IndustRE workshop:

Valorisation of Flexible Industrial Demand

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ProFLEX

IndustRE

Using the
flexibility potential
in energy intensive industries to facilitate further grid integration of
variable renewable energy sources

Chemicals

Non-ferrous metals

Steel

Cold storage

Water treatment

WIP

Universidad Pontificia ICAI ICADE Comillas Madrid – Instituto de Investigación Tecnológica

vito Energy Ville

Imperial College London

BBH Becker Büttner Held

Cu European Copper Institute – Copper Alliance

scmgroup

SER

Contents

Part I	Foundry case study	→ day-ahead BC
Part II	Paper industry case study	→ imbalance BC
Part III	Waste water treatment case study	→ onsite VRES BC
Part IV	The need for something more simple	→ **Pro*FLEX***
Part V	**Pro*FLEX*** in distribution center case study	
Part VI	Conclusions **Pro*FLEX***	

Steps of a demand response audit

Demand response audit execution in 3 major steps:

Identification: *"Which parts of the facility contain demand side flexibility?"*

Quantification: *"How much flexibility is available in the identified parts?"*

Valorization: *"How much money can be made with the quantified flexibility?"*

Identification of flexibility in a foundry

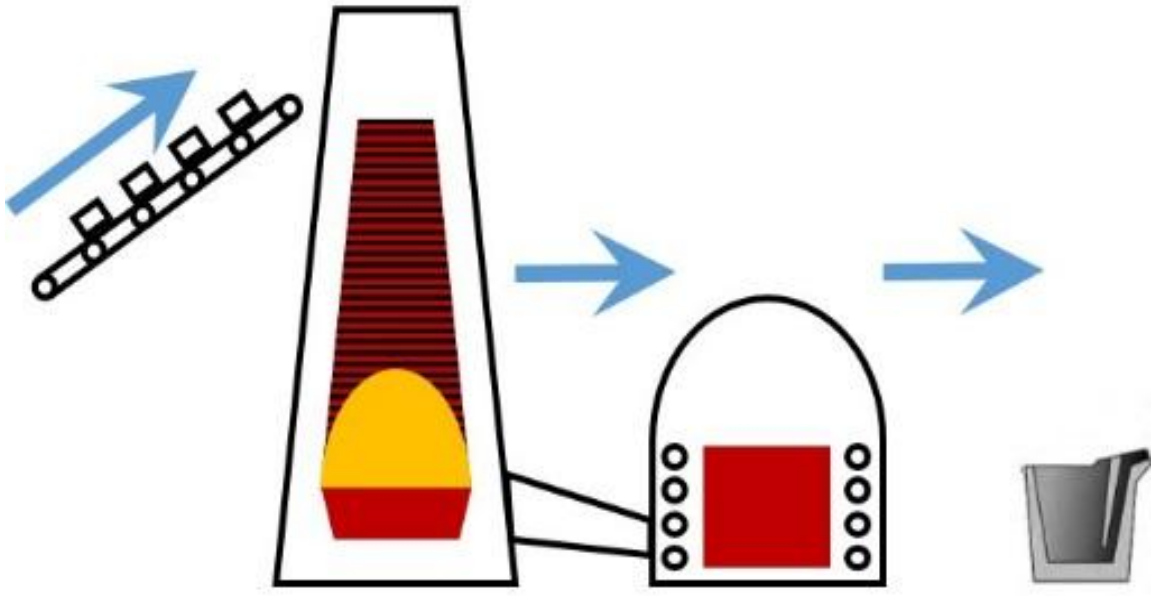
"Which industrial processes or equipment contains Demand Side flexibility?"

