ITELYUM

AIEE Symposium:
Current and future Challenges to Energy Security

Renewable energy, clean energy technologies and critical raw materials: A perspective on Waste-to-Energy

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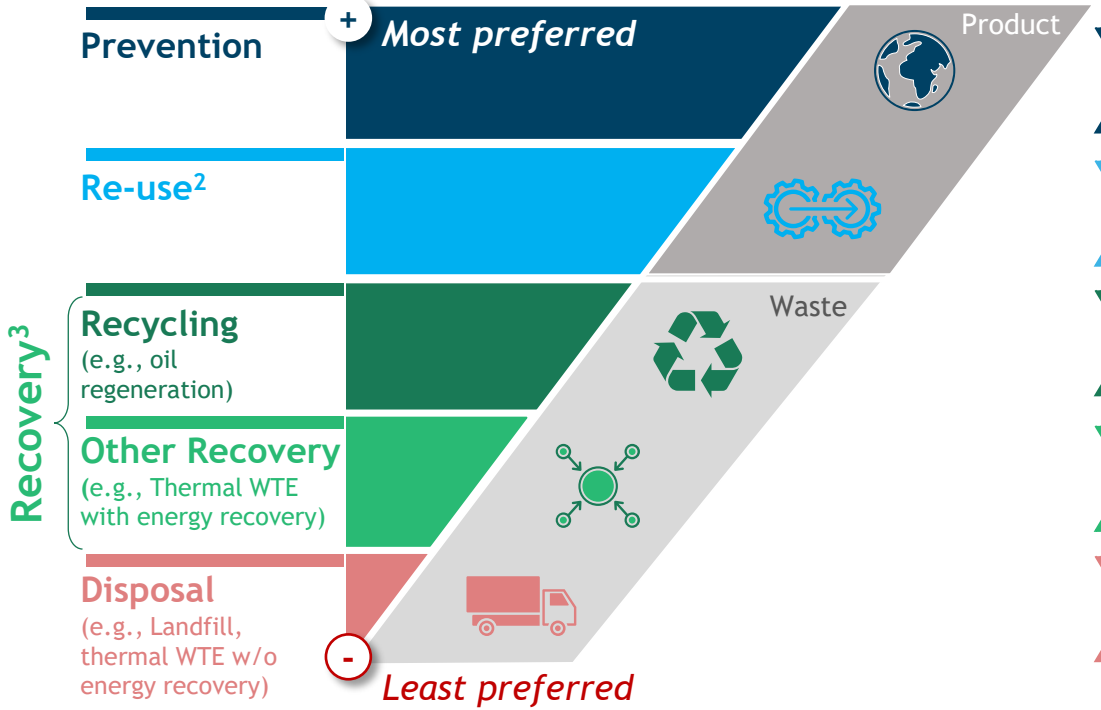
Why it matters: Waste-to-Energy (WTE) is a key enabler of a circular economy where non-recyclable waste is an energy resource

The EU waste strategy commands a priority waste management order[1]



Description

- Manufacture multiple-use products, designed for long life and economic usage
- Get a product or its parts ready for reuse, without structural changes (i.e., repairs, cleaning, refurbishment or backfilling)
- Recovery of waste to produce new products materials or substances (also with structural changes in materials)
- **Recover energy in any other form (i.e., fuels, heat, steam, electricity) from waste incineration**
- Dispose leftover waste to landfill, or incinerate it without capturing any of the generated energy

WTE has a multi-functional role within the system

- Waste avoidance and recovery of resources and energy are guiding principles of the waste hierarchy to enable circularity
- Waste-to-Energy contributes to follow the waste hierarchy through:
  1. Improved recycling:
     a. Diversion from landfill
     b. Removal of toxic non-recyclable waste streams[4]
  2. Supply of energy to districts (partially renewable)
  3. Recovery of raw materials

Note: 1. The waste hierarchy is established by Directive 2008/98/EC (EU's Waste Framework Directive or WFD); this framework was later updated by the Directive 2018/851 , which confirmed the hierarchy, strengthened separate collection targets, and revised EPR schemes. In Italy, the WFD (and related waste hierarchy) was implemented primarily through DL 205/2010, which amended Part IV of DL 152/2006 (Environmental Code) and updated the definitions of waste, by-product, end-of-waste, as well as national obligations on prevention and recycling. Subsequent amendments (DL 116/2020), implemented the updates from Directive 2018/851 further aligning Italian legislation to EU requirements; 2. Preparation for re-use refers to waste stage; 3. Recovery includes recycling, backfilling and energy recovery from incineration; 4. Sources: Itelyum analysis, EC, ESWET WTE 2050, CEWEP, EC: The role of waste-to-energy in the circular economy

