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RESOURCE CIRCULATION
International Conference

WASTE-TO-ENERGY TECHNOLOGY AND ACHIEVEMENTS IN TAIWAN

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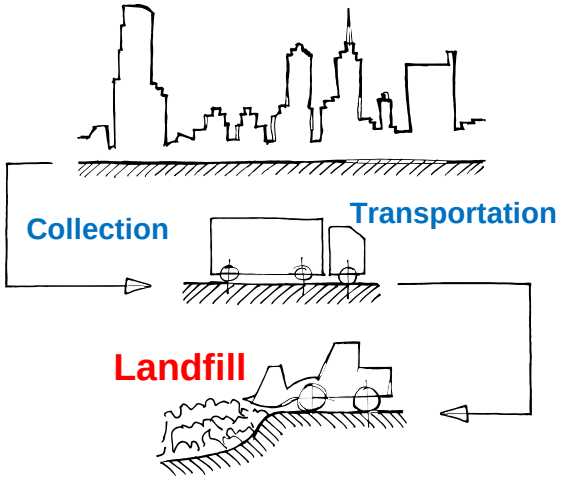
OUTLINE

- **Backgrounds**
- Waste-to-fuel in Taiwan
  - Policy, regulation and fuel standard
  - Current status and future challenges
- Environmental Benefit
- Conclusions