"What do we see top-down?" → **Electricity consumption pattern analysis**

"What does the company think themselves?" → **Questionnaire**

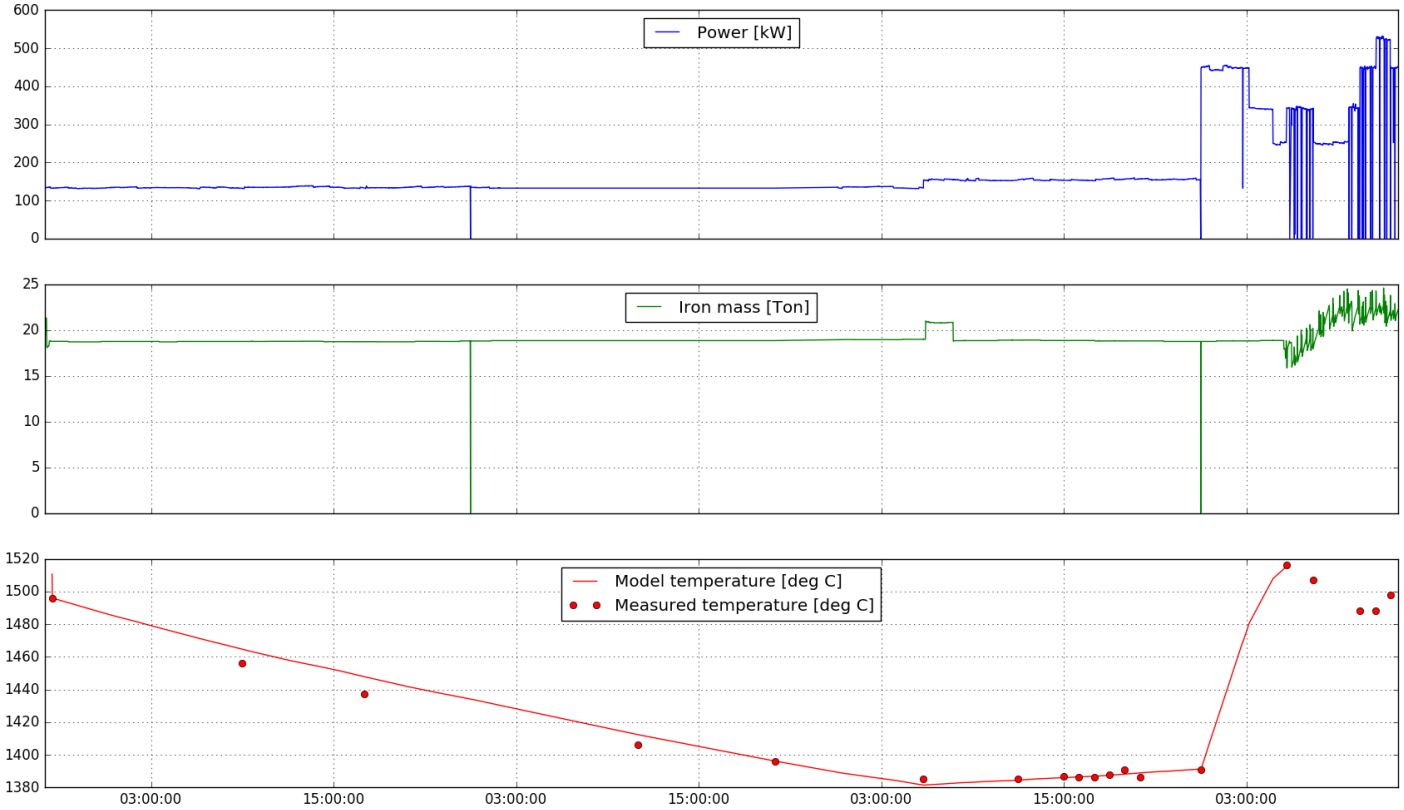
"What do we see bottom-up?" → **Site visit**

Identification of flexibility in a foundry



- Induction furnace is identified as the major source of flexibility
- Induction furnace acts as a buffer between the furnace and the individual pouring ladles
- Induction furnace keeps the iron at a temperature between 1480°C and 1520°C

