

Role of Waste-to-Energy for Circular Economy: Experience of S. Korea

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SUSTAINABLE
DEVELOPMENT GOALS

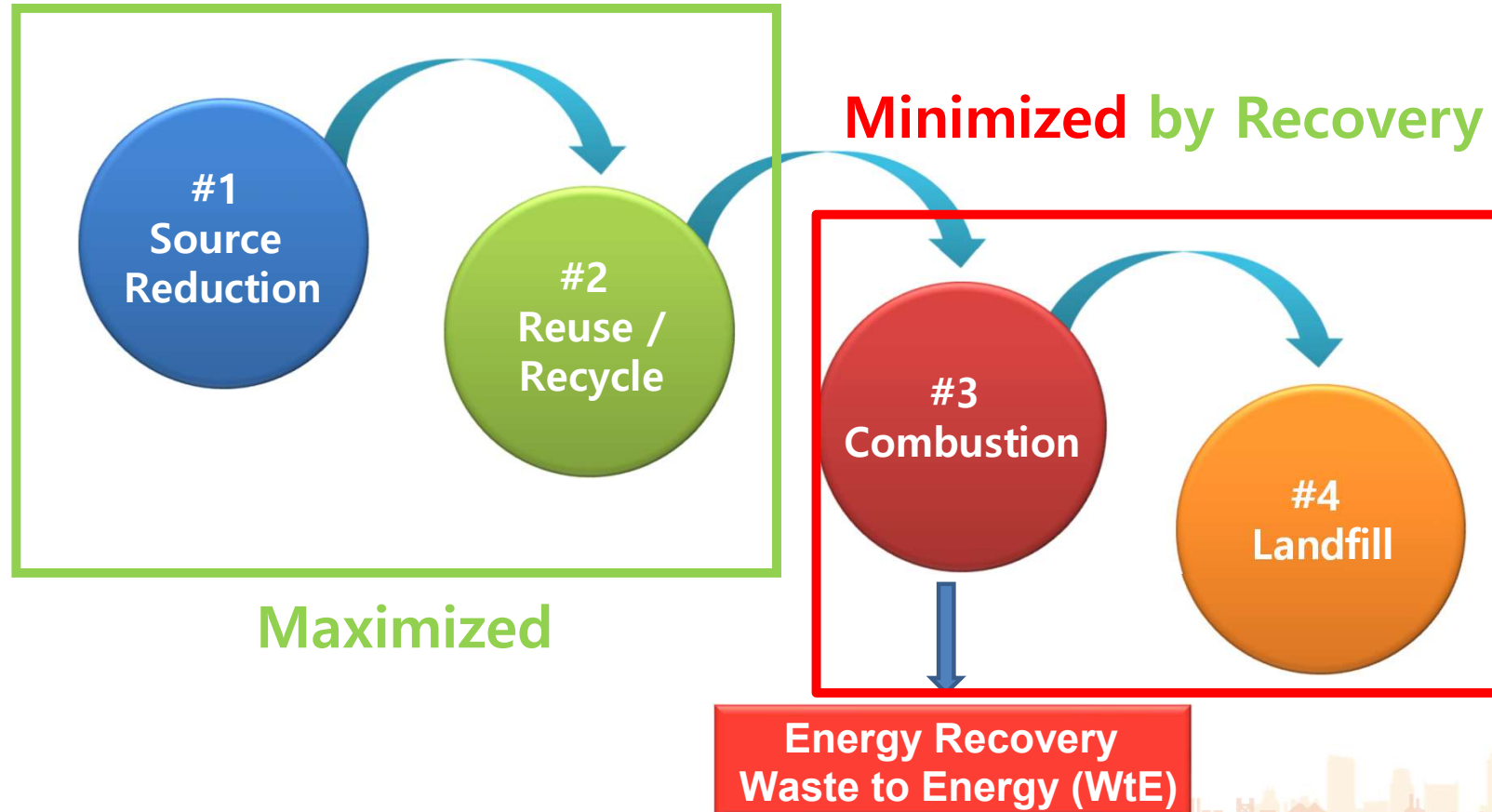
Session 4: SDG 7 – Affordable and Clean Energy
International Mayors Forum

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Principles of Waste Management

- IWM (Integrated Waste Management): Adopted with **WM Law (1986)** in **S. Korea**
All are **Vital** components of waste management with the **Priority** as follows;



Benefits and Challenges of Waste-to-Energy

Source: Guidelines on Promoting People-first Public-Private Partnerships
Waste-to-Energy Projects for the Circular Economy (ECE, 2019)

• Benefits of Waste-to-Energy

1. it can better protect public health by **avoiding uncontrolled (illegal) disposal**
2. it can **optimise the land use and reduce the quantity of waste**
3. it can save resources **for protecting the earth/planet through recycling**
4. it can become **an independent district green energy supplier** to contribute to achieving carbon-neutral goals

• Challenges of Waste-to Energy

1. it may be turning **unsorted and usable trash** into a valuable fuel commodity, not complying with Circular Economy policy.
2. it will be **exacerbating climate change, emitting toxic emissions** and giving rise to air pollution.
3. it raises **public health concerns**, emitting carcinogenic pathogens. Communities are **opposed** to them in their neighbourhoods.

