Chapter 2

Circular Economy Potential and Public–Private Partnership Models in Japan

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1. Introduction

Circular economy is an ideal economic model in a world facing climate and resource constraints. Departing from 'mass production, mass consumption economy' and linear economic model, it is now considered necessary to give fair price on both resources and waste, like hydrocarbon energy and carbon dioxide (CO_2) emissions, when seeking for circular economy through market-based approach. Putting price on waste removes certain externalities.

Three drivers direct circular economy.

1.1. Stable Resource Procurement

Mostly importing its energy and mineral resources, Japan puts higher priority on using resources efficiently and recycling materials to reduce its dependence on imports.

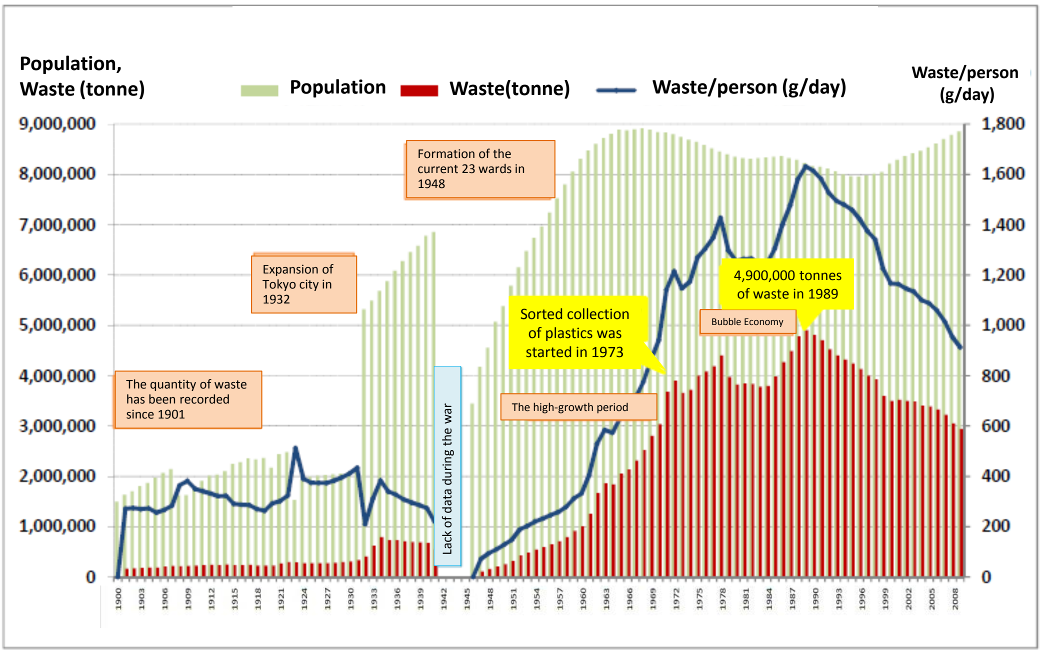
A conventional recycling business model in Japan is paper production, where waste paper, particularly newspapers and magazines, are collected by small businesses and local governments to produce new paper. In 2013, 80.8 percent of waste paper was collected and shared 63.9 percent to the total production of recycled paper. By recycling paper, import of virgin pulps is minimised and fluctuation of prices in the international commodity market is mitigated.

1.2. Cost of Waste Disposal

In the 1970s, the Tokyo Metropolitan Government faced a conflict among cities disposing municipal waste. Because municipal waste was being dumped in landfill sites in Tokyo Bay in those days, residents living near dumping sites suffered from environmental nuisance and heavy traffic caused by garbage trucks.

The then governor of the metropolitan government decided that 'waste from the city shall be disposed in the area of the city'. Although waste incineration was a common practice at the time, incineration residues and unburnable solid wastes were still to be disposed at landfill sites. The cities then adopted, in addition to incineration, the reduction, reuse, and recycle (3R) of waste. Per capita waste was reduced to 0.9 tonne from over 1.6 tonnes in 20 years.

Figure 2.1. Waste from Tokyo's 23 Cities



Source: Tokyo 23 Cities Clean Association and author.