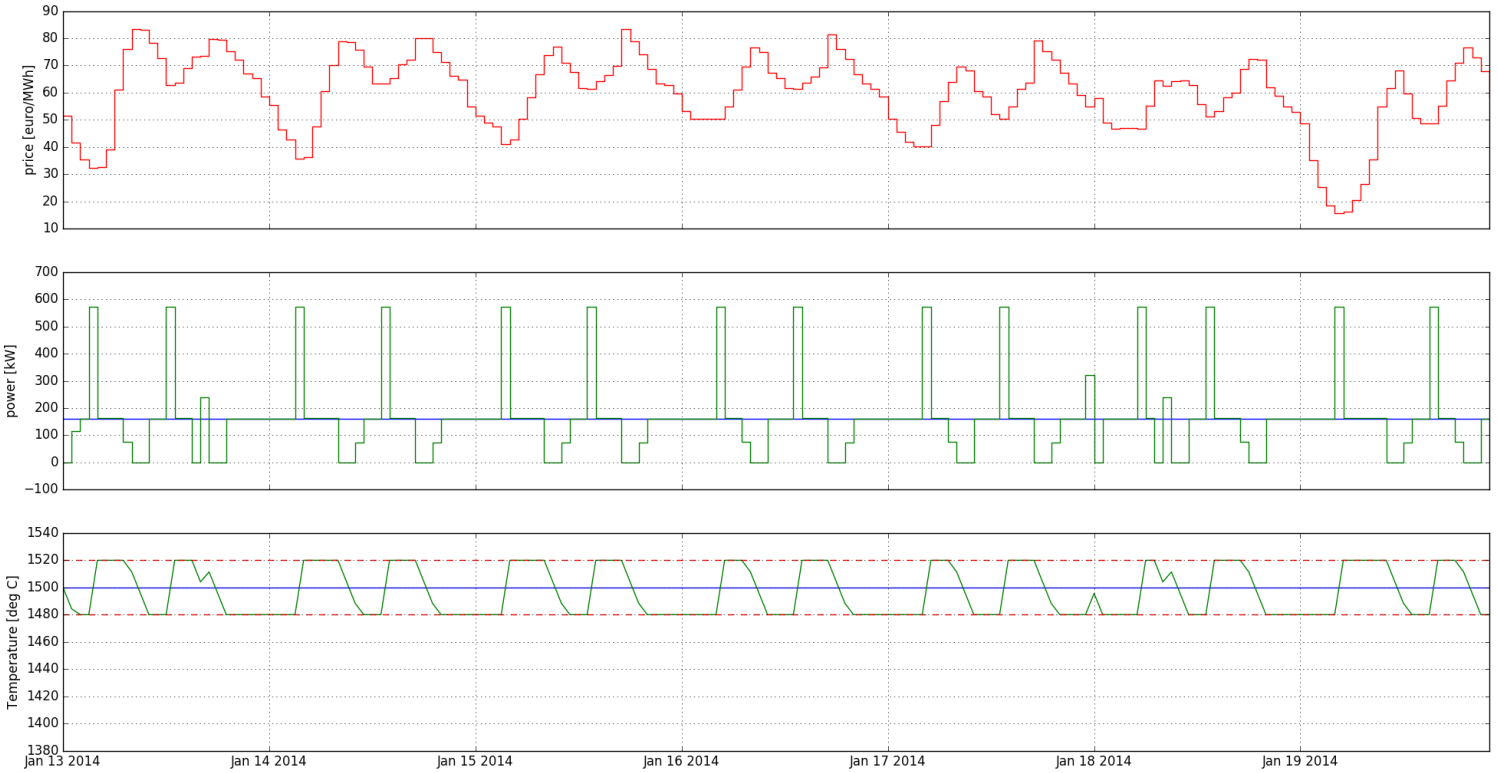
Quantification of the flexibility



- Create an inductance furnace model which predicts the induction furnace temperature as a function of variable power consumption

