

ENGAGING COMMUNITIES IN WASTE-TO-ENERGY DEVELOPMENT IN KOREA



[Picture 1] Somaegok Waste-to-Energy Community in Hongcheon, Republic of Korea

The Republic of Korea has taken an integrated waste-to-energy approach to utilize waste as a source of renewable energy while considering social, economic, and environmental dimensions. Based on lessons learned from a first phase, the current approach for the expansion of waste to energy developments aims to prevent a “not-in-my-backyard” reaction from residents living in the vicinity of waste treatment plants by ensuring that they benefit from the recovered energy. Korea’s waste-to-energy approach provides economic benefits to the local communities through energy sales, and concurrently mitigates the impact of energy and environmental issues. The approach is designed to ensure circular economy and sustainable use of natural resources with environmental integrity. This policy brief analyses the Republic of Korea’s waste-to-energy model. It also provides policy considerations on achieving sustainable management of waste and energy at the national and subnational level with perspective of UN Sustainable Development Goal (SDGs).

Korea's Waste to Energy Approach at a Glance

Based on the principle of 4Rs (Reduce, Reuse, Recycle and Recover), the Waste-to-Energy Approach in Korea has been encouraged for achieving a circular economy, energy efficiency, and economic development through sustainable management of resources including waste. The approach promotes low-carbon development and reduces greenhouse gas emissions as opposed to dumping waste into landfills. Korea has implemented waste separation and collection policy based on strict national acts such as “Waste Management Act” and “Act on the promotion of saving and recycling of resources.” Korea's waste management national acts are outlined in Table 1. Hence Korea is well positioned to utilize waste as resources of producing energy. With already sorted and segregated waste such as municipal solid, agricultural and food waste, Korea has been constructing and operating waste to energy facilities based on methods such as solid recovered fuel (SRF)¹, biogasification² and incineration³. Since 2010, as one of the waste-to-energy approach policies, Korea has established resource-efficient communities equipped with waste to energy infrastructures and technologies. Biogasification and incineration are mainly used for treating local waste in the community⁴. Through biogasification, in particular, household food and agricultural waste are turned into biogas, which then refined into city gas or electricity. For incineration, the remaining heat can be utilized in supplying steam or hot water, which can also be useful in creating electricity through a steam turbine. Table 2 shows the main technologies used for waste-to-energy recovery in resource-efficient communities in Korea.

[Table 1] Waste management acts in Korea

1980s	1990s – early 2000s	Mid 2000 – current
<i>Safe Waste Management</i>	<i>Recycling Management</i>	<i>Waste Circulation</i>
Waste Control Act (1986)	<ul style="list-style-type: none"> - Act on Promotion of saving and Recycling of Resources (1992) - Act on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (1994) - Act on Promotion of Installation of Waste of Waste Facilities (1995) - Act on Recycling of Construction Waste (2003) 	<ul style="list-style-type: none"> - Act on the Resource Circulation of Electrical and Electric Equipment and Vehicles (2007) - Basic Act on Resource Circulation (2018)

¹renewable energy produced by shredding and dehydrating solid waste, typically consisting of combustible components of municipal solid waste(clarity.eu.com)

²process of converting biomass to biogas(ec.europa.eu)

³process of heat from the combustion generates very high heat steam in boilers, and the steam drives turbo generators to produce electricity(nea.gov.sg)

⁴ Korea's waste-based energy produced was increased from 5,998,509(2012) to 9,358.998(2017)

[Table 2] Sources of Recovered Energy in Korea

Recovered Energy	Processes
Biogas	Methane from decomposing organic waste such as food waste, sewage sludge, and livestock excrement through anaerobic digestion is transformed into electricity, heat, and city gas.
Incineration heat	The remaining heat from incineration plants is recovered to produce electricity, steam or hot water. Produced steam or hot water can be used for industrial processes, heating or generating power via steam turbines.

In the face of urgent needs for renewable energy production and greenhouse gas reduction, Korea started to proactively introduce waste-to-energy policies. The Korean government started to put successful and sustainable waste-to-energy models in place. Under the model, communities benefited from locally produced renewable energy while minimizing the impact of so-called “NIMBY” facilities. This newly regenerated energy is an excellent source for local economy boost, increased number of jobs, communities’ income, and population growth. Also, decentralized energy production presents using waste resources definite chance for national resources efficiency.

