<https://www.ellenmacarthurfoun; dation.org/circular-economy/concept>

Interpreting Figure 1 based on the circular economy model example, one can see that the model has two cycles: a biological one and a technical one. The biological cycle contains all the processes that are directly related to natural systems, like farming, composting, biochemical products, etc.

For better understanding, the technological cycle contains all the processes that are related to human activity, especially technology, and are mostly present in industrial settings, like refurbishing, remanufacturing, and recycling. In all cases, the circular model is based on the assessment of the entire cycle of a product, from extraction to production, to disposal, and proposes a design that eliminates waste from all of its processes, and improves the efficient use of the resources all across the supply chain. It has benefits both from a business stance and an environmental standpoint as well.

One other concept present in the model is local production, to reduce the carbon footprint of transportation, along with the environmental and economic positive impact of using locally produced and manufactured products. Another critical factor in the model is the use of renewable energy.

2. Circular economy in Japan

Across most developed nations, landfill remains the primary means of waste disposal. Many countries are attempting to minimize the amount of waste going to incinerators and landfill sites by developing recycling programs. (McCarthy, 2016). As we can see from Figure 2, in OECD countries, their efforts have had varying degrees of success. The results can be explained in terms of countries' access to information, resources and everyday situations they face. Now, successfully dealing with change in today's volatile and complex global business landscape is more important than ever. Recent OECD data show that most OECD countries have experienced improvements in material productivity. From the Figure 2 we can notice that material productivity and recycling rate increased significantly in Germany, Korea, the Netherlands and more moderately in countries such as Japan, Canada and Greece.

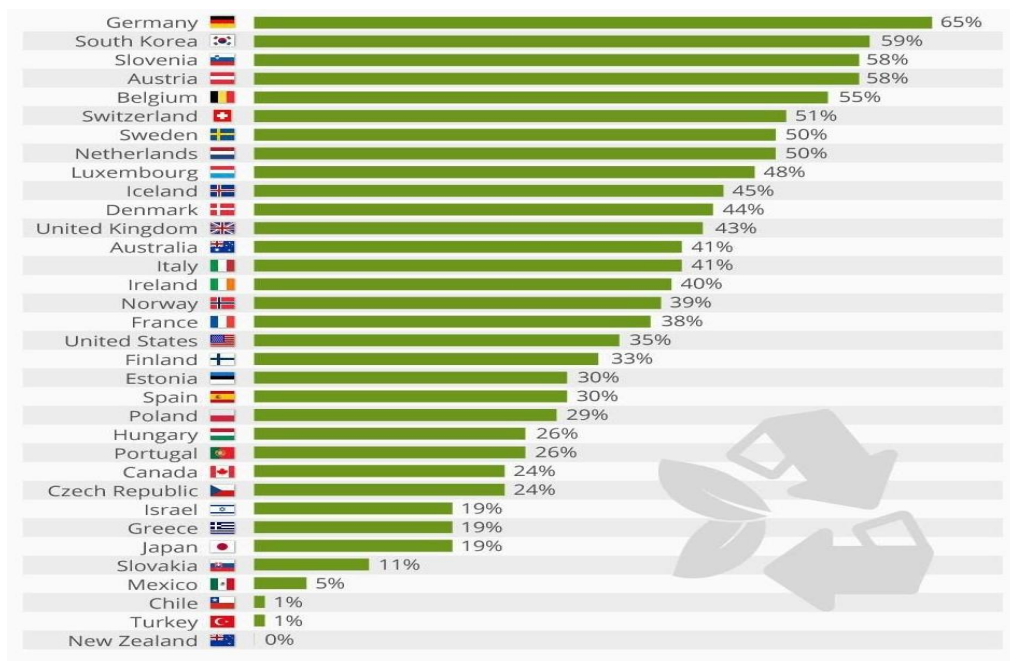


Fig.2. The Countries Winning the Recycling Race. Recycled and composted waste as a share of total municipal waste in OECD countries (2013)

Source: OECD

A circular economy (CE) can be defined as an economic model aimed at the efficient use of resources and has the potential to lead to sustainable development while

decoupling economic growth from the negative consequences of resource depletion and environmental degradation (Morseletto, 2020). It is important to note that there are many benefits to the application of the circular economy in business:

1. The existing recovery system is not optimal. To be more specific, only 17 out of 40 chemical elements used in the manufacturing of a mobile phone can be recovered for remanufacturing.

2. The carbon footprint of most products begins in the manufacturing process, with around 75% when it comes to phones, tablets, and laptops. Electric vehicles have roughly double the embodied carbon of internal combustion vehicles (Tecnologia libre de conflicto, 2020).

3. Mining and refining of finite virgin materials can be reduced. For example, the extraction of 1kg of gold produces 18773kg of CO₂.

The circular economy refers to the closed circuit of consumption, where waste is not produced, and additional resources are not introduced. And Japan is actively promoting it. Japan is one of the developed countries that, at the local, regional, and national levels, has implemented the circular economy model to improve the living standards of its citizens and further contribute to the successful development of the country. Since the early 2000s, Japan has been advancing the 3Rs (Reduce, Reuse, Recycle) effort ahead of the rest of the world and has been steadily making achievements (e.g., reducing final disposal and improving the recycling rates). Meanwhile, as significant changes are seen in economic and social situations at home and abroad, global society, against the backdrop of population and economic growth, faces the need to transform from a linear economy based on mass production, mass consumption, and mass disposal pattern to a circular economy (Ministry of Economy, Trade and Industry, 2020).

Also, in 2000, the Basic Act on Establishing a Circular Society was passed. This was the reaction to a number of problems related to waste in the late 1990s. These included the high generation of waste, difficulty in finding new waste treatment facilities and an increase in illegal dumping. It is also a push to promote recycling efforts even further. The law comes in twofold. One, it dictates a move away from mass production, mass consumption and mass disposal. Two, to guide the development of laws for individual waste and recycling. In order to keep the above law relevant, the Plan of Establishing a Circular Society is reviewed and updated about every five years. This is done by the Central Environmental Council. On June 19, 2018, the 4th plan was decided. There are three main drivers in the plan. First, a regional revitalization through a circulation system. Second, the full circulation of resources' life cycle. And finally, the appropriate processing of waste or regeneration of resources (Ministry of the Environment, 2018).