Waste-to-Energy is a structural component of a sustainable energy system[1]

1. ~100M tonnes/year of residual waste in EU treated out of ~500 Thermal WTE plants[1]

   (60% of EU's plants are CHP)

Generate ~40M tCO2eq[7]

2. Generating: 35 000 GWh electricity *(supplying 21M inhabitants)* + Generating: 87 000 GWh heat *(supplying 17M inhabitants)*

Equivalent to: 20-22 billion m3 of natural gas[6]

3. Saving vs fossil resources[2]
   - ~70M-80M barrels of crude oil[3]
   - 30-35M tCO2eq

   Recovering ~20M ton ashes[4]
   - ~2M tons of recovered ashes (10% recovered; 90% disposed)
   - ~6M tCO2eq

Waste-to-Energy technology is a robust and effective alternative energy option:

- To save limited fossil fuel resources used by traditional power plants and/or reduce imports: in 2024 EU imported ~50 bn m3 of natural gas from Russia[5] (EU WTE natural gas substitution at ca. 40% of that)
- WTE is almost carbon neutral, without accounting for the positive climate of landfill diversion and carbon capture

Notes: 1. Data mainly referred to non-hazardous, however, according to ISPRA (2020) there are ~70 plants of hazardous thermal WTE, a share of them included in the aforementioned 500 plants; At global level, in early 2024, there where 2,800+ WTE plants in operations with total capacity of ~570-580M ton/year, estimated to grow to 3,100 plants and 700M+ ton/year by 2033); 2. In the future, the positive climate impact of energy substitution could be lower given possible higher content of biogenic content in residual waste (better plastic separation, and increased bio-based products in the market; 3. Depending on the fuel replaced – in this calculation 1 ton of crude oil ≈ 7.33 barrels (bbl); 4. ~3M tons of metals and 17M tons of minerals; 5. Import from Russia (EC): https://www.consilium.europa.eu/en/infographics/where-does-the-eu-s-gas-come-from/?utm_source; 6. Assuming 55% efficiency (i.e., 120GWh → ca. 215-220GWh of primary energy) and 1 m3 NG = 10.5 KWh); 7. based on 60% of waste coming from the biogenic fractions, such as residual paper and cardboard, wood, leather, food, and green residues that are contaminated and thus not able to be recycled | Sources: EC; ESWET; CEWEP

WTE technologies: different options for waste streams; WTE can unlock industrial symbiosis with chemicals, plastics, fuels

Overview of WTE technologies

	Tech	Feedstock	Operating Conditions	Main output	Strengths	Limitations	TRL
Thermal WTE Direct Combustion	**Grate**	MSW mixed	850-1100°C	Thermal Energy	**Most robust; handles heterogeneous waste; proven**	Lower electrical efficiency than other thermo-chemical routes	9
	Fluidized bed	Pre-treated waste (RDF/SRF), biomass, sludge	750-950°C	Thermal Energy	Higher efficiency; stable temperature	**Needs homogeneous pre-treated feed**	9
	Rotary kiln	Hazardous waste, medical waste, sludges, chemical residues	850-1200°C	Thermal Energy	**Very good for hazardous waste; high destruction efficiency**	Smaller scale; long treatment time	9
Other technologies (not exhaustive)	**Gasification**	Pre-treated waste (RDF/SRF), biomass	800-1200°C, low O_2	Gas-fuel: Syngas ($CO+H_2$)	Higher efficiency potential; cleaner syngas;	Sensitive to feed variability; needs gas cleaning	7-9
	Plasma Gasification	Hazardous waste, mixed waste, special industrial residues	>3,000°C	Gas fuel: Syngas ($CO+H_2$) ultra-clean	Highest destruction efficiency; minimal residues	Same as above + very energy-intensive	6-7
	Pyrolysis	Plastics, tyres, biomass	300-700°C, no oxygen	Liquid Fuel: Pyrolysis oil	Potential for chemical recycling competencies	Requires very homogeneous feed; oil needs upgrading	6-8

Commercially viable / most diffused

Highlights

- **The most diffused technology is grate**
- **Rotary kiln technology is the most established choice for the energy recovery of hazardous special waste, as it ensures the greatest operational flexibility**