In this regard, in 2010, Korea introduced its waste-to-energy model “Low Carbon Green Community,” which met with the community’s disapproval and some of the policy limitations. A more recent and successful model “Eco-Friendly Energy Town” was later implemented with positive pilot projects in Hongcheon. Main challenges of Korea’s experience with waste-to-energy models as well as best practices, will be explored in the following chapters.

Challenges faced in Low-Carbon Green Communities

The national government promoted the waste-to-energy approach as ‘Low-carbon Green Community’ from 2010 to 2013 in three communities (Gwangju, Tongyoung and Hongcheon). In practice, the communities were unwilling to engage as a leading stakeholder and invest in the approach due to the insufficient level information on its effectiveness. The local authorities either changed the target area due to the community’s objections or amended the model mainly because of insufficient funding, including private financing. Insufficient profit led to an uneven income distribution within the community, and government-led public engagements were not successfully promoted to involve various stakeholders, including the community members. *Box 1* describes a community with the model application.

[Box 1] A case of Low-Carbon Green Community: Gwangju Gwangsan

The community with 66 households and 124 residents installed treatment facilities for livestock excrement and food waste for 30 tons per day with an investment of US\$ 2.5 million from the national government and US\$ 1.45 million from the local government. A public-private partnership was established as a special purpose corporation (SPC) through build-transfer-operate financing and community involvement as agricultural association. Disapproved over potential loss, the community was divided on committing investment and establishing SPC for management of treatment facilities. As a result, a private donation of US\$ 1.05 million contributed to founding the SPC. Income from livestock waste treatment and electricity sales were still planned for distribution among partners, but the community had relatively low profit as it had a low share in the initial investment.

A comprehensive review on the first phase led to the identification of the following challenges of implementing the waste-to-energy model in practice: short-term planning, lack of policy experiences in modeling, economic feasibility and minimal public engagement. The government had initially lacked a national-level selection process to select participating communities. Formulating applicable model in consideration of each communities' unique characteristics also proved to be a challenge. Also, the government had not engaged the public for building consensus on the model and common understanding of the interconnectedness of economic, social, and environmental development in the community.

Integrated Eco-Friendly Energy Community

Building on the lessons learned from the previous model, Korea rolled out a new waste-to-energy model in 2014⁵, 'Eco-friendly Energy Town.' The new model resembled 'Low-carbon Green Community' to an extent. Both approaches aimed at addressing the environmental integrity and energy efficiency, but the new integrated approach comprehensively addressed economic, social, and environmental issues and prioritized a high level of public engagement from an early stage. As a result, the communities approved the new approach when the government engaged the communities to hold informative sessions on the economic, social, and environmental sustainability for the residents. The new approach utilized the existing waste treatment plants and reshaped them into waste-to-energy and recycling facilities by installing biomass treatment plants for agricultural and food waste. Besides, renewable energy facilities, including the solar panels, were installed on available land within the premises of treatment plants for efficient use of space and extra profit. Recreational facilities such as sports complex, community center, and green space with

⁵ 'Eco-friendly Energy Town' was implemented in phases of pilot projects. It was rolled out in Hongehon in 2014, and 5 more communities(Cheongju, Asan, Youngcheon, Gyungju and Yangsan) in 2015, and then 3 communities(Inje, Eumsung and Jeju island's Hanrim-eup) in 2016.

landscaping was offered desirable value with upgrading environmental infrastructure such as sewage system, gas pipes, and odor reduction facilities. The components of the facilities for the waste-to-energy approach that are divided into waste-to-energy, renewable energy, and others can be found in *Table 3*.

[Table 3] Components in the Integrated Waste-to-Energy Approach

Classification	Facilities
Waste-to-energy component	<ul style="list-style-type: none"> Waste-to-energy biomass treatment for food waste and livestock excrement Electricity generator, boiler, biogas refinement and energy storage system (ESS) Compost utilization for digestion tank supernatant and sludge Recovered energy supply including electricity, gas, and heat
Renewable energy component	<ul style="list-style-type: none"> Renewable energy facilities such as solar power, hydropower, and geothermal heat Energy-efficient facilities with solar panels and lamps
Others features/ component for public benefits	<ul style="list-style-type: none"> Greenhouse for crops using waste resources Energy-efficient community center including a sports complex and lounge space Environmental mitigation on decreasing odor and noise level of facilities with green spaces and parks Facility remediation for odor and noise level reduction Environmental infrastructures such as water supply and sewage

Best Practice: Somaegok Community in Hongcheon

Actively engaging throughout the model application, the Somaegok community in Hongcheon was mostly satisfied with its outcomes. This chapter assesses the applied model in Somaegok and introduces its renewable energy facilities, profit mechanism, and the role of the stakeholders.

