How well can the potential of industrial excess heat be estimated?

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Erwin CORNELIS – Johan VAN BAEL

eceee Industrial Summer Study

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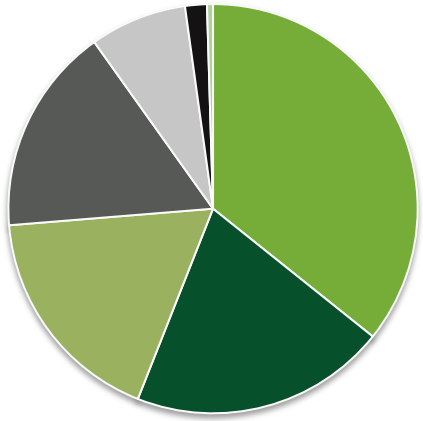
Context of this study

- The recovery of industrial excess heat can make heating in Europe m sustainable

  Results of the STRATEGO project

  - Technical potential of excess heat of 1.222 industrial facilities EU28: ~3 EJ
  - Industrial excess heat can cover 12% of the heat demand for buildings



- Fuel supply - refineries
- Non-metallic minerals
- Iron & steel
- (Petro)chemical
- Paper, pulp & printing
- Non-ferrous metals
- Food & beverage

Aim of this study

- Challenge
  - An accurate estimation of the quantities of industrial excess heat is essential to include it in heating & cooling action plans
- Objective of the paper
  - Comparing three different methods to estimate industrial excess heat
- Aim of the paper
  - Learn more about the accuracy of these estimations

Method of this study

Applied methods to estimate industrial excess heat

- Following the classification of S. Brückner et al. / Renewable and Sustainable Energy Reviews 38 (2014) 164–171

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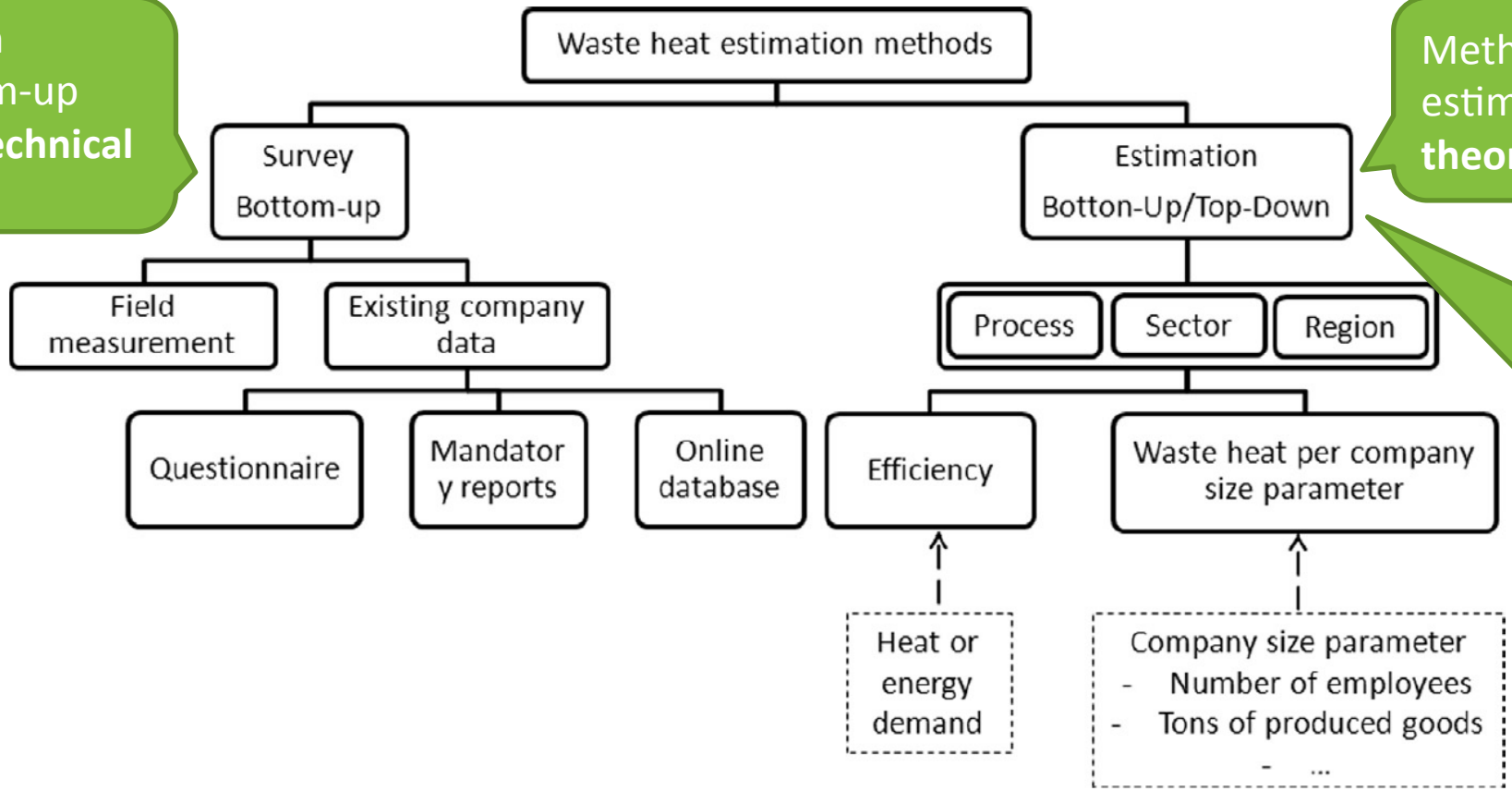
e heat potential