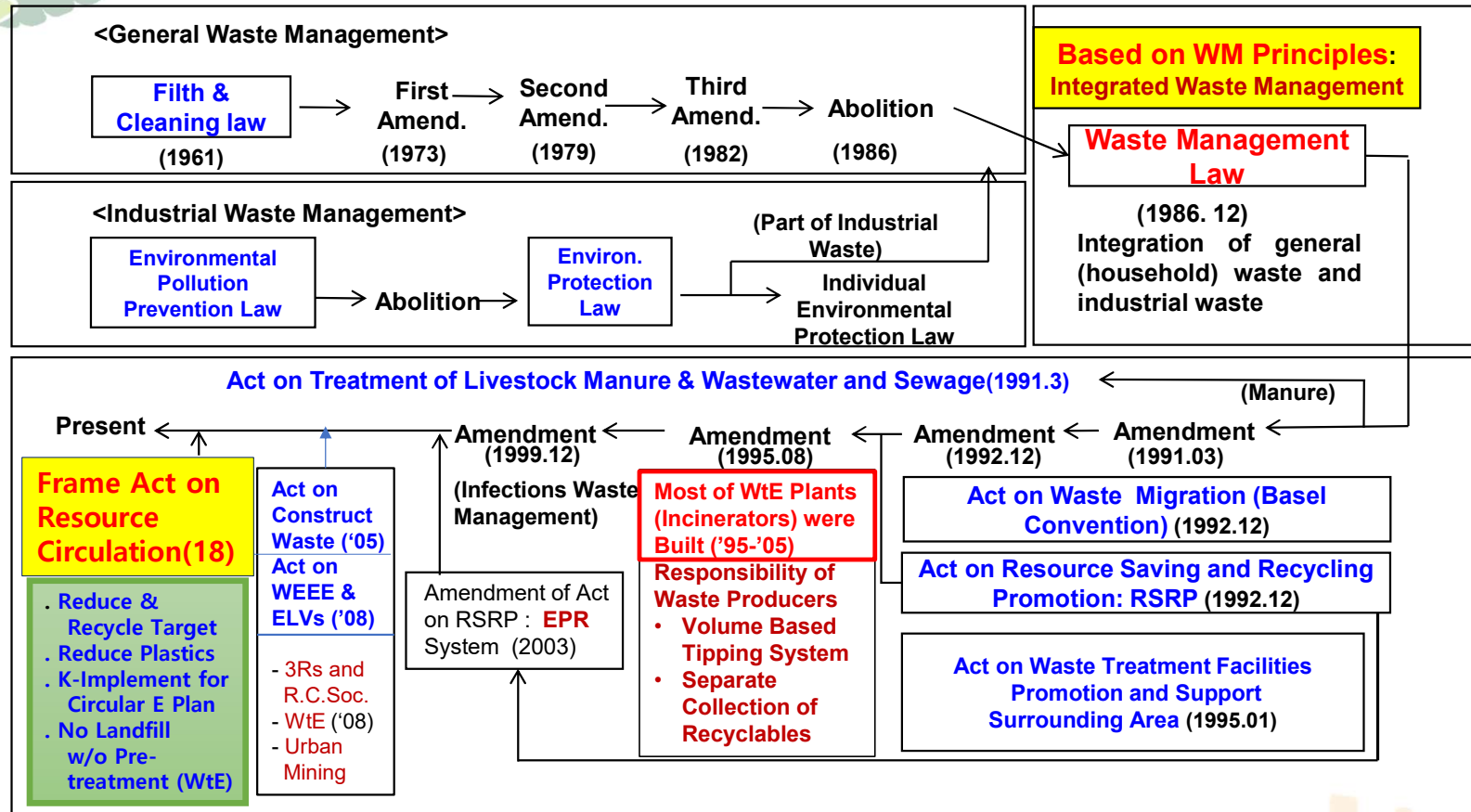


How to overcome the challenges

Sources: 1) 2022 Waste-to-Energy Research and Technology (WtERT) Asia Meeting('22)
2) based on People-first Public-Private Partnerships Evaluation Methodology for the Sustainable Development Goals (ECE, 2020)

- Municipal Waste to Energy Project is a public service/project through PPPs (Public-Private Partnerships) ?
- Evaluated by Five criteria for PPPs to reach People-first. (1. Access and equity, 2. Economic effectiveness and fiscal sustainability, 3. Environmental sustainability and resilience, 4. Replicability, 5. Stakeholder engagement), UNECE
- The project and its realisation process **are suitable** in respect of PPP. The resulting score reaches from satisfactory **to good**.
- Consequently, at present, many advanced countries have utilized a number of **appropriate WtE plants** (incinerators and new technologies) for the **least emission of air pollutants with better energy recovery** from wastes, to follow the **waste management principle**, and to accomplish **circular economy with carbon reduction by zero waste**.

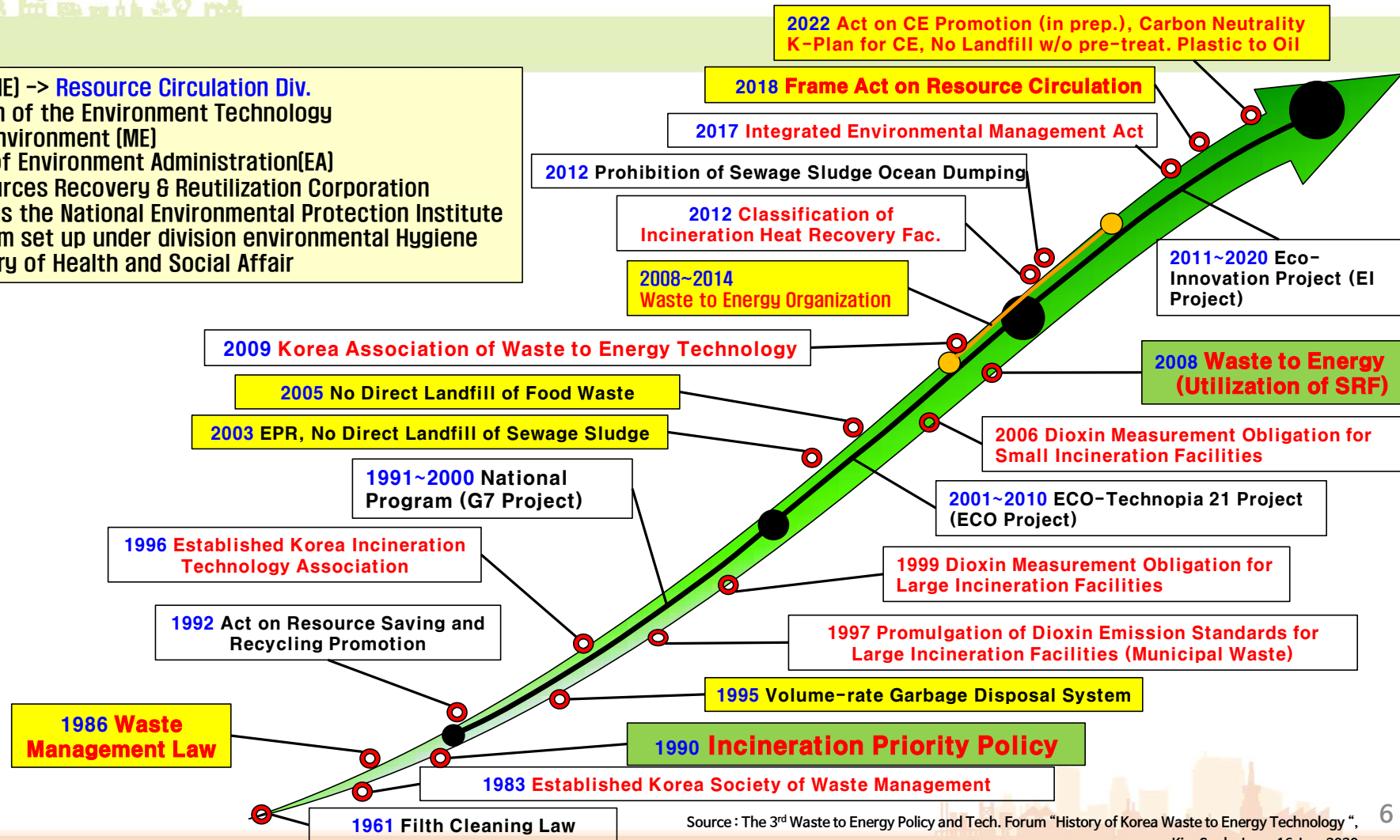
History of Legislation for Waste Management in Korea



Reference: Yang & Seo et al (2015) J Mater Cycles Waste Manag 17:207-217.

History of Waste Management (Major Policies & Issues Related to **WtE**)