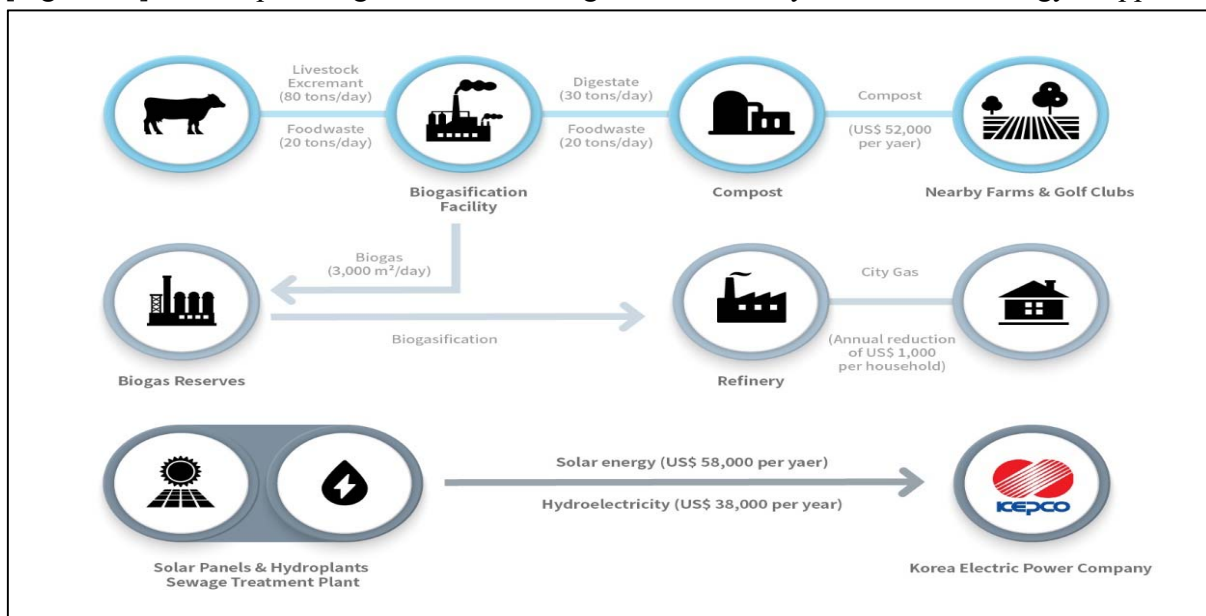
Challenges before implementation

Somaegok, a small community with an area of 7.7 km², had a shortage of water supplies and individually supplied household gas system rather than a city-wide infrastructure-based gas supply. Moreover, existing treatment plants for livestock excrements and sewage caused some undesirable odor. The community complained about the treatment facilities for its inconveniences and possible land value decrease in the future. As a result, the number of households had gradually decreased from 107 in 1980 to 57 (119 residents) in 2014. The community suffered from a proportional increase in the aging population and emigration.

Introduction of New Energy Production System

The community produces 3,000 Nm³ of biogas from 100 tons of livestock excrements and food waste per day and sells the biogas to a local gas company. Liquid waste as a byproduct is used to produce liquefied compost (20 tons per day). Digestive sludge is transformed into compost (30 tons per day) to be sold to nearby farms and country clubs. Newly installed gas pipes supplied the community with recovered biogas. Solar panels that were installed on available land at the wastewater treatment facility produce 340kW of electricity. A set of artificial waterfalls installed at the effluent also produces 25kW through hydroelectric generators. Another set of solar panels installed on the roof of the town hall produces 7kW. Consequently, the community produces a total of 579MW each year and profits from the sale of extra power.