Valorization of the flexibility

Use optimization software to maximize the profit



Valorization of the flexibility

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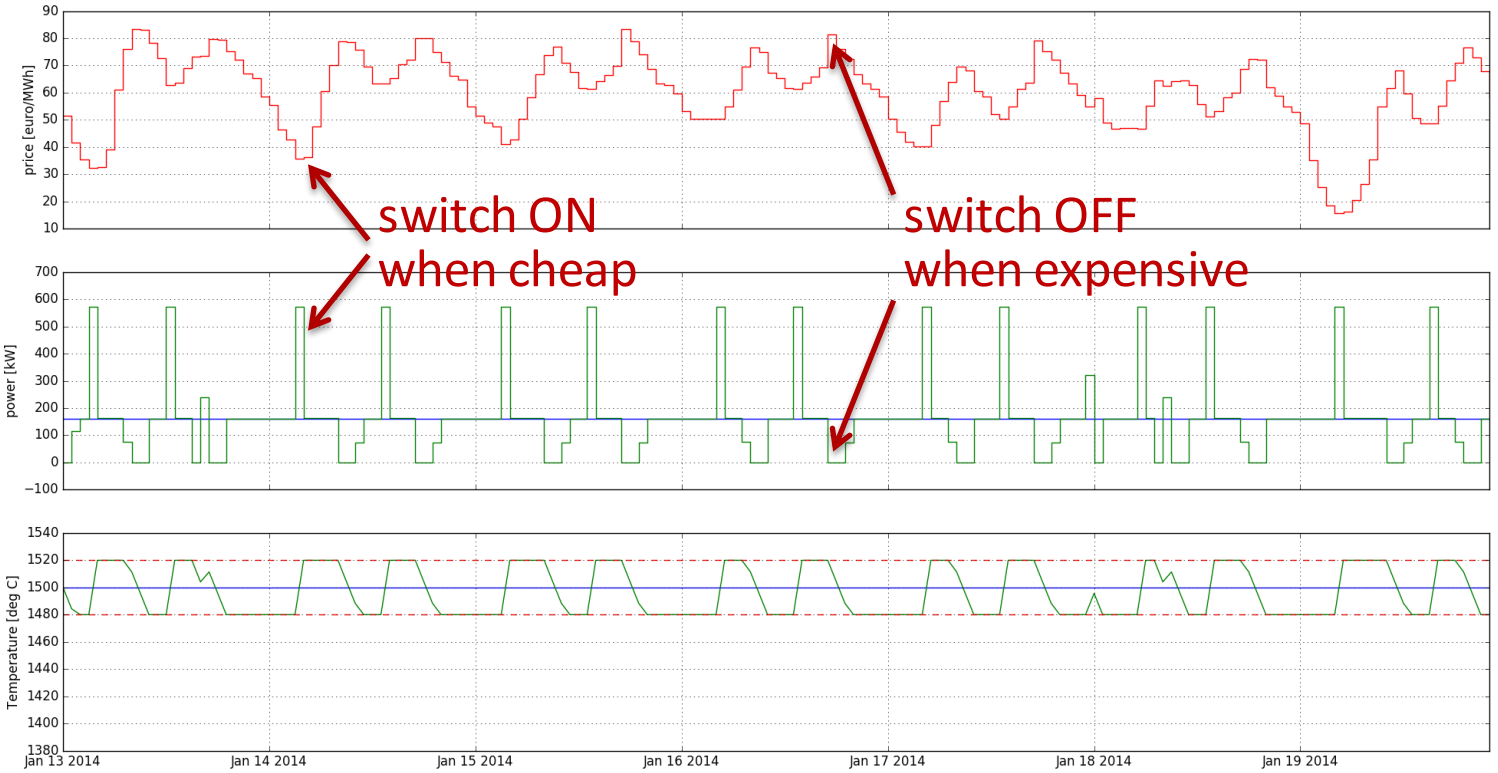
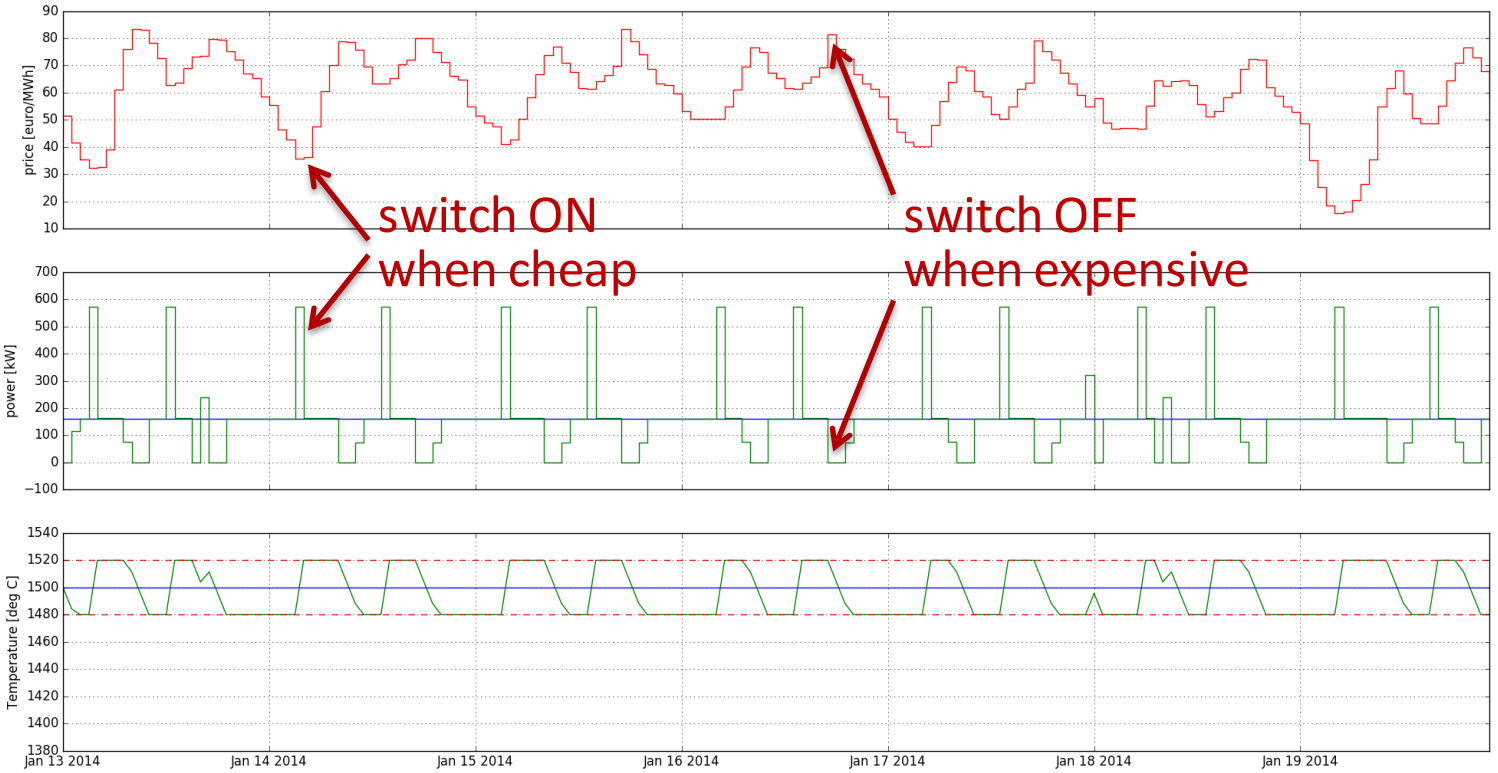


