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Towards a Circular Regenerative Urban Model

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ECO-INDUSTRIAL DEVELOPMENT AS A CIRCULARIZATION POLICY FRAMEWORK TOWARD SUSTAINABLE INDUSTRIAL CITIES. LESSON AND SUGGESTIONS FROM THE ECO TOWN PROGRAM IN JAPAN

Tsuyoshi Fujita, Satoshi Ohnishi, Dong Liang, Minoru Fujii

Abstract

Eco-industrial development is widely considered as an effective policy and a business concept to realize sustainable circularization through collaborative networks among industries. Japanese government has accumulated practices as its national Eco Town Program in 26 cities since 1997. The operation of facilities and policy implementation have provided lessons and suggestions particularly for industrializing cities who desperately seek for the sustainable solutions achieving environment management and economic growth simultaneously. This paper aims to review the policy framework as well as accomplishments of the Eco Town Program and to provide lessons and suggestions for industrial cities' management. We reviewed and analyzed the experience of the Eco Town Program for a decade from viewpoints of the policy framework and circular situation; and provided general implications such as combination of recycle technologies and social system, symbiotic network among recycle entities and energy intensive industries as well as suitable locational planning.

Keywords: industrial symbiosis, eco-industrial development, spatial analysis

LO SVILUPPO ECO-INDUSTRIALE COME STRUTTURA DI UNA POLITICA DI CIRCOLARIZZAZIONE PER CITTÀ INDUSTRIALI SOSTENIBILI: LEZIONI E PROPOSTE DEL PROGRAMMA GIAPPONESE ECO TOWN

Sommario

Lo sviluppo eco-industriale è considerato in larga misura una politica efficace e un'idea di impresa per realizzare la circolarizzazione sostenibile attraverso reti di collaborazione tra le industrie. Dal 1997, il governo giapponese ha raccolto le esperienze di 26 città del Programma nazionale Eco Town. L'attuazione delle politiche e delle agevolazioni hanno rappresentato un buon esempio, in particolare per le città industriali che cercano disperatamente soluzioni sostenibili per perseguire contemporaneamente la gestione dell'ambiente e la crescita economica. Questo articolo vuole esaminare il quadro delle politiche, come anche i risultati raggiunti dal Programma Eco Town, per fornire indicazioni per la gestione delle città industriali. È stata esaminata l'esperienza del Programma Eco Town per dieci anni dal punto di vista delle politiche strutturali e della condizione di circolarità, ed evidenziate le implicazioni generali, quali la combinazione di tecnologie del riciclo e del sistema sociale, il network simbiotico tra il settore del riciclo e le industrie ad alta intensità di energia oltre ad un'adeguata pianificazione locale.

Parole chiave: simbiosi industriale, sviluppo eco-industriale, analisi spaziale

1. Introduction

To utilize waste/by-product within the region efficiently, Eco-Industrial Development (EID), according to the principles of industrial ecology, is considered as a promising system that "delivers sustainable development" in environmental, social, and economic dimensions at the urban and regional scale (Chiu and Geng, 2004). Substantial practices in the industrial district, city or region of EID in recent years were mainly practiced in the form of Industrial Symbiosis (IS) and eco-industrial parks worldwide, and in Japan, practices are known as the Eco Town Program (Chertow, 2007; Gibbs and Deutz, 2007; Park *et al.*, 2008; van Berkel *et al*., 2009a; Costa *et al.*, 2010; Shi *et al*.; 2010). These various practices for different terminology are considered as the innovative frontier of recycling and waste/by-product and energy exchanges among firms located near each other (Chertow, 2000).

The concept of EID has been gradually accepted by industries and governments in different geographical scales from industrial districts to cities and regions. Companies located in developed industrial districts and surrounding municipalities also start considering EID as a strategic tool (Laybourn and Lombardi, 2012), while allocation procedure in an effective and efficient way is still to be discussed (Gibbs and Deutz, 2007; Shi *et al.*, 2010; Behera *et al.*, 2012; Laybourn and Lombardi, 2012). On a company level, self-organizing of waste/by-product exchange among companies seems to be important, while designing and planning played an important role in developing a national practice. Japanese Eco Town Program were initially planned and supported by national and local governments as well as companies' attempts for self-organizing, was one of biggest drivers for effective EIDs.

This paper aims to review the policy frames as well as the accomplishments of the Eco Town Program and to provide lessons and suggestions for industrial cities' management. In Section 2, cities approved as Eco Towns were analyzed and the accomplishment of the projects were quantitatively analyzed in Section 3. The lessons and suggestions from the analysis were discussed in Section 4. Finally, this paper was concluded in Section 5.

2. Japanese Eco Towns as EID

Concepts, practices and researches of EID were reviewed and policy framework and social system concerning the Eco Town Program in Japan were described as one of a practice of EID.

EID and similar concepts have been proposed since 1970's, and several projects trying to implement these concepts have started their program after the discovery of Kalundborg. Accumulative knowledge for physical exchange of material/energy and water of these projects has been described and quantitatively analyzed as in Table 1.

Primary concepts were provided as "industrial ecosystem" by Cloud (1977) and Frosch and Gallopoulos (1989), and as "industrial metabolism" by Ayres (1989). These concepts systematized the results of law of thermodynamics, resulting in laying the base of life cycle thinking, material flow analysis and system analysis. After the earth summit was held in 1992 and sustainable development has become a key global strategy, policy makers had started to implement these concepts in their countries. It was Kalundborg that became a model of the existing practice. The initial government project, called Eco-Industrial Park project, in the United States, was set up in 1996. The Japanese Government has started its Eco Town Program since 1997 based on a concept of zero emission. Chertow (2000) published a review paper and pointed out that EID concepts of this period defined as industrial symbiosis and «industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity» (p. 313). One of the most important points is that this definition emphasis on local condition and spatial analysis.