[Figure 1] Concept Diagram of Somaegok Community's Waste-to-Energy Approach

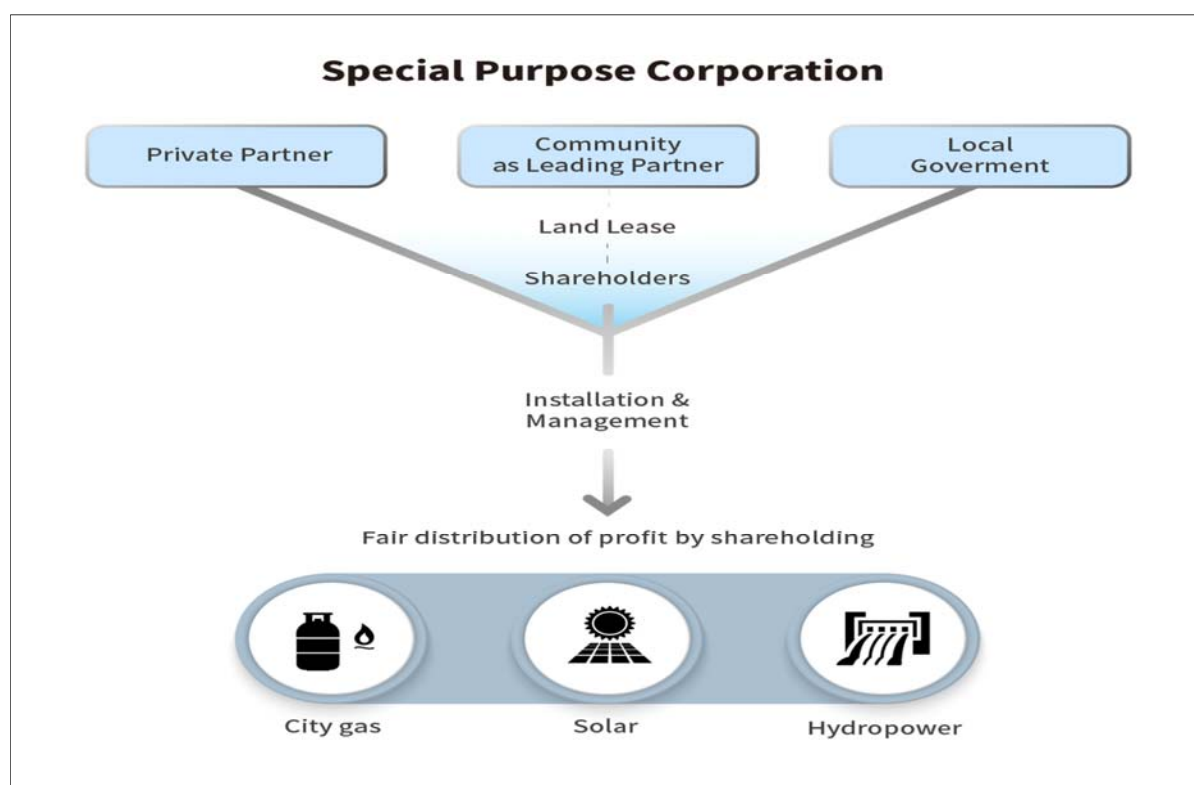


Fair Profit Mechanism

The community established a set of regulations, while engaged in its development process and fairly distributed the profit shares. A community cooperation union was organized to distribute the profit from the sales of compost. The initial investment with 71 percent of SPC from the community and 29 percent from the local gas company was also set up. Through public-private partnership (PPP), the community and its partners agreed on reinvesting the profit from solar power sales into community development. Taking advantage of employment opportunity, eight residents managed community union and operated the plants. Currently, each household in the community earns an annual net profit of USD 3,300, a total of USD230,000 for the community, from the sales

of compost, biogas, and electric power. Early public engagement and involvement in profit mechanism in forms of SPC and cooperation union helped the community to achieve economic sustainability.

[Figure 2] Special Purpose Corporation for Waste-to-Energy



Main Success Factors for Hongcheon

1) Community's leading role

As a leading stakeholder, Somaegok community engaged other stakeholders to ensure waste-to-energy development. Unlike other communities with miscommunication between different stakeholders, Mr. Jinsoo Ji, Somaegok community leader, had a more significant role with affirmative support from other stakeholders to form a consensus on the waste-to-energy conversion. In close cooperation with the leader, the local government established a code of regulations and provided an institutional basis for the continued dynamics of model application.