Valorization of the flexibility

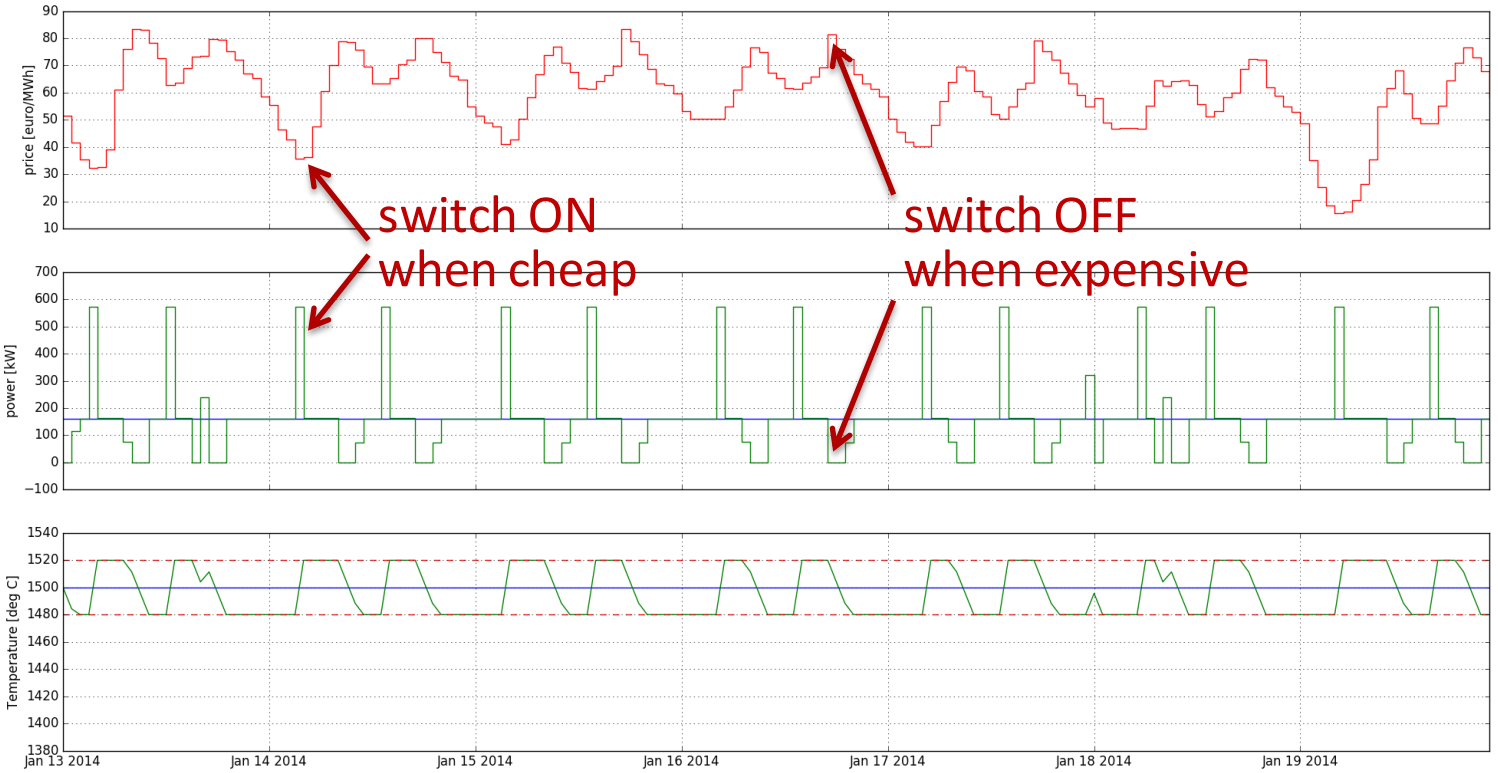
Use optimization software to maximize the profit