1.3. New Business Model

The amount of wastes reduced and the products and materials recovered by 3R still have some value as energy. Municipal wastes of food and beverage and unrecycled paper and plastics have calorific value high enough to generate power. Thermal recycling by power generation is the last measure for recycling. In the case of Tokyo, biomass components account for 55 percent of total wastes. Power from waste provides additional value as low carbon energy. The premium electricity generated from waste-to-energy mitigates climate change and reduces cost of waste management.

With increase in income, consumers are purchasing more electronic appliances and, as a result, stocks of waste accumulate. These stocks contain valuable metals like gold, copper, cobalt, rare metals, and rare earth elements. For instance, the gold content of electronic substrates is higher than that of gold ores. As technology develops, many resources can be extracted from waste at reasonable cost. These are called 'urban mines'. The development of urban mines in Japan is pushed by regulations on waste disposal, such as the Home Appliance Recycling Law. Waste-to-power schemes or urban mines generate cash flow and could be public–private partnership (PPP) projects once boosted by financial support.

2. Structure of Policy Framework

2.1. National Legislation

Regulations drive proper waste disposal. In Japan, such regulations are created or promulgated and implemented at national and municipal levels. The principle of circular economy in Japan is defined by the Basic Law for Establishing the Recycling-based Society (2000). The Japanese government also decides and regularly updates the basic plan for implementing the Basic Laws. It determines numerical targets and allocates budgets for measures to be taken.

Figure 2.2. National Legal Setting in Japan

<Basic Law>
The Basic Law for Establishing the Recycling-based Society (2000)
- **Follow Environmental Impact Assessment Law (1993)**
- **Encourage reduce waste and reuse and recycle of products, materials, resources and energy**
- **Partnership with national government, local government, corporate and citizens**

<National Laws>
- **Containers and Packaging Recycling Law**
- **Home Appliance Recycling Law**
- **Food Recycling Law**
- **Construction Materials Recycling Law**
- **Automobile Recycling Law**
- **Electronic Appliance Recycling Law**

The Fundamental Plan for Establishing a Sound Material-Cycle Society
<2020 Target (from 2010)>
- **Resource productivity ; 85% improvement**
- **Circular ratio : 17% points increase**
- **Final disposal : 70% reduction**

Source: Author.

2.2. Municipalities

Japan's municipalities are responsible for providing services following national laws and developing necessary laws for implementation. Some municipalities have initiated plans and targets to realise a circular economy. For instance, Kyoto City, in March 2010, announced the Basic Plan for Promoting Circular Society and targeted waste reduction by half from its peak level by 2020. The city also promotes de-carbonisation through waste-to-energy schemes.

A serious concern regarding the implementation of these measures is the weak budget capacity of Japan's municipalities. They expect budgetary support from the national government.

2.3. Beyond Recycling Regulations

Recycling certain items is stipulated in Japan's recycling laws and should be followed by manufacturers, sellers, and consumers. Corporates sometimes do more than what regulations require. For instance, the automobile recycling law does not cover waste rubber tyres but tyre manufacturers reuse and recycle them anyway. In 2012, 56 percent of tyres were thermally recycled, 16 percent were reused, and only 1 percent was reclaimed. The costs of collection and recycling and fees paid by tyre manufacturers were cheaper than if the tyres were reclaimed. Thus, both tyre manufacturers and users for thermal recycling, such as paper mills and cement and steel companies, benefitted from the scheme. This is a 'win–win' model.