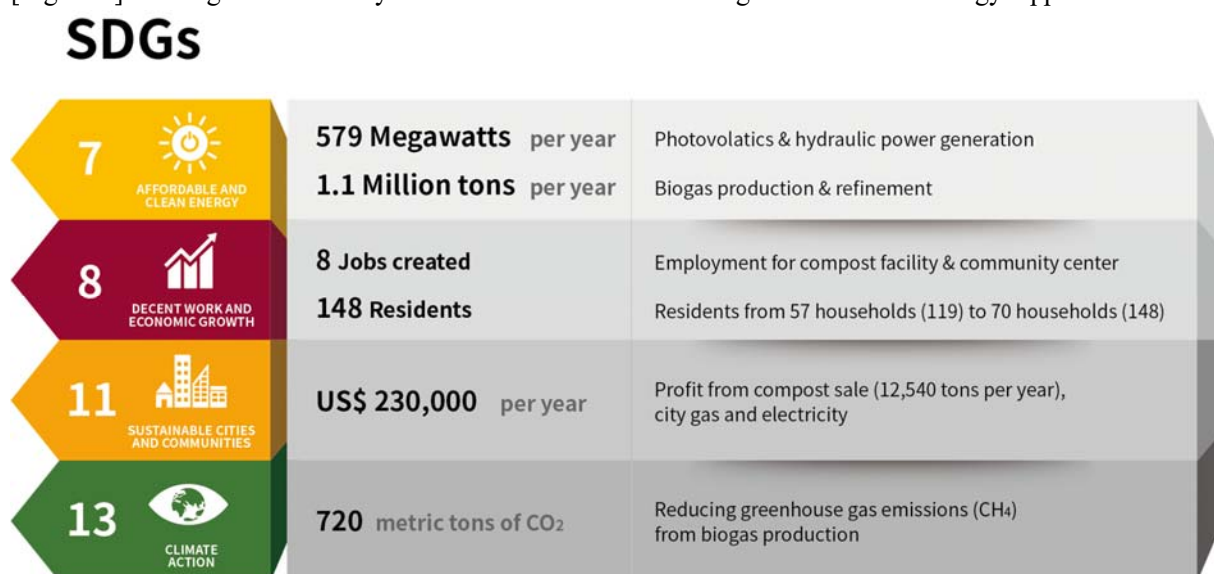
2) Multi-dimensional support from the government

In the initial stage of development, the government had conducted a feasibility study and primarily funded waste-to-energy facility installations. Out of US\$ 13 million, the investments were made by the national government in US\$ 6 million, local government in US\$ 6 million, and

community in US\$ 1 million which was donated by the private entity in agreement for commercial rights to the recovered gas. As part of the early engagement of stakeholders, the government had provided administrative support, advisory services, and training programs for the selection and management of renewable energy facilities.

With modeling based on the consideration for local conditions, early public engagement and support for governance and partnerships, the Waste-to-Energy approach for the Somaegok Community has achieved the production of sustainable and clean energy (SDG 7), green jobs and economic growth for the community (SDG 8) and reduction of greenhouse gases from the waste (SDG 13). Overall, the achievement of the SDGs 7, 8, and 13 contributed to creating a sustainable community (SDG 11). Specifically, the SDG Targets 7.2, 7.B(ensuring access to affordable, reliable, sustainable and modern energy for all), 8.4, 8.9(promoting sustained, inclusive and sustainable economic growth), 11.3, 11.6, 11.7, 11. A(making cities and human settlements inclusive, safe and resilient) and 13.2(taking urgent actions to combat climate change) have been measured to show the community's successes. *Figure 3* shows the measurements for the successes of the Waste-to-Energy development in Somaegok Community.

[Figure 3] Somaegok Community's Achievement of SDGs through the Waste-to-Energy Approach



Current Actions and Future Plans

Korea already has waste treatment facilities installed in most areas, and the demand for new installations is relatively low at this stage due mainly to adequately provided number of facilities. Without the waste-to-energy facilities, local governments currently manage 623 environmental facilities, including 225 landfills, 186 incinerators, 117 sewage sludge treatment plants and 95 food waste treatment plants that present the least concern for their negative impacts and energy

recovery from the waste. After pilot engagements with the communities from the first phase, the government continues to select a handful of communities to upgrade preexisting waste management facilities by further equipped them with full components of waste-to-energy facilities. It assesses the communities and their existing facilities based on facility type and durability, energy type, the potential use of energy, geographical conditions, and community involvement. Strengthening the stakeholder engagement, the government continues to implement the approach to model each community based on their characteristics. Table 3 shows communities with full and partial application of waste-to-energy approach inclusive of planned implementation. Each community provides the publicly available land and invest in installation and management of energy facilities with its plan for the use of recovered energy and profit mechanism.