Other synergies with WTE

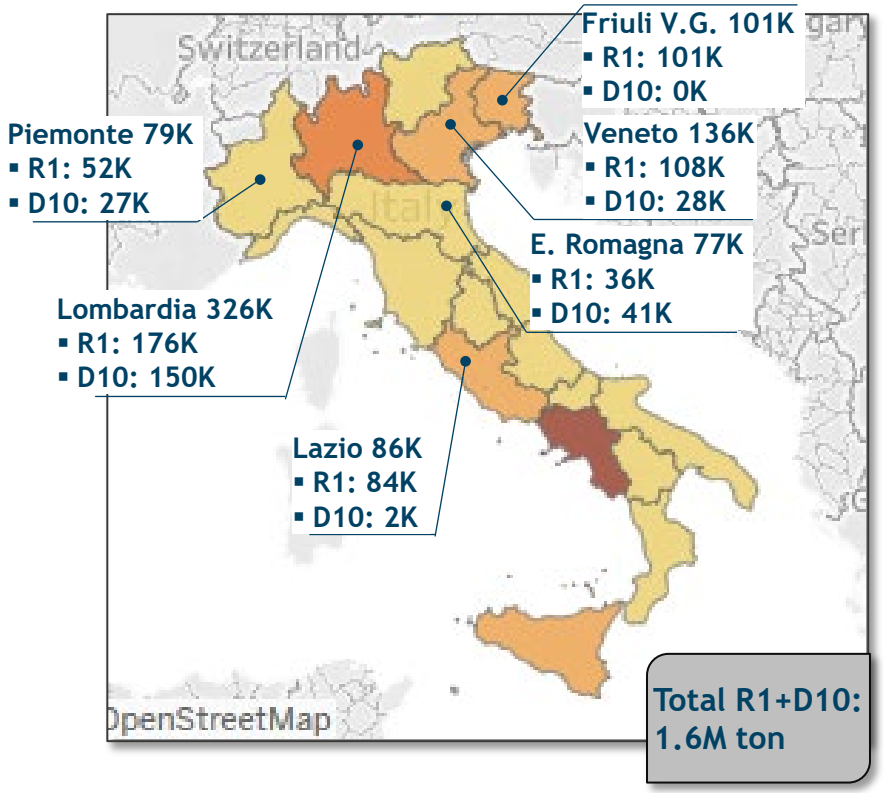
- **A promising route is to turn CO2 from a waste into a resource and use it as feedstock to produce chemicals, plastics, or fuels**

Note: Syngas = Synthesis Gas is a fuel gas made mainly of Hydrogen (H_2), Carbon monoxide (CO), Carbon dioxide (CO_2), can be burned to generate electricity and heat, converted into methanol, synthetic diesel, ammonia, used to produce hydrogen, employed as a chemical feedstock; RDF = Refuse-Derived Fuel (Combustibile da Rifiuti); SRF = Solid recovered fuel (CSS) | Source: Itelyum market analysis; Rapporto Utilitalia

Italian situation: waste-to-energy infrastructure in Italy shows structural and persistent undercapacity

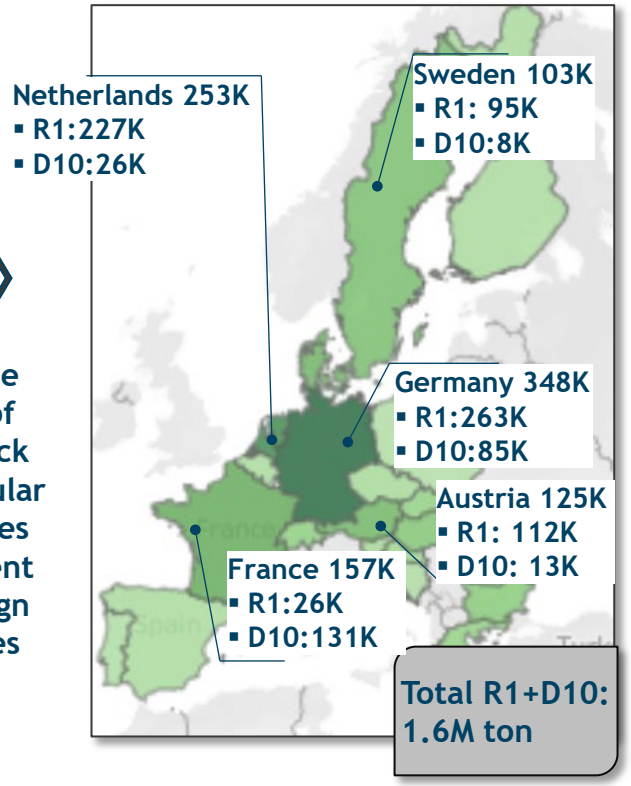
Italian waste export streams (Tons, 2023, to R1 and D10 treatment, hazardous and non-, “commercial & industrial” + “municipal” waste)

