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DEVELOPING THE FIRST COMMERCIAL MSW GASIFICATION FACILITY IN GREECE - CHALLENGES AND OPPORTUNITIES

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9th International Conference on Sustainable Solid Waste Management
Corfu, 17th JUNE 2022

Before we start

- This presentation will show the developing process of the first commercial MSW gasifier in Greece

- **Can we develop a small waste-to-energy plant? What are the lessons learned?**

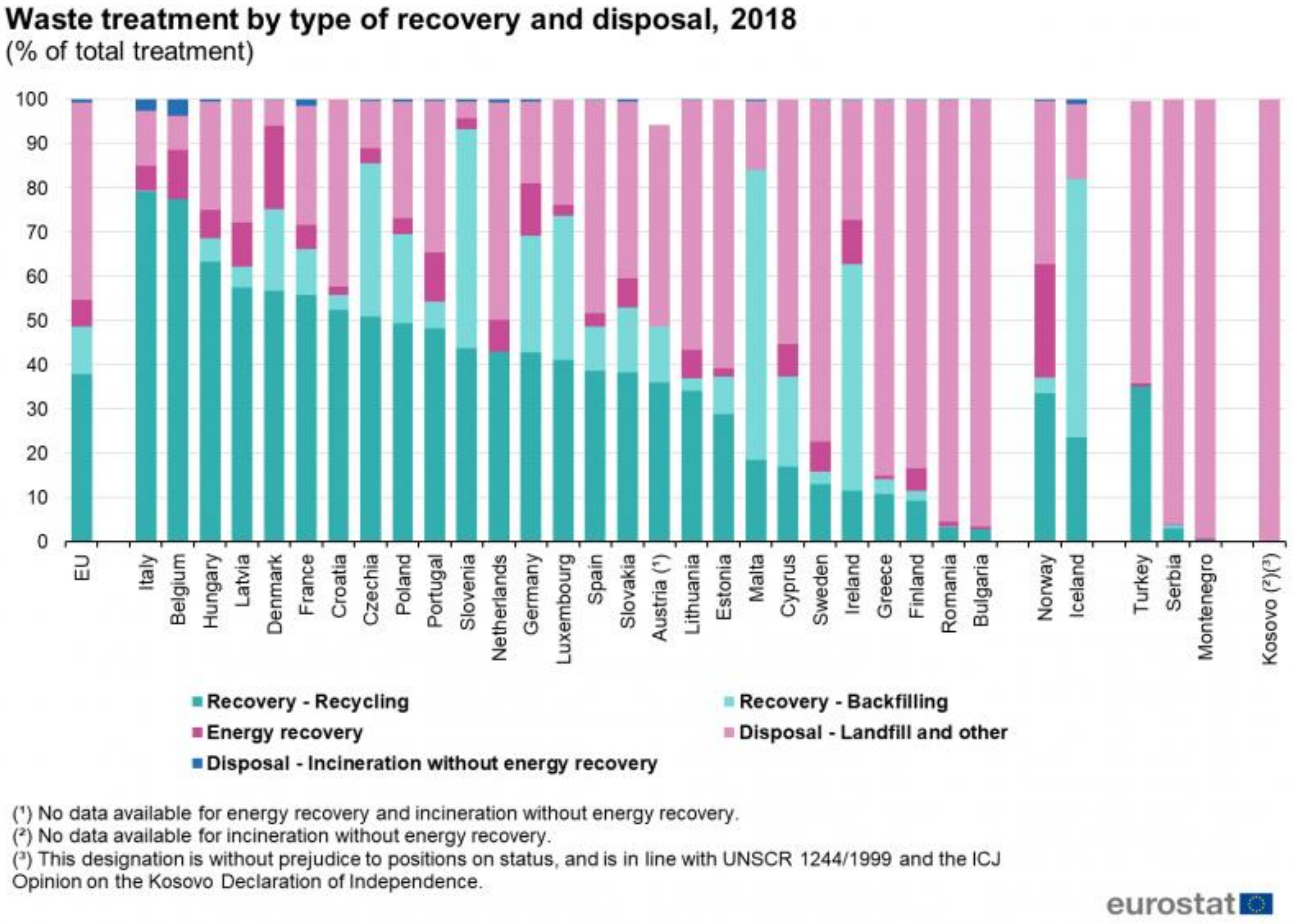
- Special thanks to:
  - Municipality of Heraklion and ESDAK
  - Mr. Georgios Iliopoulos and the EPTA Team
  - Mr. Papazisis and the Thalis Team.