[Table 4] Various Cases of Waste-to-Energy Approach in Korea

Area	Renewable Energy Source	Serviced Facilities
Asan	Biogas, incineration heat, solar power	Greenhouse (paprika, insect breeding), laundry plant
Cheongju	Biogas	Crop drying, electricity sale, home heating
Eumseong	Biogas	Electricity sale, greenhouse (agricultural processing)
Gunwi	Biogas	Electricity sale, smart farm
Gyeongju	Incineration heat	Camping site
Hongcheon	Biogas, solar power	City gas, compost, electricity sale
Inje	Incineration heat	Greenhouse (crop drying, crop market)
Jeju	Biogas, Incineration heat	Electricity sale, greenhouse (fish breeding farm), zero-energy house
Tongyeong	Incineration heat	Greenhouse (insect breeding)
Yangsan	Incineration heat	Crop market, electricity sale, greenhouse, recreational facility

Lessons Learned and Way Forward

The community-based waste-to-energy cases in Korea since 2010 have noticeable characteristics. The success of waste-to-energy largely depended on governance, finance, socio-economic benefits, and technological availability. The national government engaged with various stakeholders and facilitated PPP in the form SPC for finding a consensus and financing the model

implementation. Korea's model has evolved into a successful practice by identifying and overcoming its constraints through many of trial-and-error. The lessons learned were drawn from Korea's policy experiences including Somaegok.

Institutionalizing the model and governance

The government needs to develop a sustainable model based on interrelated collaboration and align the systems with waste-to-energy policy. Following up on the phases, it can initiate discussion among relevant actors, organize partnerships among stakeholders, administer implementation, review outcomes, and reinvent or sustain the model.

With a careful assessment of local conditions, the government can provide a platform for discussion on the sustainable model in planning with other sub-national governments, civil society, business, academia, and research institutions. Opening opportunities for various stakeholders to learn about each other's role, the government can build partnerships and nurture consensus among stakeholders. It can then comprehensively institutionalize the model and its practice by mobilizing available resources and relevant stakeholders. Partnerships can help overcome and address the challenges such as the development of training programs for management of environmental and energy facilities, advisory services for technical and administrative requirements, and establishing sustainable financing schemes with profit distribution.

Learning from Korea's cases, the government needs to ensure early public engagement and establish a platform for waste-to-energy and sustainable community. By keeping the community informed and engaged at an early phase, the government can support the stakeholders to partner for model application. Initial engagement will be an essential consideration for determining the project outcome.

Community Customized Partnership and Financing

The stakeholders can secure partnering agreement to commit for collaboration after finding common goals and objectives. Such agreement among involved partners is particularly important in defining the problems, in specifying the roles and responsibilities as well as in establishing a framework for managing the partnership and guiding the decision-making process. Numerous local factors such as geographical, environmental, and economic conditions of each community can have a significant impact on the framework for partnership management and guidelines on the decision-making process. Inclusiveness of community also plays a critical role in driving the success of the model application. Modeling based on an appropriate representation of partners and profit opportunities where recovered energy can be used for the community must be considered in the partnership framework.

Community as a leading partner can engage various stakeholders to secure an agreement in forms of SPC or community-owned business, taking advantage of profit opportunities and maximizing the use of available financial and technical resources such as business, academia and research institutions. Partners with technical resources can assess the local conditions to devise applicable model in consideration of available and suitable technologies. Stakeholders with financial resources can provide funding for the initial phases, including assessment and feasibility studies. Green businesses can also be involved as donors out of corporate social responsibility for the community's economic opportunity. Private financing and support for devising financial schemes in partnership can be a contribution to rebuilding the community. Partnering with green businesses can present real opportunities to re-invest the profit into the community's capacity building and outreach programs for reputation and image branding.

In efforts to encourage community members' continuing participation, the local council can regularly hold dialogues with partners and stakeholders as technical and advisory resources. Implementing community-led regulatory measures are essential to sustainable project management. Under council guidance, the community can also create a cooperative association and green outreach activities to support its capacity building and network for finding an open market in pursuit of a circular economy.