Flows exported from Italy for R1 & D10 treatment…



valuable flows of feedstock and circular resources being sent to foreign counties

…being treated in other EU countries



- Italy could retain exported waste to generate domestic electricity and steam, reducing dependence on imported natural resources
- Landfill capacity—especially in Southern Italy—is nearing exhaustion
- Italian industries face higher disposal costs and greater uncertainty compared to countries with sufficient treatment infrastructure
- Germany and France treat roughly 4× and 2.5× Italy’s thermal WtE volumes

Note: (1) 6M ton non hazardous in 2022, as per CEWEP; Source: Itelyum market analysis, Ecocerved, ISPRA, CEWEP

Safety concerns: myths vs reality

Is WTE safe?

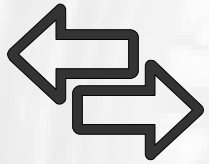
- Strongly regulated, and in real time
- Less impacting than several industrial activities as well as of landfilling
- Plants meet the strictest industrial emissions requirements placed on any EU industry in terms of monitored pollutants, emission limit values and operating conditions
- Recycling and Waste-to-Energy recovery have complementary roles in sustainable waste management practices

Note: CEWEP

Key Barriers Hindering Waste-to-Energy Development in Italy

1. 

   Strong public prejudice and negative perception

2. 

   Lack of steer and attention from policymakers

3. 

   Not enough accurate and evidence-based information

4. 

   Limited awareness of the systemic costs of not having WtE facilities in the country

Long-distance waste transport imposes major environmental and economic costs:

- *160 000 truck trips per year (~89 000 000 km)*
- *55K tons of extra CO2*
- *€75 000 000 in additional charges*
- *€50 000 000 in EU fines for non-compliant waste management*

Source: Lit. search; https://energiaoltre.it/ecco-di-quanti-impianti-ha-bisogno-litalia-per-centrare-i-target-ue-sui-rifiuti/ Utilitalia 2023; ISPRA 2022

ITELYUM manages 2.400.000 t/year of waste through a flexible platform, integrated across the entire value chain, operating as a “one-stop” shop

86% Circularity index (in 2024)

500 000 tons CO_2 avoided in 2024

Milan, Italy

Vast European reach: **Germany, France, Serbia, Croatia**

Founded in **1963**
PE-owned since **2011**

1 800+ Professionals

50 000+ customers in **60 countries**

€628 Mln € (FY 2024)

ITELYUM
REGENERATION SOLUTIONS

Leader in the **production of regenerated base oils through the regeneration of spent oils**, used by the world-class lubricant manufacturers, and with **performances equivalent to those of bases obtained from virgin materials. Chemical recycling** of **post-consumption PET**

ITELYUM
PURIFICATION SOLUTIONS

European leader in the purification of **chemical waste and used solvents** from the pharmaceutical and chemical industries and in the production of **high-purity virgin solvents**

ITELYUM
ENVIRONMENT SOLUTIONS

Provider of **integrated waste management services for industrial and commercial producers of hazardous and non-hazardous special waste**: collection, storage, transport, recycling, pre-treatment, thermal treatment, industrial wastewater treatment, export notifications and brokerage

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New Businesses

Chemical recycling of post-consumption **PET**

Hydro-metallurgic **recovery of REO from PM**

Source: Lit. search

Itelyum is already active with one WTE facility and is developing two new initiatives

Focus: brownfield project in Lombardy

- **Industrial waste,** hazardous and non-hazardous
- Treatment capacity up to **100K ton/year** of hazardous, non-hazardous, medical waste
- **Lines**: 2 rotary kilns + 1 grate (BAT upgrade)
- **Thermal power**: **96MWt**
- **Electric power**: 19.5 MWe (145 GWh out of 7500h/year, able to supply 54K families)
- **Methanol production** through CO2 capture to produce PET, PE, pharma solvents, biofuels

POLITECNICO
MILANO 1863

Source: Itelyum team


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WTE In Italy: statistics (1/2)

Rifiuti urbani + rifiuti derivanti dal trattamento degli stessi

Tabella 3.4.1 – Numero di impianti di incenerimento e quantità di rifiuti totali inceneriti per macroarea geografica, anni 2019– 2023