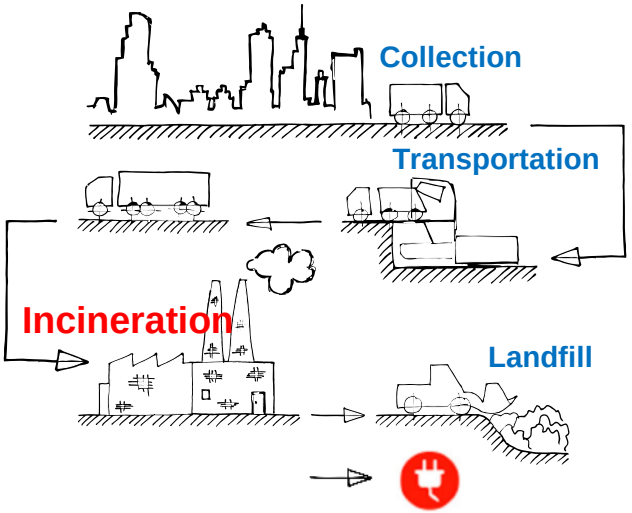
Evolution of Solid Waste Treatment

DISPOSE



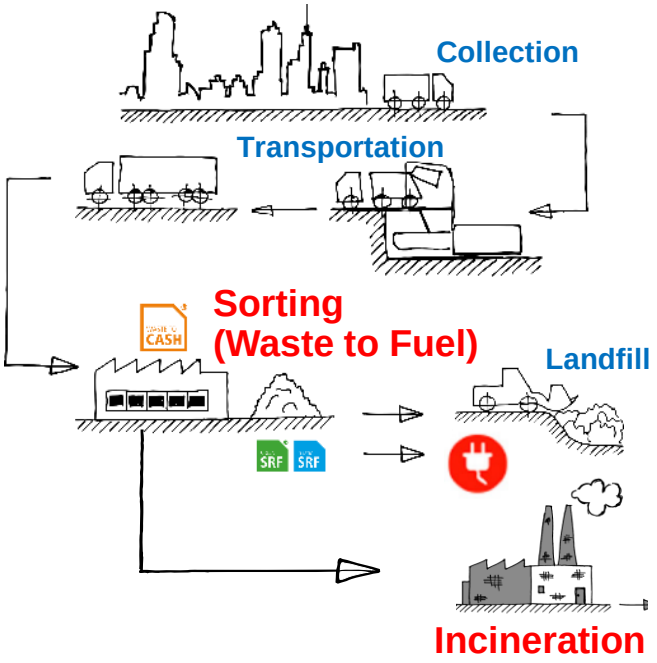
NO Energy Efficiency

WASTE TO ENERGY



Low Energy Efficiency

WASTE TO Energy & RESOURCE

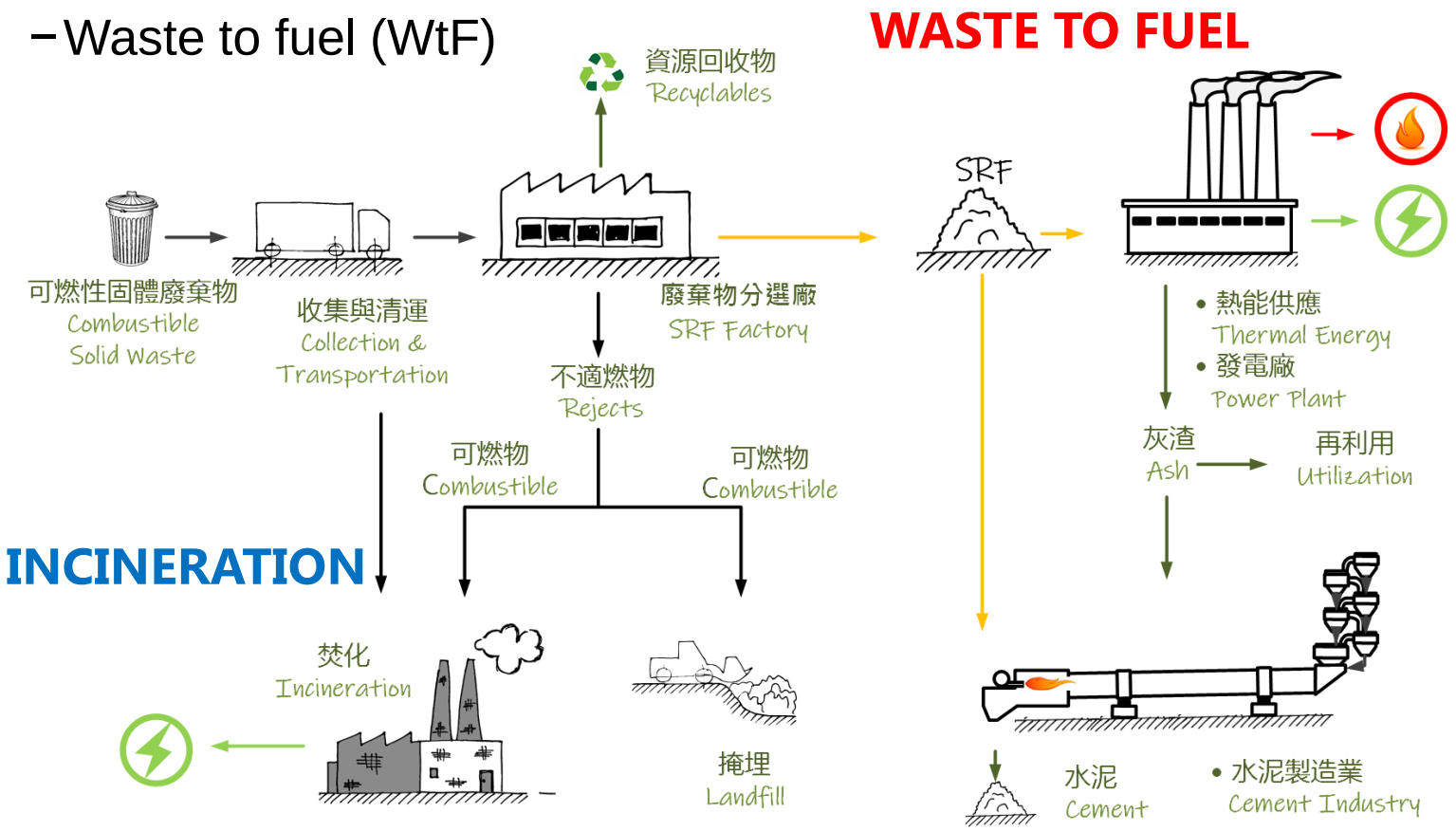


High Energy Efficiency

Source: BIANNA Recycling.