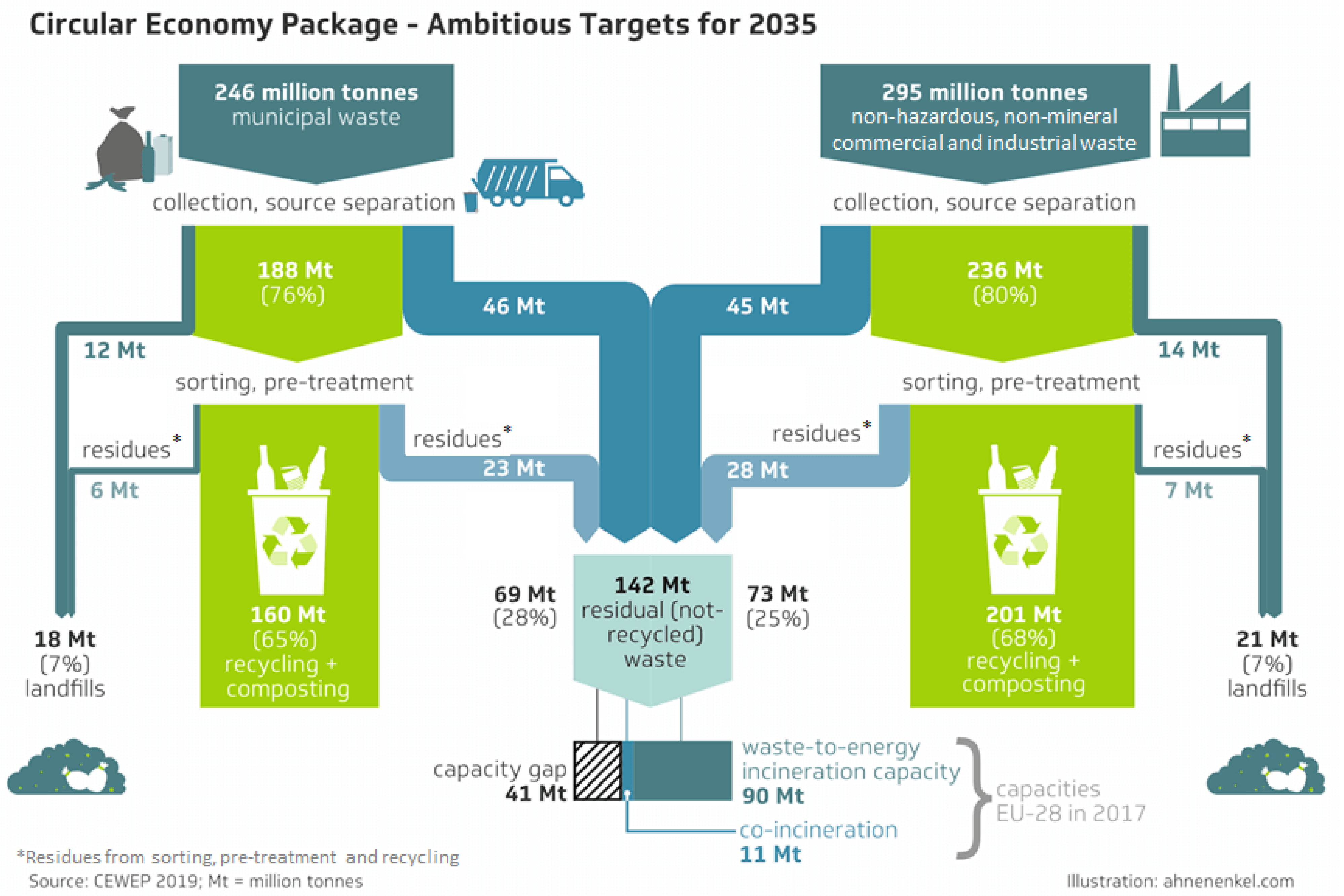
Development of a demonstration waste gasification unit in the Environmental Park of the Circular Economy of Heraklion - ESDAK

A brief overview of WM situation in Greece

- In the EU (on average) only 22.6% of waste ends up in landfills but in Greece this number is closer to 80%.
- Under the framework of Circular Economy 65% of MSW should be recycled and less than 10% should be landfilled.
- These values cannot be reached without the integration of waste-to-energy technologies.

Waste Management in the EU





Source: CEWEP website

Circular Economy Environmental Park

Green point

Upgrading of WTS for biowaste

Pilot unit F4F

Pilot unit for bioplastics

Pilot unit of mech. composting

Upgraded MBT

Pilot unit for gasification of MBT residues

Methodology – How to choose a gasifier?

1. Calculation of elemental waste composition based on their qualitative and quantitative characteristics - Performance of gasifiers
2. Thermodynamic modeling aimed at the indicative quality of the produced synthesis gas
3. Research on commercial technology MSW modern technology gasifiers
4. Development and implementation of a Multi-Criteria Analysis and Decision-Making tool I. - Selection of gasification groups (Group C)
5. Development and implementation of a Multi-Criteria Analysis and Decision-Making tool II - Selection / proposal of a specific technology

Available residues for energy recovery

- The residues of the MBT can be used as fuel and are estimated at 18,511 tons / year, with a moisture content of less than 15% by weight and particle size up to 25mm.
- 23% (4,200 tn / year) of the above material is planned to be pelletized.
- The final product (fuel pellet) is estimated at 4,000 tn / year with a moisture content of less than 12% by weight
- Estimated calorific value between 15.5 and 16.0 MJ / kg.

