FACULTY OF ENGINEERING
AND ARCHITECTURE

DEPARTMENT FLOW, HEAT & COMBUSTION MECHANICS
RESEARCH GROUP THERMAL ENERGY IN INDUSTRY (TEI)

IraSME & CORNET Partnering Event Aachen 2018

26 November 2018 / Aachen, Germany

PROJECT IDEA:

MAKE YOUR CHP MORE FLEXIBLE BY ADDING THERMAL ENERGY STORAGE

Bruno Vanslambrouck, lecturer-research coordinator

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AGENTSCHAP INNOVEREN & ONDERNEMEN

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- 41.000 students
- 9000 staff members: professors, researchers, technical and administrative staff, etc.
- 11 faculties

↳ Faculty of Engineering and Architecture (4900 students)

↳ Department of Flow, Heat and Combustion Mechanics

↳ 5 research groups:

Fluid Mechanics
Transport Technology
Combustion, Fire & Fire-safety
Thermal Energy in Industry
Applied Thermodynamics & Heat Transfer

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RESEARCH GROUP TEI

200 YEARS
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Thermal Energy in Industry

The Thermal Energy in Industry (TEI) research group of the Department of Flow, Heat and Combustion Mechanics of Ghent University focuses on **industrial thermal energy systems** such as Organic Rankine Cycles, industrial heat pumps, combined heat and power, thermal energy storage and heat networks. Waste heat recovery and industrial energy efficiency are the main challenges.

The main research topics are

→ Energy efficiency of thermal systems in industry, waste heat recovery.

→ (Organic) Rankine Cycle technology, industrial heat pumps, combined heat and power, heat storage.

→ Volumetric compressor and expander design.

→ Process integration and optimization methods.

→ Heat networks, district heating.

www.tei.ugent.be

These topics are studied in a combined experimental and numerical approach, often in cooperation with other research groups of the university. Industrial contacts and partnerships, and research driven by industrial challenges characterize our work.

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COMPARABLE TEI PROJECTS

- Flemish TETRA-IWT project (2007-2009):

Waste heat recovery via ORC on renewable energy applications

User group counting 15 members

- Flemish TETRA-IWT project (2010-2012), within **European ERA-SME** frame:

Waste heat recovery via Organic Rankine Cycle

German partner: Hochschule für Technik, Stuttgart
36 members within the Flemish user group, 7 within the German one

- CORNET-project (2012-2013): **From waste heat to process heat (W2PHeat)**

2 German partners (PFI and PTS); 29 Flemish user group members, 7 within the German one

- CORNET-project (2014-2016): **Energetic and environmental optimisation of drying processes by integration of heat pumps (HP4Drying)**

6 German partners (PFI, IZF, wfk, Fraunhofer WKI, ITV, ATB)
29 members within the Flemish user group, 6 German user groups

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ONGOING CORNET PROJECT: SHORTSTORE

Short term heat or cold storage in industry

01/01/2017 – 30/06/2019

UGent TEI + VITO + 3 German partners (DLR, IZF, GFaI)
21 members in the Flemish user group, 1 German user group

- Cost/benefit HT TES questionable in industrial applications on which stored and thus saved thermal energy is the only profit (because of still very low gas prices).
- Also looking for other more promising applications, such as **CHP**

150 kWh demo TES @ UGent
(CORNET Shortstore)
Melting t° 223°C
(Un)loaded by thermal oil