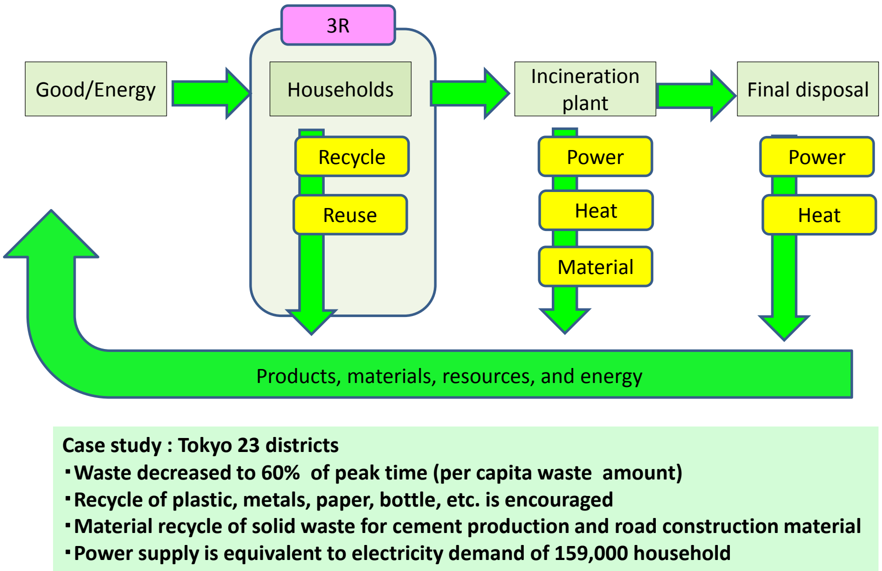
3. Public to Public–Private Partnership

3.1. Waste to Power, the Tokyo Model

Waste to power, particularly of municipal waste, has become very common in Japan. More than 300 waste incineration plants generate electricity with a total capacity of 1700 Mh or almost equivalent to the generating capacity of 17 units of a nuclear power station.

Figure 2.3 shows the basic flow of waste-to-power scheme. 3R has higher priority while thermal recycle is considered the last option for 3R.

Figure 2.3. Concept of Material Flow Under 3R



Source: Author.

The concept of power generation at waste incineration plants goes back to the mid-1940s although it was not realised due to World War II. In the 1970s, the calorific value of waste was over 1,400 Kcal/kg and incineration for power generation became feasible from technology's perspective.

At present, all waste incineration plants in Tokyo generate 10 GWh of electricity a year or a supply equivalent to the consumption of 159,000 households.

Some lessons learned from Tokyo's 23 cities:

Technology

In the case of Tokyo's 23 cities, the calorific value of municipal waste with 40 percent moisture content is around 2,200 kcl/kg. In general, lignite coal with 30 percent moisture content has a calorific value of 4,500–5,500K cl/kg, while peat with 50 percent or more moisture content has 2,300 Kcl/kg or more. At present, incineration technology uses waste with calorific values of 1,700–3,400 Kcl/kg for power generation without additional fuel. In addition to technology, waste-to-power generation requires proper management system and well-trained operators as the property of waste varies day by day.

Various substances are found in garbage. Without appropriate pollution control devices, pollutants such as particulates, dioxins, and heavy metals are likely to be emitted to the atmosphere by incineration. Also, public acceptance is crucial and Japan's municipalities require lower toxic elements emissions than that regulated by national standard.

Collection system

Garbage separation at collection system is an essential condition for efficient and safe waste incineration. Waste classification varies by municipality, but most are categorised as burnable, unburnable, paper, plastics, bottles and cans for recycling, and hazardous waste. Incineration plants are obliged to stop operation, clean up, and replace filters once toxic materials, like mercury, are found at emission control devices. Such incidents are caused by improper separation, as when a significant amount of fluorescent lamps, for instance, is mixed in the waste. Clean-ups and change of filters are very expensive (¥280 million at an event in June 2010, not a negligible amount considering that the annual electricity sale is around ¥5,000 million).

Tokyo provides information on waste separation through various channels, including education programmes at schools.

Dialogue with local people

Although technology reduces the risk of pollution, unexpected things could still happen. Thus, dialogues are important in improving mutual understanding.

This combination of technology, service provision system, and local community involvement is called the 'Tokyo Model' and is presently shared with governments and municipalities in Asia, South America, and the Middle East.