1. Waste Formula Calculator - 1

Material	**Quantity/y (t)**	**%**
Organics	5.174,20	28,0%
Paper - Carton	3.512,00	19,0%
Plastics	7.002,20	37,8%
Glass	125,84	0,7 %
Metals	592,28	3,2%
Rest	2.104,20	11,4%
Total	***18.511***	***100,0 %***

1.1 Waste Formula Calculator – example

FILL HERE (ONLY THE BLACK FONTS)

FORMULA

mass % of elements	C	H	O	N	water
	41.4	4.07	25.7	0.32	24.6

##			weight (grams per kilo of waste)								
		% weight	C	H	O	N	H2O	C	H	O	N
C6H	paper	15.00%	293.3333333	40.740741	325.92593	0	340	44	6.1111111	48.888889	0
C31	carton	4.00%	421.8556701	38.556701	199.58763	0	340	16.874227	1.542268	7.9835052	0
don	wood	6.00%	435	52.2	365.4	8.7	138.7	26.1	3.132	21.924	0.522
don	garden waste	7.00%	350	42	294	7	307	24.5	2.94	20.58	0.49
C6H	Cellulose	0.00%	444.4444444	61.728395	493.82716	0	0	0	0	0	0
C_{34}H	Lignin	0.00%	639.1752577	58.419244	302.4055	0	0	0	0	0	0
C5H	Hemicellulose	0.00%	396	66	528	0	10	0	0	0	0
	Textiles	6.00%	487.1005917	59.921105	432.9783	0	20	29.226036	3.5952663	25.978698	0
C5H	rubber	1.50%	882.3529412	117.64706	0	0	0	13.235294	1.7647059	0	0
	leather	1.50%	428.269	28.799	340.014	13.1918	189.7262	6.424035	0.431985	5.10021	0.197877
C10	PET	0.00%	625	41.666667	333.33333	0	0	0	0	0	0
C2H	PVC	0.00%	888.8888889	111.11111	0	0	0	0	0	0	0
C3H	PP	0.00%	857.1428571	142.85714	0	0	0	0	0	0	0
C2H	PE	0.00%	857.1428571	142.85714	0	0	0	0	0	0	0
C8H	PS	0.00%	923.0769231	76.923077	0	0	0	0	0	0	0
	plastics	37.80%	591.2144703	46.236003	242.54953	0	120	223.47907	17.477209	91.683721	0
	food waste	17.30%	176.3	21.648	200.572	11.48	590	30.4999	3.745104	34.698956	1.98604
iner	metals	3.20%									

1.2. Elemental composition of the available waste

C	**41.43% ***	54.94%	52.20%	49.45%	**48.35%**	46.70%	43.96%
H	**4.07%***	5.40%	5.13%	4.86%	**4.75%**	4.59%	4.32%
O	**25.68%***	34.06%	32.36%	30.65%	**29.97%**	28.95%	27.25%
N	**0.32%***	0.42%	0.40%	0.38%	**0.37%**	0.36%	0.34%
Τέφρα	**3.90%***	5.17%	4.91%	4.65%	**4.55%**	4.40%	4.14%
Υγρασία	**24.59%***	0.00%	5.00%	10.00%	**12.00%**	15.00%	20.00%