Table 1 – Theory, practice & projects, and research on EIDs

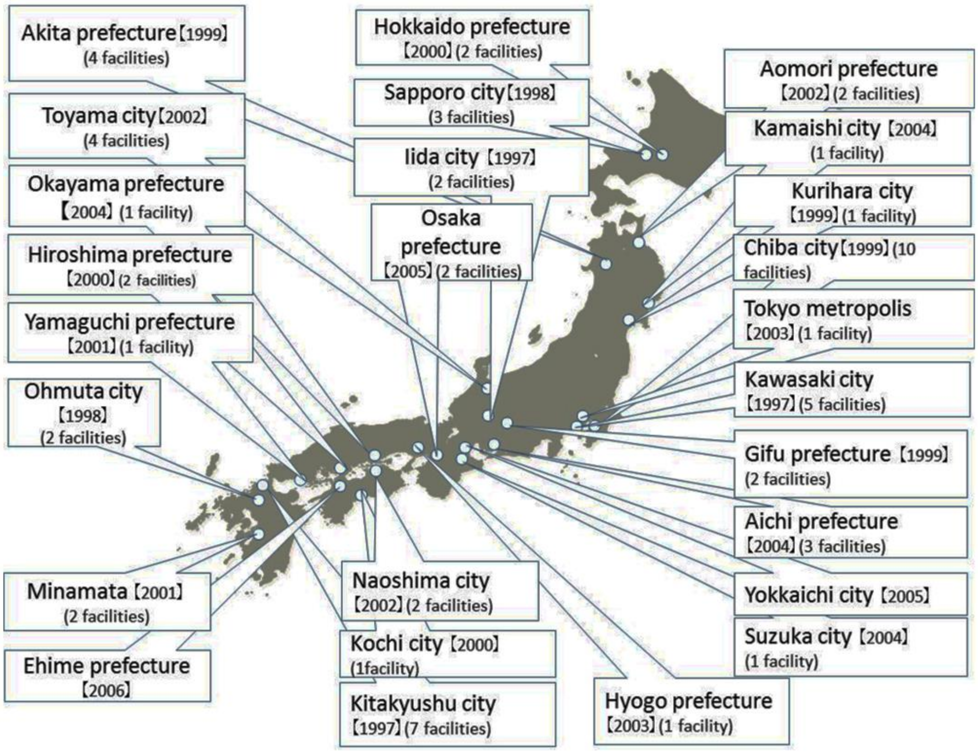
Years	Theory	Pactice & projects	Research
70's	• Industrial eco-system (Cloud, 1977)		
80's	• Industrial metabolism (Frosch and Gallopoulos, 1989)	• Kalundborg (1989~)	
90's	• Zero emission (Pauli, 1997) • Eco-industrial park (PCSD, 1996)	• Eco Industrial Park in Netherland (1994~) • Eco Industrial Park in the United States (1996~) • Eco Town in Japan (1997~)	• Ehrenfeld and Gertler (1997) for Kalundborg • Lowe (2001) for the United States
00's	• Industrial symbiosis (Chertow, 2000, 2007) • Eco industrial development (Côté, 2000) • Eco industrial network (Lowe, 2001)	• National industrial symbiosis project in U.K. (2000~) • Eco industrial park in China (2001~) • Regional synergy project in Australia (2003~)	• Heeres et al. (2004) for Netherland • Mirata (2004) for U.K. • Roberts (2004) for Australia
05's	• Urban symbiosis (Van Berckel et al., 2009a)		• *Chertow and Lombardi (2005) for Guayama, United States* • *Jacobsen (2006) for Kalundborg, Denmark* • Van Berckel et al. (2009a) for Japan • *Van Berckel et al. (2009b) for Kawasaki, Japan* • *Shi et al.(2010) for China*

Note: The papers described in italics focused on quantitative analysis of economic and environmental benefits

Since middle 2000's, national projects such as Eco Industrial Park project in Netherlands, National industrial symbiosis program in the United Kingdom, and Eco Industrial Park project in China started. As the projects has moved ahead, detailed case studies including quantitative analysis on environmental and economic benefits can be found in the literature on Denmark (Kalundborg) (Jacobsen, 2006), the United Stated (Puerto Rico) (Chertow and Lombardi, 2005), Australia (Kwinana and Gladstone) (van Beers *et al*., 2007), Japan (Kawasaki) (van Berckel *et al*., 2009b) and China (Guigang and Tianjin) (Shi *et al*., 2010).

These literatures have accommodated a request to dematerialization and a low carbon society.
Recently, several new concepts based on the cases' analysis have been proposed in the literature. Authors, for example, set up the concept of "urban symbiosis" that facilities located in industrial complex would accept and utilize household waste from urban area close to the industrial area, though the review of the Eco Town Program in Japan (van Berkel *et al.*, 2009a). Several authors supported the idea that geographical scale of exchange among entities have been expanding from industrial district to urban area and region (Sterr and Ott, 2004; Lyons, 2007).