Waste to Energy

- **The waste to energy (WtE) includes**
  - Incineration
  - Waste to fuel (WtF)



The waste to energy (WtE) system of Taiwan

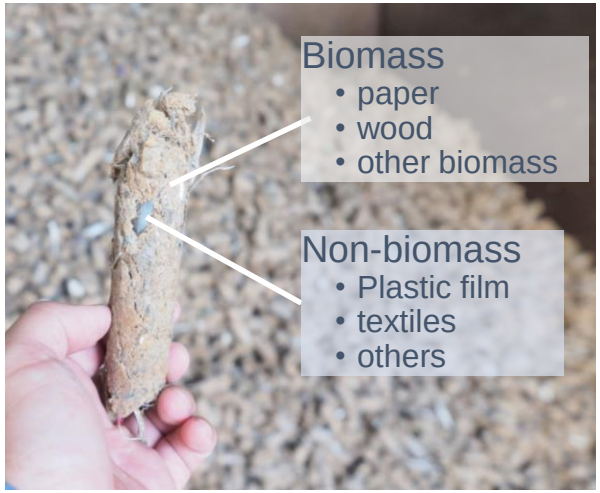
Waste to Energy in Taiwan

- Since **1984**, Taiwan has built **26 WtE plants** by incineration, treat more than **6.5 million tons MSW/C&I waste** and produce over **3,200 million kWh electricity** per year.
- From **2019**, Taiwan Environmental Protection Agency (EPA) started the promoting the **WtF policy** to convert non-hazardous combustible solid waste to **SRF** that can be used in industrial boilers and combustion devices.

[1] MSW: municipal solid waste
[2] C&I waste: Commercial and industrial waste
[3] SRF: solid recovered fuel

What is SRF?

- SRF is a high-quality alternative to fossil fuel and is produced from **non-hazardous waste** including paper, card, wood, textiles and plastic.



- Source
  - Commercial and industrial waste (C&IW)
  - Municipal solid waste (MSW)
- Combustion characteristics
  - Compared with coal lower ignition point, higher volatile content and rapid combustion.
- SRF form


Pellets


Briquettes


Flakes


Chips


Powder

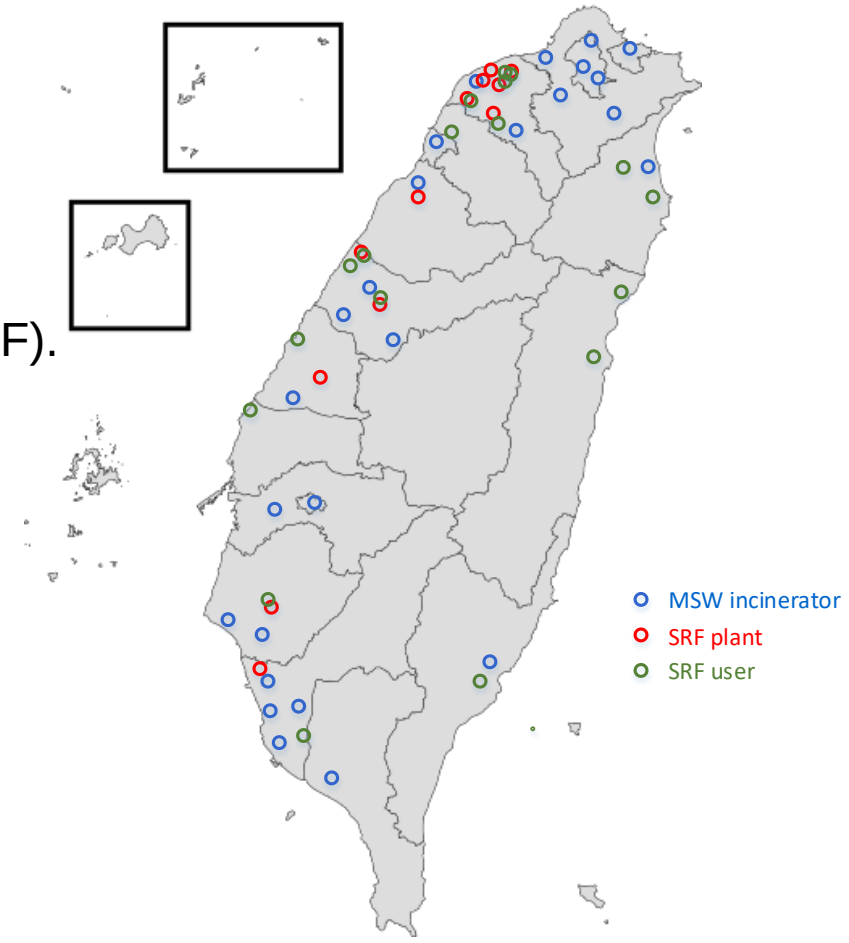

Fluff

Waste to Energy in Taiwan

- By solid management of waste source, sorting equipment, SRF quality control and end user, the annual production of SRF has reached 200,000 metric tons in 2022.
- The SRF can replace **155,000** metric tons of coal and reduce **132,500** metric tons of greenhouse gas emissions.
- Compared to incineration, WtF conversion can increase **300 million kWh** power generation per year.