3.1.1. Low-carbon energy incentives for waste-to-power

From 2011, Japan has adopted the feed-in-tariff (FiT) programme and offered premium price on electricity from renewable wastes. Waste-to-power generation is eligible for FiT but tariff depends on the types of waste. In the case of plants in Tokyo, the cost for recovering investment is calculated at ¥12.72/kWh, ¥14.99/kWh, and ¥16.47/kWh. In general, FiT tariff for waste is ¥17/kWh, determined by taking into account estimation of investment recovery cost and CO_2 emissions-reduction contribution (cost and environment value).

Figure 2.4. Tariff of Power Generation under FiT in Japan April 2015

	Tariff (¥/Kwh)	Contract period (year)
Waste (general)	17	20
Industrial waste (construction)	13	20
Industrial waste (wood)	24	20
Photovoltaic (10Kw over)	29	20
Wind (20Kw over)	22	20
Geothermal (15Mw over)	26	20

Analysis of cost of power generation from waste
・Cost of power generation from incineration power plant in Tokyo
¥ 12.72/Kwh – ¥ 16.47/Kwh Average of 3 plants are ¥14.45 Kwh
・Biomass contents
55.5% (assumption)

FiT = feed-in-tariff, kW = kilowatt, MW = megawatt, PV = photovoltaic.
Source: Ministry of Economic, Trade and Industry.

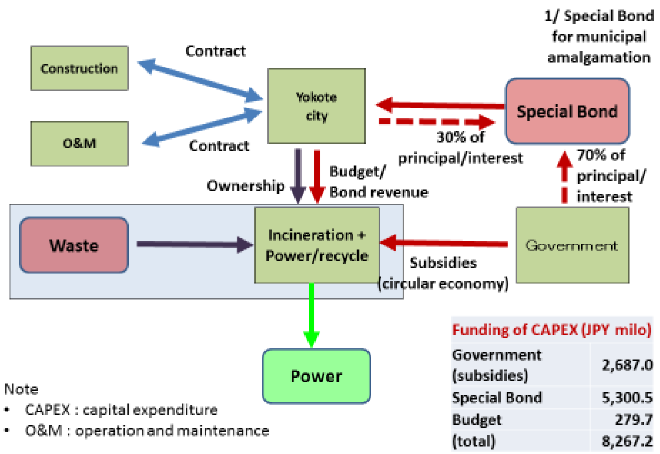
3.1.2. Public–private partnership for municipal waste: the case of a local city

Although many cities have introduced power generation at waste incineration plants, they are not financially strong enough to make large-scale investment. Discussed below is the case of Yokote, a city located in an agricultural area with a population of 100,000.

Firstly, after evaluating the costs of different business models, including conventional engineering, procurement, construction (EPC model) and design, build, and operate (DBO model), the city chose the latter. The city offered a tender and concluded contracts with a private consortium for construction operation and management for ¥8,267 million and ¥7,070 million, respectively, for 20 years.

The city prepared the funding for the construction of the plant, using the Special Bond for Municipality Amalgamation where about 70 percent of principal and interest payment was shouldered by the national government, and a government subsidy programme for promoting investments that contribute to circular economy. More than three quarters of capital expenditure were directly or indirectly paid by the national government. The DBO model is a standardised approach in Japan.

Figure 2.5. Funding of a Waste-to-Power Project – Case of Yokote City



CAPEX = capital expenditure, O&M = operation and management.
Source: Author.

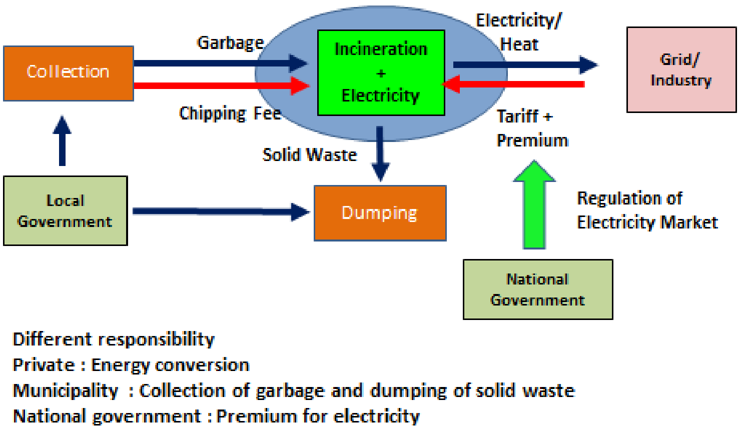
3.1.3. Diffusion of the PPP model for the Asian market

Incineration technology, both for construction of facilities and operation and management, is available and could be implemented through the PPP model. A study group formed by the Tokyo's 23 Cities Clean Association (Clean Authority of Tokyo) is analysing the potential of the PPP model in Asia and other developing countries and the necessary condition for PPP approaches.