Fig. 1 – Distribution of 26 Eco Towns in Japan

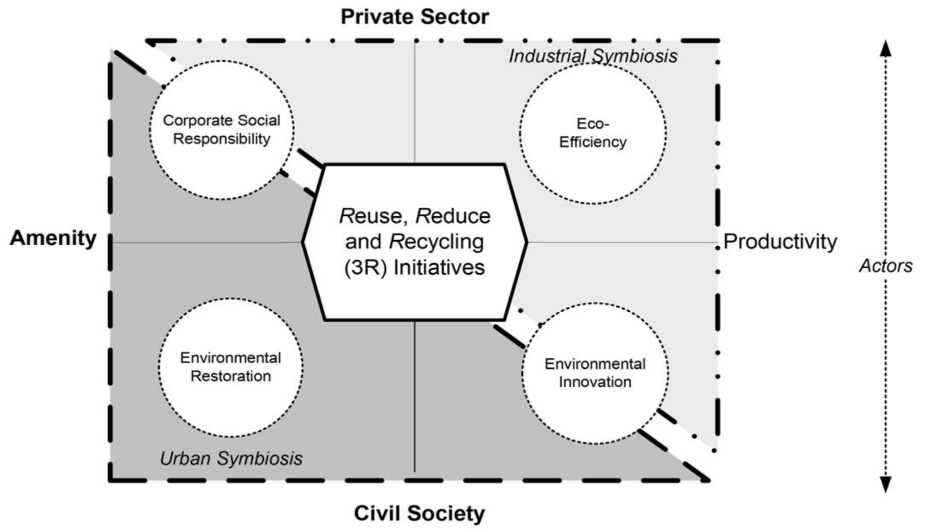


Source: Fujita, 2006
Note: Dates between black lenticular brackets are dates of formal approval of the Eco Town Program and dates between parentheses are number of subsidized facilities

The Eco Town Program in Japan was initiated in 1997. It adopted the concept of zero emission and aimed to address both new industry development and waste management issues in Japan (van Berkel *et al.*, 2009a, GEC, 2006). Totally 26 Eco Towns (Fig. 1) were designated jointly by Ministry of the Environment (MOEJ) (Department of Environment under Ministry of Welfare as of 2001) and Ministry of Economy, Trade and Industry (METI) of Japan. Eco Town plans consisted of two parts: "software projects" (e.g., town planning, community recycling, and outreach activities) and "hardware projects" (i.e., innovative recycling facilities and associated infrastructure) (Fujita, 2006; van Berkel *et al.*, 2009a). Recycling processes were designed to be connected with industrial production by utilizing wastes as alternative materials or energy for Energy Intensive Industries (EIIs) such as iron/steel, cement, and chemical industries. From 1997 to 2006, in twenty six local governments of Eco Towns, 170 plants set up their operation, including 61 plants subsidized by the national government; 56 facilities were waste plastic recycling plants and 31 facilities were for waste food recycling plants. In addition, home appliance recycling plants, end-of-life vehicles recycling plants and waste metal refinery plants were also under operation (Fujita, 2006).

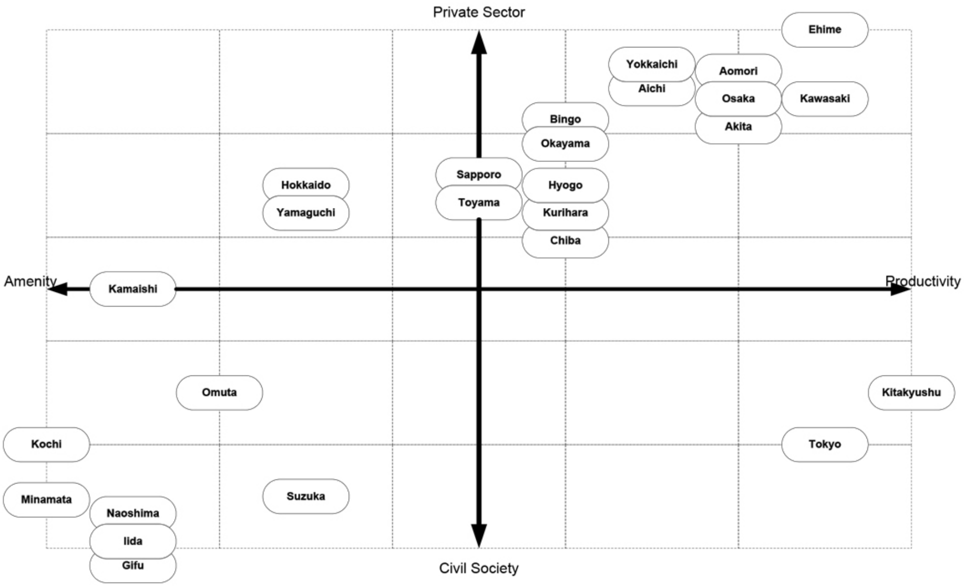
Authors proposed the categorization of Eco-Towns into five types based on their main motivations: namely waste management, development of recycling industry, industrial modernization, environmental remediation and town planning and community development (van Berkel *et al.*, 2009a). Fig. 2 shows dimension of Eco Towns consisting of four parts of eco-efficiency, corporate social responsibility, environmental restoration and environmental innovation. Using the pseudo-quantitative axes, 26 Eco Towns have been illustrated on the conceptual impact diagram of Fig. 3. The largest group is in the Eco-Efficiency quadrant (12 Eco-Towns), followed by the Environmental Restoration quadrant (7 Eco-Towns) and the Environmental Innovation Corporate Social Responsibility quadrants (2 Eco-Towns each). In 16 Eco-Towns, the private sector is a more important actor than civil society and that in total for 14 Eco-Towns productivity benefits are more important than amenity benefits.