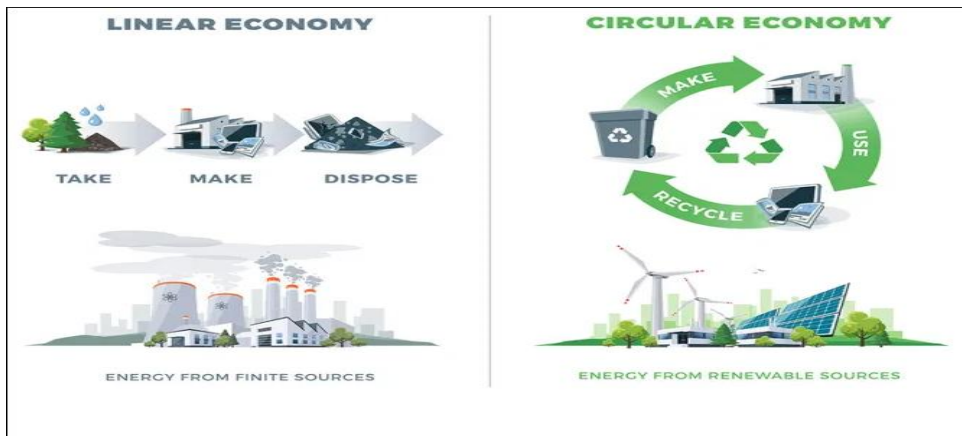


Fig.3. Basic Act on Establishing a Circular Society (2018)

Source: Ministry of the Environment

According to Google Trends since the beginning of 2019, the awareness of the circular economy in Japan has risen exponentially. As more Japanese citizens and businesses discover how they can make the world a better place, and circular economy became one of the tools.

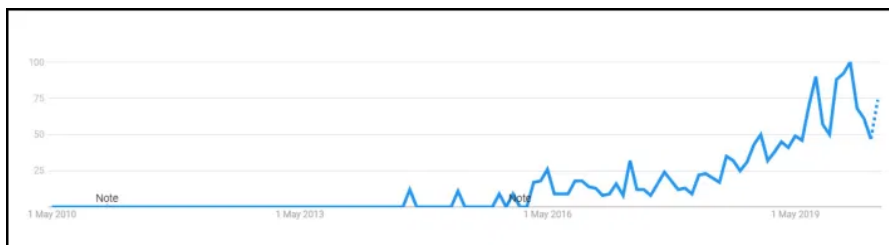


Fig.4. Circular Economy Trends in Japan. The rising popularity for “circular economy” on Google Trends. **Source:** trends.google.com

3. Recycling in Japan

Japanese recycling rates are high: 98% of metals. In 2007, 5% of Japan’s waste was landfilled. Japan’s appliance recycling laws ensure that the great majority of electrical and electronic products are recycled. Of these appliances, 74–89% (Ministry of the Environment, 2010), of the materials they contain are recovered. Many of these materials go back into the manufacture of the same type of product (Panasonic, 2015). To show that Japan has a good capacity for dealing with waste. Upon researching, we have found that Japan’s initiative of going circular began in the 1990s.

1) Due to geographical challenges such as mountainous topography and volcanoes as well as large population density, there is limited space for landfill. Japan had little options left but to search for alternatives to landfill since the 1950s, and in the 1990s started moving away from incineration following dioxin-related health concerns (such as hormonal interference, developmental and reproductive disorders, altered immune system, as well as cancer)

2) Recycling and remanufacturing are enticing in Japan due to the country being a major industrial manufacturer with limited domestic materials such as metal and mineral. The significance of access to raw materials is not to be downplayed, especially in the circular economy policy in Japan.

3) Collaboration plays a huge role in the business culture in Japan, resulting in a comprehensive approach in the action and measures applied.

3.1.1. Measuring the circular economy

The Japanese assessment of the circular economy at a national level includes:

1) Resource productivity indicator. Measuring the use of material in proportion to the GDP

2) Material cyclical use rate indicator. Measuring the rate of material reuse in proportion to total material usage by the economy

3) Output indicator. Measuring landfilled waste quantity

4) Target associations. Linking indicators to sector-specific measures which could sometimes be industry-specific targets

5) Societal effort. Measuring the effort within the society toward a circular economy. From a macro perspective of considering environmental factors impacting the market for rental, leasing or sales of products such as reusable packaging, to a micro perspective of impact of an increase in prices of production factors towards the sales of a particular product (e.g. sales of disposable chopsticks in proportion of the population utilizing reusable chopsticks).

4. Public Cooperation

The public plays a vital role in separating out recyclables, in paying recycling fees directly and in holding companies to account when necessary. Manufacturers also do their part (Association for Electric Home Appliances 2007) by using more recycled materials, and making longer-lasting products that are easier to repair and recycle.

Here are 4 key features of the collection and recycling system:

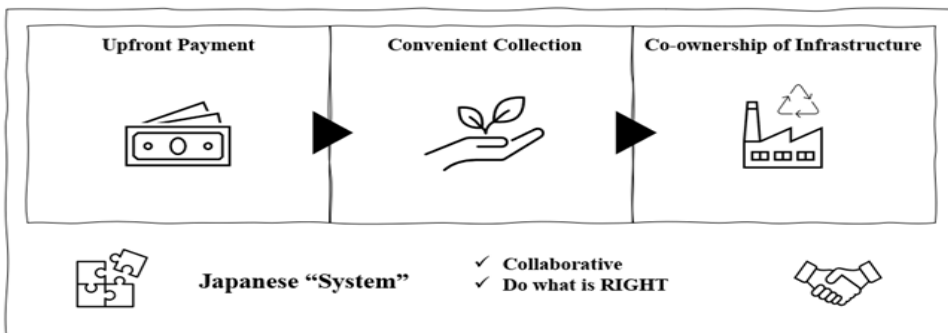


Fig. 5. The 4 key features of the collection and recycling system in Japan

Source: Designed by Lim Michelle based on the 4 key features of the collection and recycling system, 2020

1. Upfront Payment:

In regard to electronics, payment for transportation and recovery is done at the point of purchase. As such, there is no disincentive for customers in participating at the end of the product life. Penalty for illegal waste dumping is hefty in Japan.

2. Convenient Collection:

With a well-designed system in place for the collection of old appliances for recycling, it becomes more challenging not to opt for recycling. When retailers sell a product in-store or deliver a new appliance, the old appliance is also collected. In regard to old IT equipment, it could be requested by the manufacturer for a doorstep collection to be done by the local authorities, or for it to be brought by specialized companies.

3. Co-ownership of Infrastructure

Companies in Japan consider long-term investments in recycling infrastructure. In order to ensure manufacture consider the benefits from recovering materials and parts, a consortium of manufacturers are required by law to run the disassembly plants. One great benefit of owning the recovery and manufacturing facilities is that the companies could experience the struggle of disassembling products that are poorly designed. Companies now have the incentive to consider redesigning their products to ensure easy disassembly and recovery of recyclable parts.

