Silesian University of Technology

The evaluation of energy consumption in transportation and processing of municipal waste for recovery in a waste-to-energy plant

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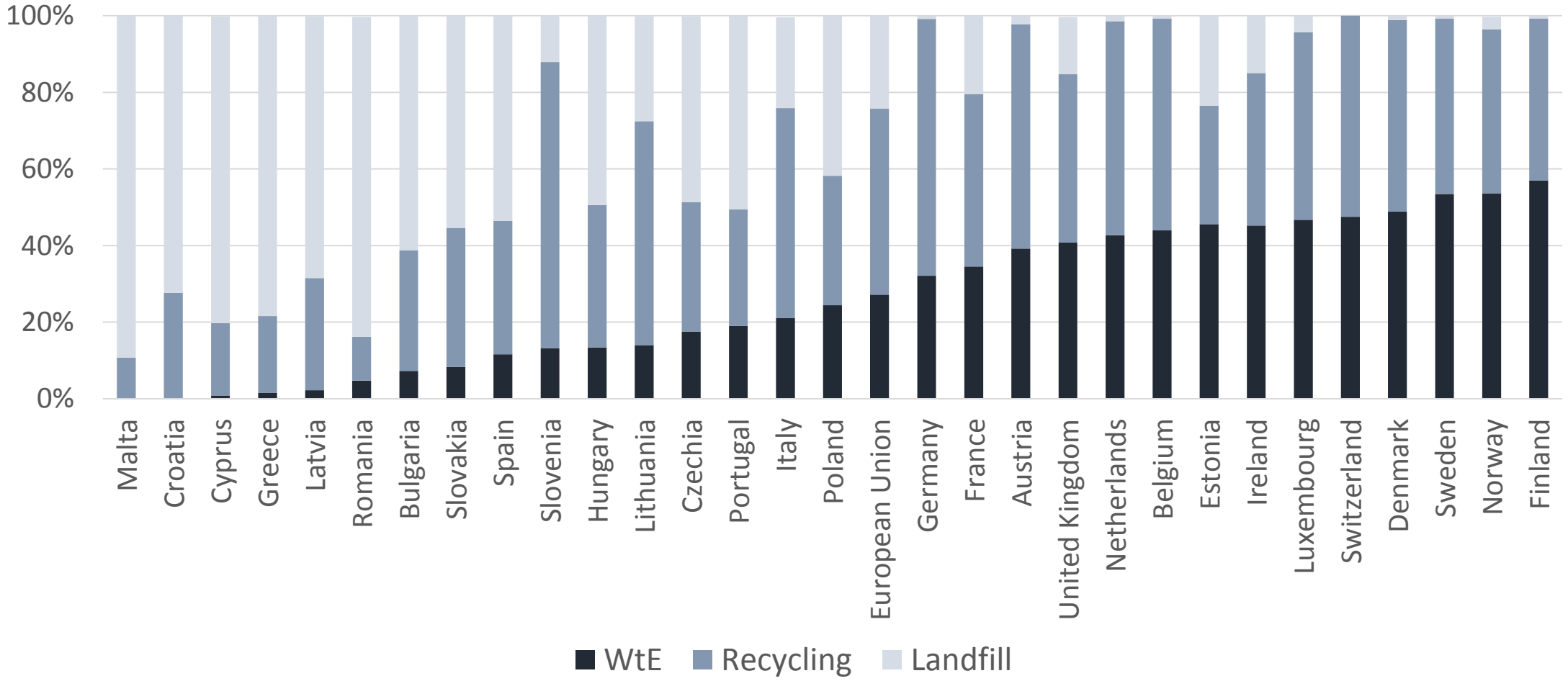
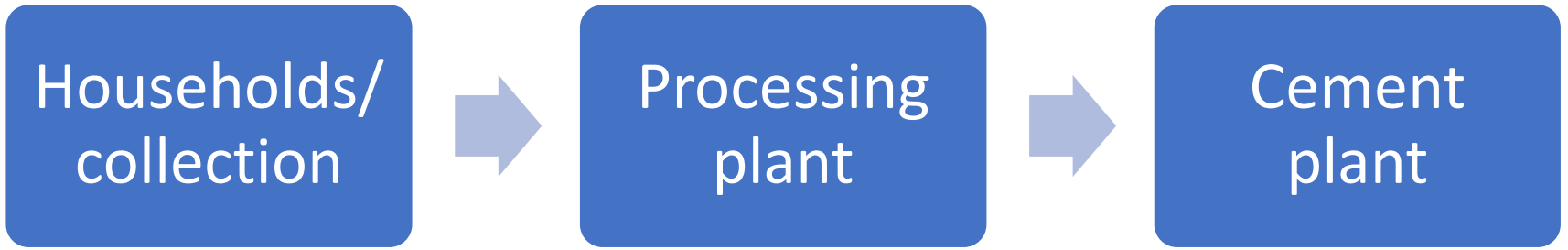
Municipal waste management operations in the EU in 2018