Fig. 2 – Contribution of Eco Towns to sustainable industrial development



Source: van Berckel et al., 2009a

Fig. 3 – Qualitative characterization of 26 Eco Towns

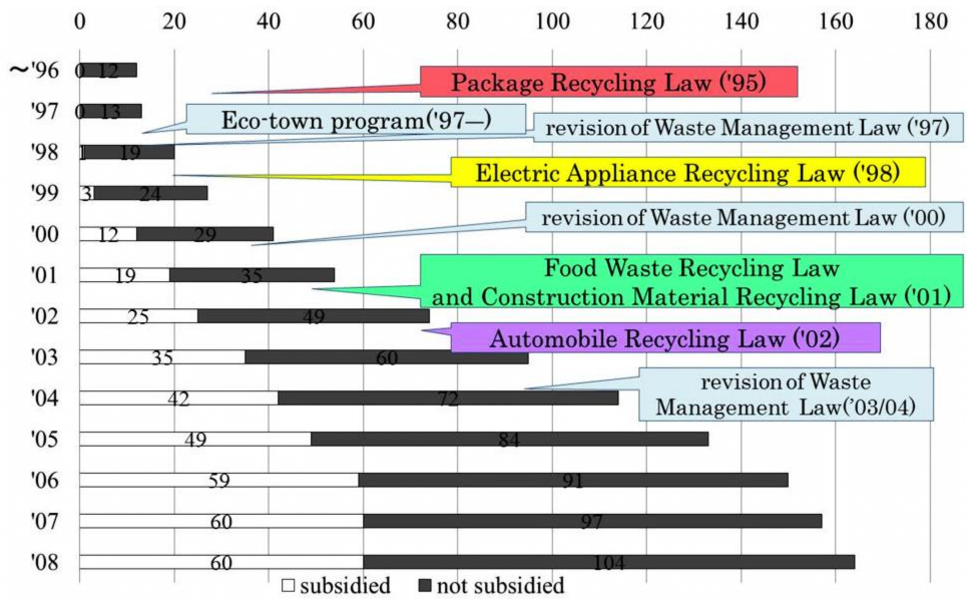


Source: van Berckel et al., 2009a

Fig. 4 shows relation between number of recycling facilities located in Eco Towns and the regal system of Japanese circularization policy. As the reasonable result, the more the laws enacted, the more facilities were starting their operation. The Japanese government reinforced the *Basic Laws for Establishing a Recycling Based Society* in 2000 as well as specific waste recycling laws such as waste plastic (1995), home appliance (1998), materials from construction work (2000) waste food (2000) and end-of-life vehicles (2002). This regal system became one of the most powerful pressures to make the recycling businesses into their practices.

Importance of appropriate social system in addition to the above legal system can be explained in detail by the plastic recycling system in Japan as an example. Technological development occurred in the industrial and research sectors, resulting in a significant increase in the number of patents from 1990 to 2000. This had been pressed by the situation that the Japanese society had faced an emergent issue which is a shortage of final disposal sites; there would be estimated no more disposal sites for household waste in 11.2 years from 1997, while that for industrial waste in 3.1 years from 1997. At the same time, Japanese economy especially EIIs struggled with the depression and needed to develop new technology and businesses. In 1993, the JFE group (formerly known as the NKK Corporation) proposed using the feedstock of the recycling system of plastics as a reductant to substitute coal for their furnace. Additionally, several small and medium companies funded by EIIs led the business in feedstock recycling by operating a test plant to produce a mixture of gasoline, kerosene and gas oil from waste plastic. These movements in niche promote design and implementation of the legal system and policy for recycling. In particular, the Eco Town Program can guarantee implementation of a recycling plant via financial support for plant construction.

Fig. 4 – Number of recycling facilities located in Eco Towns



As one of the other pressures, the Japanese government tightened the regulation on illegal disposal especially by raising the penalty charge in 1991, 1997, 2000, and 2003. This resulted in increasing recycling and sound treatment of waste, as well as decreasing industrial waste. Municipalities also started to separate collection of plastic packaging and containers since 1999. This collection system was used in 1,030 municipalities in 2009. Moreover, waste separation by citizens increased the awareness of 3R (reduce, reuse and recycling) activity including NPOs' glass-roots activity, resulting that high quality waste plastic could be collected. As the result of all these efforts, the recycling rate of waste plastic improved by more than 30% (in 2009, except for incineration generation). Systematic and comprehensive scheme of regal and regulation system as well as activity promotion for stakeholders is significant to realize the circulation of waste and by/product. Those social systems for circularization provided the appropriate platform for recycling business in the Eco Town Program.

MOEJ has started a budget for highly-development of Eco Towns since 2010 including Kawasaki (focusing on waste plastics and papers from industries), Kitakyushu (focusing on waste wire harness and plastic, and traceability system for domestic circulation), Akita (focusing on waste plastic from offices), Hokkaido (focusing on transportation of incineration ashes by trains) and Osaka (focusing on food waste carbonization). These attempts reveal several fruitful facts. For example, industries located in Kawasaki Eco

Town has a large potential amount to accept waste plastics and papers, which serve as fuel as RPF (Refused Plastic and Paper Fuel), however parts of waste plastic ends up simple incineration or a landfill although incineration examination of RPF from 10 facilities resulted that low carbon effects was estimated as 2.2-2.9 t-CO_2 reduction by utilizing 1 ton waste plastic depending on the calorie. These waste plastics are regarded as the unharnessed energy of wastes for procurers; therefor the carbon credit scheme named J-VER in Japan would be applicable which effects expansion of this project. J-VER stands for Japan Verified Emission Reduction which set up the offset credit scheme by MOEJ in 2008, for credits generated through the reduction/removal by sink of greenhouse gases carried out.

Accordingly, Japanese Government is establishing a new policy called the SMC blocks which «generated in a particular area or that are perishable will be circulated within an area, while those that require advanced treatment technology will be treated in wider areas» (Government of Japan, 2008, p. 12). For implementing this concept, MOEJ established a study committee for SMC blocks promotion, in which the chairman is a first author of this paper, to investigate the future direction and discuss a planning method of SMC blocks based on quantitative assessment. This committee provided a fundamental method of evaluation procedure consisted of database of emission distribution of recyclable wastes/by-products, future scenario design, configuring material and energy flow, input-output inventory of each technologies and estimation of several indicators such as GHG emission reduction, final disposal saving, raw material saving, cost, etc. In addition, MOEJ collaborated with the committee to produce a useful guideline on local recycling block planning for local municipalities (MOEJ, 2012).