Macroarea	n. impianti					Quantità totale incenerita (t/a)				
	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
Nord	26	26	26	25	25	4.596.644	4.602.984	4.472.376	4.462.489	4.666.047
Centro	5	5	5	5	5	571.058	537.478	527.104	504.991	505.220
Sud	6	6	6	6	6	1.129.744	1.102.046	1.066.700	1.051.140	1.062.216
Italia	**37**	**37**	**37**	**36**	**36**	**6.297.446**	**6.242.509**	**6.066.180**	**6.018.620**	**6.233.483**

Fonte: ISPRA

Tabella 3.4.2 – Numero di impianti di incenerimento e quantità di rifiuti urbani inceneriti per macroarea geografica, anni 2019– 2023

Macroarea	n. impianti					Quantità RU incenerita (t/a)				
	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
Nord	26	26	26	25	25	3.905.723	3.739.077	3.869.124	3.789.562	4.012.658
Centro	5	5	5	5	5	566.711	532.399	526.804	503.813	503.913
Sud	6	6	6	6	6	1.049.216	1.053.166	1.013.556	1.013.803	1.003.690
Italia	**37**	**37**	**37**	**36**	**36**	**5.521.650**	**5.324.641**	**5.409.484**	**5.307.178**	**5.520.261**

Fonte: ISPRA

Tabella 3.4.3 – Rifiuti inceneriti per regione (tonnellate), anno 2023

Regione	RU (t)	FS, CSS, BS (t)	Totale RU (t)	RS pericolosi (t)	RS non pericolosi (t)	TOTALE (t)	% rispetto ai RU prodotti	N° impianti
Piemonte	462.915	92.340	555.255	0	44.247	599.502	28,0	1
Lombardia	1.048.078	922.145	1.970.223	24.771	369.028	2.364.022	50,0	12
Trentino-Alto Adige	94.294	3.473	97.767	0	29.603	127.370	24,1	1
Veneto	172.400	79.399	251.799	3.375	13.401	268.575	11,1	3
Friuli-Venezia Giulia	123.599	32.552	156.151	0	34.806	190.957	30,5	1
Emilia-Romagna	653.021	328.442	981.463	7.636	126.522	1.115.621	39,2	7
Nord	**2.554.307**	**1.458.351**	**4.012.658**	**35.782**	**617.607**	**4.666.047**	**35,1**	**25**
Toscana	79.541	130.198	209.739	7	1.300	211.046	9,8	4
Lazio	0	294.174	294.174	0	0	294.174	10,3	1
Centro	**79.541**	**424.372**	**503.913**	**7**	**1.300**	**505.220**	**10,1**	**5**
Molise	0	90.142	90.142	0	38	90.180	82,0	1
Campania	327	706.769	707.096	0	0	707.096	27,3	1
Puglia	0	51.104	51.104	0	0	51.104	2,8	1
Basilicata	6.016	9.016	15.032	29.599	25.498	70.129	36,8	1
Calabria	0	85.734	85.734	0	0	85.734	11,7	1
Sardegna	49.594	4.988	54.582	149	3.242	57.973	8,1	1
Sud	**55.937**	**947.753**	**1.003.690**	**29.748**	**28.778**	**1.062.216**	**17,3**	**6**
Italia	**2.689.785**	**2.830.476**	**5.520.261**	**65.537**	**647.685**	**6.233.483**	**25,5**	**36**

rappresentata da rifiuti urbani pretrattati (rifiuti combustibili, frazione secca e, in minor misura, bio-essiccato e frazione organica non compostata

Source: ISPRA Report Rifiuti Urbani 2024, pag. 150-165

WTE In Italy: statistics (2/2)

Tabella 3.4.7 – Recupero energetico in impianti di incenerimento che trattano RU, anno 2023

	n. impianti	totale rifiuti trattati (t)	ReEnergetico		ReEnergetico per kg	
			REElettrico (MWhe)	RETermico (MWht)	kWhe/kg	kWht/kg
Impianti con RET&E	13	3.245.289	2.246.611	2.245.642	0,69	0,69
Impianti con REE	23	2.988.194	2.205.737	0	0,74	-
Totale	**36**	**6.233.483**	**4.452.349**	**2.245.642**	**0,71**	**0,36**
Legenda - ***RET&E***=*impianti con ciclo di cogenerazione;* ***REE***=*impianti con solo recupero energetico elettrico.*						

Fonte: ISPRA

CHP

6.23M MWh = 6 233 GWh

4.45M MWh = 4 450 GWh

2.25M MWh = 2 245 GWh

EU: 100M ton = 120 000 GWH
IT: 6.2M ton = 6 200 GWh

Source: ISPRA Report Rifiuti Urbani 2024, pag. 150-165