Cost **without** using flexibility: **73.767** €/year

Valorization of the flexibility

Use optimization software to maximize the profit



Cost **without** using flexibility: **73.767** €/year

Cost **with** using the flexibility: **65.295** €/year

➡ profit **8.472** €/year

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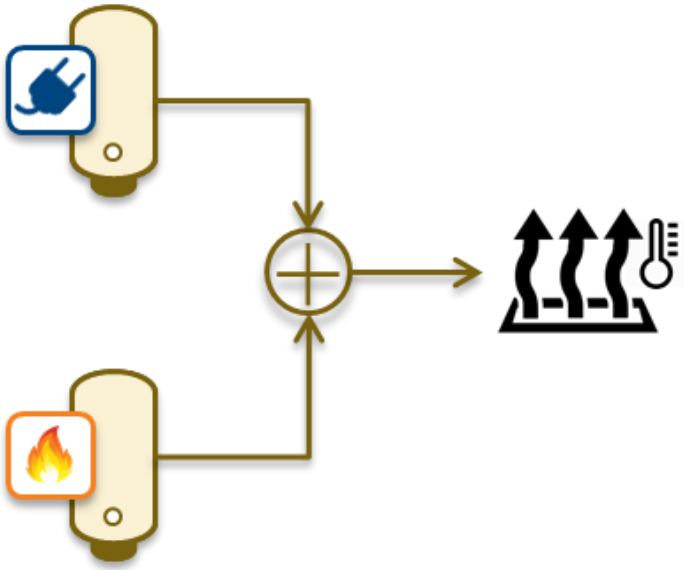
Identification of flexibility

Company profile:

- Paper mill of a large world-wide company
- Very advanced in terms of demand response
- Large volume imbalances, due to the size and discrete nature of the plant
- Agreed business case: is there a business case for electric boilers in the paper industry?

Quantification



Assumptions:

- 10 MW electric boiler
- Efficiency of gas boiler is 0,9, efficiency of the electric boiler is 1
- Electric boiler used when imbalance prices are lower than the gas prices
- Historical imbalance volumes and prices for 2016 used

Valorisation

1

In ideal conditions, a **theoretical** cost reduction of around **1,7%** can be achieved by a 10MW electric boiler

Valorisation

1

In ideal conditions, a **theoretical** cost reduction of around **1,7%** can be achieved by a 10MW electric boiler

Realistiv value expected to be much larger due to assumptions:

- Only commodity cost taken into account
- Perfect foresight of imbalance volumes and prices

2

The achieved cost reduction corresponds to around 300k€/year

To put it in perspective:

- The investment costs of a 10 MW electric boiler are between 600 k€ and 1,3 M€
- Expected lifetime for electric boilers is shorter than for gas boilers