Waste-to-Energy in Taiwan

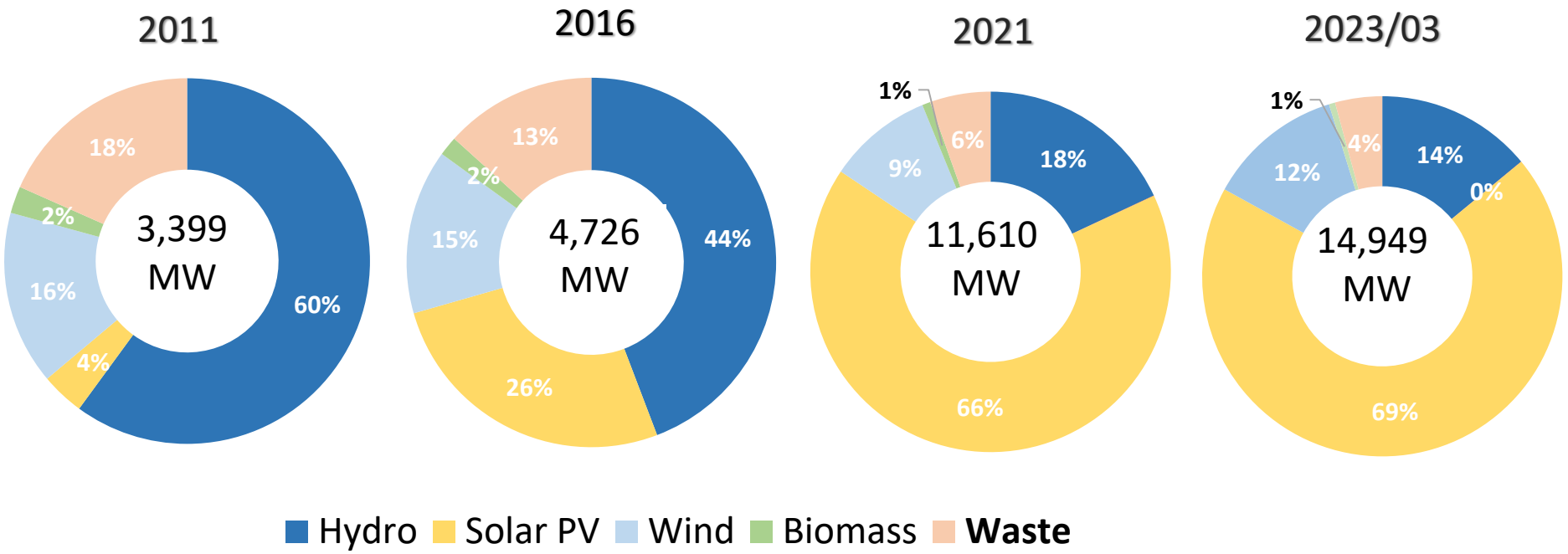
- **In 2023 Taiwan WtE consists of**
  - Waste-to-Energy Plants
    - 26 MSW Incinerators
  - Waste-to-Fuel Plants
    - 12 Active Waste-to-Fuel Plants (SRF).
    - 18 End user



MAP Source: https://commons.wikimedia.org/wiki/File:Blank_Taiwan_map.svg, 2023

State of Renewable Energy in Taiwan

- **Renewable Electricity Installed Capacity of Taiwan**



Source: Ministry of Economic Affairs (MOEA) of Taiwan, 2023

OUTLINE

- Backgrounds
- **Waste-to-fuel in Taiwan**
  - **Policy, Regulation and fuel standard**
  - **Current status and future challenges**
- Environmental Benefit
- Conclusions

Policy, Regulation and Fuel Standard

- Energy Transition Promotion Scheme
  - Based on "promote green energy, increase natural gas, reduce coal-fired, achieve nuclear-free" to ensure a stable power supply and to reduce air pollution and carbon emissions.

Promote Green Energy

To promote the development of renewable energy, Ministry of Economic Affairs (MOEA) has set a target of 20% renewable energy generation by 2025.