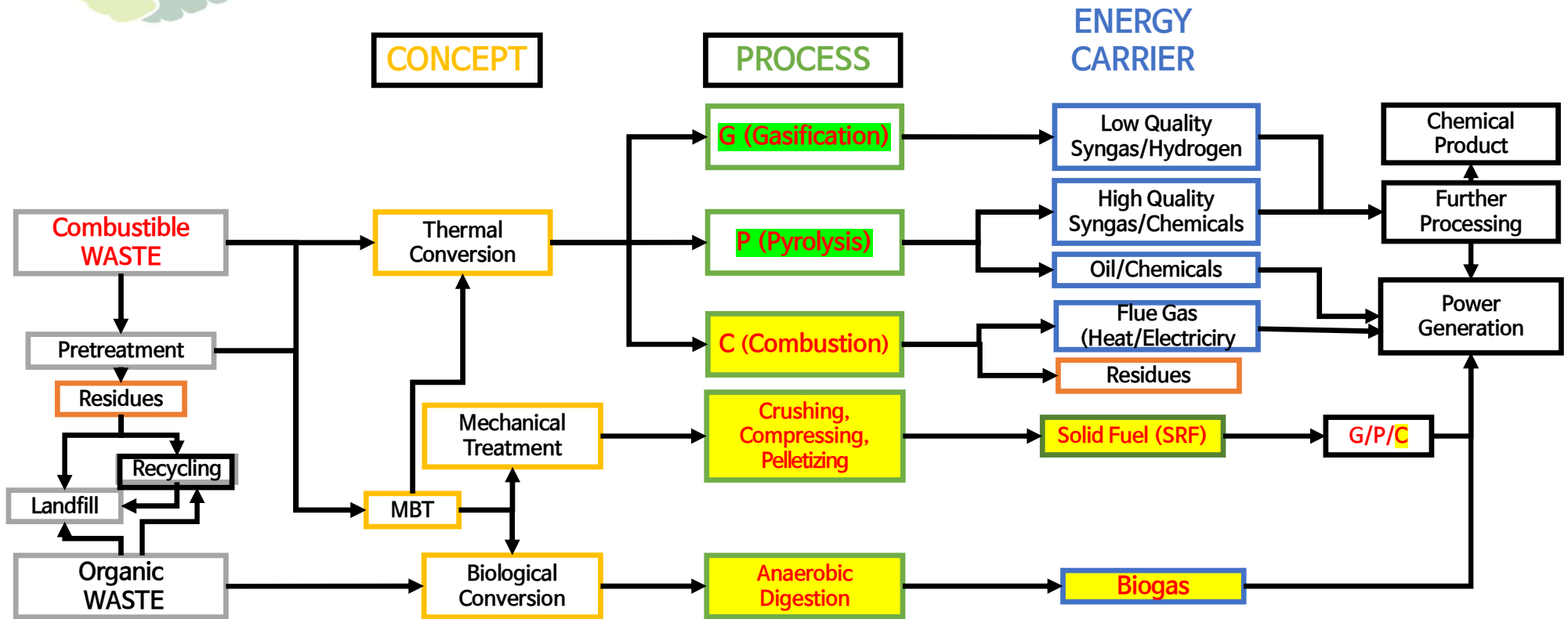
- ❑ 2005 Waste Div. (ME) -> Resource Circulation Div.
- ❑ 2000 Incorporation of the Environment Technology
- ❑ 1994 Ministry of Environment (ME)
- ❑ 1980 Established of Environment Administration(EA)
/Korea Resources Recovery & Reutilization Corporation
- ❑ 1978 Established as the National Environmental Protection Institute
- ❑ 1967 Pollution team set up under division environmental Hygiene
in the Ministry of Health and Social Affair



Source : The 3rd Waste to Energy Policy and Tech. Forum "History of Korea Waste to Energy Technology",
Kim Seok-Joon, 16.Jun. 2020

WtE Technologies for Combustible Wastes

Conversion Technology to Produce Energy from Wastes

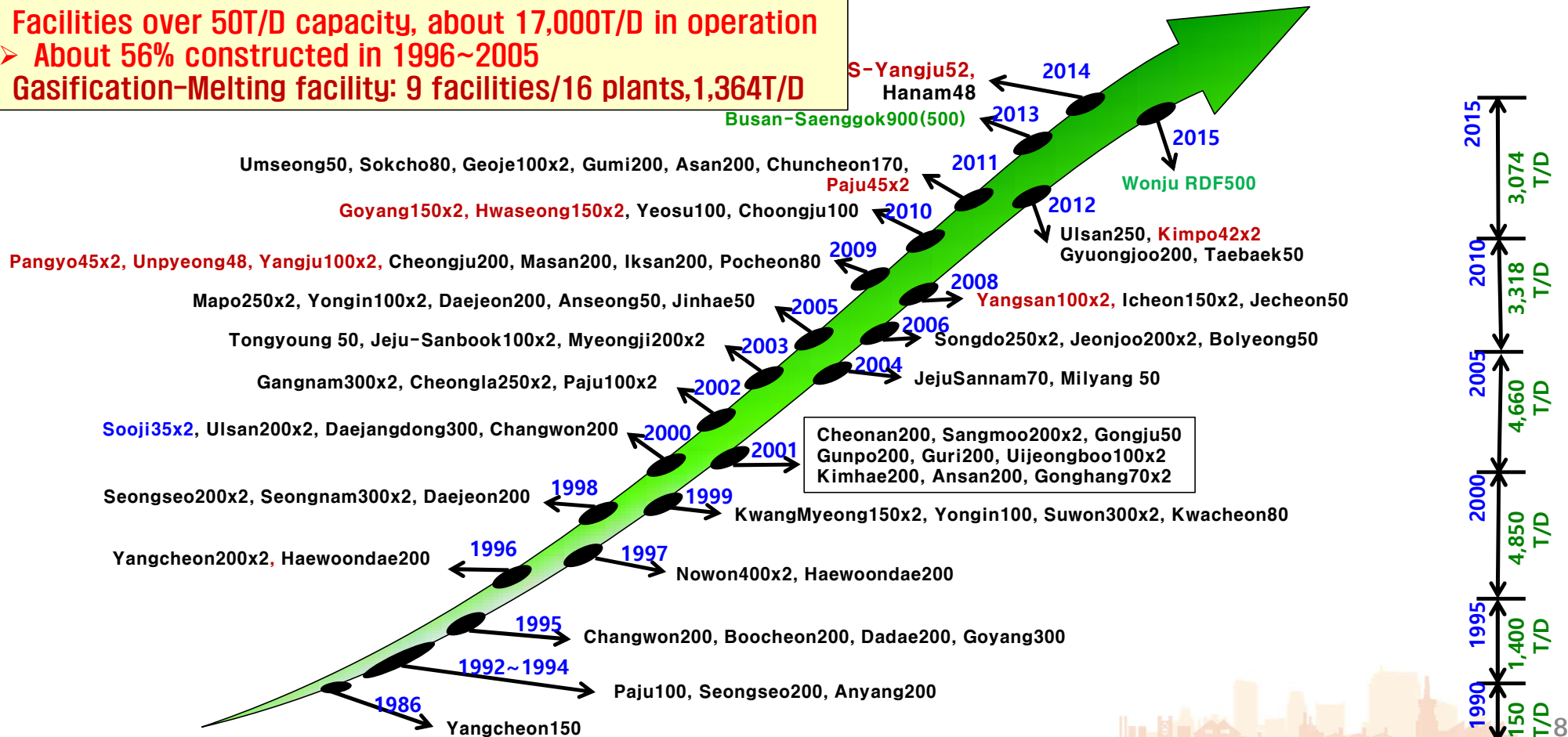


WtE : Combustible/Organic Wastes

Experience of WtE Technologies (Incineration)

Household Waste Incinerators (Replacement with High Efficiency & CCUS is Needed)

- ❑ Facilities over 50T/D capacity, about 17,000T/D in operation
 - About 56% constructed in 1996~2005
- ❑ Gasification-Melting facility: 9 facilities/16 plants, 1,364T/D