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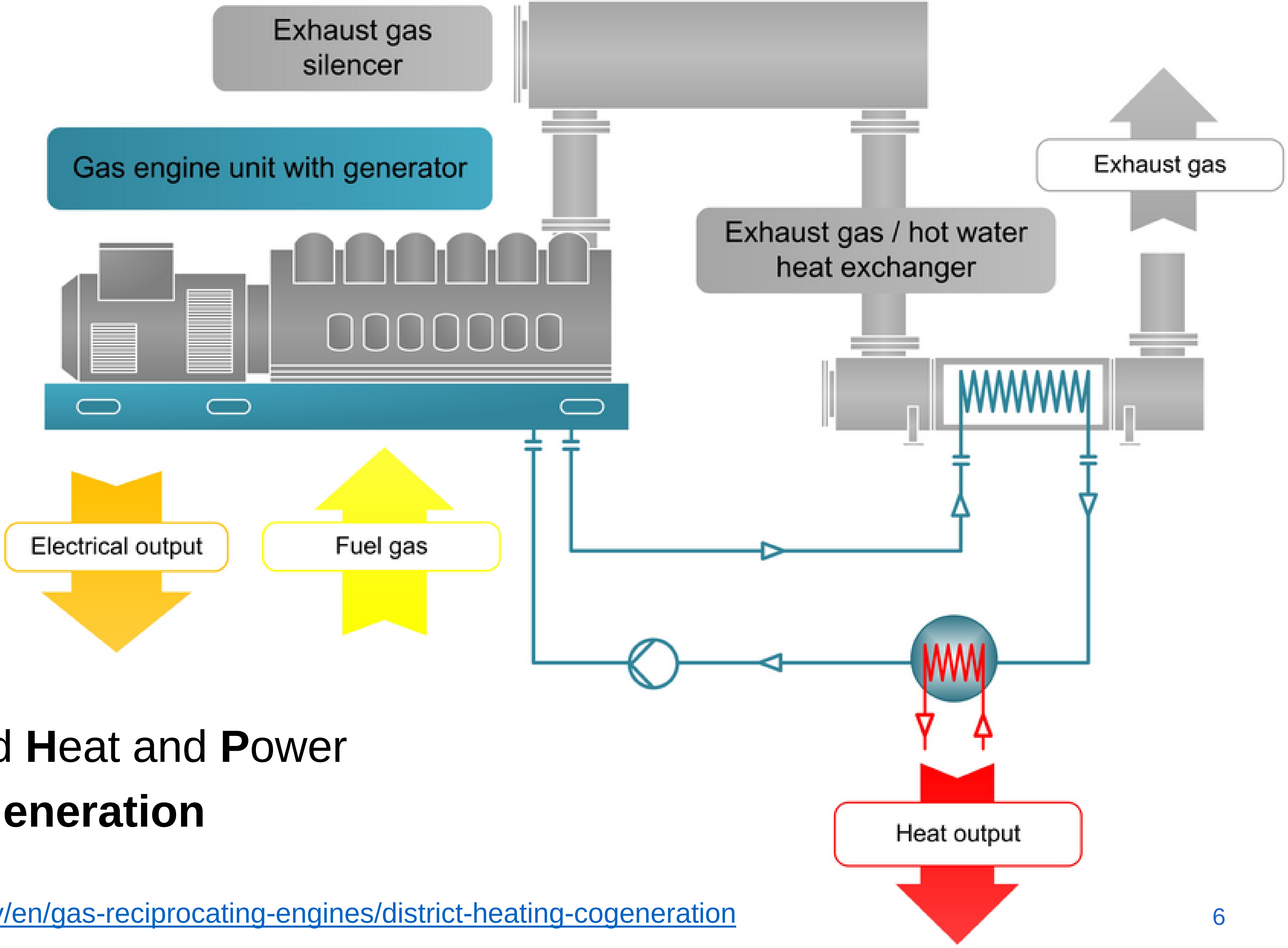
WHAT IS CHP ?