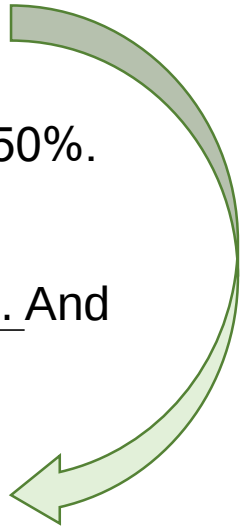
Increase Natural Gas

The natural gas fired power generation's share will increase to 50%.

Reduce Coal-fired

No new coal-fired electricity generation will be built before 2025. And the exciting plants will be replaced by gas-fired units after the decommissioning.

Achieve nuclear-free



60 billion kWh renewable electricity shortage in 2025

Policy, Regulation and Fuel Standard

- Trend of Coal & GHGs Reduction in Taiwan
  - Coal reduction target of industrial city in Taiwan
    - New Taipei City: zero coal use for industrial facilities (achieved in 2019)
    - Taichung City: Reduce 40% coal for industrial boilers in the end of 2023.
    - Kaohsiung City: zero coal use for cogeneation and power plant in the end of 2025.
    - Taoyuan City: under planning

Policy, Regulation and Fuel Standard

Feed-in Tariff (FIT) of Biomass and Waste Energy in Taiwan

Years	Bio-energy			Waste to energy[1]	
	Biogas		Agricultural and forestry[2]	General wastes	Agricultural wastes[3]
	Without anaerobic digestion facilities	With anaerobic digestion facilities			
2019	2.5765	5.0874	-	3.8945	-
2020	2.6871	5.1176	-	3.9482	-
2021	2.6884	5.1176	-	3.9482	-
2022	2.8066	5.1842	-	3.9482	5.1407
2023	2.8066	7.0089	3.1187	3.9482	5.1407

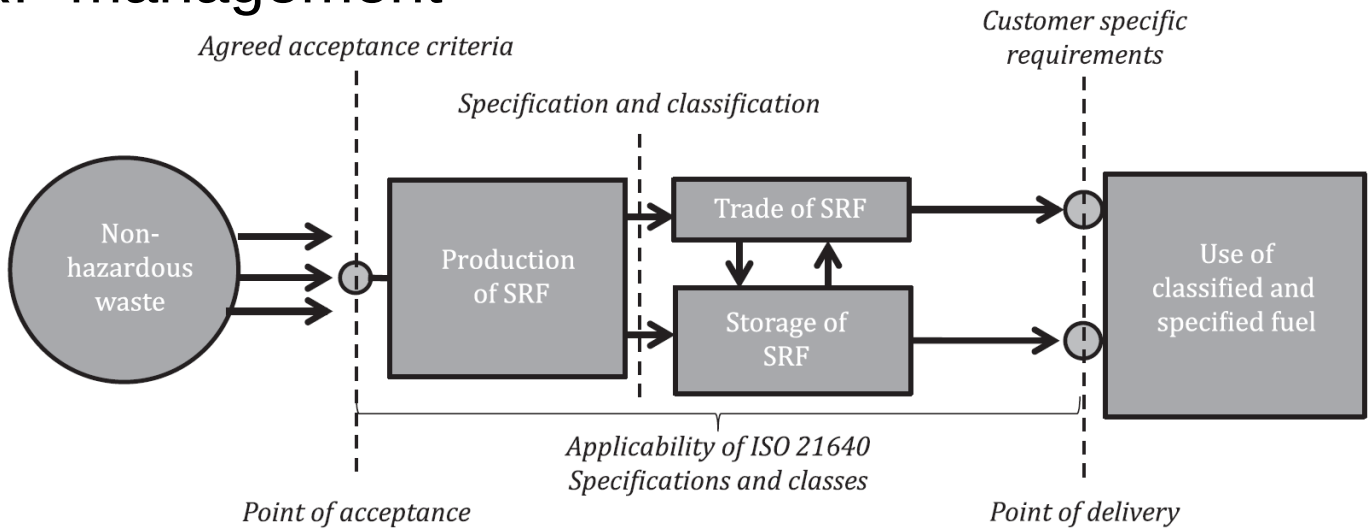
[1] Power generation efficiency need to ≥ 25%
[2] Suitable for imported biofuel.
[3] Suitable for domestic fuel.