4. The Japanese “System”

Collaboration is the backbone of the Japanese system whilst incentivising people to do what is right, shaping the public enthusiasm of the Japanese. With consistent and strong appreciation for honesty, the lack of looting following the Fukushima earthquake further solidifies the importance of the system. Not only did the system bring value to the society but also to the profitability of the country, with the reuse and recycling economy of Japan employing 650,000 people and worth £163 billion in 2007 (7.6 % of GDP).

5. Technological Cycles

5.1. Description of the recovery of a unique material

Japan has a very successful car industry and is steadily shifting to hybrid and electric vehicles, which require a supply of rare earth metals for their NiMH batteries. Rare-earth elements are well dispersed throughout the planet's crust, but very rarely occur in commercially viable quantities. So, their production is associated with serious environmental risks: mining creates large, toxic, slightly radioactive ponds and the refining process requires the use of hydrochloric acid. Poor practices have been blamed in the past for serious pollution of agricultural land and watercourses (Bailey, Mancheri and Karel, 2015).

In contrast, life-cycle analysis of recycling neodymium, a rare earth, suggests it has a human toxicity score 80 per cent below that of mining (The institution of environmental sciences, 2015). Japan has always sought steady access to raw materials for industry, and thus in 1999 began recovering rare-earth elements in car batteries as part of a wider effort to recover steel. However, until 2012, these rare-earth metals were mixed into stainless steel, making them unavailable for use in new batteries. Chinese restrictions on exports, starting in 2010, provided a catalyst for the development of a battery-to-battery recycling process, which showed how national government leadership, company collaboration, and

effective reverse logistics combined to enable a novel material to be recovered. With China's announcement of rare-earth mineral export restrictions, the Japanese Ministry of Economy, Trade, and Industry (METI) introduced a grant program in accelerating the commercialization of rare-earth recycling technology.

As Honda and Japan Metals and Chemicals Company (JMC) had already spearheaded a collaboration on an effective but expensive method of rare earth recovery, the grant enabled investment into improving the technical aspects of their process. Now, about 400 tonnes of rare earth can be recovered per year by the recycling facility operated by JMC and Honda (The Institution of Environmental Sciences, 2015).

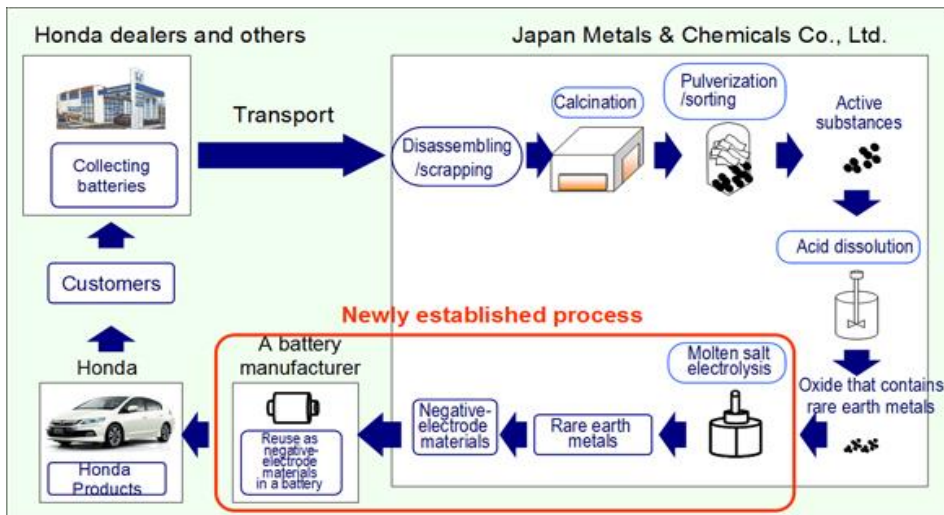


Fig. 6. Honda 's process for recycling nickel-metal hydride batteries

Source: Honda in America, <https://hondainamerica.com/news/honda-establishes-worlds-first-process-to-reuse-rare-earth-metals-extracted-from-nickel-metal-hydride-batteries-for-hybrid-vehicles/>

With further research and development, Honda succeeded in the extraction of metallized rare earth with a purity of more than 99%, which is as high as newly mined rare earth metals. The process was created through a newly established process of molten salt being applied to the extracted oxide. The metallized rare earth could be directly used by nickel-metal hydride batteries as negative-electrode materials. The new process has also enabled an extraction of rare earth metals above 80% in nickel-metal hydride battery (Honda, 2013).

According to the study, the commercialization of new recycling process stretches across the supply chain to include:

- a) The Government- the industrial policy supports recycling by including collection requirements as well as setting spending target on innovation;
- b) Corporations- even before the pressure on rare earth resources, corporations had a head start in investing in collaborative research and design for recycling;
- c) The Public - public expectations form the basis of the need for recycling to be promoted.

6. Transition to Renewable Energy

6.1. Study Case – INPEX (INPEX, 2008)

Nagaoka is home to an oil and natural gas extracting corporation called INPEX. In this paper, the authors analyze how a company that relies heavily on non-environmentally friendly processes for their income are striving to shift towards renewable energy and more sustainable practices.

6.1.1. Geothermal energy development

Geothermal Energy is run by a gas corporation called INPEX in the city of Minami Nagaoka. INPEX continually explores the business potential of various types of renewable energy such as geothermal, which has synergies with conventional oil and gas development, but also wind power and photovoltaic power generation.

Geothermal power generation comes from the rotation of turbines, by using steam extracted at the surface from groundwater, which had been initially heated by extremely hot underground magma. Geothermal is considered a precious, clean energy source because it has low CO₂ emissions. Compared to the other types of renewable energy, geothermal energy is also stable and is not influenced by the weather or the changing of seasons

Since 2011, INPEX has been constantly participating in the joint development studies on geothermal energy in Oyasu, Akita Prefecture and Amemasu, Hokkaido. For the sake of this study, 7 exploratory wells were drilled in the Oyasu area while 6 others were drilled in the Amemasu area during 2013-2017. In 2018, flow tests were conducted at the two wells. In the meantime, an environmental impact assessment has been conducted as a step toward initializing commercial operations in the Oyasu area.

INPEX is also making efforts in geothermal energy development initiatives outside of Japan. In June 2015, INPEX became part of the Sarulla Geothermal Independent Power Producer (IPP) Project. IPP is the world's largest single-contract geothermal power project located in Sarulla, Indonesia. The power generated from the project is sold to Indonesia's government-owned electricity company over a period of 30 years.

INPEX aims to become an integrated energy company that contributes to a stable energy supply to broader communities, so it put a lot of effort into commercializing renewable energies and reinforcing Research and Development activities for the next generation.