Method 1: a top-do
estimation resulting
theoretical potenti

Method 3
combined
bottom-u
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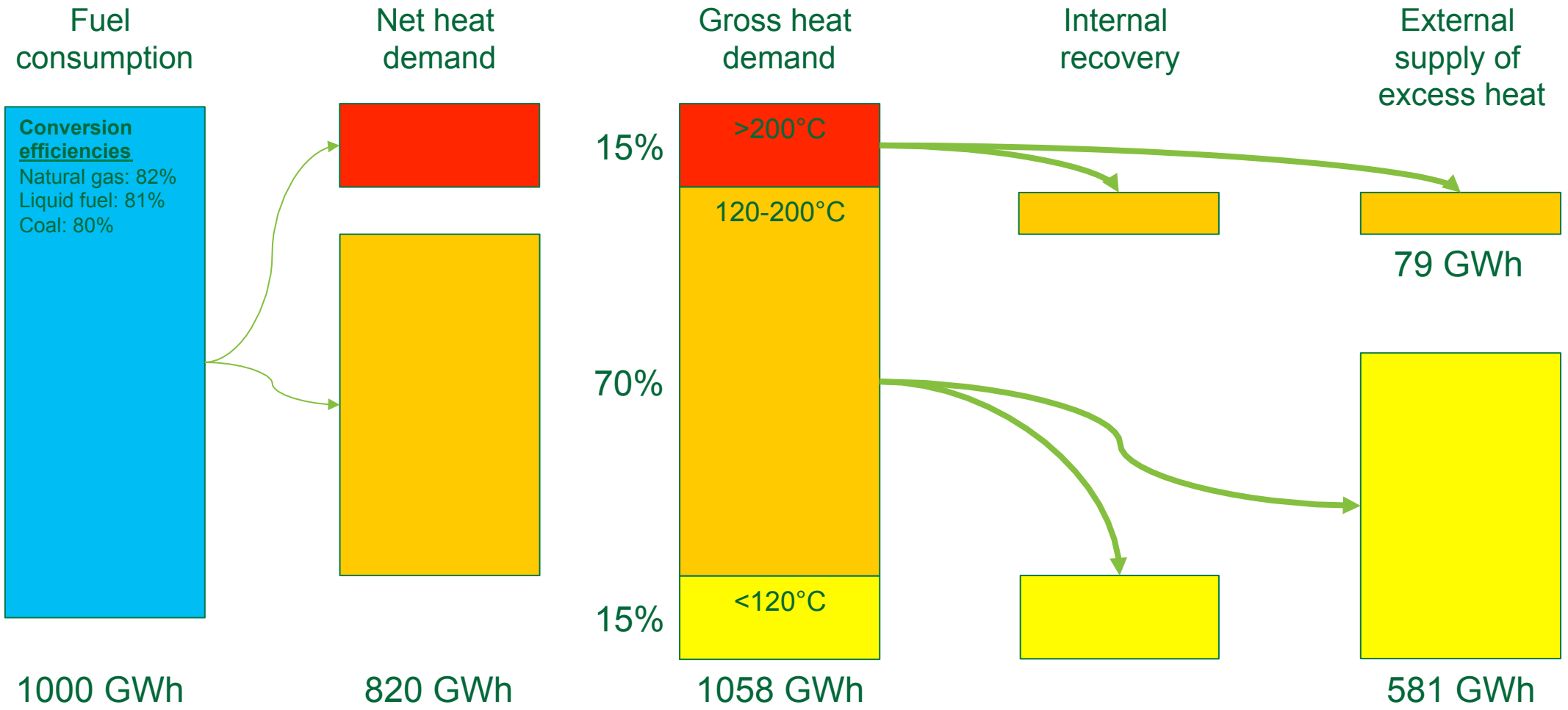
estimatio
resulting
an **techni**
potential

Method of this study

- Method 1: a top-down estimation resulting in a **theoretical** potential
  - Developed in the Netherlands
  - Subdivides the heat demand into three temperature ranges
    - <120°C / in between / >200°C
    - Uses a data set with a distribution of the gross heat demand in these three temperature ranges for 148 subsectors
      - Based on expert judgements
  - Basic assumption
    - Half of the gross heat demand in an upper temperature ranges can be recovered internally
    - The other half is available as excess heat to external heat customers

Method of this study

Method 1: a top-down estimation resulting in a **theoretical** potential



Method of this study

- Method 2: a top-down application of a bottom-up survey resulting in a **technical** waste heat potential
  - Basis: Overview of waste heat in the industry in France – M. Berthou and D. Bory (eceee 2012 paper 4-012-12)
  - Rescaled to data sample of this study
    - Based on ratio between the total amount of excess heat and the fuel consumption
    - For five sectors only