These additional policies and planning method development have been based on the insights of quantitative analysis on the circularization in the cities approved as Eco Towns.

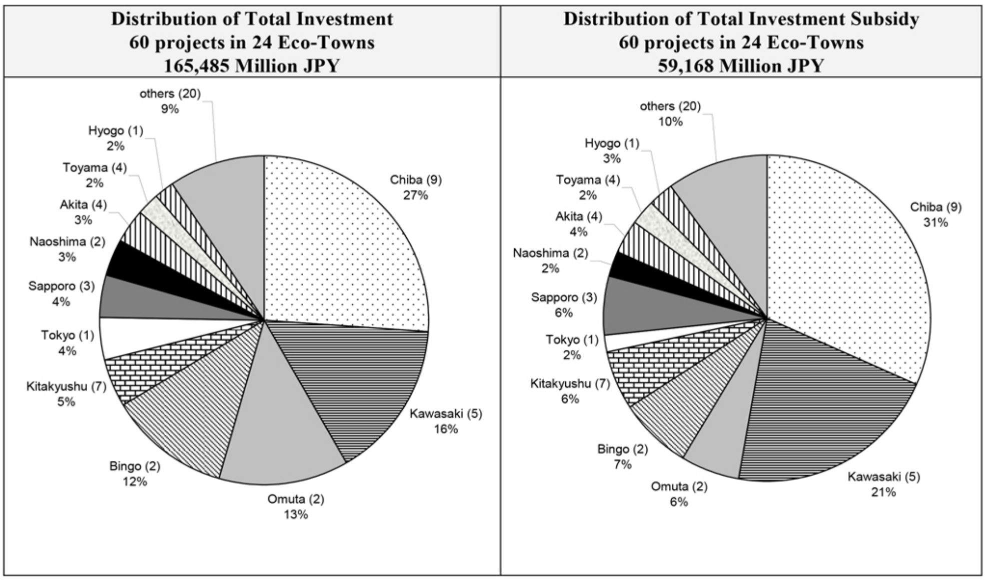
3. Quantitative analysis on Eco Towns Program in Japan

The economic and environmental effects of Eco-Towns were quantitatively analyzed such as the financial support and revenues, the environmental gains such as circularization ratio, material saving as well as low carbon effects. The spatial characteristics were also analyzed.

Authors investigated financial features of Japanese Eco Town Program based on the national survey of the program by METI for 61 projects in 25 Eco Towns (van Berkel *et al.*, 2009a). Total investment for 60 projects in 24 Eco Towns was 165,485 million JPY and total investment by subsidy for 60 projects in twenty four Eco Towns was 59,168 million JPY, which was 35.7 % of total investment (Fig. 5). In addition to initial investment, 1,460million JPY additional investment was existed such as spending on plants and equipment for “kaizen” or reinforcement. The Eco Town subsidy also had positive impacts to job creation, environmental education by site tours and communication with managers on recycling plants.

Authors also conducted intensive surveys, in collaboration with MOEJ, on operational condition and material flow and energy consumption of 170 operating recycling facilities in Eco Towns. A total of 90 valid responses were collected from recycling facilities. Among the total responses, 55% were valid, and among facilities that received subsidies, 64% of responses were valid.

Fig. 5 – Levels of subsidies and total investment by Eco Towns



Source: van Berckel et al., 2009a

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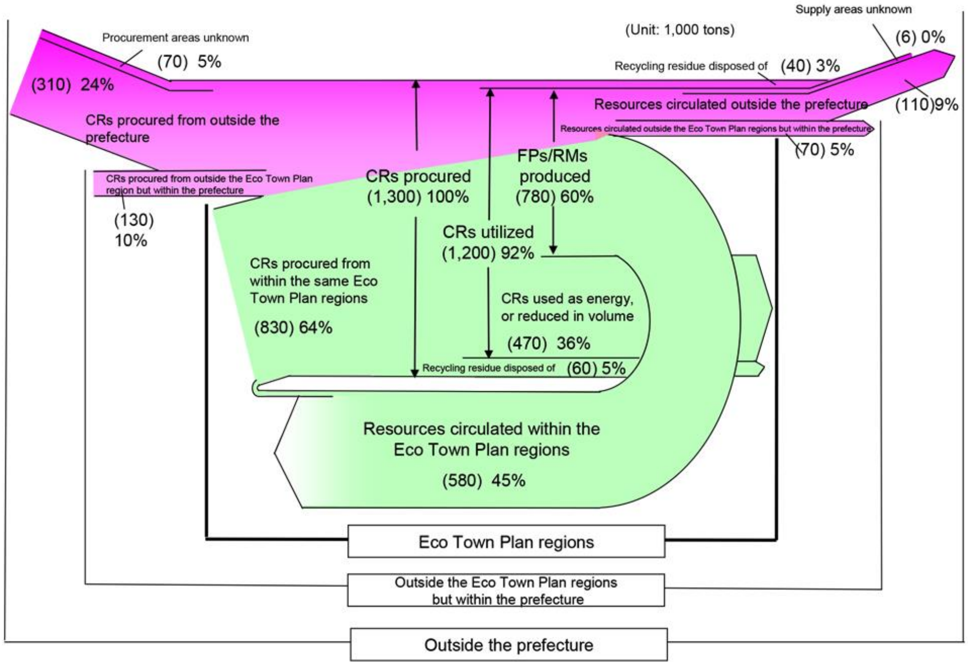
Fig. 6 shows the material flow of waste and recycled products in recycling facilities located in Eco Towns. Inputs to recycling plants are wastes or by-products for utilization and outputs from the plants are recycled products and residues. Direct Material Input (DMI) of waste or by-product was 1,030Mt/yr. DMI was consisted of two types, including waste or by-product from the same Eco Town region (830Mt/yr, 64%), from other regions (130Mt/yr, 10%) and the other input was unknown. Analytical results revealed that 45% of inputs utilized within the same Eco Town region as alternative materials and 36% of inputs as energy, etc. The circularization use ratio of by-product in all facilities located in Eco Towns was identified as much as 92% and intra-Eco-Town circulation ratio was 60%, which also provided the saving effects of virgin resources to be 900,000ton/yr and CO_2 reduction was estimated to be 480,000 ton-CO_2/yr.