6.1.2. Photovoltaic power generation

When it comes to photovoltaic power generation, large-scale systems with a power generating capacity of 1MW or more are called Mega Solar facilities. Since the 2011 Tohoku Earthquake, which was followed by a tsunami, the expectations for even greater photovoltaic power generation capabilities have expanded to try and mitigate the concerns regarding power supply shortages. Mega Solar facilities are extensively being promoted throughout Japan.

In the year 2013, INPEX started the process of generation and supply of electricity at its first photovoltaic power generation system with a maximum output of 2MW, in the city of Joetsu, Niigata Prefecture. In July 2015, the second photovoltaic power generation

system began operations also at a maximum output of 2MW. The INPEX Group refers to the 2 photovoltaic power generation systems as "INPEX Mega Solar Joetsu". The 2 photovoltaic power generation systems are expected to generate, together, around 5,330,000kW of electricity per year, which is the equivalent of the annual power consumption of approximately 1,600 households (INPEX, 2015)

a) Wind power generation business

INPEX is currently in the process of developing an onshore wind power generation business in Japan. The company plans to use its experience to proactively pursue business development opportunities in the offshore wind power generation sector, both inside and outside of Japan.

b) Artificial Photosynthetic Chemical Process

Recently, hydrogen has been considered to have tremendous potential as the ultimate renewable energy resource. This is because, when combusted, hydrogen produces only water as a bi-product. Hydrogen can also be made into hydrocarbon fuels and chemicals, when mixed with CO₂ gas, making hydrogen an exceedingly clean source of energy.

INPEX is part of the "Japan Technological Research Association of Artificial Photosynthetic Chemical Process" commissioned by NEDO (New Energy and Industrial Technology Development Organization) and is also part of an R&D project which aims to produce chemical products, such as plastics and hydrocarbon fuel from hydrogen obtained through the decomposing of water using catalysts that use solar energy and CO₂.

6.1.3. CO₂ Methanation

INPEX is currently developing methanation technology as one of its core technologies. The company aims to create technologies which transform electricity into hydrogen, hydrogen into methane and methane into electricity. It is also engaged in building an "electricity-hydrogen-methane value chain" that uses INPEX's existing methane production and transportation system.

Methanation is a technology that converts carbon dioxide into methane. INPEX has been part of a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO) to develop technologies which effectively utilize CO₂. What INPEX does is it evaluates the technological development and production sequence of carbon capture and utilization (CCU) technology which produces and effectively utilizes methane using a high concentration of CO₂ emitted from thermal power plants and hydrogen produced using electricity from renewable energy sources.

6.1.4. High-capacity lithium-ion battery

INPEX has been a constant supporter of ELIY Power Co., Ltd., which develops, manufactures and sells lithium-ion batteries. The company's high-capacity lithium-ion batteries can store electricity generated from renewable energy sources like solar and wind. It can provide access to this electricity any time. Their initial goal was to contribute to the conservation of the global environment using a more effective renewable energy source that can generate enough power in time with the increase in demand.

7. Biological cycles

7.1. Local Production

Analyzing the evolution of the Niigata prefecture in the past years, it should be noted that the Nagaoka area contains fertile soil, clear and cold phreatic water streams, and clean air, which makes it an excellent area for growing rice. As such, there are 17 sake breweries in Nagaoka city, putting Niigata prefecture at the top in both production and consumption quantity of sake, and its economy relies heavily on the selling.

Heavy snowfall and hot and humid summer climate combine to make the Nagaoka Vegetables a brand vegetable that takes advantage of nature. "Nagaoka Vegetables" refers to plants that have passed the following criteria set forth by the "Nagaoka Vegetables Brand Association" made up of farmers, consumers, Agricultural organizations and marketers in and around Nagaoka City in Niigata Prefecture (Nagaoka Incorporated Association of Tourism and Conventions, 2020).

7.2. Farm-to-Table Study Case

7.2.1. Omoiohoka (Local to table, 2018)

Competition, innovation, and growth have been investigated in the literature, and the interaction between them has been debated since the days of Schumpeter. Ever since Schumpeter's vision of the lone and creative entrepreneur, innovation and creativity have been essentially viewed as a black box, unknowable and random. Not surprisingly, with innovation and creativity viewed as such, the field of strategy predominantly focused on how to compete in established markets, creating an arsenal of analytic tools and frameworks to skillfully achieve this. Certainly, Japan has not always had sustainable development strategies, many industries, particularly in the manufacturing sectors, rapidly expanded in Japan after World War II. The development of these industries was underpinned by firms; successful activities including innovations. During a period of rapid growth, Japanese firms expanded and gained market share while competing with domestic and foreign rivals. At the same time, a substantial number of creative products developed by Japanese firms emerged and dominated the market. However, many industries stagnated during the so-called lost few decades after the collapse of the bubble economy due to reduced competitiveness and inactive innovation (Honjo, 2017).

Based on these historical cases, it is important to note that strategic creativity can be unlocked systematically, to better understand this formula we analyzed Japanese models of the circular economy. These patterns have allowed the development of tools and methodologies to systematically link innovation to value and reconstruct industry boundaries in an opportunity-maximizing way (Mauborgne; Kim, 2015).

7.2.2. Fish Market Street

At the local level, the crowded fish market boasts of a large number of shops providing fresh marine products at reasonable prices. "Crab", "namban ebi shrimps", and "grilled squid" are at the top of the lists of local shoppers and tourists. The biggest fish market street is Aramachi, Teradomari, in Nagaoka.

7.2.3. Kumatsu Farm

One example is a local eggplant in the shape of an actual egg, called “The Roots of Shun”. Eggplants are a popular vegetable seen commonly on the dinner table of any Japanese household, but few know eggplants are a very popular vegetable in Niigata Prefecture, famous for rice production.

An interesting fact is that taking advantage of the hot and humid weather, Niigata produces as many as 20 different varieties of eggplants from region to region. At the same time, they have different shapes and textures, so the locals have formed a unique food culture, cooking these diverse varieties in ways that best match each variety’s character.

“Kinchaku eggplants” are nutritious specifically because they are grown in Nagaoka. Niigata has long been a place of eggplant farming because farmers could grow eggplants in the idle period between rice planting and harvesting, when rice farmers are at their busiest, and also because Niigata has hot, humid summers perfect for growing eggplants.

Nagaoka is a basin surrounded by mountains, so it is especially humid. In the summer it is hot and humid, and in the winter, the snow is also very moist. The soil is sedimentary soil from the Shinano River, making it rich in minerals. Kobayashi grows eggplants at his outdoor farm naturally as possible (i.e. with no cover). He deliberately gives them no water so that the eggplants suck up moisture from the soil and grow larger over time, becoming shiny, tight and rich in flavor. The harvest time is from around June to October. Niigata has the largest farming area for eggplants in the country, yet eggplants from Niigata are hardly known, because most of the eggplants are consumed within the prefecture. The residents of Niigata use different varieties of eggplants for different dishes.