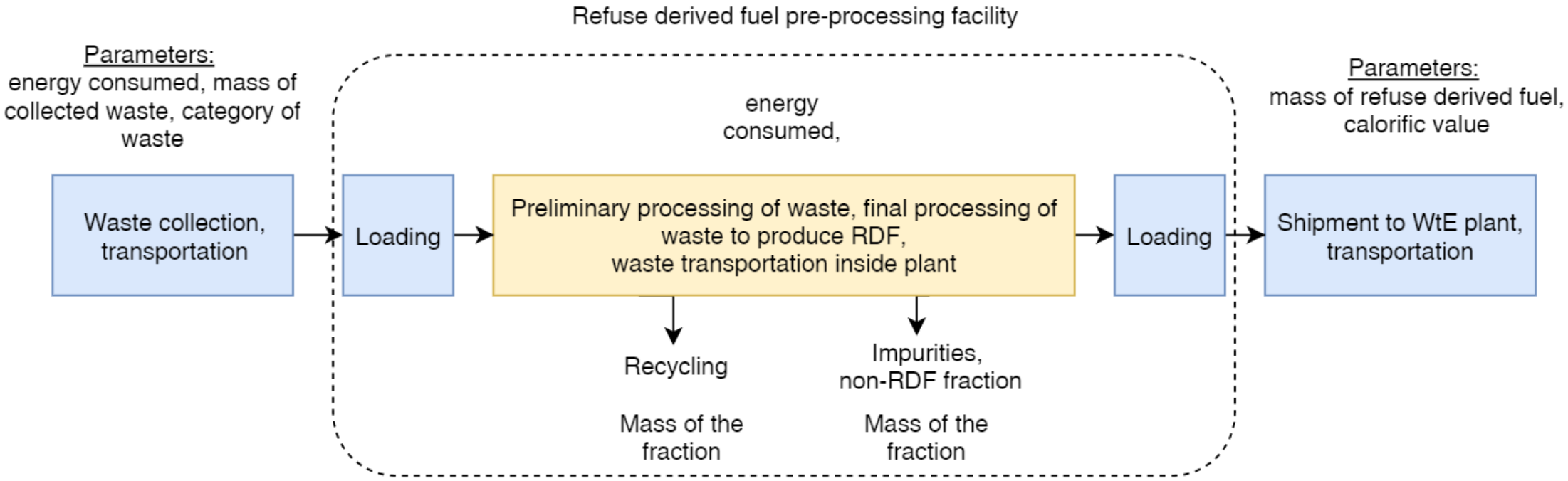
A purpose of this study

This study focuses on the evaluation of energy consumption in the entire reverse supply chain of the bulky and MSW.

The primary source of waste is households and the final destination is a WtE plant – the cement plant. This study identifies and evaluates the energy consumption for each of the operations including waste collection, transportation, handling, processing, compacting, and final shipment to a waste-to-energy plant.