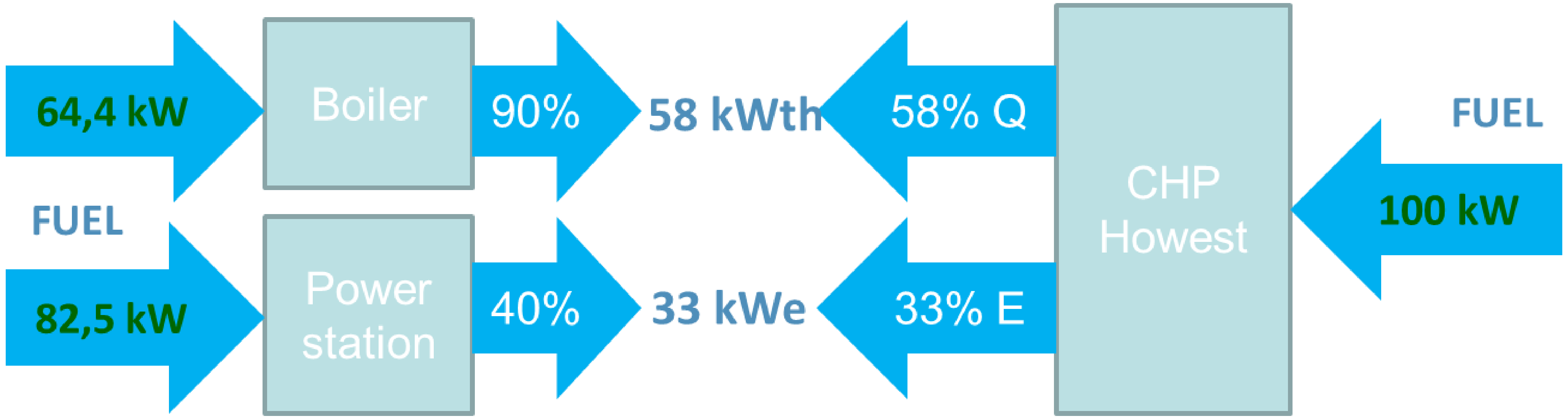
CHP: Combined **H**eat and **P**ower

Also called **Cogeneration**

https://www.iec-energy.by/en/gas-reciprocating-engines/district-heating-cogeneration

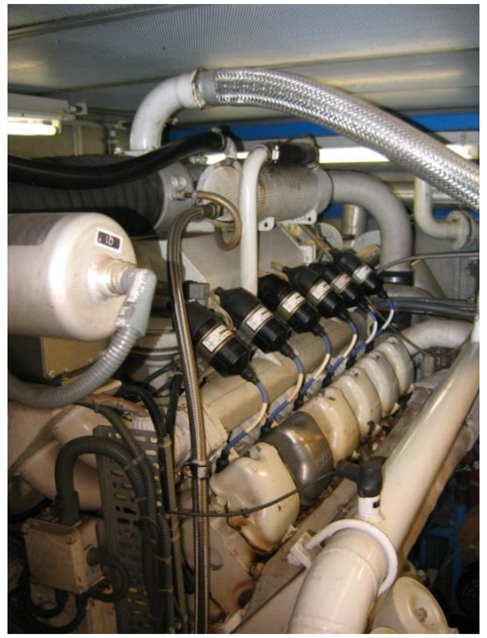
WHAT IS CHP ?

Fuel savings compared with separated E and Q generation

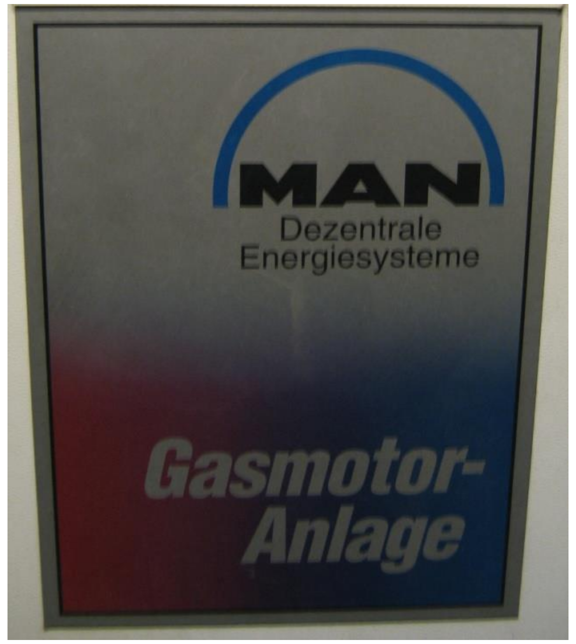


Σ = 146,9 kW

$$RPE = \frac{146{,}9 - 100}{146{,}9} x100 = 32{,}0\%$$



288 kWe/478 kWth CHP in UGent-TEI lab since 1995, still in working order, engine replaced (2018)



As a result, in a lot of countries CHP is promoted by offering investment and/or exploitation support (CHP-certificates).