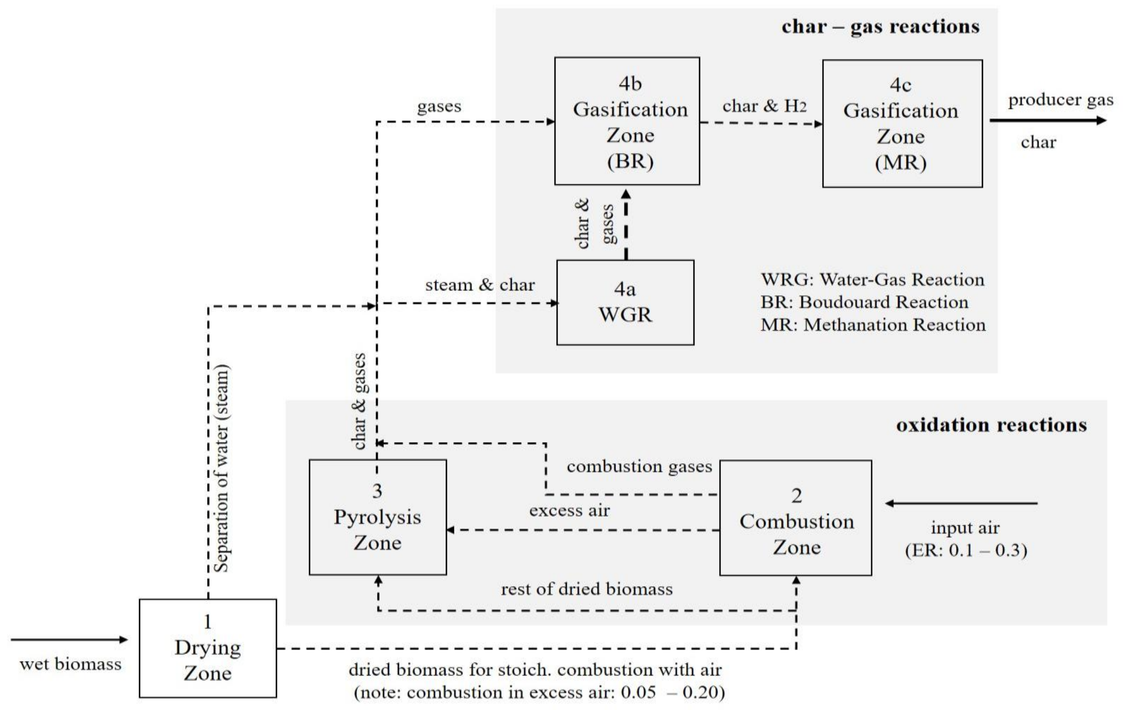
* With calculated moisture

2.1. Thermodynamic modeling

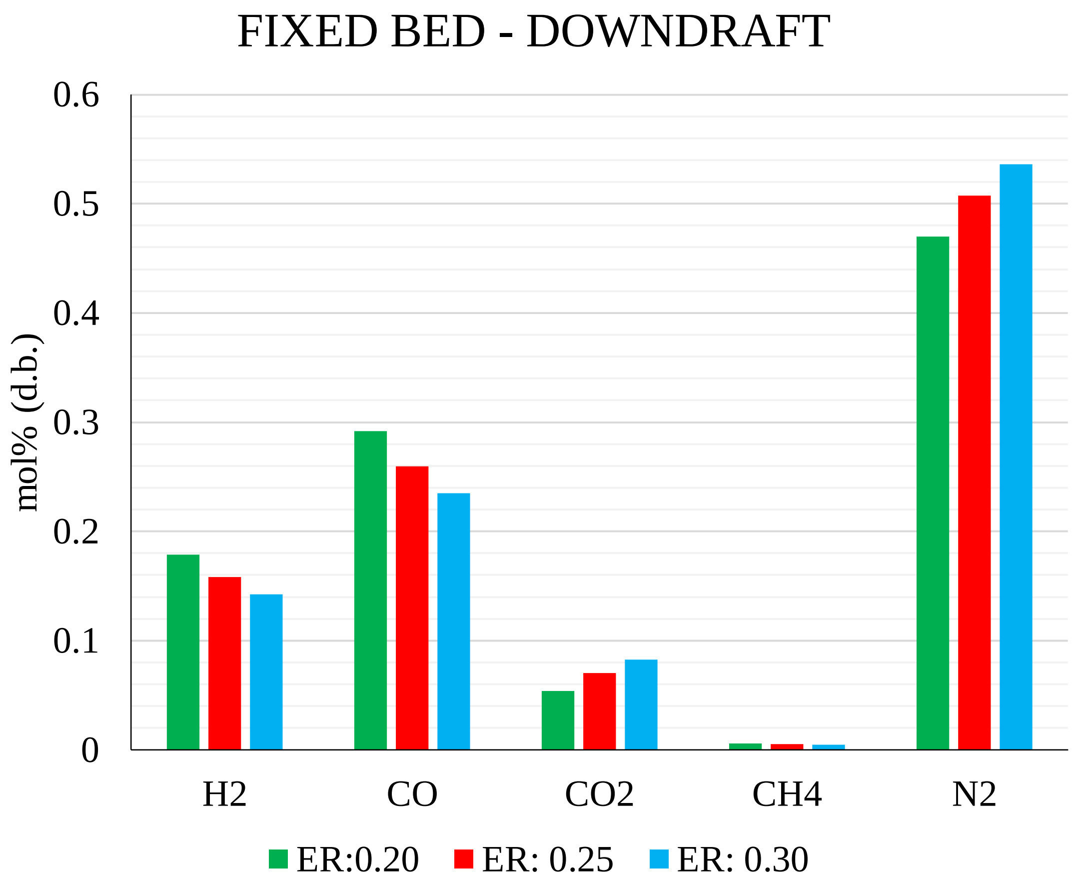
Use of the MAGSY model

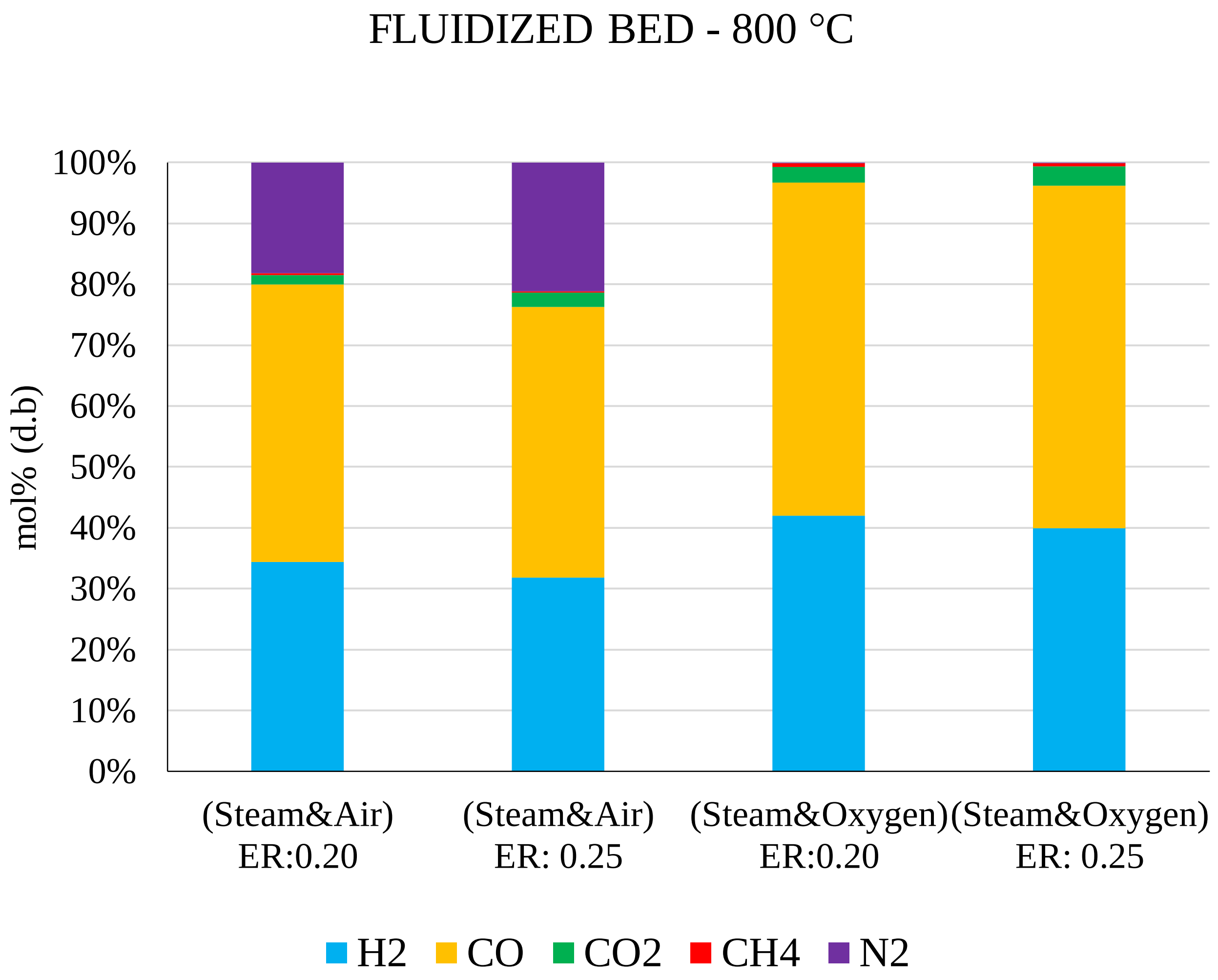
Analysis of different gasification technologies

Use of different gasification mediums



2.2. Thermodynamic modeling





3. State – of – the- art and categorization of gasifiers

- Group A → < 50 kWe biomass gasifiers
  - air gasifiers, fixed-bed
  - pellets/ chips
- Group B → 100 kWe - 500 kWe biomass gasifiers
  - Mostly air gasifiers, fixed-bed and some unique design (rising cc, fluidized beds)
  - Various biomass pretreatment but mainly pellets/ chips
- Group C → up to 2 MWe waste gasifiers
  - Steam/air gasifiers, fluidized beds and some fixed bed designs
  - pellets/ chips for fixed bed
  - Shredded biomass for fluidized beds, some unique designs
- Group D → > 2 MWe waste gasifiers
  - Steam/ oxygen gasifiers
  - Shredded biomass, also ‘as is’
  - Most are two stage combustion facilities

4. Multicriteria Decision Analysis I (MCDA)

- Multicriteria Decision Analysis was utilized for the selection of the optimal group
- For a given problem, a set of criteria is defined. Each criterion has a weighting factor that corresponds to its significance.
- MCA overcomes the mathematical obstacle of maximizing for more than one parameters simultaneously.
- Different methodologies can be applied for this “optimization”
  - Outranking method – PROMETHE II (Degree of superiority of one alternative over another)