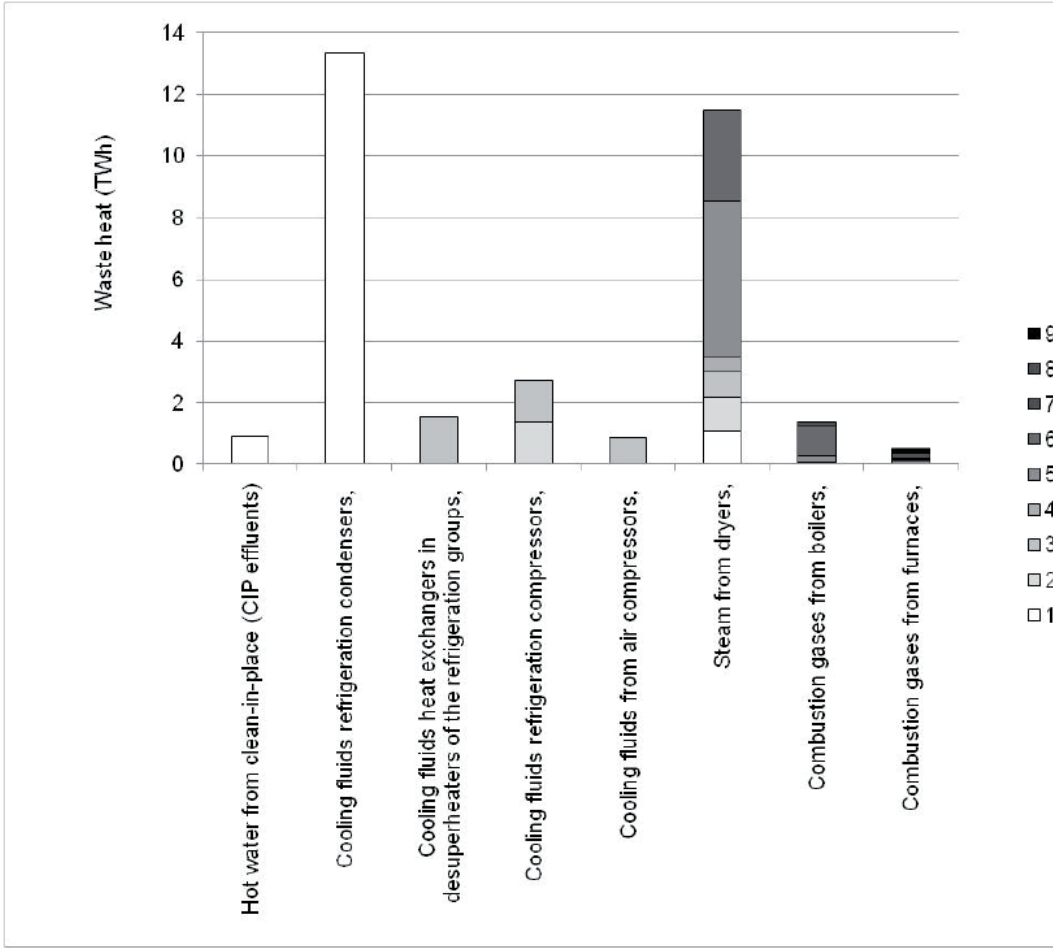


Figure 2: "Food product and beverages": waste heat by warm effluent and by temperature [7].