Unit：NT$ per kWh

Source: Bureau of Energy, Ministry of Economic Affairs, Taiwan, 2023

Policy, Regulation and Fuel Standard

- SRF management



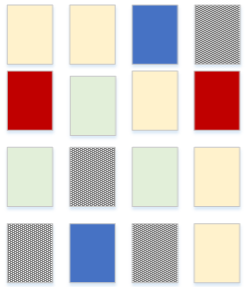
SRF chain–The SRF specifications and classes is applicable after production up to the point of delivery

ISO 21640- Classification for SRF

Classification characteristic	Statistical measure	Unit	Classes				
			1	2	3	4	5
Net calorific value (NCV)	Mean	MJ/kg (ar)	≥ 25	≥ 20	≥ 15	≥ 10	≥ 3
Chlorine (Cl)	Mean	% in mass (d)	≤ 0,2	≤ 0,6	≤ 1,0	≤ 1,5	≤ 3
Mercury (Hg)	Median 80th percentile	mg/MJ (ar) mg/MJ (ar)	≤ 0,02 ≤ 0,04	≤ 0,03 ≤ 0,06	≤ 0,05 ≤ 0,10	≤ 0,10 ≤ 0,20	≤ 0,15 ≤ 0,30

Policy, Regulation and Fuel Standard

- SRF manufacturing technology



Mixed solid waste

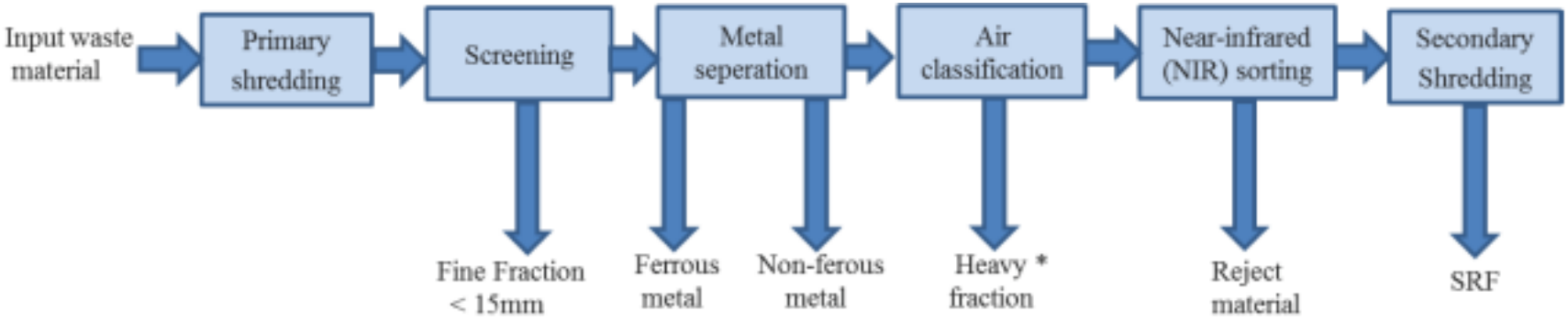
Sorting
- Pretreatment(shredding、drying、biotreatment)
- Screening
- Gravity separation
- Metal separation
- Homogenisation, compacting

Products
- SRF/RDF
- Fertilizer
- Recyclables

Biomass
Light combustible
Heavy combustible
Metal
Non-combustible

Waste
- Non-combustible (Landfill)
- Heavy combustible (Incineration)

DaKing, 2021



SRF process for C&I waste(Nasrullah et. al., 2014)

Policy, Regulation and Fuel Standard

- SRF fired facilities
  - Fluidized bed boiler (CFB/BFB)
  - Cement kiln
- Combustion mode
  - Co-firing with coal
  - Direct fired