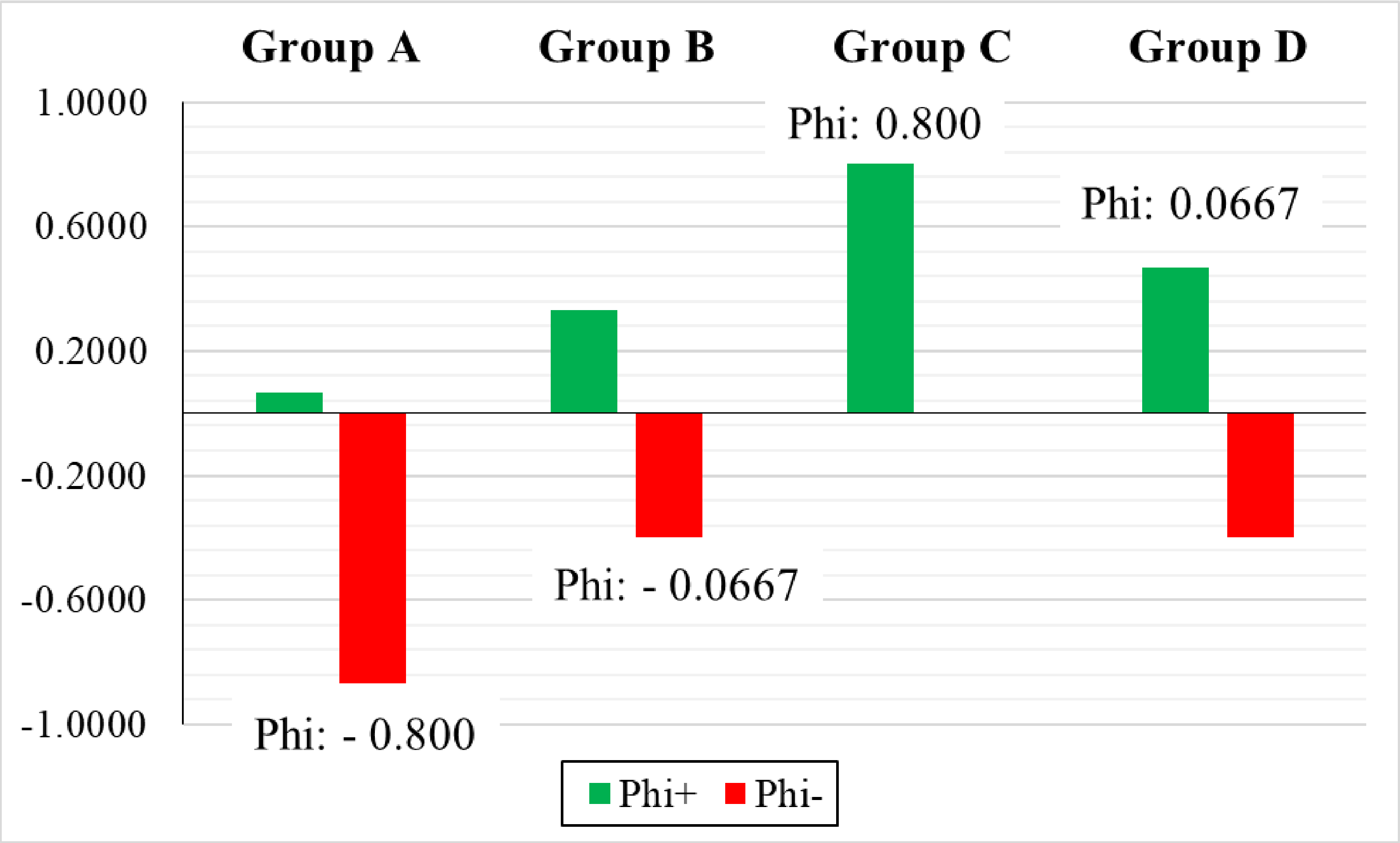
4. Assigning values for MCDA

	Group A	Group B	Group C	Group D
Ability to handle waste (SRF)	1	2	5	4
TRL	4	5	5	5
Gasification medium	1	2	5	4
Gas upgrading capabilities	2	2	4	3
Land use	3	5	4	2

4. Weighting factors for scenario analysis

	Scenario 1	Scenario 2
Ability to handle waste (SRF)	0.2	0.3
TRL	0.2	0.3
Gasification medium	0.2	0.1
Gas upgrading capabilities	0.2	0.2
Land use	0.2	0.1

4. Multicriteria Analysis results



Note: Results from scenario 1 analysis

4. Group C – Comments on technologies

- For most technologies, the use of a fluidized bed reactor becomes a common place.
- A few fixed-bed alternatives exist in the market but are limited on the ability to process complex feedstock
- Successful technologies use dual stage reactors or circulating fluidized beds in order to optimize the heat transfer
- The downscaling of gasifiers can be limited by the retention time that is needed for the production of high-quality syngas
- Several dual-stage designs combust the produced syngas