For private investors, an ideal option of the PPP model is the energy conversion model where a private entity, for example, constructs and operates an incineration plant with power generation and receives garbage as fuel for electricity generation. Its revenue is to come from electricity sales and chipping fee from municipalities. When premium price is given to power from garbage as low-carbon electricity, cash flow from plant operation is boosted.

Waste collection and final disposal are to be shouldered by the municipalities because relationship with local people and land acquisition for plants and landfill sites are tough for private companies, particularly non-local entities. Crucial for the success of the PPP model is a stable collection system.

Figure 2.6. Conceptual PPP Model for Waste-to-Power Scheme



Source: Author.

3.1.4. Industrial waste

In Japan, industrial waste is handled separately from municipal waste. Many waste incineration plants are constructed and operated by private companies. The capital expenditure incentive, offered as low-carbon power source, and sale of electricity with premium price drive the waste-to-energy initiatives at industrial waste plants. Power from wood industry waste and construction waste is purchased at ¥24/kWh and ¥13/kWh, respectively. Some industrial waste incineration plants are reported to have eliminated over 10,000 tonnes of CO_2 emissions.

Figure 2.7. CO_2-Emission Reduction at an Industrial Waste Treatment Plant (Case Study)

Waste	Outline	CO_2 Reduction
Industrial waste	Combination of Gasification Melting Process and	16,100t PA
Medical waste	Combination of Gasification Melting Process and	5,000t PA
Biomasswaste	Using tinned wood, pruning waste from fruit farm, construction waste and other wood materi-als for biomass chip production	9,507t PA
Solid waste from waste water treatment	Using biogas from solid waste treatment process for co-generation.	1,000t PA
Solid waste from waste water treatment	De-watering of solid waste by using waste heat from cement kiln and use it for fuel for kiln.	3,900t PA
Food waste and beverage waste	Biomass fuel production using waste	31,554t PA

Source: Author, using data from the Ministry of Environment Japan.

Figure 2.8. Modality of Incentives for Waste-to-Energy in Japan

1. Incentive for capital expenditure of heat recovery from waste
   - ➢ Eligible entities
     - Private sector and administrative agency (excluding local authority)
   - ➢ Incentive
     - Incremental capital expenditure for energy recovery and use, but limited up to 1/3 of total capital expenditure
   - ➢ Eligible equipment
     - Heat recovery from incineration plant (23% or above energy recovery ratio)
     - Biomass heat supply
     - Biomass co-generation
     - Fuel from waste (60% or above energy recovery ration)
     - Biomass fuel supply

2. Incentive for power from waste
   - ➢ Under Feed-in-Tariff system, preferred tariff is applied for power generation from incineration plant
     - ¥16.5/Kwh for 25-30 years

Source: Author.

3.2. Urban Mines

As a result of increase in income and drop in prices of appliances, demand for electronic home appliances in Japan is increasing. However, this also leads to increased burden of waste disposal. Waste appliances contain various types of valuable metals like gold, copper, steel, cobalt, lithium, rare metals, and rare earth elements. For instance, the total amount of gold contained in appliances is enormous and, in Japan, is estimated at 6,800 tonnes or the equivalent of 16.3 percent of the world's gold reserves. As waste is considered an important source of resources, a new business model known as 'urban mines' is emerging as a private initiative driven by regulations on waste disposal.

Table 2.1. Potential of Urban Mines

	World Reserves	Urban Mines Japan	Share (ton %)
Gold	42,000	6,800	16.2
Silver	270,000	60,000	22.2
Lithium	4,100,000	150,000	3.7
Cobalt	7,000,000	130,000	1.9
Tantalum	43,000	4,000	9.3

Source: National Institute for Materials Science.

