

Smart conversion of residual heat into electricity: the electricity market point of view

Damien Ernst – University of Liège
Email: dernst@ulg.ac.be

Restwarmterecuperatie - iets voor uw bedrijf?
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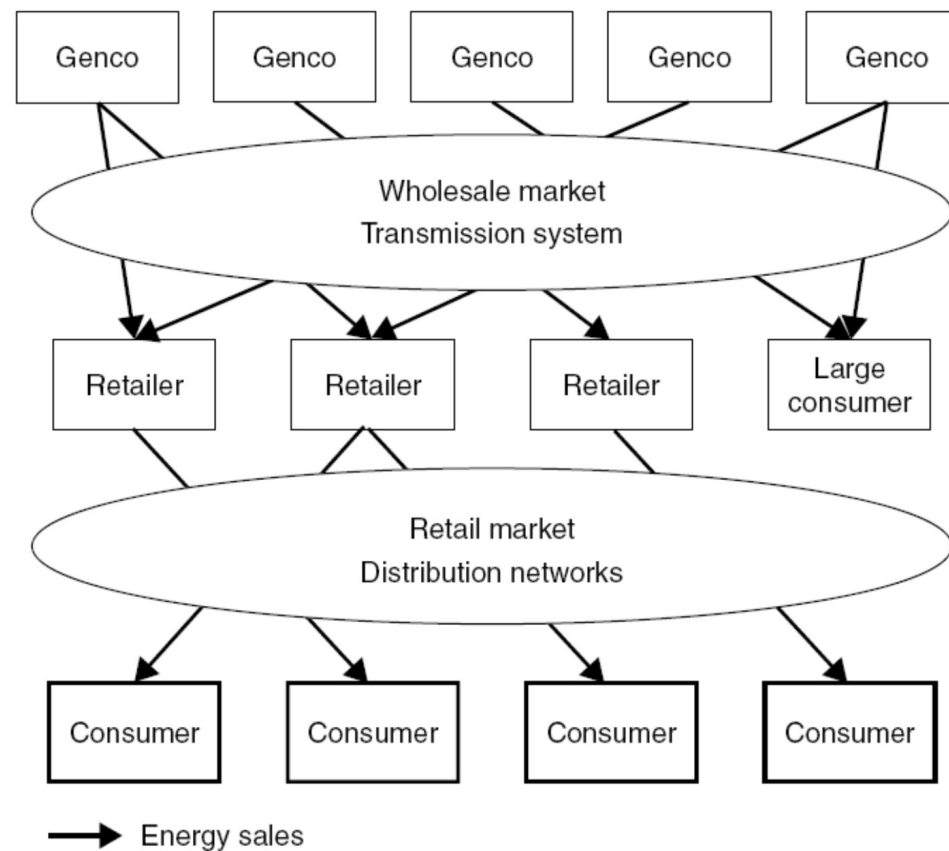
Problem statement

- 1.** You have a (or several) source(s) of residual heat.
- 2.** You have devices for transforming residual heat into electricity.
- 3.** You would like to know how to **interact with electricity markets** in a smart way so as to maximize the revenues of your sources of residual heat.

In this talk, we will:

- 1.** Describe the very basics of electricity markets.
- 2.** Understand the opportunities that exist in primary electricity markets, with or without storage of heat.
- 3.** Understand the opportunities that exist in ancillary markets.

Organisation of the power industry: a simple sketch



Primary electricity markets: the basics

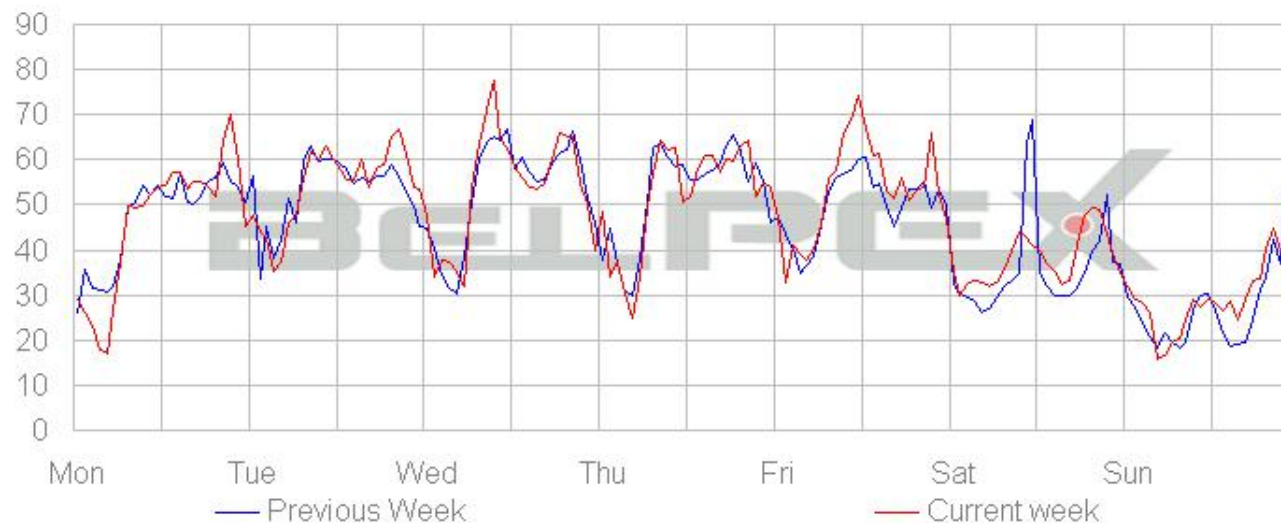
- Trading of electrical energy refers to an amount of megawatts-hours to be delivered over a specific period of time. 15 minutes in Europe.
- Every injection or off-take points are associated with a **Balancing Responsible Party**. A **BRP** is responsible for maintaining quarter-hourly balance between total injections and total off-takes. Can buy/sell contracts for energy for ensuring this balance.
- BRPs may be unbalanced and have to pay a price for this.
- All of the market participants; including generators, suppliers, traders and consumers; must notify their expected final position by gate closure.
- The Transmission System Operator (ELIA in Belgium) is the ultimate actor for ensuring that consumption is always equal to production.