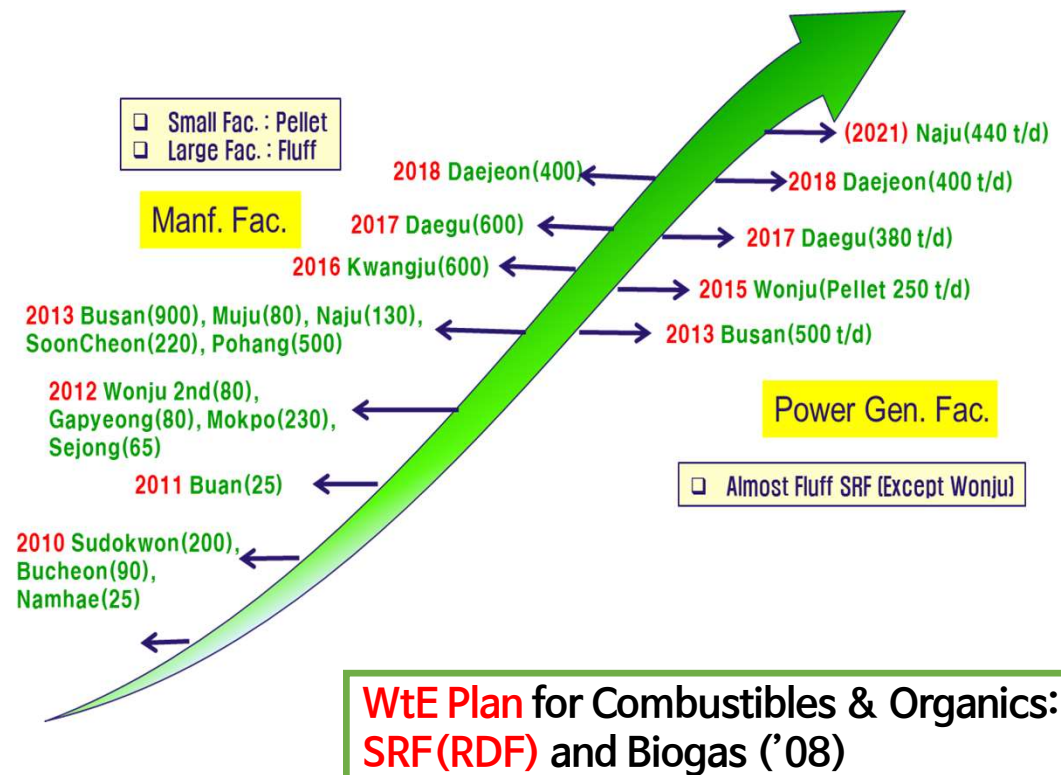
Source : The 3rd Waste to Energy Policy and Tech. Forum "History of Korea Waste to Energy Technology ", Kim Seok-Joon, 16.Jun. 2020

Experience of WtE Technologies (SRF: Solid Refuse Fuel)

SRF Manufacturing and Power Plants ('08~ WtE Plan, Still negative Perception. No Continuation of policy)

State of Municipal Waste SRF Manufacturing Facilities

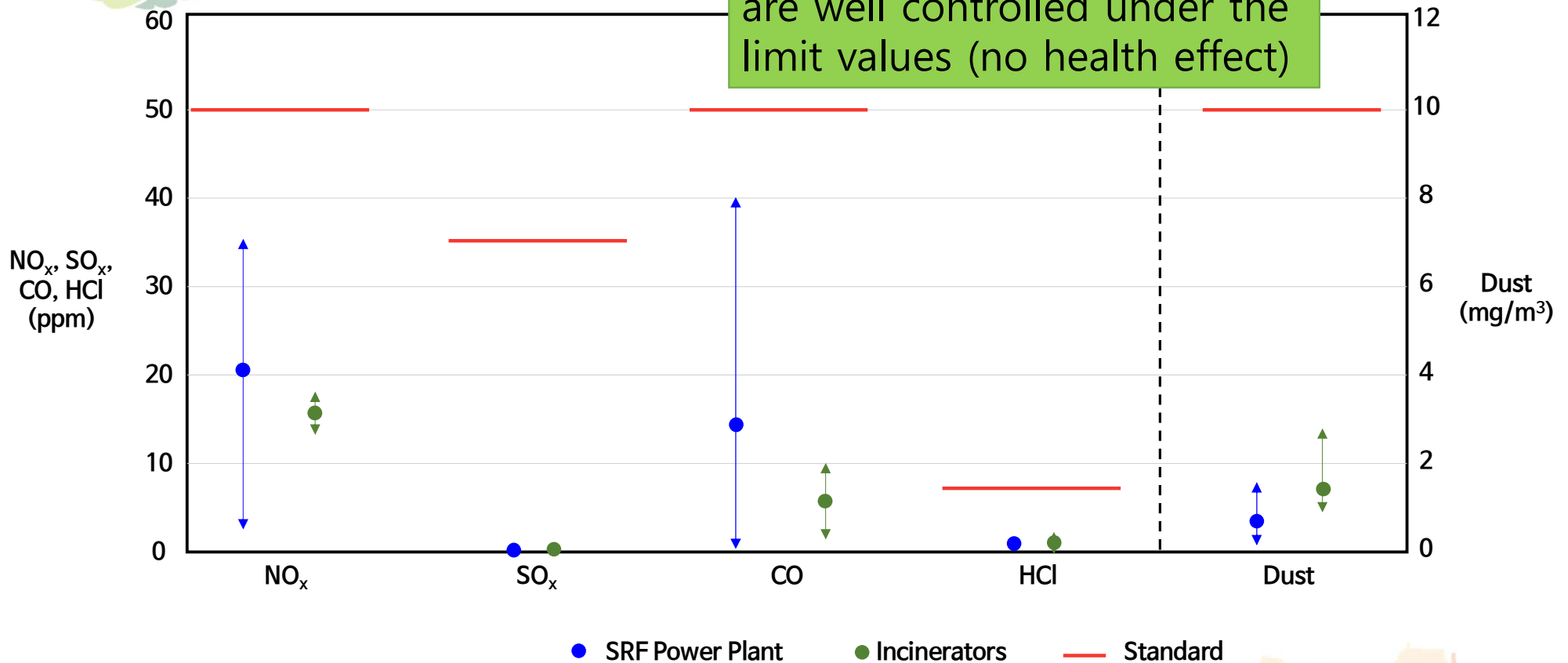
Region	Business Period	Capacity (ton/day)	Fuel Type	Business Fund
Sudokwon Landfill	07-10	200	Pellet	Finance
Gyeonggi	Bucheon	90	Pellet	Finance
	Gapyeong	80	Pellet	Finance
Jeonbuk	Buan	25	Pellet	Finance
	Muju	80	Pellet	Finance
Gangwon	Wonju 1 st	80	Pellet	Finance
	Wonju 2 nd	80	Pellet	Private
Jeonnam	Naju	130	Pellet	Finance
	Sooncheon	220	Pellet	Private
	Mokpo	230	Pellet	Finance
Busan	09-13	900	Fluff	Private
Gyeongbuk	Pohang	500	Fluff	Private
Gyeongnam	Namhae	25	Pellet	Finance
Choongnam	Sejong	65	Pellet	Finance
	13-16	600	Fluff	Private
Daejeon	15-18	400	Fluff	Private
Daegu	14-17	600	Fluff	Private



and Medium scale Self Development Tech.)