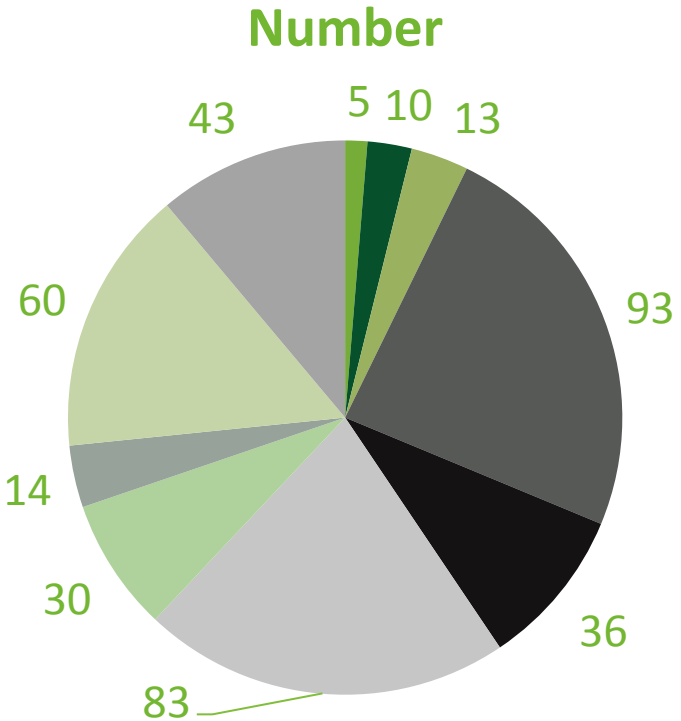
Method of this study

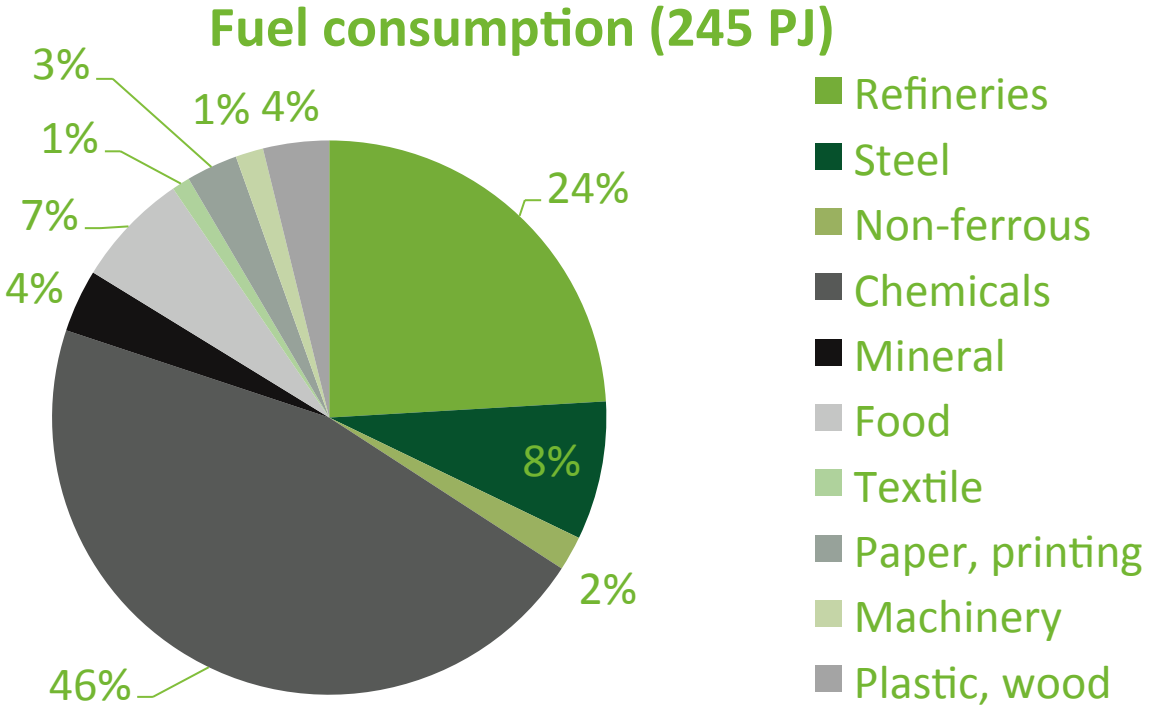
- Method 3: a combined bottom-up/ top-down estimation resulting in an **technical** potential
  - Based on a Swedish study (Cronholm L.-Å. et al. Spillvärme från industrier och lokaler. Svenska Fjärrvärme AB. Rapport 2009:12)
  - Set of sector specific figures indicating the ratio between actual excess heat deliveries and the total heat consumption

Sector	Excess heat / fuel use	Sector	Excess heat / fuel use	Sector	Excess heat / fuel u
Quarrying and mining	3.5%	Paper production	3.2%	Metal processing	8.8%
Food and beverages	8.6%	Oil refineries / chemicals	24.3%	Machinery	2.8%
Textile industry	0%	Plastics	1.2%	Micro-electronics	0%
Wood processing	18.2%	Non-metallic minerals	1.7%	Vehicle assembly	2.7%
Paper and printing	5.8%	Non-ferrous metals	11.2%	Furniture / Waste treatment	30.8%
Pulp	2.8%	Iron and steel	2.5%		

Method of this study

- Used sample of industrial companies
  - 384 most energy-intensive companies in Flanders, Belgium
    - Method 1 and 3: all sectors except textile: 354 companies
    - Method 2: 5 sectors: 286 companies

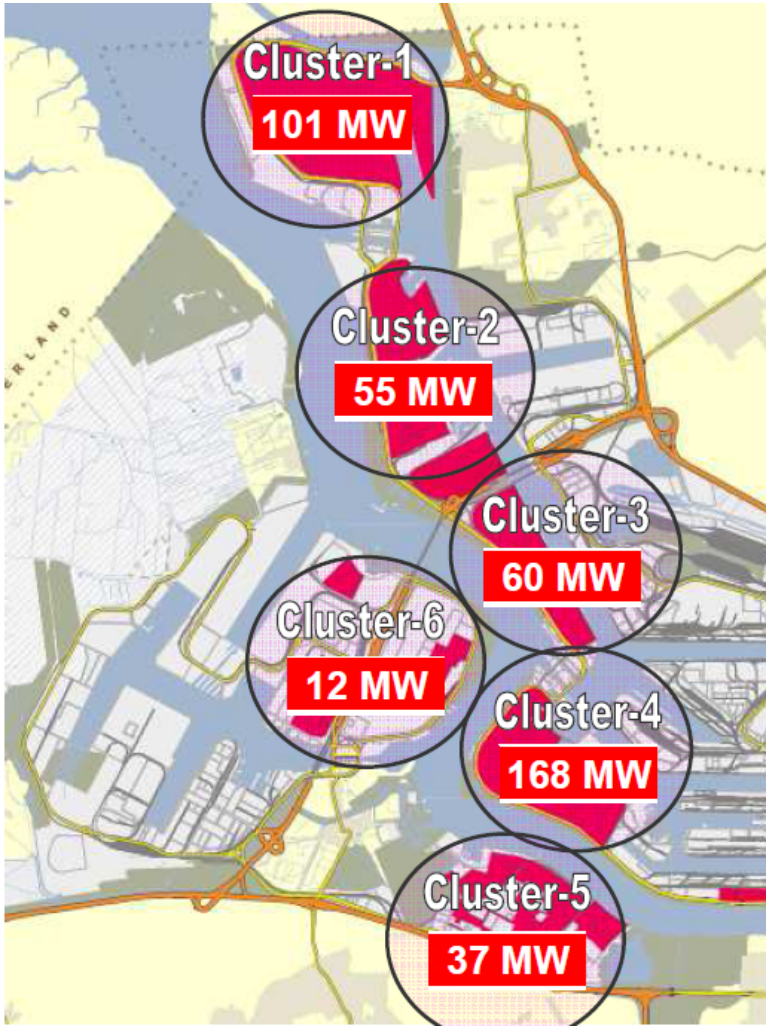




Method of this study

Validation of the estimation results

- Survey 1: estimation of technical excess heat supply in the Port of Antwerp
  - Survey of 3 oil refineries and 15 petrochemical companies (Fuel consumption 175 PJ/a)
  - Focus: 80-120°C / thermal capacity > 1 MW
- Survey 2: technical potential of excess heat of 41 other industrial companies
  - Of which 17 are also part of the study sample
  - Covers 8 sectors
  - Average annual fuel consumption: 5 PJ (4 – 43 PJ)