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HOW TO EXPLOIT A CHP ?

- **Heat driven:** CHP load follows immediate onsite (process) heat demand, electricity is used onsite or (partially) sold to the grid.
- **E-driven:** if onsite E-demand is lower than CHP-capacity, partial load even if heat demand is high enough (no arrangement for E-delivery to the grid)

Control:

- Own exploitation
- Exploitation by third party (f.i. ESCO)

Both options (Q or E driven)

- Often cause part load operation (and also generate less CHP certificates, if applicable)
- Impede flexibility because of the hard link between E and Q generation, hard to take advantage from variable E-prices

HOW TO EXPLOIT A CHP ?

UGent-TEI CHP:

E-driven, limited by Q-demand

Part load:

- Morning (low E-demand while high Q-demand…)
- Evening: low E and often also low Q-demand
- No night operation (E-price too low)

Boilers needed in the morning and during night…

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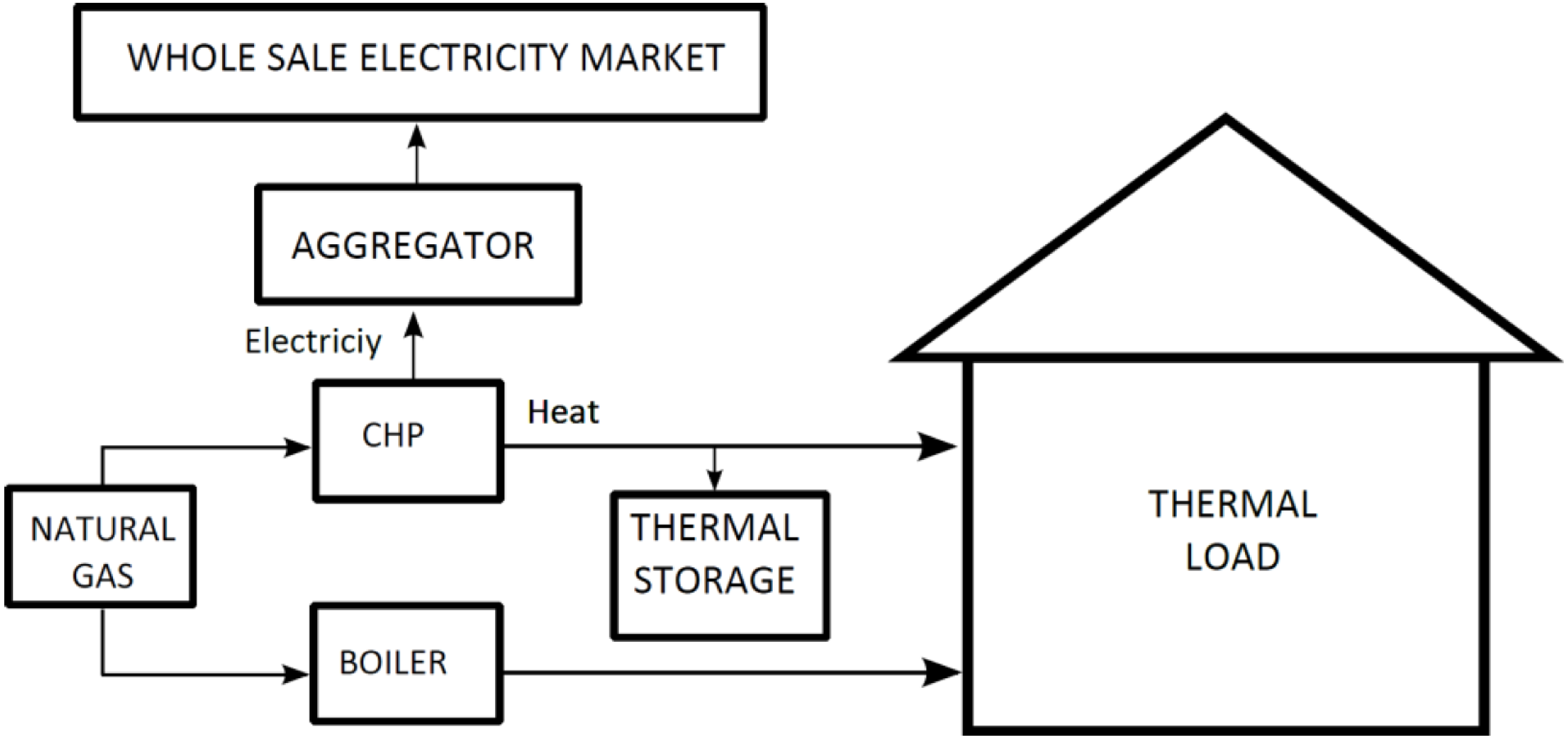
ADDING FLEXIBILITY BY INTEGRATING TES