Policy, Regulation and Fuel Standard

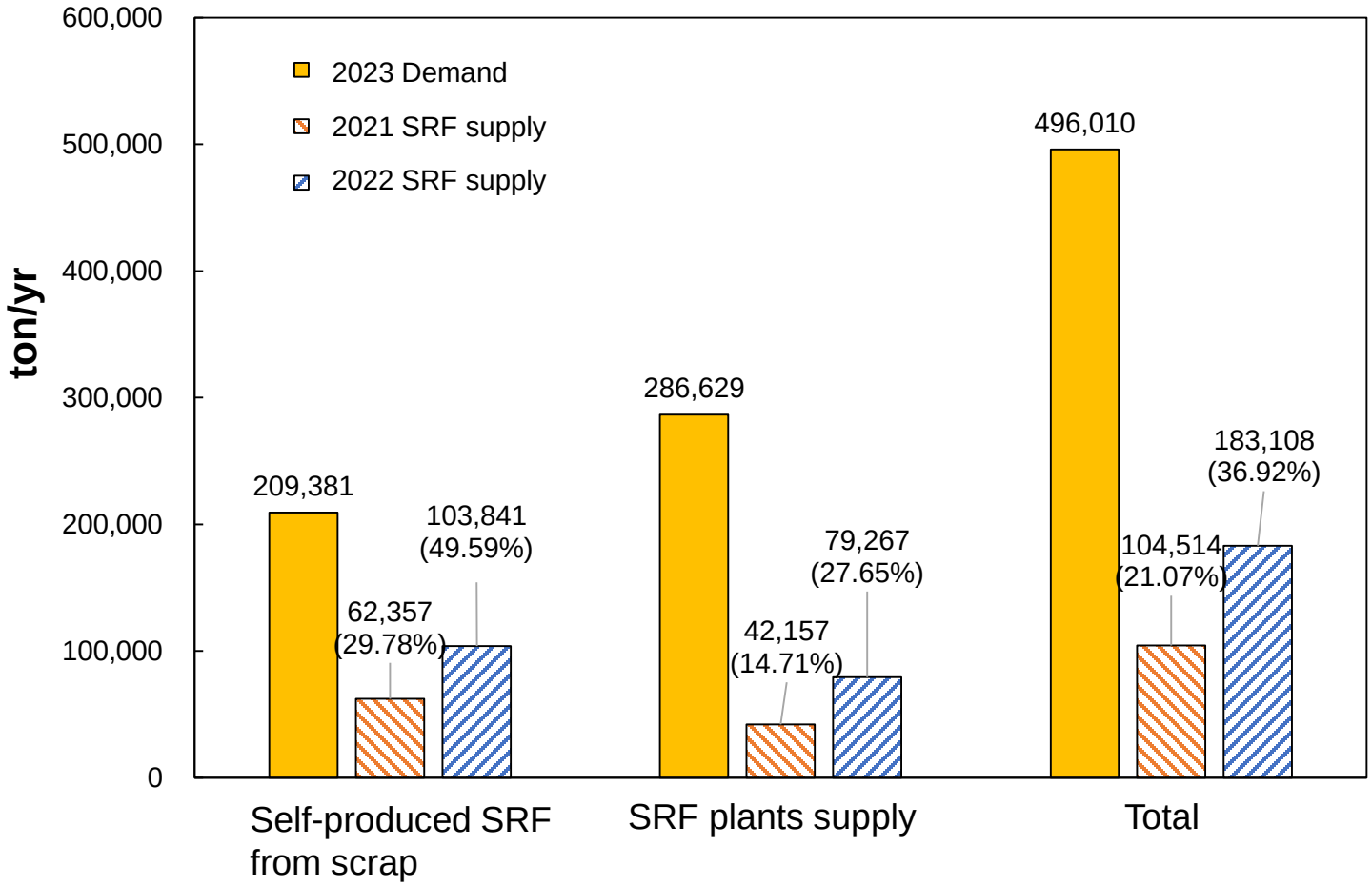
- Alternative solid fuel standards
  - Taiwan EPA regulates "alternative solid fuel (ASF)" into three categories for stationary air pollution sources control **(draf)**
    - Type I Solid biofuel: biomass pellet, PKS, wood chip etc.
    - Type II Solid recovered fuel (SRF): waste to fuel.
    - Type III other alternative solid fuels: From combustible waste but the quality or management do not meet the solid biofuel or SRF quality specification.

Alternative solid fuel classification and standards of Taiwan

Property Class	Unit	Standard value		
		Type I	Type II	Type III
Cl	wt% dry	≤ 0.1	≤ 3.0	From combustible waste but the quality or management do not meet the SRF quality specification.
Pb	μg/g, dry	≤ 10	≤ 150	
Cd	μg/g, dry	≤ 0.5	≤ 5.0	
Hg	μg/g, dry	≤ 0.1	≤ 5.0	
LHV	kcal/kg, as received wet basis	≥ 3,465	≥ 2,392	

Current Status and Future Challenges

- SRF demand and supply



Current Status and Future Challenges

- Future Challenges
  - Insufficient quantity of non-hazardous combustible C&I waste
- Countermeasures
  - Increase equipment to improve sorting capacity
  - MSW to SRF via mechanical biological treatment (MBT)