Sustaining the model

Solid partnerships can support mobilization of available resources for assessment on technical, economic and financial feasibility. The local conditions of each community must be assessed for planning a suitable model. Partners can inform the public about social and profit opportunities. With an appropriate financing scheme, the community can mitigate environmental impact and promote a circular economy.

The integration of multiple systems for energy recovery requires intricate supervision and technical advice for sustainable management. Technological resources from the partnership can be used for advising on community council's regulatory measures, installation, management, and maintenance of environmental and energy facilities, enhancing the model's sustainability. Greening of available space is a societal incentive for the community where the model is adopted. The quality of life and well-being of the community can gradually improve as energy efficiency is improved, and the negative consequences of treatment plants are reduced.

The management and maintenance of energy recovery systems require an understanding of waste-to-energy processes and technical and managerial training. Stakeholders, including green businesses and academia, can serve the community with its technical needs to ensure the sustainability of adopted systems. Recreational areas planned for the community can also be used for education and training on the waste-to-energy model to co-benefit the community. Green spaces and parks can also be another source of income through eco-tourism.

Stakeholder partnership can ensure model sustainability and progress monitoring on sustainable project management. An assessment checklist (see *Table 4*) can be used to determine the feasibility of the installation of a new waste to energy facility and for monitoring its performance.

Further Consideration to conclude

As part of Korea's sustainable development and circulation economy, the Ministry of Environment's community-based waste-to-energy policies have been presented. Through trial and error, Korea has managed to solidify some level of success such as Hongcheon's case. Waste-to-energy approach is admittedly not a simple policy to roll out. It is multifaceted policy project with social, economic and environmental dimensions to consider. Even though tricky, however, this policy brief hopes to present an opportunity for many countries to consider in initiating new policies as well as in evaluating current systems.

As explored above, the viability of policy depended largely on governance, finance, socio-economic benefits, and technological availability. Early and proactive engagement initiated by relevant authorities as well as adequate participation of the local leaders were also repeatedly proved to be a success booster. Above presented Korea's waste-to-energy policy development will better equip countries with similar aspiration to navigate their approach in a more effective manner.

[Table 4] Review Checklist for the Waste-to-Energy Model

MULTI-STAKEHOLDER ENGAGEMENT
1. Governance
<input type="checkbox"/> Does the community council have the institutional capacity to monitor and enforce regulatory compliance? <input type="checkbox"/> Are economic, social, and environmental implications of the model application assessed? <input type="checkbox"/> Is the public engaged at an early phase?
2. Public engagement
<input type="checkbox"/> Does the community as a leading partner participate in planning and implementing the model? <input type="checkbox"/> Is the community briefed on the waste-to-energy model including the use of renewable energy, reduction in greenhouse gas emission, and social and environmental mitigation? <input type="checkbox"/> Is the community well informed and advised on the technical requirements of the model application? <input type="checkbox"/> Is the community provided with an education program on the concept of waste-to-energy and training program on the management and maintenance of environmental and energy facilities?
3. Financing
<input type="checkbox"/> Is the financial scheme devised based on public and private funding? <input type="checkbox"/> Does the model application contribute to financial sustainability? <input type="checkbox"/> Is there any contribution from a private partner(s) for community development and outreach programs?
MODEL SUSTAINABILITY
1. Economic benefits
<input type="checkbox"/> Is the microeconomic dynamics analyzed? <input type="checkbox"/> Is the land value in the community retained or reversed after the model application? <input type="checkbox"/> Are there employment opportunities for the community? <input type="checkbox"/> Is there a fair distribution of income from waste-to-energy activities?

2. Social benefits

- ☐ Are the well-being and quality of life for the community improved after the model application?
- ☐ Is the living condition improved in the community due to lessened foul odor?
- ☐ Do green spaces and parks developed at the environmental and energy facilities enhance social satisfaction and ensure higher social acceptance?
- ☐ Is the community fairly represented in the stakeholder partnership?
- ☐ Is the community well informed and involved in participatory decision-making?

3. Environmental benefits

- ☐ Are the negative impacts on the environment (i.e., soil and water contamination) minimized?
- ☐ Is there a policy switch from fossil fuel to renewable energy in the community?
- ☐ Is energy efficiency, including independence for the community enhanced?

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