Main recycling technologies of Eco Towns are called co-production, which is «waste material replaces primary fossil fuels and virgin mineral resources in industrial processes to conserve resources, to reduce emissions of GHGs and other environmental impacts, as well as to save landfill space and minimize associated pollution» (Mutz *et al.*, 2007, pp. 5-6). Authors pointed out that waste acceptation capacity was insufficient, waste utilization by co-production had higher efficiency, and resulted in production system with larger low carbon effects than incineration system with energy recovery (Fujii *et al.*, 2012).

Fig. 6 – Material flow of waste and recycled products in recycling facilities

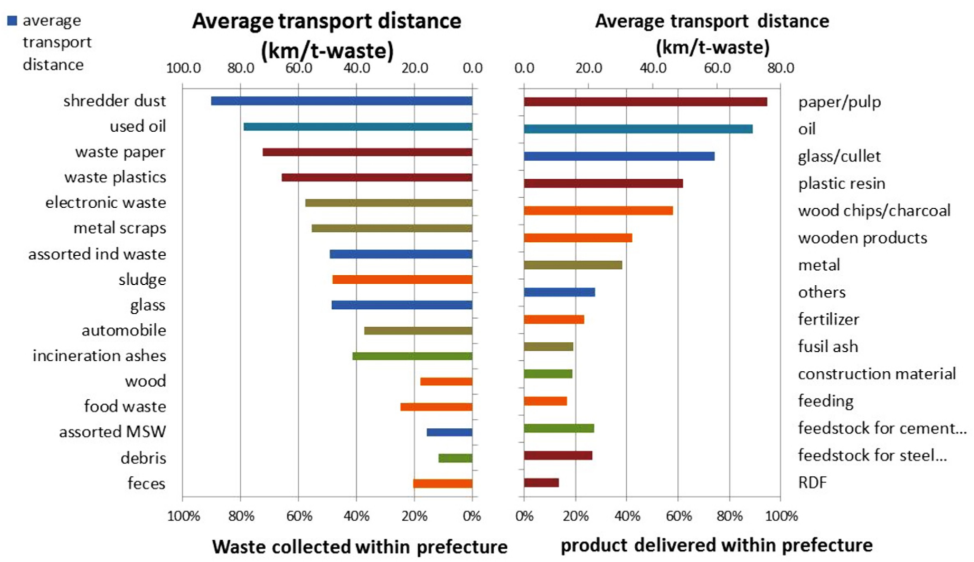


Source: MOEJ, 2009

Low carbon effects by policy simulation of industrial and urban symbiosis in collaboration with production system in EIIs were identified from life cycle perspective. Authors developed the evaluation methodology to identify the extensive co-processing effects for cement, iron/steel and non-ferrous industries (Hashimoto *et al.*, 2010) Low carbon effects for a cement company in Kawasaki Eco Town were simulated for taking industrial sludge and municipal waste plastics from Kawasaki city as the alternatives for the fossil fuel resources. The results showed larger amount of CO_2 reduction was expected by accepting municipal solid waste. Policy simulation also provided cost of the low carbon effects in Kawasaki Eco Town for its urban symbiosis scenario as 185$/t-$CO_2$ (Geng *et al.*, 2010). Their technology transfer effects to a Chinese city, Shenyang, was also identified although the cost would be an obstacle (Chen *et al.*, 2011).

Suitable circular scale, which defined as transportation distance of collected waste and procurement of product, were investigated for different by-products and wastes (Chen *et al.*, 2012). Fig. 7 shows that different types of waste had their own recycling distance considering the cost and the wastes' features. On the material procurement side, wastes that have higher transportation cost by the volume due to the smaller value by a volume such as MSW (municipal solid waste), debris, wood, and feces, were mostly collected in a distance less than 20 km. On the contrary, wastes that had relatively higher market value like the metal, WEEE (waste electrical and electronic equipment), plastics, paper, automobile shredder dust (containing metals), and oil are mostly collected in longer distances. On the provision side of recycled products, similar features were identified. The results indicated that recycled products with higher transportation cost by volume are usually delivered in short distances, whereas high-valued products that are relatively cheap for transportation are delivered in long distances.

Fig. 7 – Transportation distance of each waste and product



Source: Chen et al., 2012

As another result, when promoting the recycling activities, circler scale and the related recycling facilities' location were important considering that different wastes had various recycling distances. Optimal design for allocating the recycling plants of different wastes could hereby enhance the eco-efficiency of the recycling and further contribute to sustainability of EID. For realization of these benefits, effects of agglomeration of recycling plants which operate different wastes and influence of logistic system including shipment would be considered.