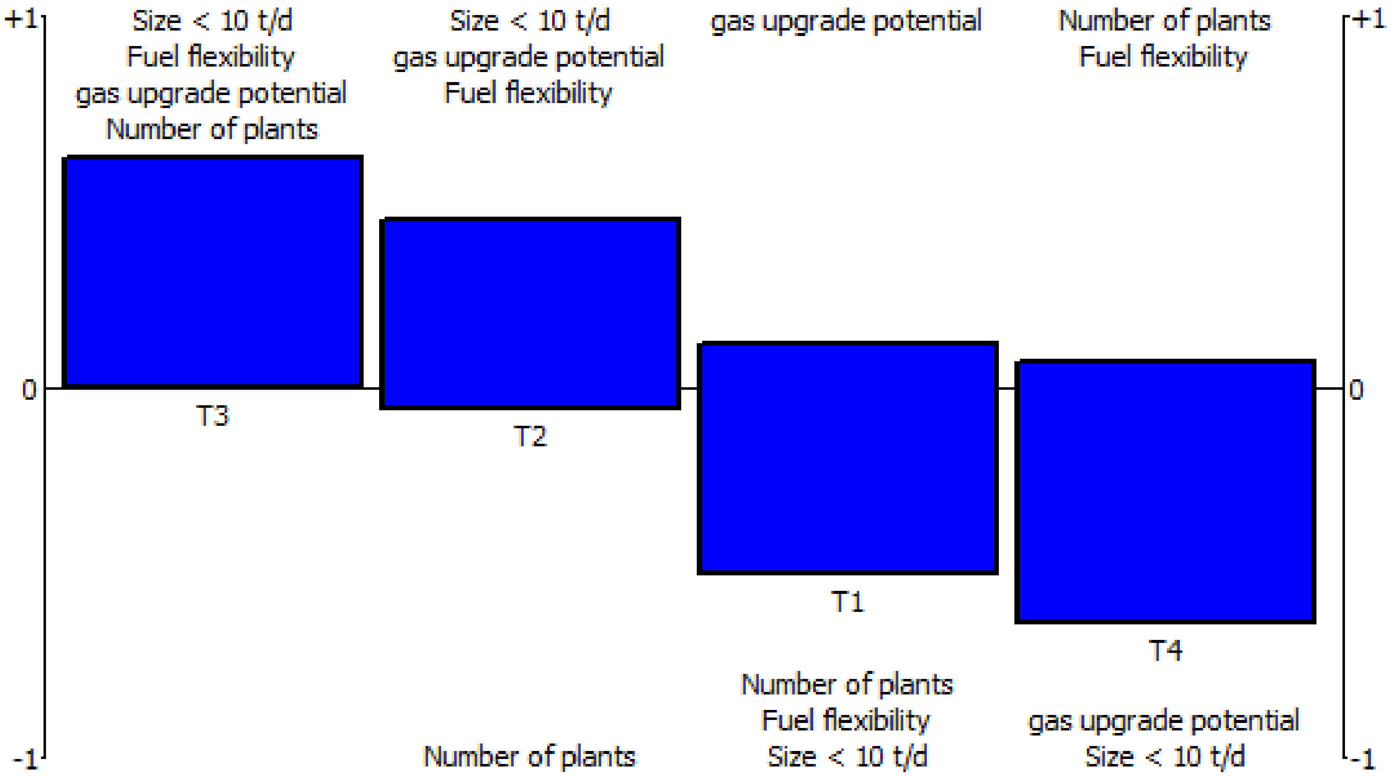
5. Multicriteria Decision Analysis II
Selection of a specific technology

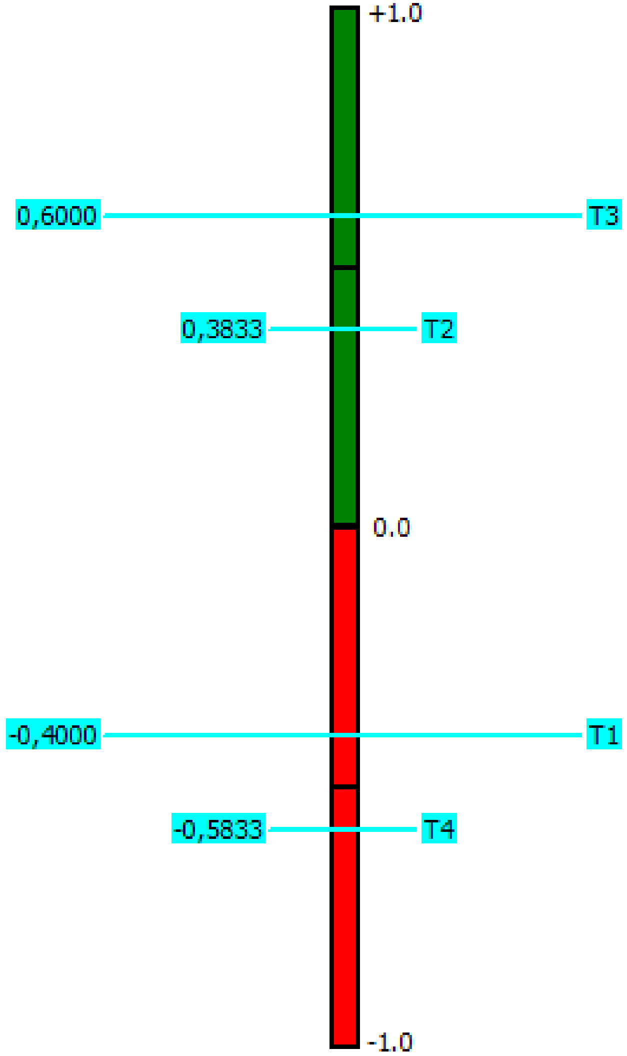
- Selection of best candidate technologies from group C.
- Categorization according to operating characteristics
- Development of criteria for analysis
- Development of weights