Results

General conclusion

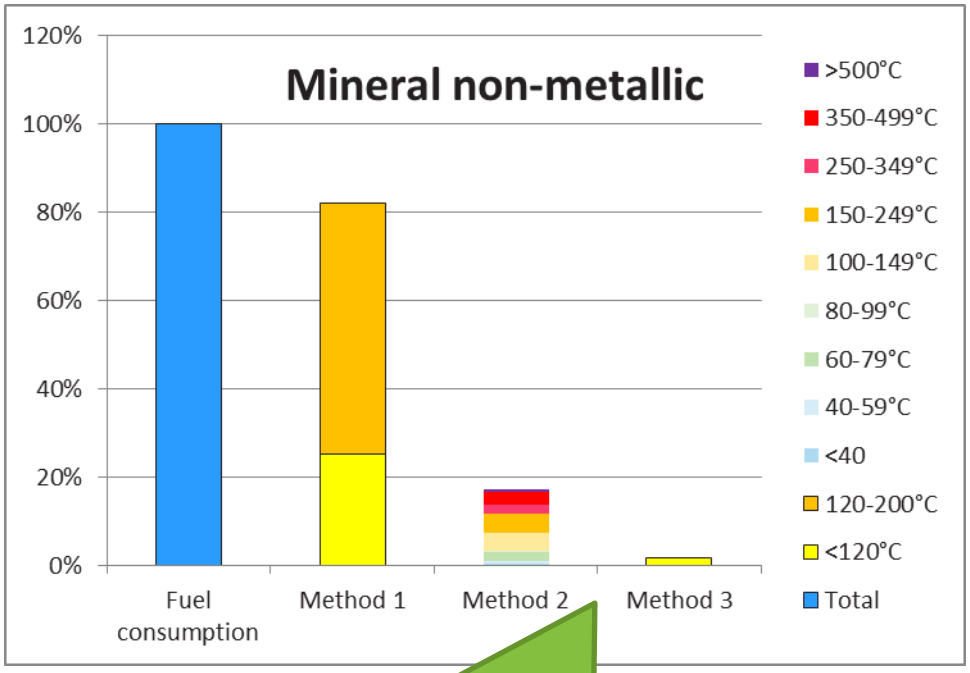
- Method 1 > Method 2 ≅ Method 3

	All sectors (354 companies)		Five sectors (286 companies)	
	PJ / a	Estimation / fuel consumption	PJ / a	Estimation / fuel consumption
Fuel consumption	301		193	
Estimation – method 1 – theoretical	217	72%	134	69%
Estimation – method 2 – technical			40	21%
Estimation – method 3 – technical	58	19%	38	20%