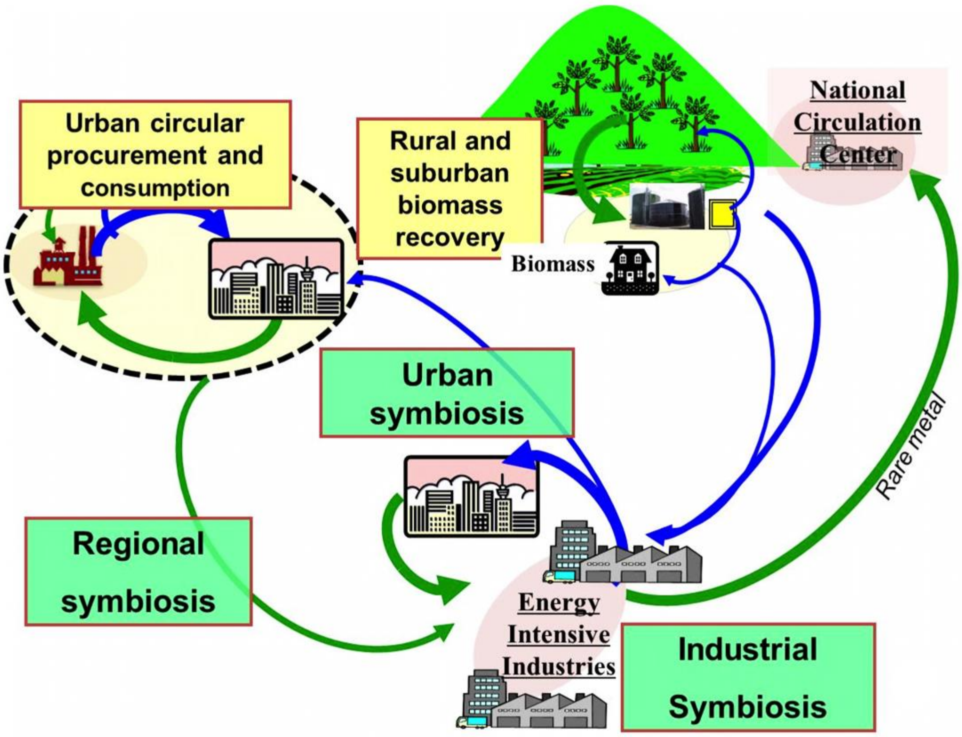
4. Lessons and suggestions from the Eco Town Program toward Sustainable EID

The following is the policy lessons and suggestions toward sustainable EID based on analyzing the social experiences in Japan.

Social system is crucial for EID implementation as well as technical innovation. Sufficient level of legal and collection system enable industrial system to symbiotic networks by the significant pressure. The appropriate and innovative waste management regulation system has played crucial roles to support the business to contribute to establishing EIDs with profitability in collaboration with stakeholders, namely circular business.

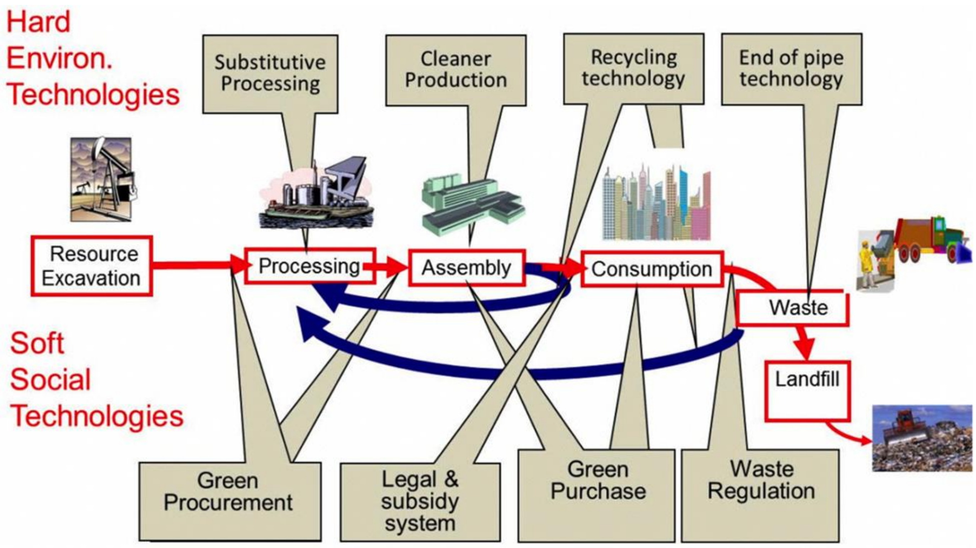
Circular business cannot keep the business only by hardware of environmental technologies including substitutive processing, cleaner production and end-of-pipe treatment technologies. The essential point making circular business successful is in collaboration with software, so called social technologies including green procurement; reuse/recycling regulation and subsidies to construction of facilities, green purchase and waste regulation along with life cycle stages as described in Section 2 and shown as Fig. 8.

Fig. 8 – Concepts for resource circulation from life cycle perspective



For establishing the circularization of material and energy, circular scale and the related recycling facilities' location play the important roles for different wastes. For an optimal design for allocating the recycling plants of different wastes, effects of agglomeration of recycling plants which operate different wastes and influence of logistic system including shipment need be considered. Fig. 9 shows conceptual overlays of different circular zones and EID as the centric functions. Eco Towns in Japan tend to locate ports along seaside because EIIs, as recycled waste acceptors, needs huge amount of imported materials from abroad. Agglomeration of EIIs, recycle plants and collection centers of waste from urban area in sites differed from each other would create new material/waste flows and incubate the recycling businesses.