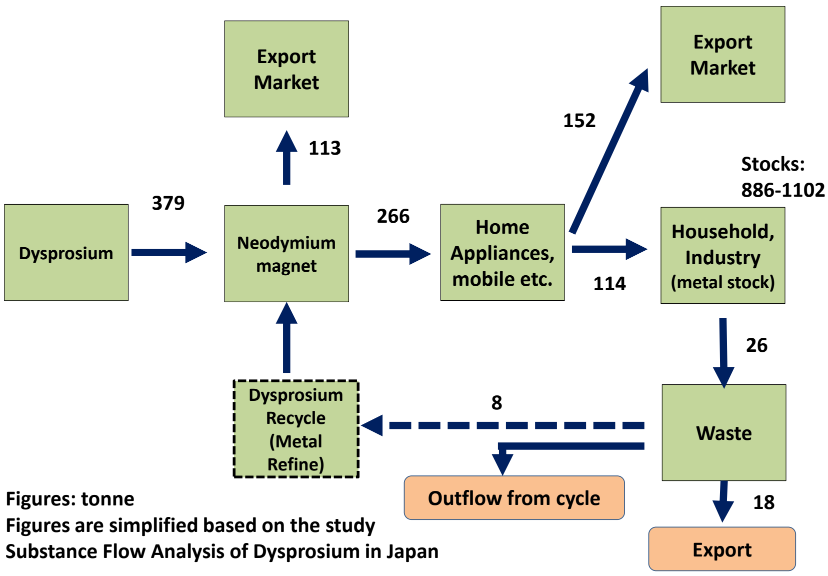
The DOWA group, a leading Japanese company, uses electronic appliances to reproduce base metals and precious metals. It separates electronic parts containing metals from electronic appliances and other waste products and then smelt and extract metals and other valuable materials from them. The company has metal-refining technology that efficiently extracts valuable materials from low-quality and mix-metal ores, and technology for controlling air and water pollution and containing hazard waste. Japanese metal-producing companies, including the DOWA group, have been losing international competitiveness due to severe competition from global non-ferrous metal companies as well as national resource development companies. Urban mining is a new business model that could make them competitive through the use of technology.

Figure 2.9 shows the material flow of recycling neodymium magnet and dysprosium as key material for it. Neodymium magnet, which has strong magnet force, is used for compact and efficient motors of personal computers, hybrid cars, and other devices. A key raw material to it is dysprosium, a type of rare earth element of which 99 percent is produced in China. In 2013, its price jumped tenfold due to China's restriction on exports. As a result, various countermeasures were taken in Japan to reduce the use of dysprosium, including switching to other material elements, diversifying the supply source, and recycling.

As Figure 2.9 shows, recycled neodymium magnet and dysprosium could be an import resource once the lifetime of products that contain it is over and it has come to waste material market.

Figure 2.9. Material Flow of Metals

(Case of Neodymium Magnet)



Source: Sakae Shirayama and Toru H. Okabe (data) and illustrated by author.

4. Lessons Learned

Legal Settings

Waste collection is a key factor in legal settings, and regulations on waste disposal, including 3R, are needed. For instance, thermal recycling is economically feasible when waste collection is done by another party and disposal fee is paid to the company that recycles. Environmental regulations on air pollution, water pollution, and solid wastes from waste treatment plants are also needed for sustainable operation.

Technology and Supporting System

For the waste-to-energy scheme, pollution-control technology is needed in addition to incineration and refining. Also, although technology is crucial, waste-to-energy cannot be realised without an efficient collection system. Once the PPP model is applied, stable collection of waste becomes a higher hurdle for private investors and is expected to be implemented by or in cooperation with local municipalities.

Government Support

Although waste may generate cash through extraction of energy and valuable metals, revenue from it is unlikely to recover the whole investment cost. Financial gaps should be covered by the public, through chipping fee or capital expenditure support. Also, a legal framework for financial support by the national government is needed because the financial capacity of municipalities, in general, is not strong enough.