The Japanese also have the tradition of passing on the seeds and the food culture. They create a bond between the producer and the chef. Kobayashi’s family have been eggplant farmers since the Edo period (1603–1868), and have been passing on their eggplant seeds in Nagaoka from generation to generation. Kobayashi has the responsibility of preserving these Kinchaku eggplant seeds and passing them on to future generations. The locals say that the phrase “chisan chisho” (locally produced, locally consumed) actually means the human body and soil are inseparable. A local said “If you eat the food grown in the place you grew up, you will stay healthy.” (Inoue and Tachibana, 2016).

7.2.4. The SUZU Group

The SUZU Group is one of the very successful local businesses who use farm-to-table practices. They only use local, seasonal vegetables to produce and sell not only fresh vegetables to restaurants, hotels and markets, but also processed products, such as sauces, pastes, creams and jams. They have multiple sub-companies: a food truck, a cafe, a restaurant, a canteen, a fast-food delivery service, an online shop and even a local gourmet magazine. All work on delivering local products to the locals. Restaurant SUZU365 (Inoue and Tachibana, 2016) for example, is a delicatessen-style restaurant with dishes created with ample ingredients from Nagaoka, is the outlet Kobayashi recommends, saying it is the liveliest restaurant in Nagaoka right now. The owner and chef Sho Suzuki born in Nagaoka. He runs a few restaurants with the concept of connecting local food ingredients and people, dispatching the attractiveness of Nagaoka’s food. Countless times, chef Sho Suzuki has talked about the importance of passing on traditional, local culture, food to future generations.

7.2.5. Yamakoshi Town

Found in the Koshi district, Yamakoshi is home to many terraced rice fields, and the location of a devastating earthquake that destroyed the village, forcing hundreds of people to abandon their homes for years.

The town is very well known locally for its thriving tourism. The tourist information office, besides being filled with information about what to do in the city, it also serves the center to rent E-bikes and even Electric Rickshaws. They pointed out the importance of a safe and environmentally-friendly transportation method for tourists, to protect as much as possible clean mountain air, crucial for creating high-quality crops.

The story of the Chūetsu Earthquake spread around Japan, and people offered money, food and even their homes to help the villagers who were now left homeless. They completely rebuilt the town and most of the locals returned to doing business as usual. Once back, the locals were determined to make the town sustainable, environmentally-friendly, based on local production and consumption, and turned to tourism and providing services to better increase their economy.

These services include e-bike and electric rickshaw rentals, visitation of alpaca and koi fish farms, visitation and vegetable or fruit picking on agricultural farms, visitation of sake breweries, hot spring resorts, farm-to-table restaurants, hand-crafting experiences, open air markets and historical locations. The activities are specific to every season, so as to protect the natural seasonality of the local environment (Nagaoka City Tourism Planning Division, 2017).

8. How The Education Sector is Supporting the Shift Towards Sustainability and Circular Economy

8.1. Study Case - Nagaoka University of Technology

8.1.1. Online Magazines

The Nagaoka University of Technology has made visible efforts to support research in the realm of sustainable development, as well as actively attract foreign input, through the publication of two bilingual (Japanese and English) magazines.

One is “Transactions on Gigaku” (Transactions on Gigaku, 2012), a free online magazine whose focus is on the science and technology related to “gigaku”, a term coined by the university itself in the year of its opening. The mission of this journal is to be a secure network for innovations in science and technology and the development of the next generations of high-level human resources. This journal, therefore, covers education and research activities in broad areas, including innovations in sustainability (GIGAKU Press, 2014).

The other is a social site called the Nagaoka Review, which is dedicated to open collaboration by establishing a communication channel in English to share information and promote cooperation between Japan and the world. The social site aims to share the latest news relating to technology and innovation across the globe to encourage the participation of local University students such as the students of the Nagaoka University of Technology to contribute to society through technological collaboration.

Besides that, the site aims to open the opportunity for cross-country and industrial cooperation in innovation. Through academic research, the young generation expresses

their concern for today's society, and the university fully contributes to their practical achievement. Also, it mirrors society's interests for a better adaption of the sustainability and circular economy to the challenges that we are living in today. The following examples are just some of the academic contributions to the local community with a substantial social impact.

8.1.2. Microbial Genetics and Biomass

Professors Wataru Ogasawara and Yosuke Shida's research is about how biorefinery technology can aid in converting biomass, a renewable carbon source, to bioethanol, food, fiber, and chemical source for industry. The most important and difficult step of the biorefinery process is saccharification, extracting available sugars from biomass, to address this issue, we use the filamentous fungus *Trichoderma reesei* (T. reesei) as a model organism. In order to understand, the fungus T. reesei is one of the most efficient producers of glycoside hydrolases, such as cellulolytic and xylanolytic enzymes, that convert biomass to sugar. By using advanced analysis techniques, such as comparative genomics, transcriptome, and ChIP analysis, a better understanding of the complexity of gene expression and enzyme production in these microorganisms has been gained. They have developed several breakthrough technologies for the biorefinery process, with the ultimate hope of contributing to building a cleaner and sustainable world (Nagaoka University of Technology, 2014).

8.1.3. Environmental Biochemistry

Another mentionable research was done by professors Yoshio Kera, Shoji Takahashi, and Katsumasa Abe's. The study focuses on enzymes and microorganisms, which can efficiently specifically catalyze various chemical reactions below 100°C under atmospheric pressure. They are, therefore, useful to develop safe, energy-saving, and eco-friendly processes and devices. Their laboratory is focused on microbial degradation of environmental pollutants, biological production of chemicals and biofuels, and physiological roles and applications of D-amino acid-metabolizing enzymes. The ongoing research activity includes the identification of novel and valuable enzymes and microorganisms from the environment and genomic information, the genetic and protein engineering to improve their properties, and the creation of bioprocess and analytical methods using these enzymes and microorganisms (Nagaoka University of Technology, 2014).

8.2 RPA (Robotic Process Automation) at Nagaoka City Hall

In a world of close to 9 billion expected by 2030-including 4.9 billion new middle-class consumers (Kharas, 2010), the challenges of expanding supply to meet future demand are unprecedented. These new consumers offer fantastic opportunities for businesses, and the next industrial revolution is already under way, with digital technologies already transforming many products and market sectors (Weetman, 2016). Based on this fact, it is essential to note that the Robotic Process Automation (RPA) is attracting attention, and we will begin by giving an example of how one local governmental institution has used innovation to improve its services for social good.