No control over the heat available - what to do?

- Sign the right contract with your retailer or sell/buy well your energy in the primary electricity market.
- Predicting well the amount of electricity produced by your residual heat has a value (e.g., it helps the BRP to fulfill its role, forward contracts possible, ...).
- Build your system so as to be able to throw away residual heat or to use it for other purposes. Downwards modulation of electricity production has a value (e.g., when the prices for electricity are negative, for a BRP that has scheduled too much generation, etc.)

Storing heat for upwards and downwards modulation of electricity production

- Even if the amount of residual heat produced by your process cannot be controlled, heat can often be stored.
- Prices for electricity fluctuate over the day:



- By storing heat when prices are low and transforming heat into electricity when prices are high, it is possible to exploit these price fluctuations to maximize gains.

What to do to exploit this flexibility?

- Either you try to exploit by yourself this flexibility by trading yourself electricity in the market. Or, you can sell this flexibility to a third party (e.g., a retailer or an aggregator). The second solution may be less risky.
- If you exploit this flexibility yourself, build the right decision-making tools for scheduling your electricity production. Note that for scheduling well the production you need **(i)** to have an accurate prediction of electricity prices **(ii)** to have an accurate prediction of the residual heat produced by your processes **(iii)** to solve a potentially complex (stochastic) optimal **sequential** decision problem. The sequential nature of the problem is related to the fact that the production level for a market period is going to influence the possible production levels for the subsequent market periods.

Ancillary markets

- Loads and generators can provide services to support electricity networks. Those are known as **ancillary services**.
- System Operators have created markets for getting access to these services.
- We discuss two specific types of ancillary services that machines converting residual heat to electricity could provide: **(i)** primary reserve and **(ii)** relieving congestions/solving voltage problems in distribution networks.

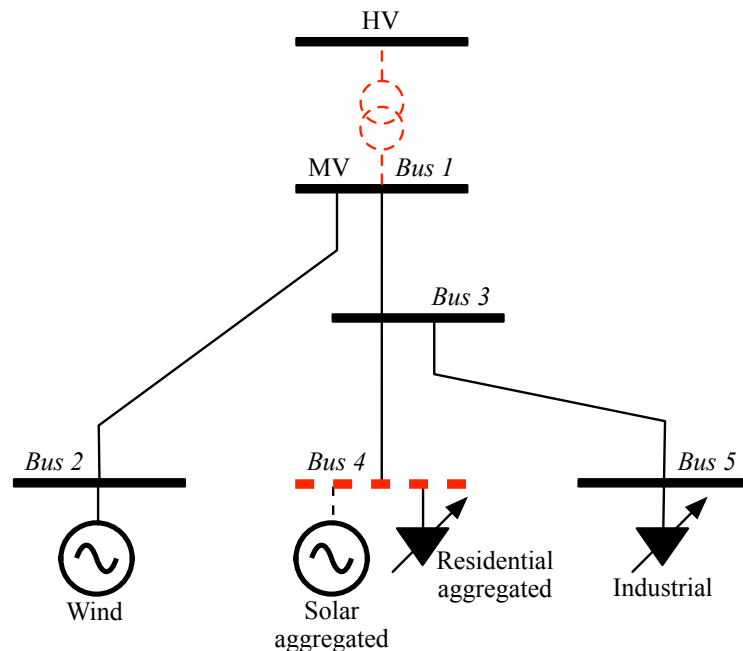
Primary reserve

■ **Primary reserve** is the ancillary service for balancing production with consumption that acts at the shortest time-scale. This service is provided by generators that detect frequency fluctuations (note: imbalances modify the frequency) and adjust their power automatically, according to $\Delta P = -K \Delta f$.

■ Machines converting residual heat could also offer such a reserve but several difficulties remain, such as for examples: individual machines may not provide enough reserve to be eligible for selling this service (need for aggregators), upwards modulation can only be done if the machine comes with a heat storage device, difficulties to carry out ex-post analyses.

Relieving congestions in distributions networks

■ Many voltage and congestion problems are caused by distributed generation in distribution networks. An academic example:



When Distributed Generation (DG) sources produce a lot of power: (I) overvoltage problem at *Bus 4* (II) congestion problem on the *MV/HV* transformer.

■ Modulating in an adequate way the active and the reactive power of machines converting residual heat into electricity could help solving these problems. They could therefore offer valuable services to distribution networks. But markets for such valuable services not yet exist.