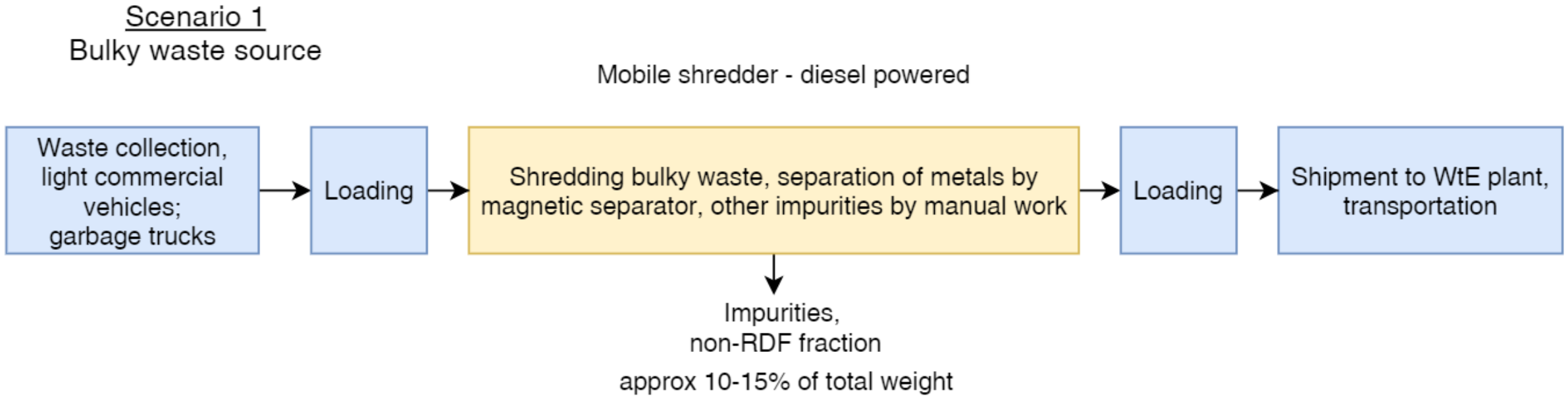
Introduction - generic material and energy flow



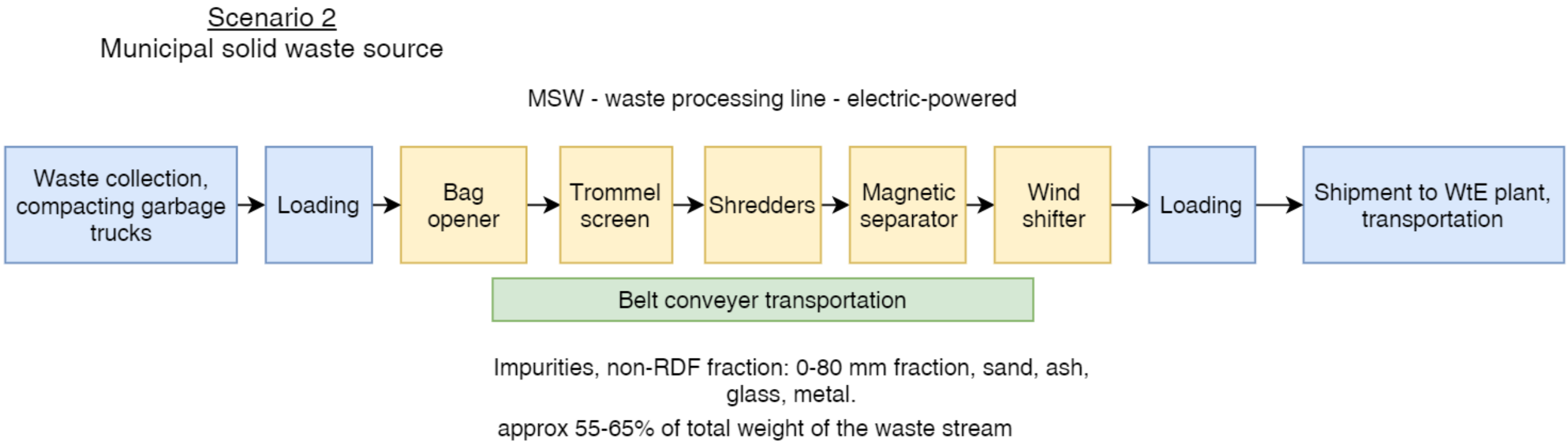
Calorific value of Refuse Derived Fuel

Energy consumed – fuel, electricity

Scenario 1 – collection and processing bulky waste



Scenario 2 – collection and processing municipal solid waste



Examples of waste handling and processing machines

Loading machine

Shredder and conveyors

Wind shifter

Categories of waste collection vehicles

Waste collection

Light commercial vehicles (LCV)

Garbage truck (GT)