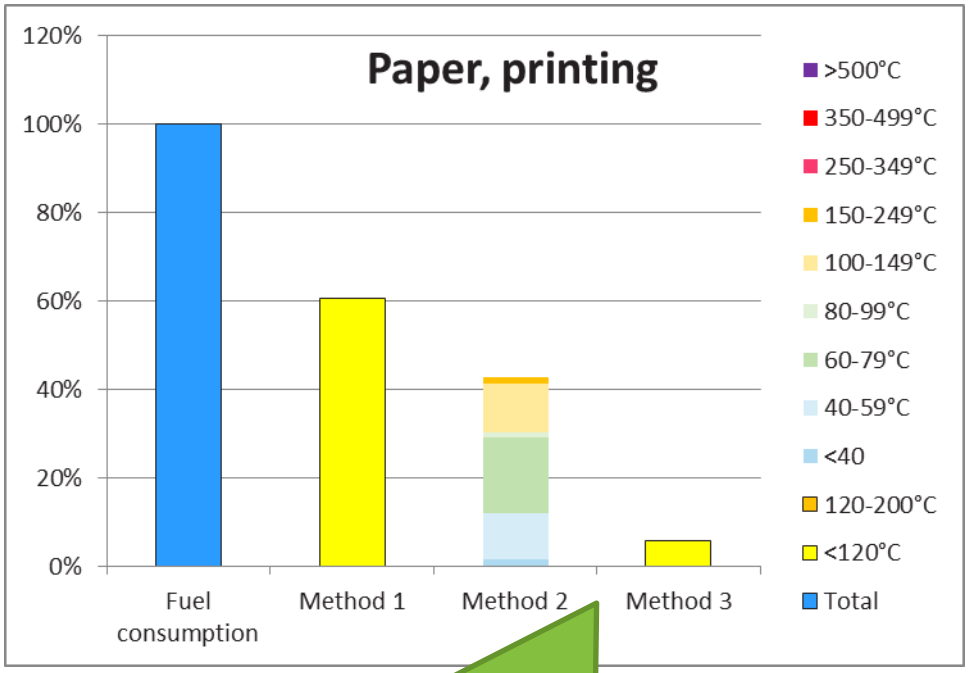
Results

Sectoral differences

Method 1 > Method 2 > Method 3



Method 2: 5% excess heat >250°C
Method 3: no excess heat >250°C

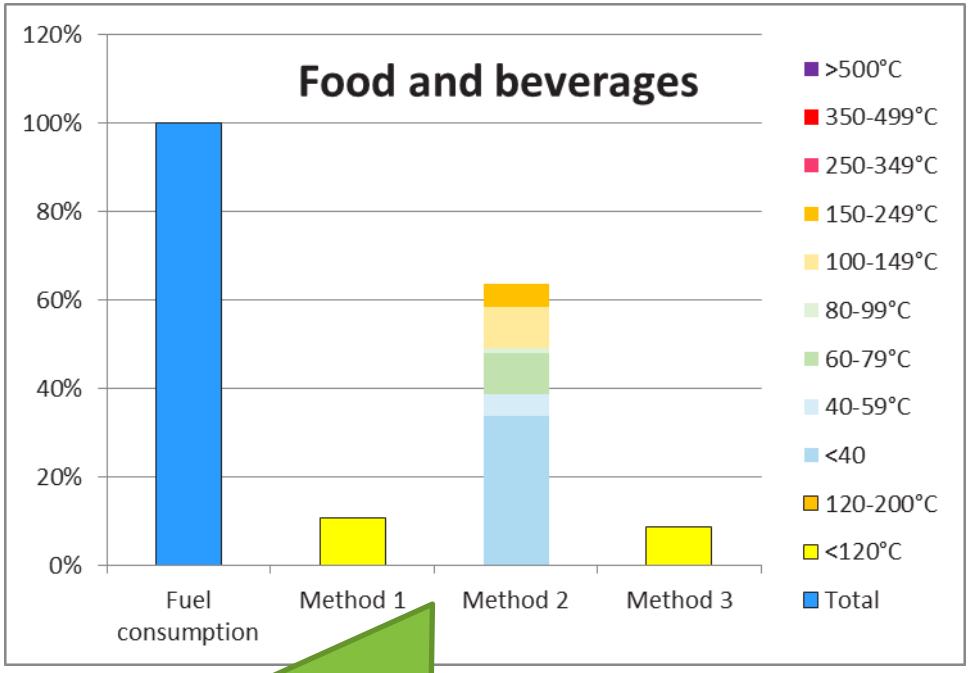


Method 2: 29% excess heat <80°C

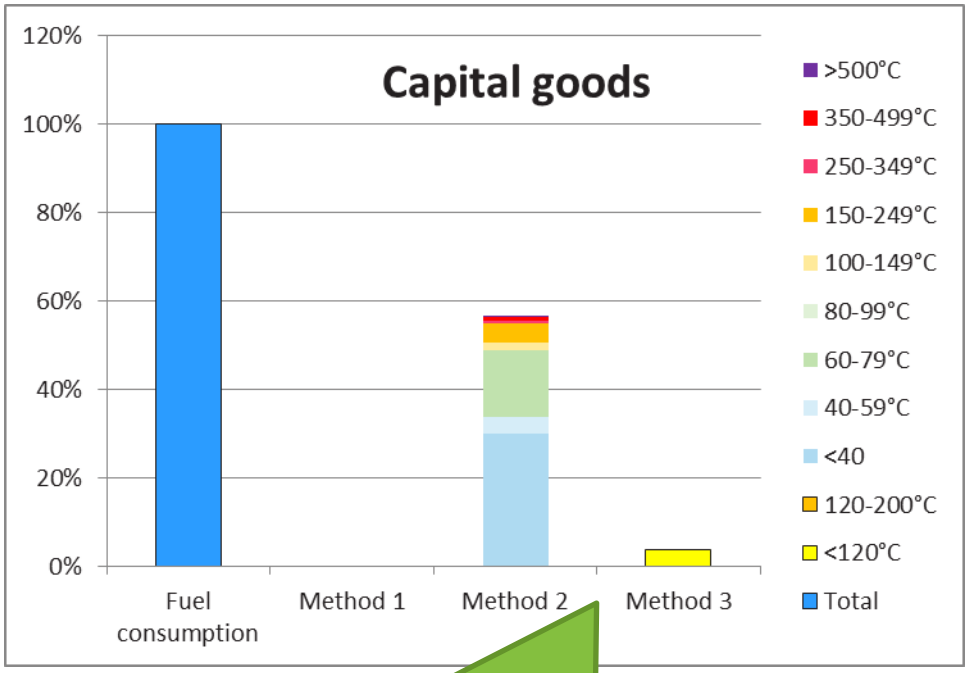
Results

Sectoral differences

Method 2 > Method 1 = Method 3



Method 2: 48% excess heat <80°C