International Material Flow

Stable supply of waste is an important element of waste-to-energy and resources-from-waste schemes. As products are traded internationally – more than half of neodymium, for example, is exported – waste should be collected internationally or regionally.

5. Recommendations

Waste-to-energy and resources-from-waste schemes contribute to sustainable economic growth and national security by reducing dependence on import of resources. This model should be diffused globally to realise circular economy. Public–private partnership could be applicable when investment climate improves.

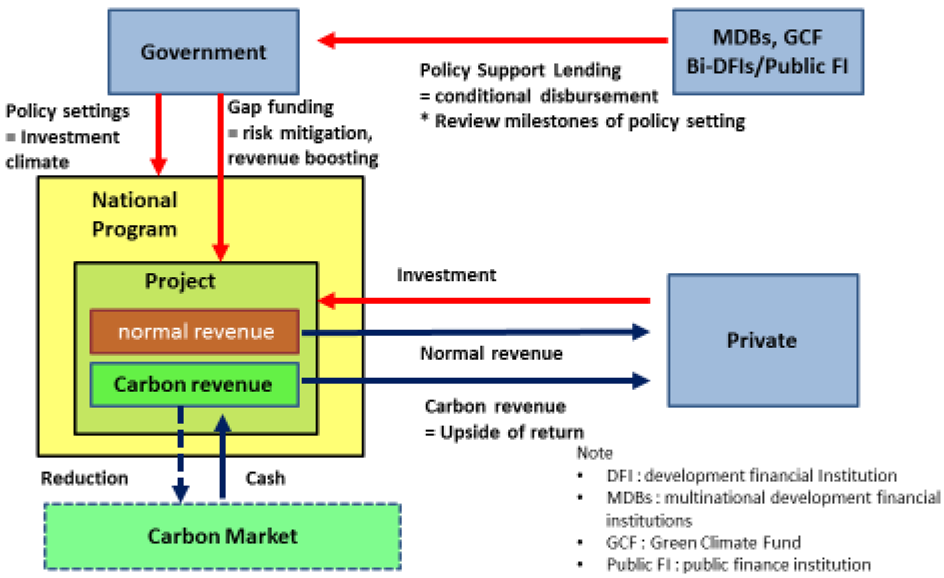
- **Legal setting.** Legal setting is crucial. Waste externalities can be removed by regulations on waste disposal. The implementation of Basic Laws and its by-products as national law for circular economy is recommended. Also, implementation of a national plan, including financial support mechanisms, should be followed and updated regularly (revolving plan).

- **Technology and system.** Advanced technology for converting waste to energy and recovering resources from waste is required. Although technology is indispensable, it is not enough. An integrated and comprehensive system, including waste collection, should be set up by municipalities. Also effective is education to put value on proper waste disposal by municipality.

- **Cooperation among municipalities.** Many public services are provided by municipalities and, therefore, expertise and knowledge accumulate at that level. Municipality-to-municipality cooperation, both international and domestic, is recommended for sharing experiences and know-how and setting up service systems. This should be supported by the national government through financial assistance and/or official development assistance.

- **National incentive mechanism**. The PPP model is possible when an integrated waste management system is developed. Financial incentive programmes, such as waste disposal fee or capital expenditure incentive, are recommended to improve investment cash flow and make the system financially viable. As many municipalities do not have sufficient budget capacity, financial gap measures by the national government, such as the viability gap fund, are recommended. An idea to push the host government's effort is policy support finance. Policy settings, like regulations on waste disposal and financial incentives for investment, are supported by international finance but its disbursement is linked with the progress of policy reform.

Figure 2.10. Combination of Policy Setting and Finance



Source: Author.

- **New framework for regional cooperation for waste management**. Scale-up of waste- to-energy market is an import measure to reduce the cost of waste-to-energy. Cross-border waste flow for reuse and recycling should be considered because a certain amount of waste is needed to recover valuable materials. International frameworks, such as the Basel Convention, which regulate 'export of waste' should be reviewed and amended if necessary.

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