Walking Floor Trailer (WFT)

RDF shipment

Tipper Semi-Trailer (TST)

Energy consumed and potential of calorific value

Energy consumption of fuel and electricity in transportation and processing of waste:

$$\mathbf{E_{loss} = C_{RDF} - E_C} \quad \mathbf{[MJ/rmu]} \quad (1)$$

where: C_{RDF} – is the calorific value of reference mass of RDF and E_C is the energy required for transportation, handling, and processing waste to produce RDF. E_C is energy from fuel combustion in vehicles and electric energy required in the processing, as MJ per reference mass unit (mass of RDF in one shipment).

$$\mathbf{E_C = E_{col} + E_{proc} + E_h + E_t} \quad \mathbf{[MJ/rmu]} \quad (2)$$

where:

- E_{col} – the calorific value of fuel in waste collection and transportation,
- E_{proc} – the calorific value of fuel or electric energy consumption in processing of waste
- E_h – the calorific value of fuel in handling and loading machines in waste processing plant
- E_t – the calorific value of fuel in RDF transportation to the WtE plant

All values are converted to MJ/rmu (reference mass unit) – one shipment to the WtE plant.

Results of energy consumption in transportation, handling and processing of the bulky for various transportation modes

Scenario – collection vehicle type	Average mass of waste in collection [t]	Traveled distance per one collection [km]	E_{col} [MJ/mru]	E_{proc} [MJ/mru]	E_{proc} [MJ/mru]	E_{proc} [MJ/mru]	Type of vehicle and calorific value [MJ] of refuse derived fuel in one shipment Average load : TST – 5 [t]; WFT – 12 [t];	Total energy consumption for all processes As [%] of calorific value of RDF
Collection of bulky waste			Calculated per one full shipment depending on a type of heavy goods vehicle					
1 – LCV	2.2 – 3.2	70 – 170	440 – 1680	234	315	3110	TST – 110 000	**3.7% – 4.8%**
2 – LCV	2.2 – 3.2	70 – 170	1040 – 4040	560	756	3920	WFT – 264 000	**2.3% – 3.5%**
3 – GT	12 – 17	70 – 170	250 – 1410	234	315	3110	TST – 110 000	**3.5% – 4.6%**
4 – GT	12 – 17	70 – 170	580 – 3430	560	756	3920	WFT – 264 000	**2.2% – 3.3%**

Results of energy consumption in transportation, handling and processing of MSW for various transportation modes

Scenario – collection vehicle type	Average mass of waste in collection [t]	Traveled distance per one collection [km]	E_{col} [MJ/mru]	E_{proc} [MJ/mru]	E_{proc} [MJ/mru]	E_{proc} [MJ/mru]	Type of vehicle and calorific value [MJ] of refuse derived fuel in one shipment Average load : TST – 5 [t]; WFT – 12 [t];	Total energy consumption for all processes As [%] of calorific value of RDF
Collection of municipal solid waste			Calculated per one full shipment depending on a type of heavy goods vehicle					
5 – GT	6 – 12	60 – 110	540 – 3900	2700	430	3110	TST – 110 000	**6,8% – 10,7%**
6 – GT	6 – 12	60 – 110	1620 – 9070	6480	950	3920	WFT – 264 000	**5.4% – 8.5%**

Conclusions

- The selection of vehicles and route length is a critical factor to minimize energy consumption in waste collection.
- The final shipment of the RDF is the most efficient by using vehicles with high capacity. The most profitable method of collecting waste from households is by a compacting garbage truck.
- A collection of the bulky waste and considering energy recovery potential is more profitable comparing to mixed municipal solid waste. In total, waste collection by LCV and GT requires up to 4.8% of energy to be recovered from RDF.
- Production of RDF from MSW consumes more energy – especially for collection and processing. In the least advantageous variant, almost 11% of energy for recovery is consumed in the transportation in the waste collection and processing of waste.
- Preparation of optimized routing of waste collection vehicles and collection schedules waste collection companies should consider verification of the vehicles used in the fleet. Higher fuel consumption of walking floor trailers are compensated by a much higher mass of RDF due to properties of the shredded fractions and the possibility of compressing RDF in WFT vehicles.

Thank you for your attention

Σας ευχαριστώ για την προσοχή σας

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