At the initiative of the city council, Nagaoka City Hall from Japan has decided to buy, experiment with, and, in December 2018, implement an RPA software called WinActor to be used at the city hall to provide the citizens with better services. The initiative also included providing training to city hall employees. RPA stands for Robotic Process Automation, which is a form of business process automation technology utilizing the idea of software robots. RPA allows business operations with personal computers to be completely automated.

In order to achieve efficiency of business processes, the city experimented on data processing operations through utilizing RPA as part of the Nagaoka-based technological innovation project. For instance, at one of the divisions of the city office, the data of employees' health checkups were processed via RPA, which can reduce manual working hours on personal computers by 117 hours per year. Therefore, the staff would be able to use these hours for other more human-based services. According to a survey conducted by the Ministry of Public Management, Home Affairs, Posts and Telecommunications, less than 4% of municipalities across Japan have so far introduced RPA in their data processing operations (Digital Labor Labo, Works ID, 2020).

At a session held at City Hall Plaza – Aore Nagaoka on January 10, 2019, the city gave reports about the experimental results of utilizing RPA. Mayor Tatsunobu Isoda stressed that the city would be able to provide better services for citizens based on such business efficiency acquired through utilizing RPA (Nagaoka International Affairs Center, 2019).

8.3. Prize-winning energy reducing robot

Another one of Nagaoka city's initiatives at providing locals with incentives for innovation is the Students' Startup Support. This project developed to help students launch new businesses and have welcomed their first student-entrepreneur. Based on the new technology of cycloid reducers, which are used in the joints of industrial robots, students and graduates of the National Institute of Technology, Nagaoka College established a robot-manufacturing company and named it Ju-ichi, Oishi Corporation (Oishi Machine Inc., 2003).

It is relevant to note that the City of Nagaoka provided financial support for the corporation to establish its business. A cycloid reducer is a device attached to a motor that efficiently produces power at a lower rotational speed. Renovating the basic structure and gears, the company has achieved higher strength along with downsizing and lightening the device. This technological renovation allows the method to be applied in nursing-care robots and household electrical appliances (Nagaoka International Affairs Center, 2019). On January 9th at Nadec BASE (on Ote Street), Oishi Corporation introduced the newly established corporation.

9. Sustainability

9.1. Sustainable Data Centers

Started in Nagaoka city, a data company called Data Dock is running the Niigata Nagaoka Data Center in Niigata Prefecture Japan, and this cold region data center is said to be the model site for the world's first sustainable data center. It is a new business model that satisfies environmental, societal, and economic aspects.

The daily operations of the data center produce excess energy such as groundwater, waste heat from IT equipment, and heat from melting snow. The data center's model converts these excess to support hydroponics activities such as aquaponics farming at the Aquaponics Nagaoka Plant. This model is expected to serve as a case study for prospective data centers with the desire to operate sustainably. Data Dock, specifically, hopes to adopt this business model to cold regions of Japan. This model is also registered for the J-credit scheme – a voluntary carbon offsetting scheme administered by the Japanese government.

9.1.1. J-SCHEME

The J-Credit Scheme is designed to certify the amount of greenhouse gas emissions reduced and removed by sinks within Japan. Under the J-Credit Scheme, the government certifies the amount of greenhouse gas emissions (such as CO₂) reduced or removed by sinks through efforts to introduce energy-saving devices and manage forests, as "credit."

This scheme, which was created by expansively integrating the Domestic Credit Scheme and the Offset Credit (J-VER; Japan's verified emissions reduction) Scheme, is administered by the central government. Credits created under the scheme can be used for various purposes, such as achieving the targets of the Nippon Keidanren's Commitment to a Low Carbon Society, and carbon offset (Japan Federation of Economic Organizations, 2016).

Scope of J-Credit Scheme

a) Projects:

- Endeavors that contribute to the reduction of emissions recorded in Japan's GHG Inventory.
- Endeavors that contribute to the enhancement of removals recorded in Japan's GHG Inventory (Japan Greenhouse Gas Emission Reduction, 2017).

b) Types of greenhouse gases:

The substances listed in Article 2, Paragraph 3 of the Act on Promotion of Global Warming.

Countermeasures (Act No. 117 of 1998) subject to the Scheme. Specifically, these are the following gases:

- Carbon dioxide (CO₂);
- Methane (CH₄);
- Nitrous oxide (N₂O);
- Those hydrofluorocarbons (HFCs) specified by Cabinet Order;
- Those perfluorocarbons (PFCs) specified by Cabinet Order;
- Sulfur hexafluoride (SF₆);
- Nitrogen trifluoride (NF₃).

c) Certification period:

The starting date of the certification period of an emission reduction project is the date of application for registration of project or the date when monitoring becomes possible,

whichever is later. However, for a forest management project, because removals are computed in units of one fiscal year, the starting date of the certification period is the first day of the fiscal year containing the date of application for registration of project. When the forest management plan, which covers the areas of a forest management activity to be registered, is not valid on the first day of the fiscal year without reasonable excuse, the certification period starts on or after the validation date of the forest management plan.

The ending date of the certification period is the date when 8 years have elapsed from the starting date of the certification period, or March 31, 2031, whichever is earlier. Any identical emission reduction or removal activities with once-registered projects, of which the certification periods have ended, may not be registered again (Japan Greenhouse Gas Emission Reduction, 2017).

d) Purposes of J-Credits

The purposes of J-Credits are as follows. Some uses may be restricted by the programs, etc. that use J-Credits, depending on the attributes of the project participant or the type of project.

- Keidanren's Commitment to a Low Carbon Society
- Reporting of emissions after adjustment under the Greenhouse Gas Accounting and Reporting

System based on the Act on Promotion of Global Warming Countermeasures

- Reporting of joint energy efficiency projects in periodic reporting under the Act on the Rational Use of Energy (Act No. 49 of 1979)
- Voluntary Carbon offset (Japan Greenhouse Gas Emission Reduction, 2017)