A new approach for near real-time micro -CHP management in the context of power system imbalances – A case study

J. Zapata Riveros[a,b], R. Donceel [a], J. Van Engeland [a] and W. D'haeseleer [a,b,1]

[a] *University of Leuven (KU Leuven) Energy Institute, TME Branch, Heverlee, Belgium*

[b] *Energyville (joint venture of VITO NV and KU Leuven), Genk, Belgium*

IS THIS GENERATING MORE REVENUES ?

(in general, not only for the UGent-TEI CHP)

- More full load operation and less start/stops if heat demand fluctuates above and below CHP capacity or is even interrupted

- Allows to buy (or sell) electricity on the “spot market”

A spot market contract is an agreement to buy or sell a clearly defined amount of a certain good which is traded for immediate delivery at a specific price.

Electricity can be (very) cheap or even negative priced during periods of huge production by renewables (solar and wind) combined with rather low demand (and vice versa).

- Allows to integrate your CHP in the reserve power system for grid balancing

FYI: ABOUT THE RESERVE MARKET

Reserve Power Type (Belgian name)	Common European name	Explanation
R1 (primary reserves)	Frequency containment reserve (FCR)	Kicks in automatically in a matter of seconds (fully activated within 30s) after the deviation from the reference frequency (50Hz in Europe). Its aim is to contain the deviation to avoid system collapse.
R2 (secondary reserves)	Frequency restoration reserve (aFRR)	These reserves are controlled centrally by Elia to restore the frequency back to its reference value. The reserves need to be fully activated within 7.5 min.
R3 (tertiary reserves)	Replacement reserve (mFRR)	The replacement reserves are meant to free up the R2 reserves after the frequency has been restored. They are controlled manually and activated locally. They are important to solve important imbalance and congestion problems, active in a time range from minutes to hours. R3 needs to be fully activated within 15 min.

https://www.next-kraftwerke.be/en/knowledge-hub/balancing-markets/

PROJECT GOALS:

Small (mostly engine based) hot water producing CHPs:

- Thermal storage well known as water buffers

⇨ Find out how to use them for grid balancing and also to generate profits from variable energy prices or by serving as reserve power

UGent-TEI CHP could be of use as a case study (20 m³ thermal storage added in 2007)

Bigger steam producing CHPs (engines or gas turbines):

- Still research needed on adapted TES design (steam buffers, PCMs, sensible heat…)

⇨
- Design and dimensioning of adapted HT TES systems
- Cost/benefit analysis

⇨ Situation will be strongly country dependent: to find out how it works in each participating country/region.

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Real life case studies are necessary !

IMPACT OF PROJECT RESULTS

- Increasing grid flexibility crucial for increasing aimed share of renewables
- Adding TES to existing and new CHPs will help on this and will even increase revenues for project owners

With this proposal we show to agree with the quote below:

ENERGY STORAGE

Report: Batteries Will Not Be the Future of Grid Balancing in Germany

Power-to-heat and demand-side management are the most cost-effective measures for the country’s grid up to 2030, concludes a government-funded study.

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