Contents

Part I Foundry case study → day-ahead BC

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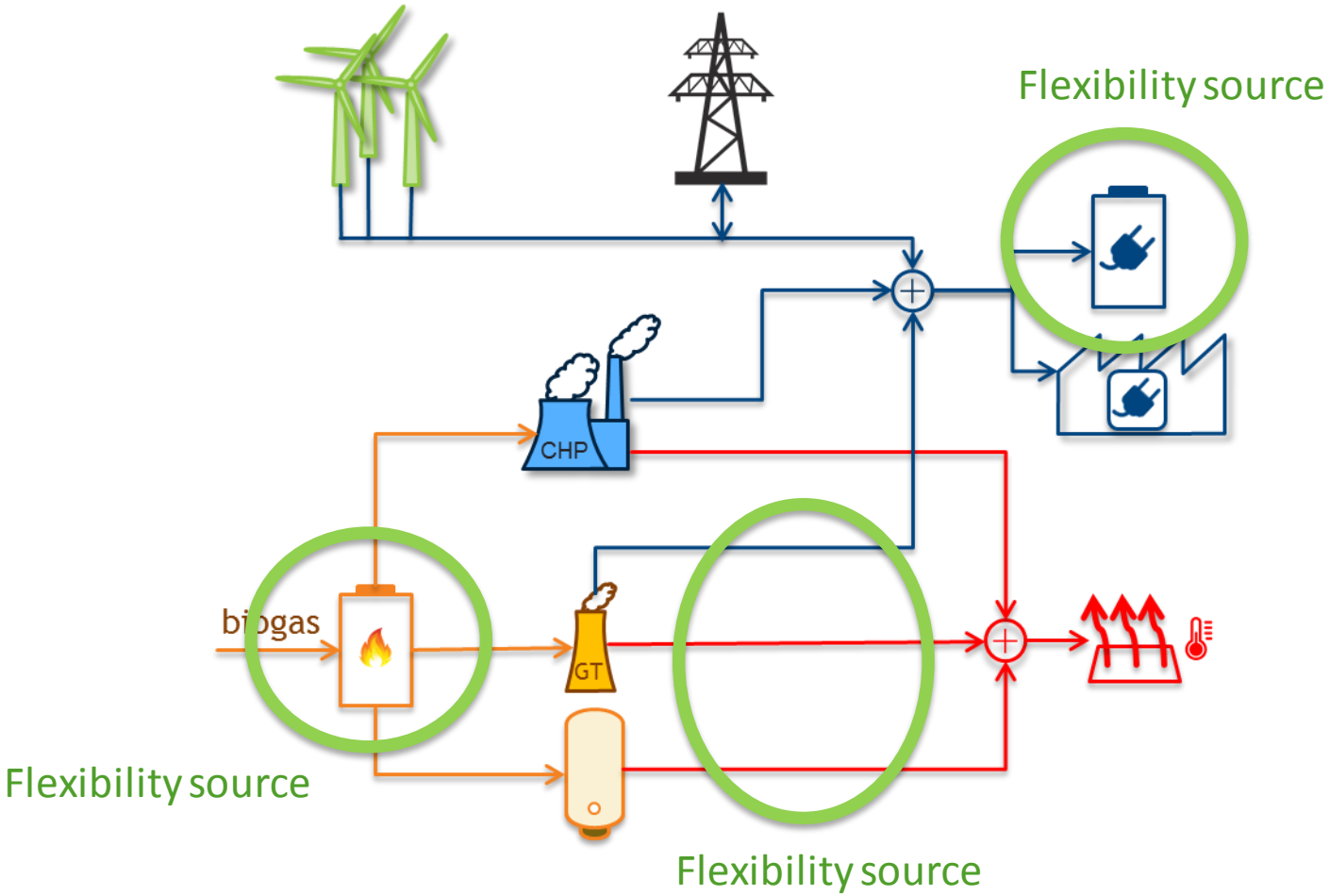
Identification

Company profile:

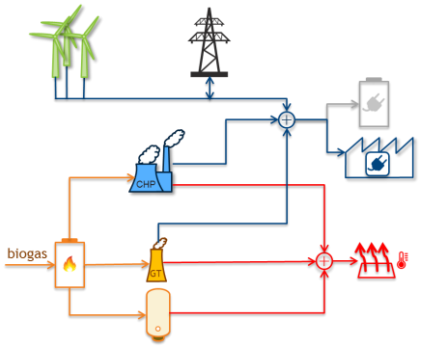
- Waste water treatment plant in a large European city
- Own biogas production on site, CHPs and microturbines
- Own wind turbines
- Agreed business case: optimal use of on-site produced renewable energy

Quantification



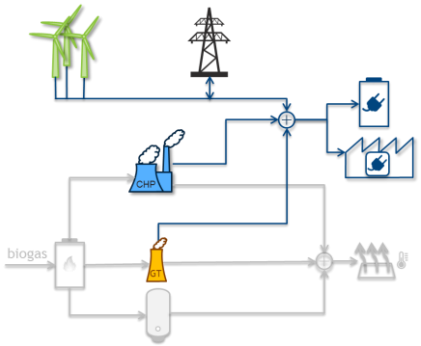
Valorisation

A



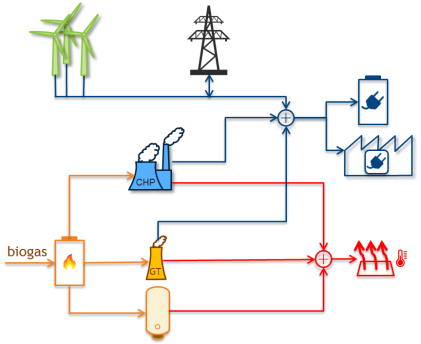
	Case A
Business case value	4.510 €/y

B



	Case B
Business case value	7.940 €/y

C



	Case C
Business case value	15.770 €/y

Conclusion for the wastewater treatment case

1

In ideal conditions, a **theoretical** cost reduction of around **1%** can be achieved …

To keep in mind:

- In the simulations, **no** flexibility from CHP was considered.
- Peak component was not considered.
- The wind production is assumed to be well known sufficiently in advance to adjust the plant operation.