All methods: ~10% excess heat 80-120°C

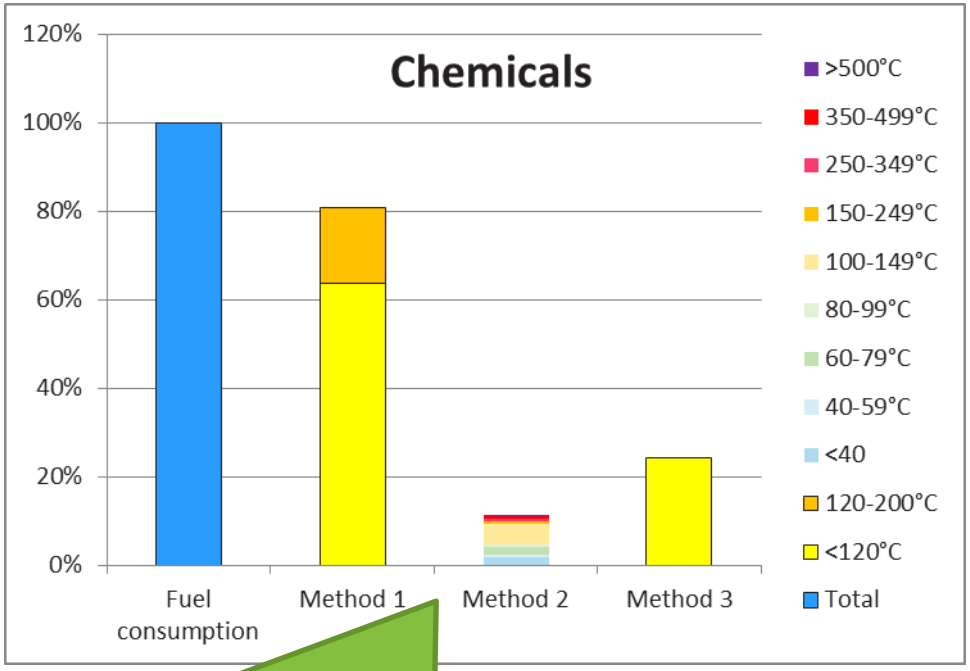


Method 1: no excess heat
Method 2: 49% excess heat <80°C

Results

Sectoral differences

Method 1 > Method 3 > Method 2

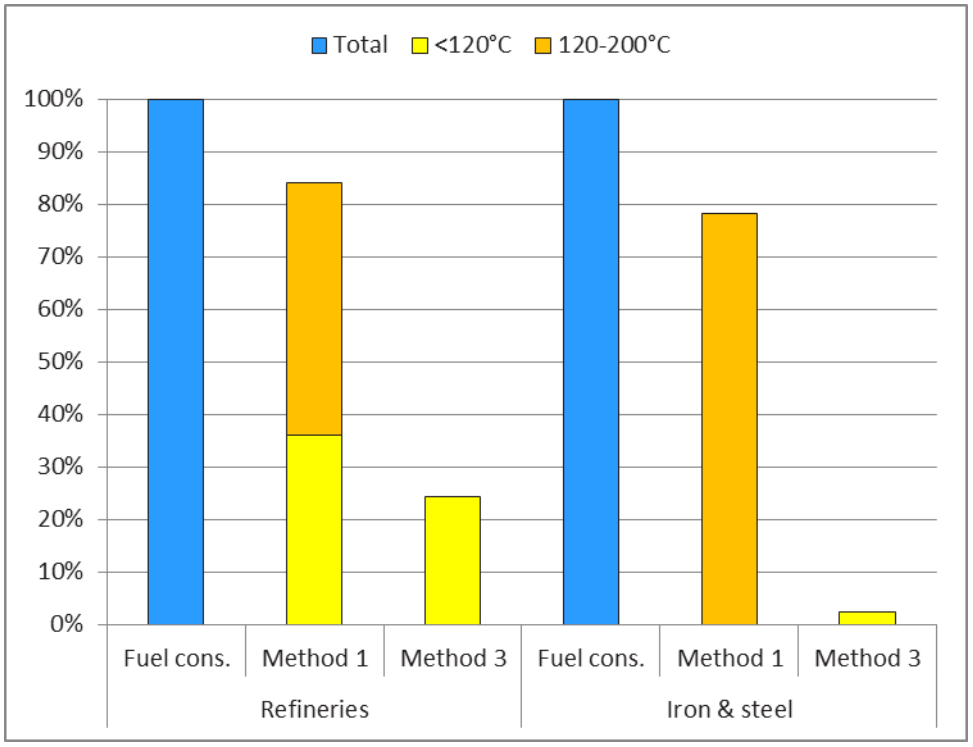


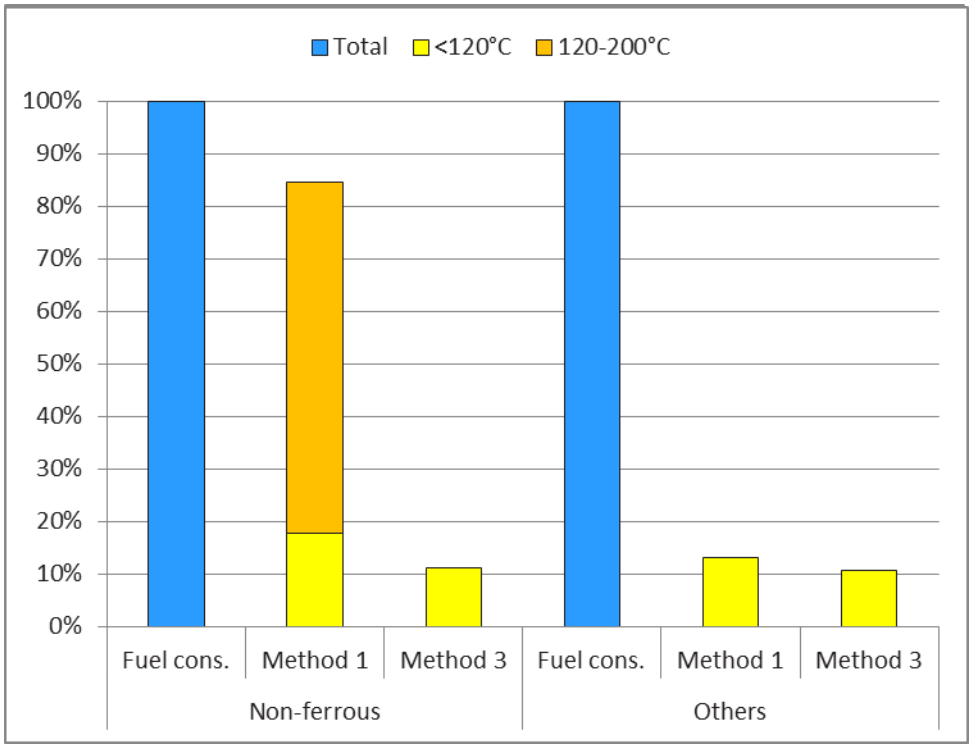
Method 1: 81% > Method 3: 24% > Method 2: 11%

Results

Sectoral differences

Method 1 > Method 3 (Method 2 could not be applied)