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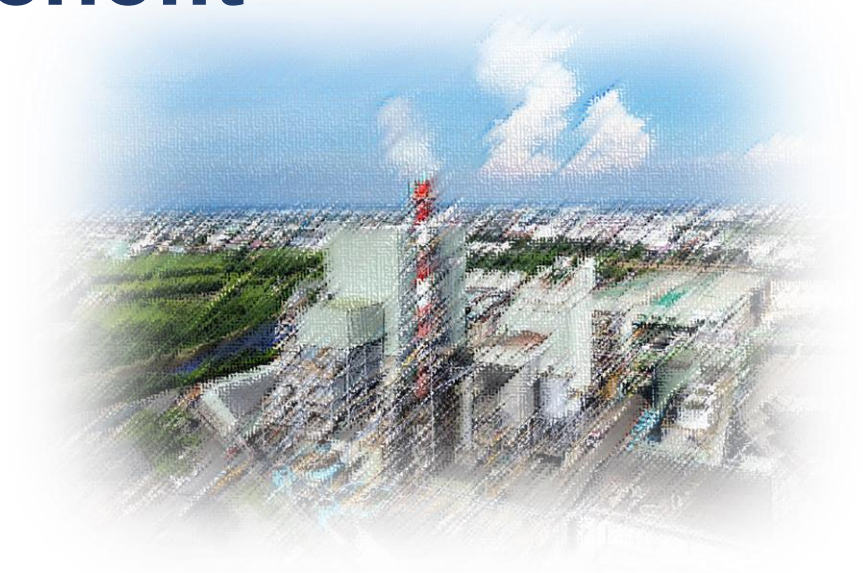

Environmental Benefit of WtF

- The use of SRF in the energy industry to replace coal combustion is a direct and effective carbon reduction model, and it can take into account environmental benefits such as air pollution reduction and resource recycling.

Environmental Benefit of WtF

- Domestic SRF properties and CO_2 emission

Properties	Unit	A01	A03	A02	A04	A05	Standard method	Limit
Net calorific value, NCV	kcal/kg ar	5,749	7,820	6,398	6,009	2,405	BS EN 15400	2,392
Moisture, M	% ar	0.97	1.78	1.01	8.17	54.47	BS EN 15414-3	-
Ash Content, A	% d	10.41	3.49	9.14	5.71	7.52	BS EN 15403	-
Sulfur, S	% d	0.13	ND	0.04	ND	ND	BS EN 15408	-
Chlorine, Cl	% d	0.64	0.07	1.41	0.60	0.39	BS EN 15408	≤ 3
Mercury, Hg	mg/kg d	1.24	ND	1.84	0.03	0.19	BS EN 15411	≤ 5
Lead, Pb	mg/kg d	56.13	2.98	42.92	24.81	10.06	BS EN 15411	< 150
Cadmium, Cd	mg/kg d	0.35	0.03	0.68	1.74	2.07	BS EN 15411	< 5
Biomass ratio	%	28.38	24.68	30.27	72.74	80.31	BS EN 15440	-
Non-biomass carbon	% d	59.17	74.56	65.63	71.72	71.73	-	-
CO_2 emission factor	kg CO_2e/kg	1.5538	2.0591	1.6780	0.7169	0.5179	-	-
CO_2 emission factor compare with coal	%	**0.65**	**0.86**	**0.70**	**0.30**	**0.22**	-	-

OUTLINE

- Backgrounds
- Renewable Energy Policy in Taiwan
- Solid Biofuel Standards and Regulations
- Demand Estimates and Challenges
- **Conclusions**

Conclusions

- In terms of environmental and economic benefits, SRF can not only meet the fuel demand of industry, but also reduce waste.
- The characteristics of SRF are different from coal, and it can be used as an alternative fuel for special combustion in large boilers or co-firing in fluidized bed and rotary kiln.
- Due to the complexity of raw material sources, the source and quality of SRF materials must be properly managed.

THE END

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About TBETA

Taiwan Bio-energy Technology Development Association

臺灣生質能技術發展協會

- Promoting the development of bio-energy and waste-to-fuel industry in Taiwan.
- Assist government agencies to formulate regulations, standards and management systems.

www.twbiomass.org.tw

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