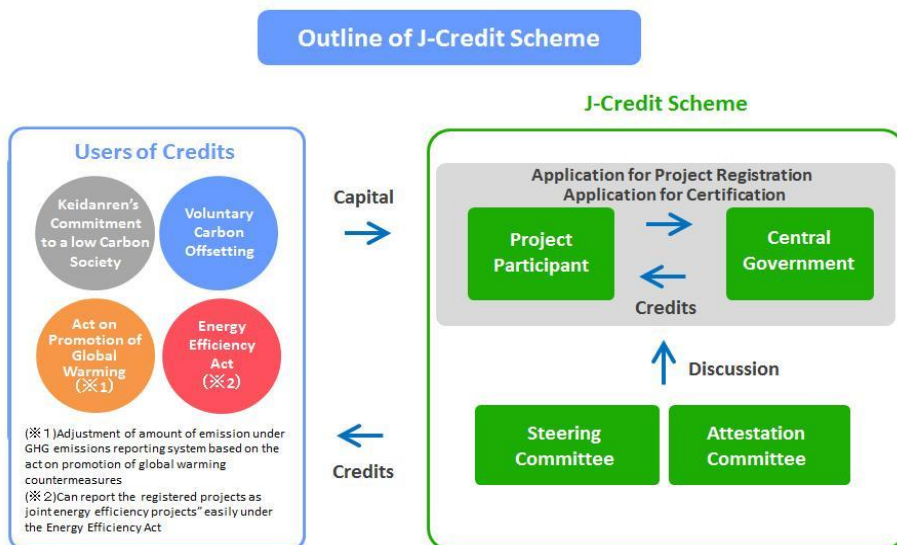


Fig. 7. Outline of J-Credit Scheme

Source: Japan Federation of Economic Organizations, official site, <https://japancredit.go.jp/english/>

Conclusion

Analyzing the standard supply chains network for local businesses in the local community of Nagaoka (Japan) we intended to illustrate the impact of education and digital technology adoption within the local community in Nagaoka (Japan) while proposing a business model focused on an increase in the creation of social value based on services, as opposed to incumbent models based on increasing the manufacturing and selling of physical products, in order to help the local businesses to establish a suitable alternative and an active exchange of waste and bi-products for a more effective recycling and a more sustainable remanufacturing system.

It is important to remark that contextually the circular economic model has been used successfully to improve both the throughout the research mentioned companies' efficiency and the quality of their outputs, with a very beneficial impact on the local community. Following the technological cycle, bright illustrations of a fruitful collaboration between the governmental bodies represented by Nagaoka city hall, the educational sector constituting the Nagaoka University of Technology, the entrepreneurial sector in the form local businesses, both big and small, and the local community, in and around Nagaoka city could be seen.

Today's long biological cycle of the circular economic model in Nagaoka (Japan) has been at the heart of industrial development and has generated an unprecedented level of growth. Our results and analysis illustrate clearly how small local businesses (Fish Market Street, Kumatsu Farm, The SUZU Group, and Yamakoshi Town) have benefited from the local production of rice, vegetables, and sake. But also, by leveraging the domestic output and using it to attract tourists and improve the local economy.

Cities play a central role as motors of the global economy, and in Nagaoka, at the local level, the opportunities of a circular economy span across economies, the environment, businesses, and citizens. Moreover, all of these benefits gathered together to offer a promising vision for a regenerative and restorative economy in the future. In the content of the present research, we presented examples of how the local research programs have helped with the dealing of biological waste are shown, by using innovative systems of compost and microbiological decomposition mechanisms. Concerning the use - and shift towards the purpose - of renewable energy, a keen interest of the local big oil and gas company (The INPEX Group) and its efforts to go renewable in the future can be seen.

As such, to continue to support the collaboration between sectors, we proposed a centralized network in the form of an online platform whose goal is to become a shared pool of knowledge and the free exchange of information between the four sectors: the. The platform can be used to assess, understand, support, and even encourage the expansion of the application of the circular economic model and the shift towards more sustainable processes and renewable energy. We hope that this platform will also become a replicable example for other cities and prefectures in Japan, and beyond, as green development, circular economy model, and sustainability, as well as coordination and cooperation, will become compulsory traits of future Japanese/worldwide policies and politics.

References

1. Ahn, Sanghoon, (2002), Competition, innovation and productivity growth: a review of theory and evidence. OECD Economics Department Working Papers. <https://doi.org/10.1787/182144868160>.
2. Andrews, Kenneth R, (1971), The concept of corporate strategy. Irwin, Homewood, Illinois.
3. Association for Electric Home Appliances, (2007), *Product Assessment Manual (4th edn): executive summary* AEHA, Tokyo. <https://www.aeha.or.jp/assessment/en/english/flame.html>, (accessed 25.07.2020).
4. Auerbach, Paul, (1988), Competition: the economic of industrial change, Basil Blackwell, Cambridge.
5. Bailey, Gwendolyn; Mancheri, Nabeel; Karel Van Acker, (2015), Sustainability of permanent rare earth magnet motors in (H) EV Industry. Journal of Sustainable Metallurgy, Volume 1. No.1. DOI 10.1007/s40831-017-0118-4, https://www.researchgate.net/publication/315916975_sustainability_of_permanent_Rare_Earth_Magnet_Motos_in_HEV_Industry, (accessed 31.07.2020).
6. BBC News Europe, (2010), Hungarian chemical sludge spill reaches Danube. BBC News Europe, www.bbc.co.uk/news/world-europe-11491412, (accessed 17.07.2020).
7. Benton, Dustin; Hazell, Jonny, (2015), The Circular Economy in Japan. <https://www.the-ies.org/analysis/circular-economy-japan> (accessed 31.07.2020).
8. Digital Labor Labo, Works ID, (2020), What are the issues faced by local governments and government agencies and how to utilize RPA? <https://digital-labor.robroid.jp/government-office-rpa/>, (accessed 20.07.2020)
9. Donald, Frances, (2020). The three stages of the global economic recovery. https://www.manulifeim.com/institutional/global/en/viewpoints/market-outlook/three-stagesglobaleconomicrecovery?cid=ASEN_MIM_IN_PS_AdWords_GI2H20_MarketIntelligence_GA_CS_TA_00_BR_00_00_AW_00_20200728_EconomicImpact_EconomicImpact&utm_source=PS&utm_medium=AdWords&utm_campaign=GI2H20_MarketIntelligence&utm_term=EconomicImpact_EconomicImpact&utm_content=ASEN_MIM_IN_GA_CS_TA_00_BR_00_00_AW_00_20200728&gclid=Cj0KCQjw6575BRCQARIsAMp-ksPu-ogpD6cOJCOF62SRNOk7K_9wyvHLuEXlKZpAi4e1p-Rtbf-FpewaAhHCEALw_wcB, (accessed 20.07.2020).
10. Ellen MacArthur Foundation, (2017), What is the circular economy concept? <https://www.ellenmacarthurfoundation.org/circular-economy/concept>, (accessed 19.08.2020)
11. Ellen MacArthur Foundation (EMF). Delivering the circular economy - A toolkit for policy makers; Ellen MacArthur Foundation: Isle of Wight, UK, 2015.
12. GIGAKU Press, Nagaoka University of Technology, 2014. Transactions on GIGAKU. Special issue of 1st International Conference on Energy, Environment and Human Engineering (ICEEHE)-2013, Vol. 2. No. 2, p. 1.
13. Honda, (2013), World's first process to reuse rare Earth metals extracted from nickel-metal hydride batteries for hybrid vehicles, <https://phys.org/news/2013-03-world-reuse-rare-earth-metals.html>, (accessed 19.08.2020).
14. Honjo, Yuji (editors), (2017), Competition, innovation, and growth in Japan. 1st Edition, Springer Nature Singapore Pte Ltd. p. 2.