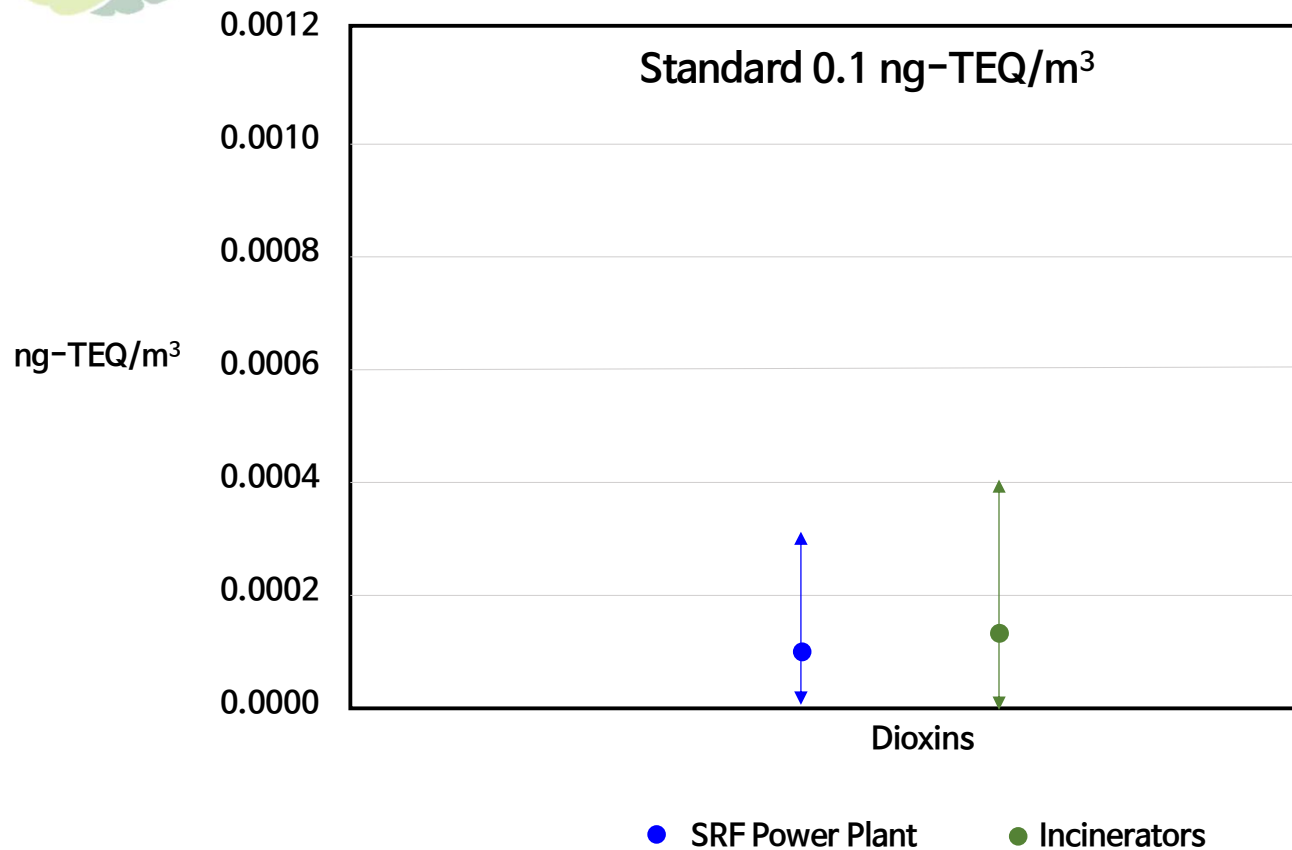
Emission of Air Pollutants from SRF & Incineration Plants

Most regulatory air pollutants are well controlled under the limit values (no health effect)



* Data from Major SRF Plants in Korea & Incineration Facilities at Seoul

Emission of Dioxins from SRF & Incineration Plants



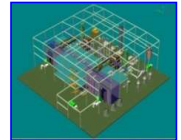
Almost zero emission of Dioxins into atmosphere with real-time and regulatory monitoring at stack.

* Data from Major SRF Plants in Korea & Incineration Facilities at Seoul

Experience of WtE Technologies (Gasification: Gas & H₂)

● Waste to Gasification R&D (High Cost, Contribute to Hydrogen Economy and Carbon reduction, Not Commercialized)

- ✓ No Commercialized, Demo-scale Development up to 8 tons/d, More R/D Support Needed.
- ✓ Present, Limitations of Private-led Commercialization in the Development Stage of Tech.



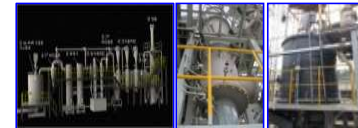
2013~ 2018 (Pilot-Scale Plants)

- ✓ SRF(Waste) with Air Gasifier - Wet Purification - Gas Engine Power Generation System Developed (8T/D)
- ✓ Waste Gasification - Syngas High Temp. Purification – Reforming - Methanol Conversion Tech. Developed (200Nm³/hr)
- ✓ High Quality Syngas Production System Developed for Industrial Waste (10T/D Capacity)
- ✓ Dyeing Sludge-Rice Husk Mixed, Catalyst Fluidized Bed Gasification Technology (2T/D Scale)
- ✓ Municipal Waste Pretreatment with Air-Gasification-Gas Engine Power Generation Tech. Developed (0.5T/D & 30T/D)



2009~ 2012

- ✓ Biomass(Rice Husk) Gasifier with Air-Wet Purification-Gas Engine Power Generation System (20T/D)
- ✓ Drying Sludge Gasification Syngas Production with Air and Wet Purification System (Pilot Scale)
- ✓ Feasibility Study on Acetic Acid Fuel Network from Fuel(CO) Produced by Oxygen Gasification Syngas Process



2007~ 2009

- ✓ H₂/CO Production Ratio Control Tech. Development for Waste Syngas Utilization with Oxygen (Pilot Scale)
- ✓ Syngas Production from Mixed Industrial Waste/Sludge Cake using a Gasification Process (Pilot Scale)
- ✓ Development of Oxygen Combustion Burner using Syngas from Oxygen-Gasifier of Waste (Pilot Scale)



2000 ~ 2007

- ✓ Development of Oxygen Waste Gasification Melter and Syngas Purification System (Pilot Scale)
- ✓ MSW, ISW, ASR, RDF, RPF etc.



Experience of WtE Technologies (**Pyrolysis: Oil & Chemicals**)

● **Pyrolysis(liquefaction)** (High Cost, Contribute to Renewable Energy and Carbon reduction, Strong Support by Gov.)

2020~ Present

Low Grade Waste Plastic Bag Pyrolysis Pilot-scale Design · Production · Operation (10 ton/day)
; Semi-Batch Kiln type, catalyst de-chlorination
Support Org. : Ministry of Environment

Since 2018

Development of Low Chlorine Eco Oil Manufacturing Tech. for Low Grade Mixed Waste Plastic
Support Org. : Ministry of Environment

2010 ~

Development of a Commercial-scale (6,000 ton/yr) Plant for Mixed Waste Plastics: **Stopped**


2006 ~ 2009

● Government-led Commercial-scale (1,000 ton/yr) R&D for **Mixed Waste Plastics**



Economically Feasible Scale-up Required

2000 ~ 2005

● Government-led Demo-scale(600~3,000 ton/yr) R&D for **Pretreatment Waste Plastic**

Support Org.	Scale(ton/yr)	Process
Ministry of Industry	1,000	

Economical Weakness

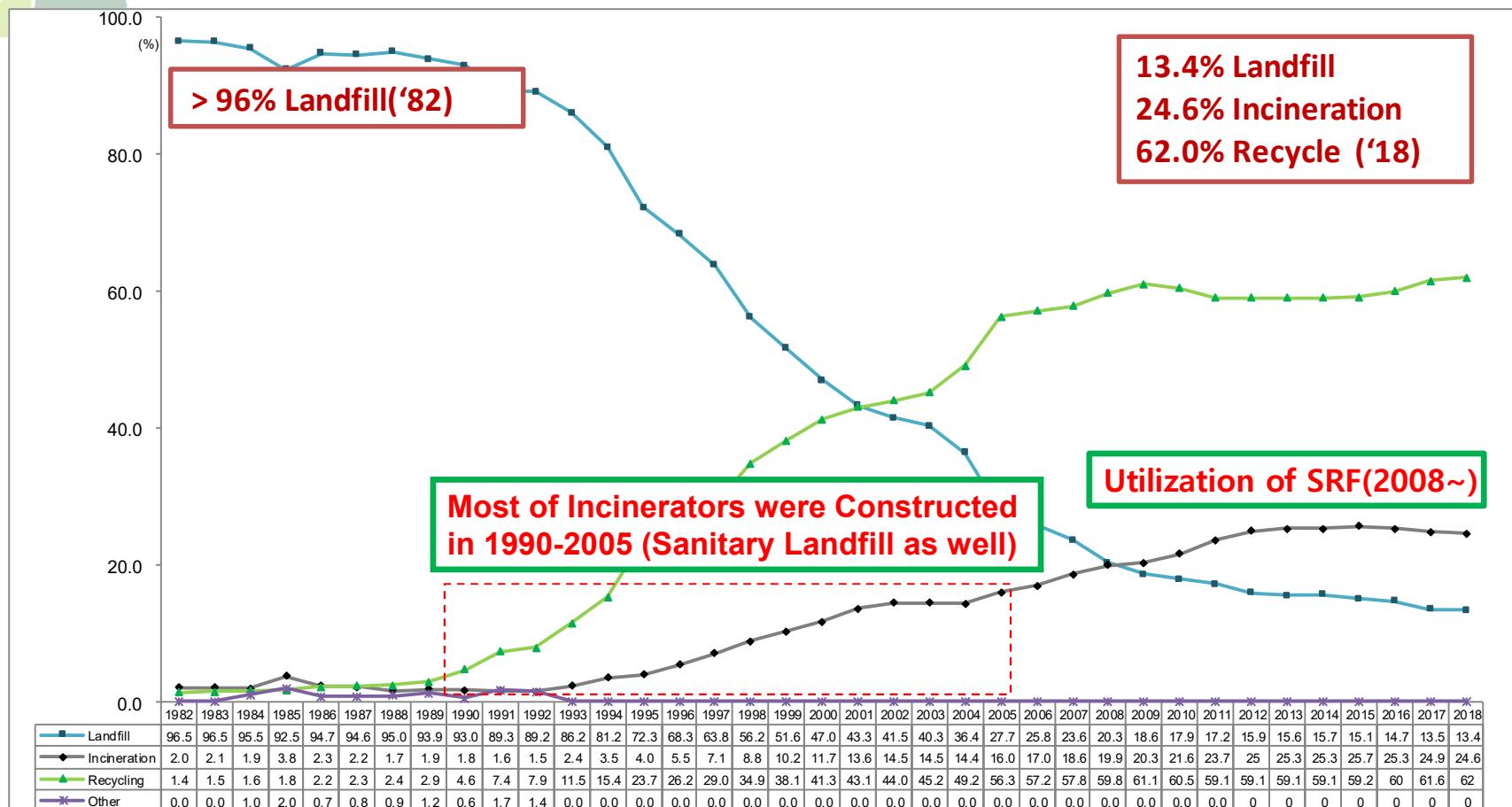
Support Org.	Scale(ton/yr)	Process
Ministry of Industry	600	
Ministry of Science and Technology	3,000	