5. Selected criteria - MCA II

	Weighting factor
Fuel Flexibility	0.15
Gas upgrade possibility	0.30
Size limitations	0.50
Developed units	0.05

5. Results - MCA II

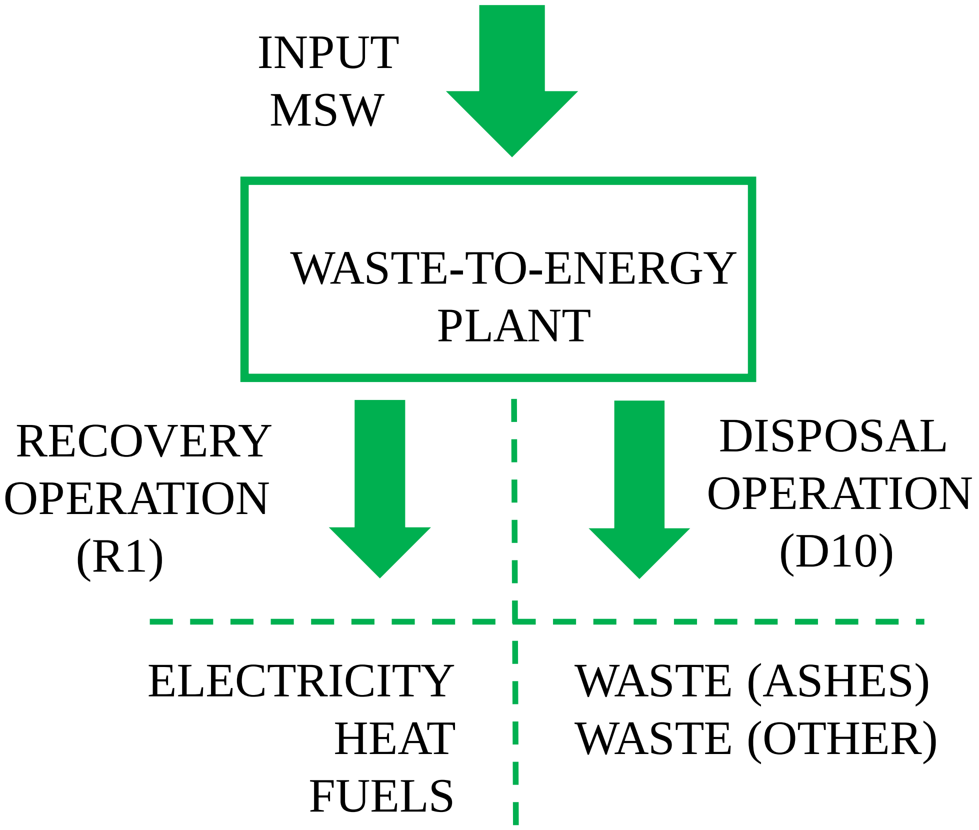




6. Challenges of WtE in Greece

- Waste-to-Energy has social acceptance issues in Greece.
- Greece has the peculiarity of having a relatively small cities.
- Misconception 1: Initially the expectation was that the organic stream (gasification feedstock) would be relatively pure.
- Misconception 2: The established knowledge and technologies in the field of biomass gasification could be utilized.
- Challenge 1: Characterization of the material (available in 2 years).
- Challenge 2: The sizing of the facility, economy of scale.
- Challenge 3: Management of the output (e.g. price of kWh).

The dual nature of waste-to-energy



Directive 2008/98/EU

(of the European parliament and of the council of 19 November 2008 on waste)

1. Waste is used principally as a fuel for energy generation and thus they belong to category 1 of the Recovery Operations (ANNEX I), i.e. R 1.

2. The residues of the treatment are landfilled on land and thus they belong to category 10 of the Disposal Operations (ANNEX II), i.e. D 10.

6. Opportunities - Beyond the R1

- This facility is the first meaningful step in Greece in order to achieve the Circular Economy targets
- Size is a limitation but also an opportunity
  - The sizing of the Park makes gasification the optimal choice
- The future lies beyond the R1 (Use principally as a fuel or other means to generate energy. Heat should be neglected as well)
  - R2 → preparation of secondary liquid fuels (SLF)
  - R4 → Recycling/reclamation of metals and metal compounds
  - R12 → Sorting, pretreatment of waste
- WtE facilities should be treated as biorefineries

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Beyond the R1: A viable pathway for waste-to-energy in the circular economy framework

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First Published September 28, 2021 | Editorial | Find in PubMed | Check for updates
https://doi.org/10.1177/0734242X211050431

Article information

Article Information

Volume: 39 issue: 10, page(s): 1215-1217
Article first published online: September 28, 2021; Issue published: October 1, 2021

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https://journals.sagepub.com/doi/10.1177/0734242X211050431

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