Validation of the results

Comparison of survey results with estimations

- Carried out for 2 subsets

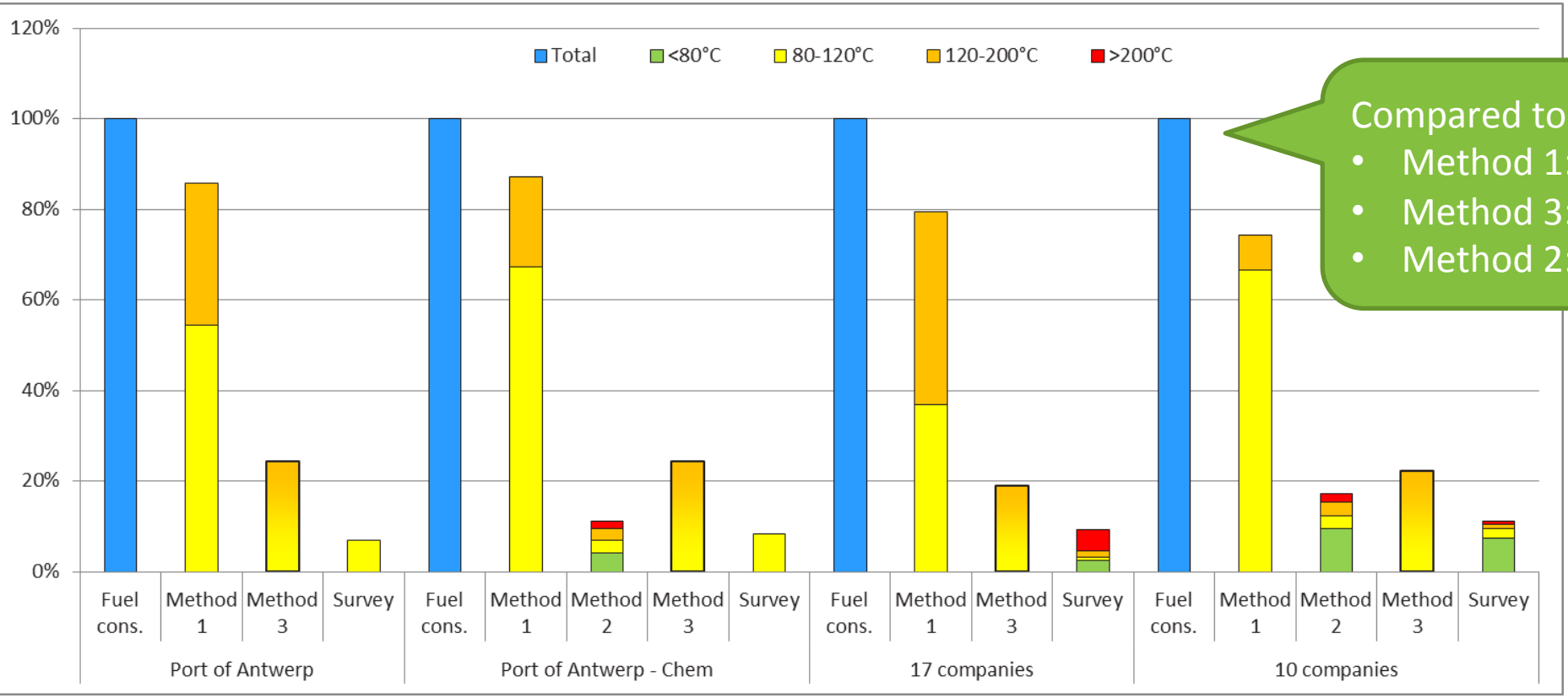
Sample	Subset	Method 1	Method 2	Method 3
Port of Antwerp	All : 3 refineries + 15 petrochemical companies	✓		✓
Port of Antwerp	15 petrochemical companies	✓	✓	✓
Elsewhere in Flanders	17 companies in 8 sectors	✓		✓
Elsewhere in Flanders	10 companies in 5 sectors	✓	✓	✓

Validation of the results

General conclusion

Method 1 >> Method 3 > Method 2 > Survey results

Bigger differences when excluding low temperate heat



Compared to the survey results:

- Method 1: 7 to 12 times highe
- Method 3: 2 to 3 times higher
- Method 2: 1.3 to 1.5 times hig

Conclusion

- On Method 1: a top-down estimation resulting in a **theoretical** potentia
  - Exceeds the estimations using the other methods with a factor 10
    - Hence a significant over estimation
    - Cause: disregards the form in which the excess heat is presented
  - Good basis for a heating and cooling action plan?
- On Method 2 and 3: resulting in a **technical** potential
  - Still 2 to 3 times higher than potential detected in surveys
  - Causes: inaccuracies in the method:
    - Excess heat generation is seldom monitored
    - How representative is the sample for companies in other countries?

Recommendation

- Use a estimation method **based on estimated or monitored excess heat assessments** of individual companies to estimate the waste heat potential of industry
  - Can still deviate with a factor 2 to 3 of what in reality can be delivered as excess heat
  - Provide a first indication of the potentially available excess heat from industry
  - Need to be complemented with site specific assessments

Recommendation

- There is about 20 to 60 PJ/a available as industrial waste heat in Flanders
  - Total annual fuel use of tertiary sector: 55 PJ
  - Fuel consumption of 1 million houses like mine: 55 PJ
  - Nutritious value of 30 billion litre of Coca-Cola: 55PJ
- Do grasp this opportunity

Thank you for your attention !

Erwin CORNELIS – Johan VAN BAEL

EnergyVille

Thor Park 8300

3600 Genk

Belgium

erwin.cornelis@energyville.be