1990s

- Basic Research and Small-scale Process Development
- Decrease in trust due to Introduction of Non-qualified Foreign Tech.
- Lack of Systematic Tech. Development

Historical Review and Status on Waste Management

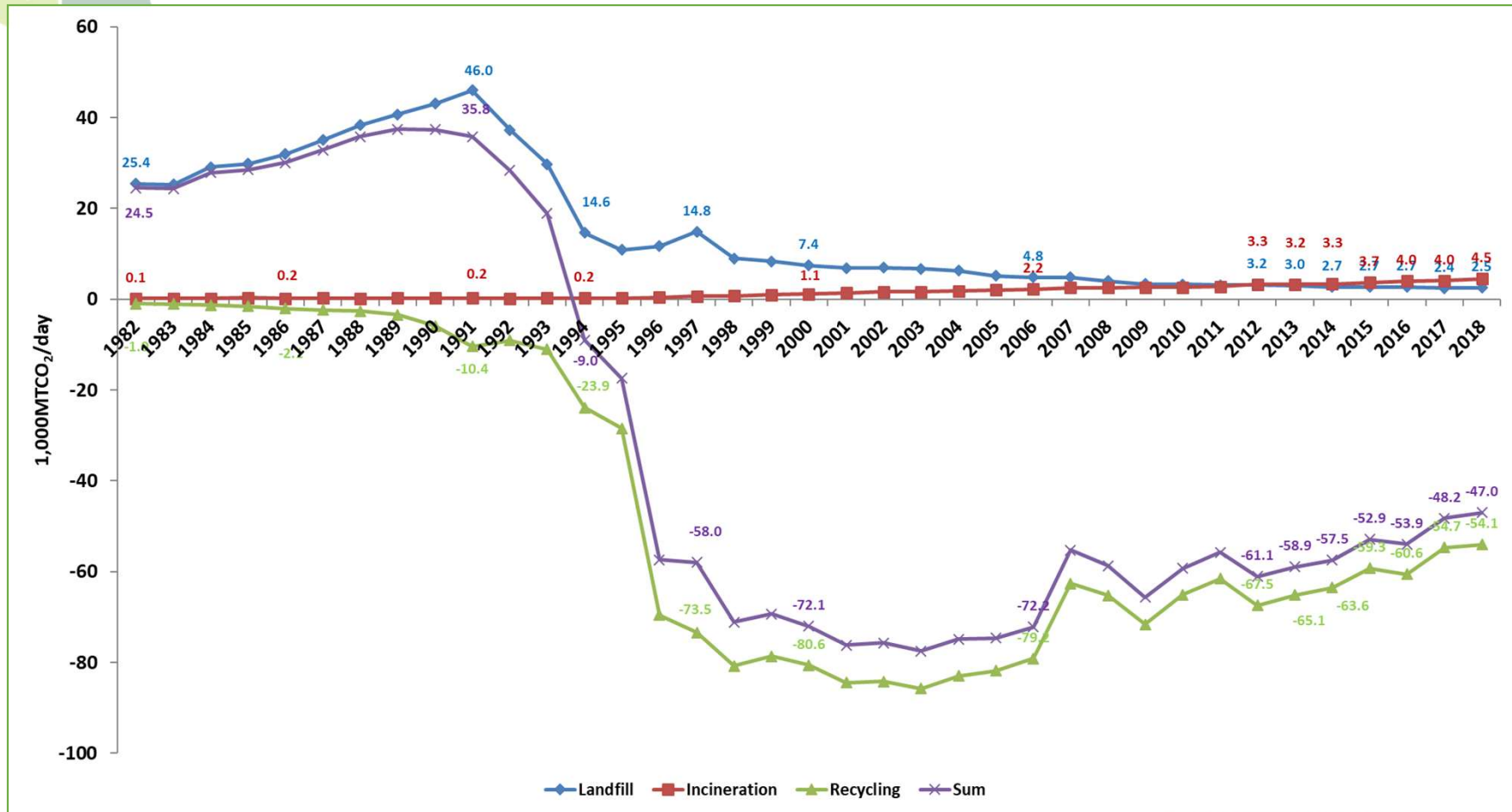
● Treatment of Household Waste in Korea ('82 ~ '18)