Fig. 9 – Image of urban symbiosis and regional symbiosis



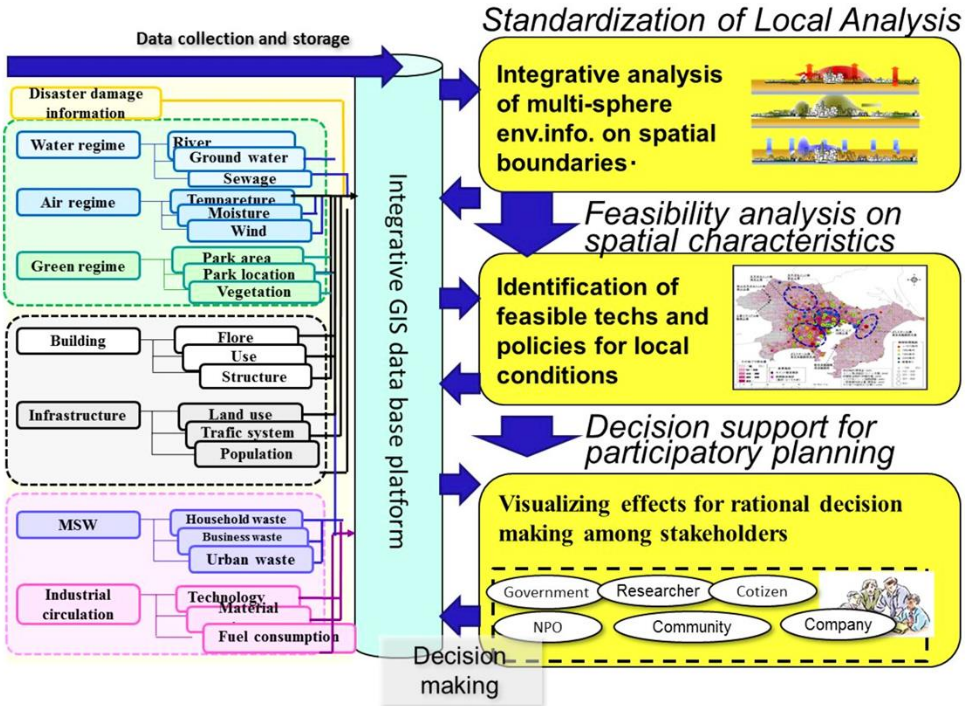
On the other hand, there is a trade-off of transformation cost and potential amount of wastes when collection boundary spreads to larger area. From a different angle, as cost of fuel/electricity and virgin material utilized by industries accepting recyclable wastes would be increasing, the added value of recyclable waste could be increasing relatively, resulting that recycling businesses could be in operation with high profitability. Establishment of multi circular scale, named regional symbiosis considering appropriate social waste transportation cost and environmental value of recycle products should be incorporated in the systems. To realize this system, social multi-stakeholder collaboration scheme for such separation, collection and green purchase would be essential issues.

EIIs with co-processing technologies have been one of key actors of EID to invest the recycling businesses. In Japan, researchers and policy makers generally express the EIIs as arteries industries and the recycling industries as vein industries by an analogy of material/energy circulation and blood circulation. As we pointed out in Section 3, EIIs would promote regional symbiosis in collaborated with recycling industries, namely arteries and vein industries symbiosis. Additionally, as the policy simulation system estimated environmental gains of CO_2 emission reduction and virgin material reduction including future scenario (Geng *et al.*,2010; Hashimoto *et al.*, 2010; Chen *et al.*,2011), EIIs could play one of the most significant roles as key actors of establishing efficient low carbon cities.

At the detailed planning stage of regional symbiosis, it is essential to identify the characteristics of local condition which are location patter of building and industries, flow of environmental resources such as water, sewage water, air etc. and material including waste and energy flow. As previous spatial analysis revealed, suitable circular scale could be considered for policy making.

To promote circularization policy and contribute to sustaining cities, the social system should be consolidated to operate recycling technology more efficiently so as to support the regional symbiosis. Consolidation of social system to internalize the value of regional symbiosis which market cannot take appropriate control will make circular business activating in various regions. Establishment of these kinds of technological and social system based on the empirical analysis and future simulation is essential.
It is one of the most significant missions for researchers to provide stakeholders with scientifically reasonable direction of implementation to regional symbiosis by identifying suitable condition for combining each regional characteristic. Fig. 10 shows an academic scheme for designing and planning regional symbiosis.

Fig. 10 – Integrated GIS database platform



At the first step of analysis of the region, a database should be constructed which consists of rainfall, water flow, air, green area, buildings, infrastructure, solid waste and industrial waste information, these information further incorporated into Geographic Information System (GIS) for decision making support. This information will be utilized for standardization of local condition analysis on location patter of building and industry, flow of environmental resources, and to integrate multi-sphere environmental information on spatial distribution and flows. These results by feasibility analysis with spatial characteristics would facilitate each region to identify the best available technologies and policies for local conditions. As the result of this analysis, we can prepare a decision support tool for the participatory planning by visualizing the effects of decision making on stakeholders in each region. These processes, which are standardization, feasibility analysis and decision support, have feedback to collection and storage of data and enrich the data platform.

5. Conclusions

We pointed out a progress of symbiosis from industrial district to urban area and region to expand collection boundary suitably. From a Japanese experience, we concluded that that EID including industrial symbiosis is significant to act as a driver for sustainable industrial system and cities, and suitable circular scale could be considered for policy planning for different by-products and wastes. For the future progress to promote regional symbiosis, integrated GIS database platform would be an efficient tool to policy makers designing plans and implementing as well as academic communities.
As future challenges, we should make data availability be built up for analyzing the characteristic of local condition. The experiences in cities approved by the Eco Town Program would promote to standardization of data collection and analysis especially concerning material and waste flow. Secondly, methodology of feasibility analysis in spatial characteristic has not been constructed theoretically. Matching system of demand-supply of material and energy source, technology assessment being appropriate for each city etc. should be researched more. Thirdly, how could we make EID concept implement into practices. We have tried to apply an integrated GIS database platform into several cities. However, we are still on a learning process to establish whole the system, so standardization of local data, evaluation methods, and optimal location model would be discussed. This challenge would make progress in this research field.

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