15. Inoue, Asako; Tachibana, Satoshi, 2016. The roots of shun. Locally produced and consumed food is the best. Shun Gate. The perfect seasons of Japan, https://shun-gate.com/en/roots/roots_50.html, (accessed 22.07.2020).
16. INPEX, (2008), Renewable Energy. <https://www.inpex.co.jp/english/business/renewable/> (accessed 27.07.2020).
17. Japan Federation of Economic Organizations, (2016), J-Credit Scheme, <https://japancredit.go.jp/english/>, (accessed 20.08.2020).
18. Japan Greenhouse Gas Emission Reduction/Removal Certification Scheme (J-Credit Scheme), (2017), Implementation Outline. Ver. 4.1, p.4. https://japancredit.go.jp/english/pdf/documents/01_youkou_english.pdf, (accessed 20.08.2020).
19. Kharas, Homi, (2010), The Emerging Middle Class in Developing Countries, OECD Development Center, Working Paper No. 285, p. 27 <https://www.oecd.org/development/pgd/44457738.pdf>, (accessed 27.07.2020).
20. Lahti, Tom; Wincent, Joakim; Parida, Vinit, (2018), A definition and theoretical review of the circular economy, value creation, and sustainable business models: where are we now and where should research move in the future? MDPI. Sustainability, vol.10, Issue 2799, pp. 1-19, doi:10.3390/su10082799.
21. Lim, Michelle, (2019), RPA: The cornerstone of co-creating the future of work. <https://nrev.jp/2019/10/30/rpa-co-creating-the-future-of-work/> (accessed 20.07.2020).
22. Local to table, 2018. Facebook. <https://www.facebook.com/omoinohoka/> (accessed 22.07.2020).
23. Mauborgne, Renee; Kim, W. Chan, (2015), Blue Ocean Strategy. How to create uncontested market space and make the competition irrelevant. First eBook Edition. Harvard Business Review Press Boston, Massachusetts, p. 13.
24. McCarthy, Nil, (2016), The countries winning the recycling race (Infographic). Forbes. <https://www.forbes.com/sites/niallmccarthy/2016/03/04/the-countries-winning-the-recycling-race-infographic/#3fb0c9e22b3d>, (accessed 17.07.2020).
25. Ministry of the Environment, (2010), Establishing a sound material-cycle society: Milestone toward a sound material-cycle society through changes in business and life styles. Government of Japan, Tokyo. http://www.env.go.jp/en/recycle/%20smcs/a-rep/2010gs_full.pdf, (accessed 25.06.2020)
26. Ministry of Economy, Trade and Industry, (2020), Circular Economy Vision 2020 Compiled. https://www.meti.go.jp/english/press/2020/0522_003.html, (accessed 25.06.2020).
27. Morseletto, Piero, (2020), Targets for a circular economy. Resources, Conservation and Recycling, Volume 153, <https://doi.org/10.1016/j.resconrec.2019.104553>, (accessed 19.08.2020).
28. Nagaoka International Affairs Center, (2019), An Endeavor Leading Other Municipalities An Experimental Introduction of “RPA” in Nagaoka City Office. Konnichiwa Nagaoka, Vol.333, p.1. <https://www.city.nagaoka.niigata.jp/kurashi/cate13/chikyuhiroba/file-kon/vol333.pdf> (accessed 20.07.2020).
29. Nagaoka Incorporated Association of Tourism and Conventions, (2020), Nagaoka has a wide variety of delicious foods. <http://www.nagaoka-navi.com/foods.html>, (accessed 22.07.2020).
30. Nagaoka City Tourism Planning Division, 2017. My Tour of Nagaoka. The Echigo Nagaoka Tourist Guidebook with Maps. Let your heart be light in the serenity of Nagaoka, pp. 1-17, <https://www.city.nagaoka.niigata.jp/kurashi/cate13/chikyuhiroba/file/maitabi-en.pdf>, (accessed 24.07.2020).

31. Nagaoka University of Technology, Department of Bioengineering, https://bio.nagaokaut.ac.jp/~en/research/microbial_genetics_and_biomass_utilization.html (accessed 27.07.2020).
32. Oishi Machine Inc., (2003), [_https://www.oishi-machine.com/en/04aboutus.html](https://www.oishi-machine.com/en/04aboutus.html), (accessed 22.07.2020).
33. Ogunmakinde, Olaborne Emmanuel, (2019), A review of circular economy development models in China, Germany and Japan. MDPI. Recycling, vol.4, Issue 27, pp. 1-14. doi:10.3390/recycling4030027.
34. Panasonic, (2015), Our approach to resources recycling, https://www.panasonic.com/global/corporate/sustainability/eco/%20resource_sp.html, (accessed 25. 06.2020).
35. SUZUTIMES vol. 17, (2019), Special Feature: TABI BAR from SUZUVEL debut! <http://suzugroup.com/> (accessed 24.07.2020).
36. Tecnologia libre de conflicto, (2020), The Environment and Electronic Devices <http://www.tecnologialibredeconflicto.org/en/environment/>, (accessed 19.08.2020).
37. The institution of environmental sciences, (2015), The circular economy in Japan. <https://www.the-ies.org/analysis/circular-economy-japan>, (accessed 31.07.2020).
38. Transactions on Gigaku first edition, (2012), https://www.nagaokaut.ac.jp/e/gigaku/archive.files/TOG_vol1.pdf, (accessed 24.07.2020).
39. Wee, Amanda, (2020), Data Dock setting an example for sustainable data centers. <https://zenbird.media/data-dock-setting-an-example-for-sustainable-data-centers/>, (accessed 27.07.2020).
40. Weetman, Catherine, (2016), A circular economy handbook for business and supply chains. Repair, remake, redesign, rethink. 1st Edition. Kogan Page Ltd, New York, p. 2.
41. Hirose, Tachishige, (2009), Gomi he no michi, Daisanbunmei-sha.
42. Yolin, Christine, (2015), Waste Management and Recycling in Japan Opportunities for European Companies (SMEs Focus); EUJapan Center for Industrial Cooperation: Tokyo https://www.eujapan.eu/sites/default/files/publications/docs/waste_management_recycling_japan.pdf (accessed 31.07.2020).