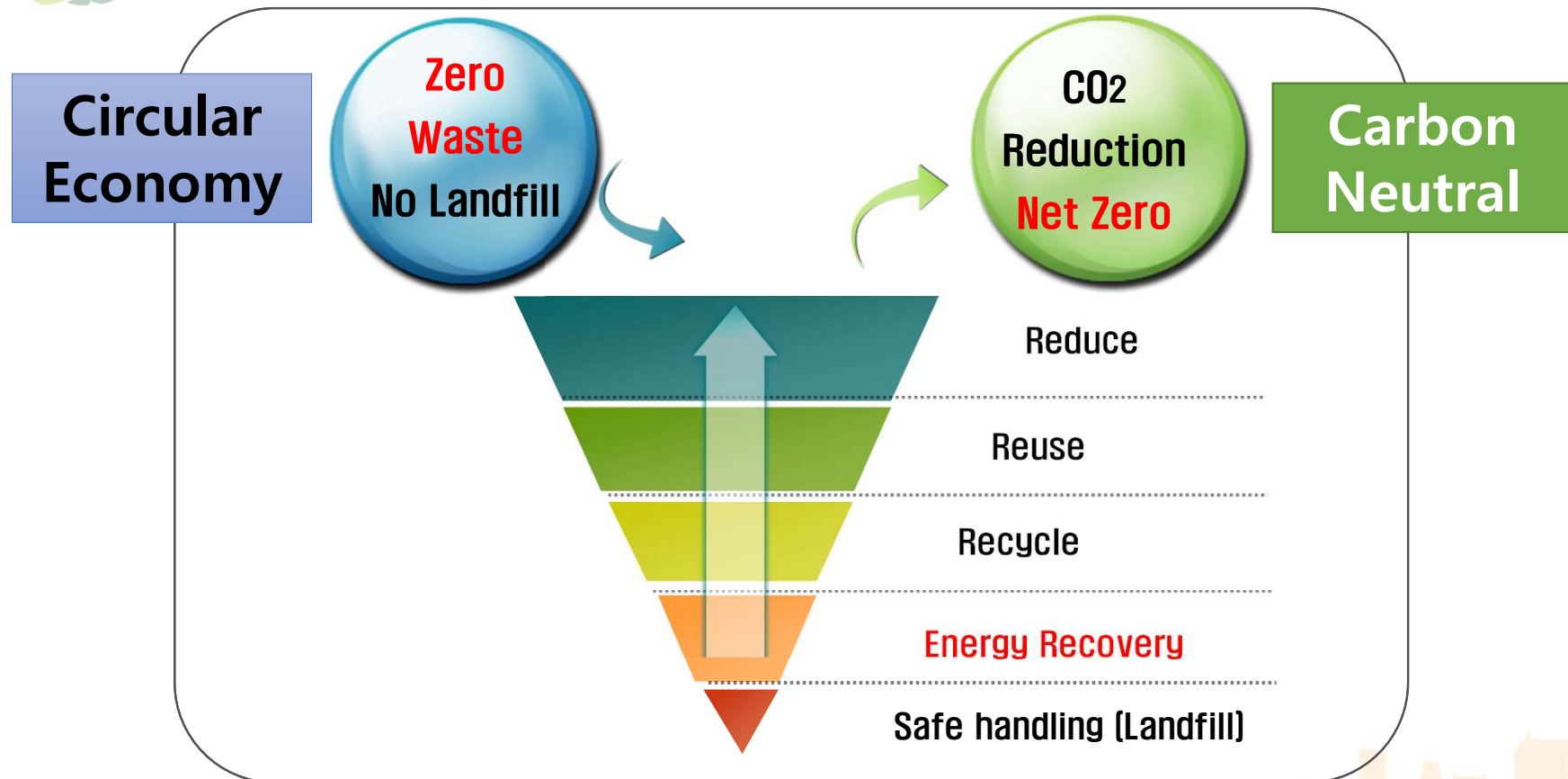
Source: Environment statistics yearbook, Korean Ministry of Environment

Historical Review and Status on Waste Management

● GHG Emission from Household Waste in Korea('82 ~ '18)

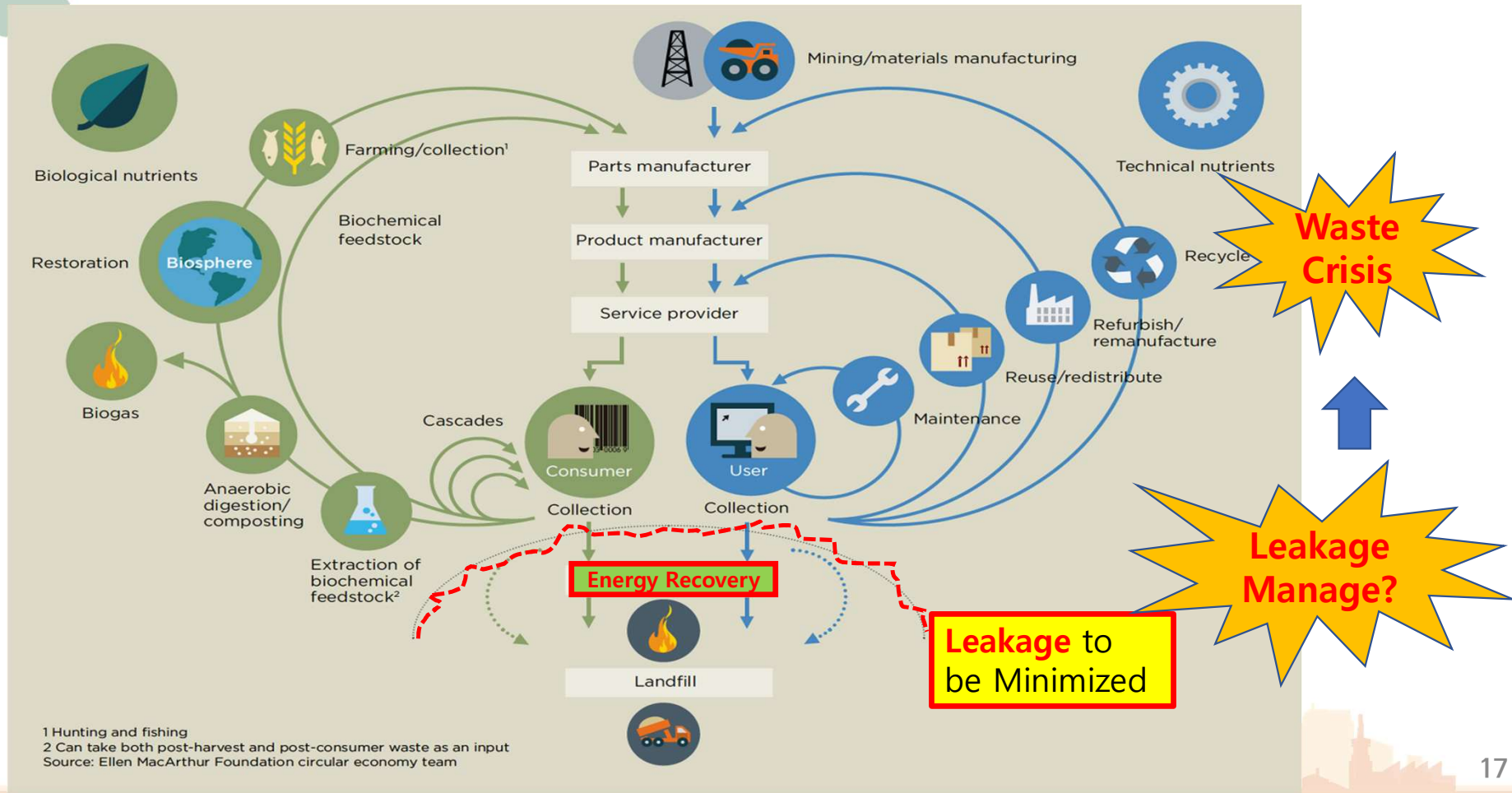


Waste Management Principles (Integrated WM)



Circular Economy and Waste Management

● Circular Economy Butterfly Diagram (Ellen MacArthur Foundation)



Future Direction of Waste Management in Korea

Waste (Household) Management for Zero Waste & Net Zero

 **Prevent of GHG Emission**

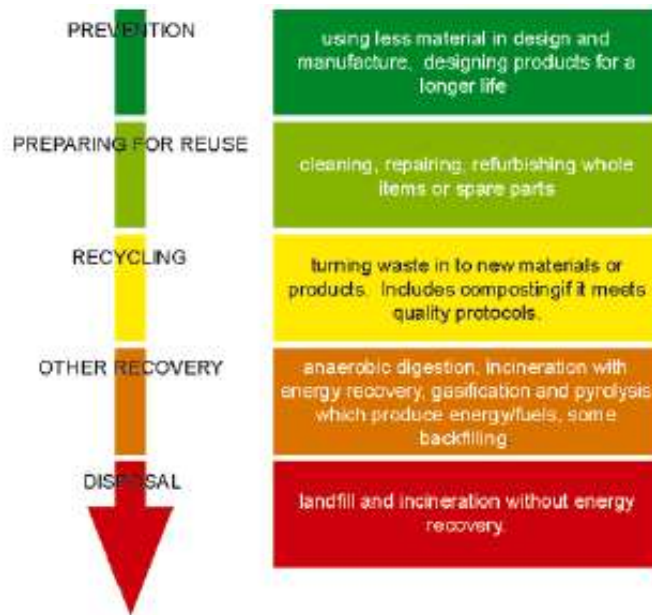
 **Reduction of Air Pollutants**

 **Energy Save**

 **Resource Preserve**

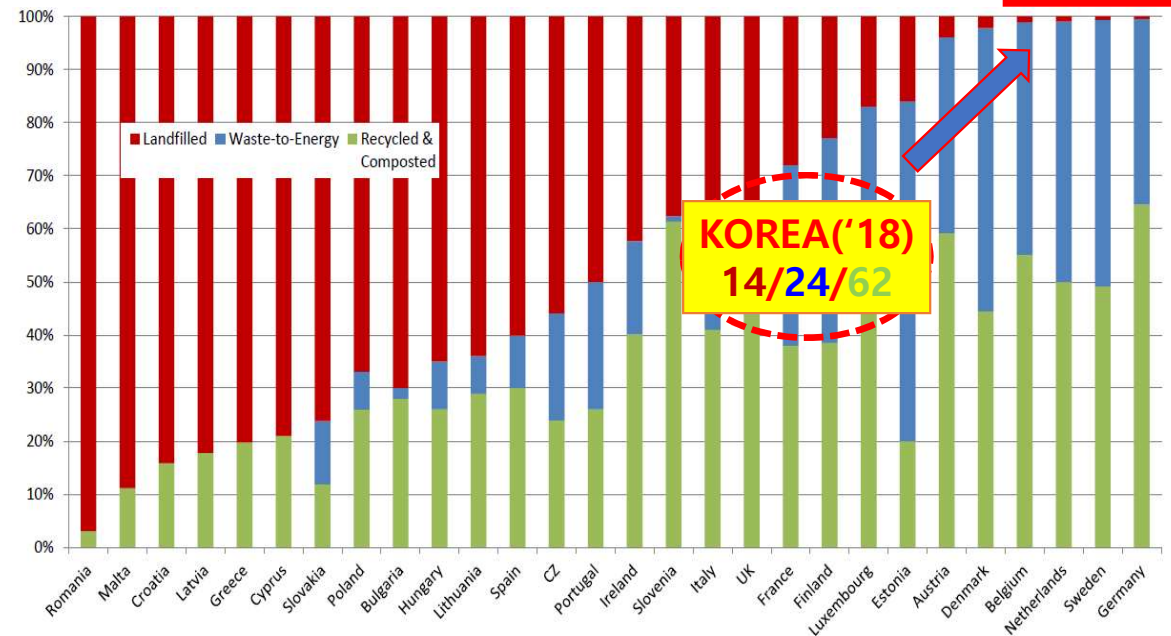
 **Job Growth**

**ZERO WASTE
NET ZERO
CIR. ECON.**



Hierarchy of WM

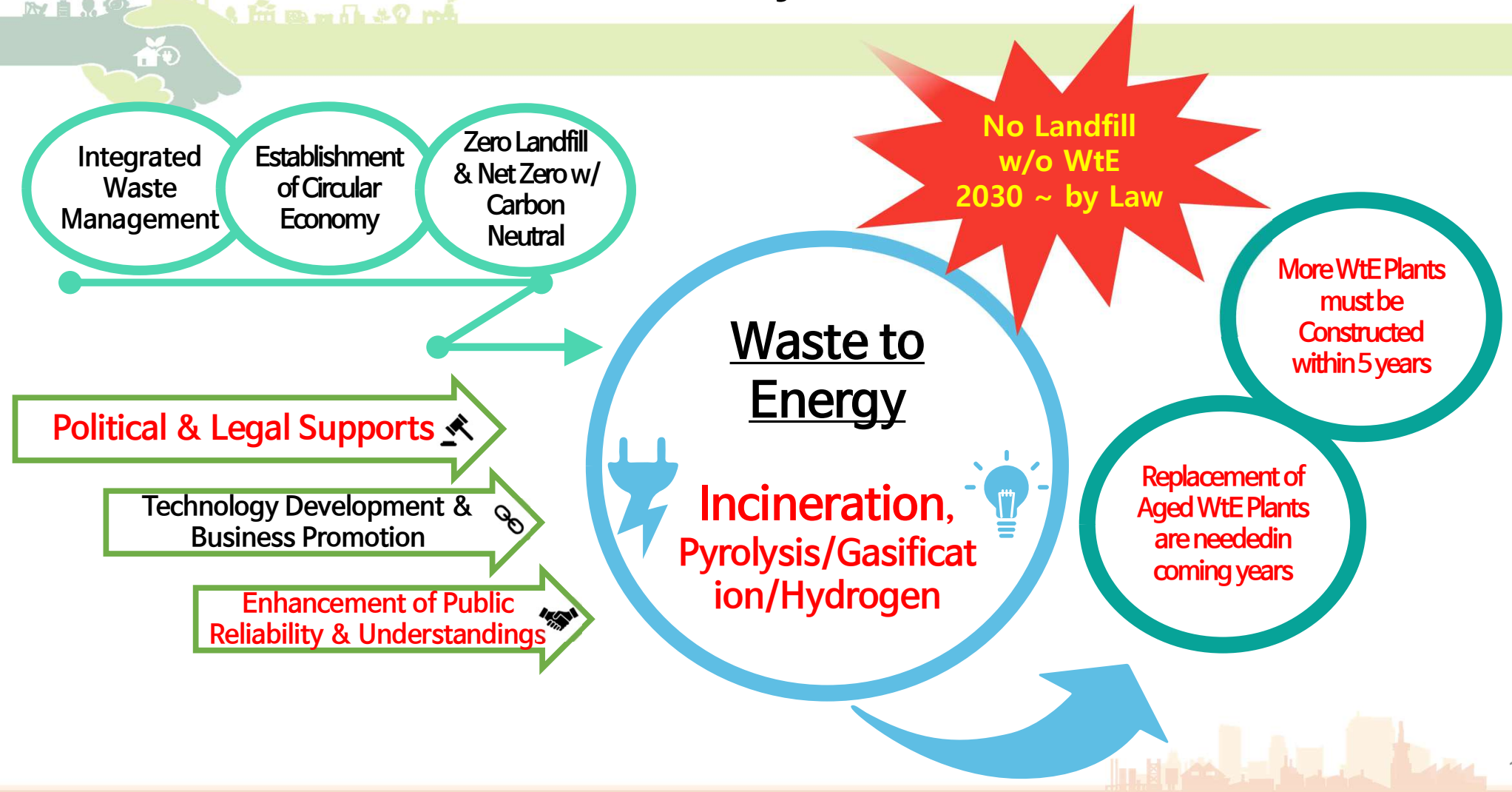
Source : Advanced Collection, Processing, Energy Recovery and Disposal Technologies for the Municipal Solid Waste Value Chain : Global Market Analysis and Forecasts, Navigant Consulting Inc., 2014



Status of Waste Management in EU

Source : Developments and trends shaping the future for Waste to Energy technology suppliers, ESWET, 2015

Role of WtE for Circular Economy and Recent Issues in S. Korea





Summary and Present Issues on WtE in S. Korea

- **Recognition of Role of WtE with Optimal** after Maximum Recycling is essential to achieve Zero Landfill, CE, and Carbon Reduce, and to Avoid Waste Adversity.
- **No Landfill without Pre-Treatment (WtE)** after 2030 in S. Korea.
- **Provision** for the **Replacement of Aged Incineration Plants** over 30yrs operation.
- **Many WtE Facilities** across the country should be Installed by 2025~2030.
- **Policy to Support WtE Facilities** and **Public Understanding** must be formulated.
- **Higher Efficiency** in Energy Conversion and **CCUS** at existing WtE plants.
- **Technology Development** for Renewables (**Hydrogen, Chemicals** etc.) by utilizing **Pyrolysis & Gasification**.