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What can **Pro*FLEX*** do for you …

Demand response audit execution in 3 major steps:

Identification: *"Which parts of the facility contain demand side flexibility?"*

Quantification: *"How much flexibility is available in the identified parts?"*

Valorization: *"How much money can be made with the quantified flexibility?"*

} ProFLEX

ProFLEX *aims at making the quantification and valorization steps faster and easier*

Accuracy of the business case value

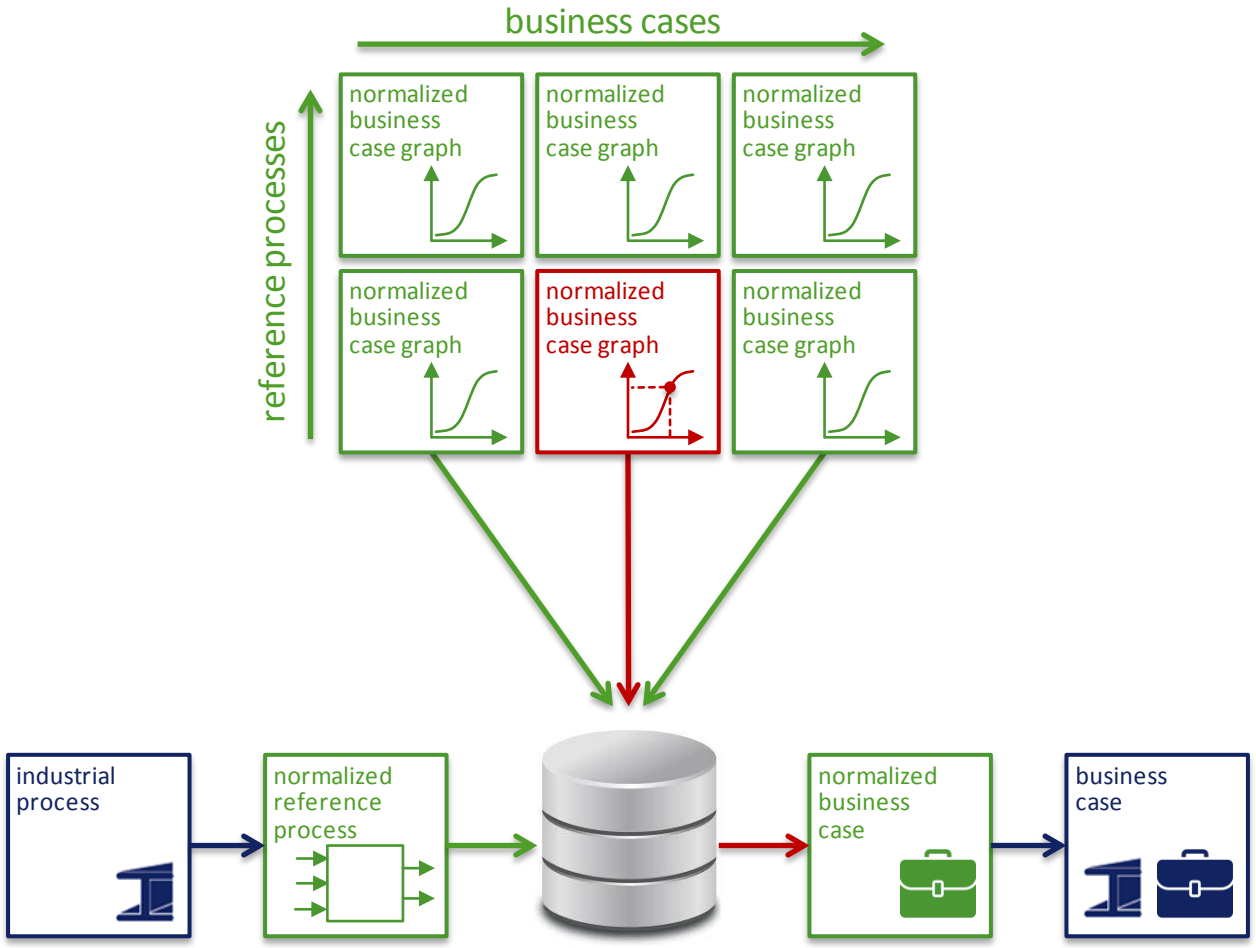
"Building up interest in demand response is for many companies a long, time consuming, multi-stage process…"

… but an order of magnitude business case estimation is enough to plant a seed"

Requirements of a simplified methodology

1. Being cost effective and time efficient
2. Order of magnitude accuracy estimation is good enough
3. No specific modelling and optimization knowledge and tools needed

Approach in 4 steps



The ProFLEX or simplified methodology is explained in more detail in an earlier webinar which can be found here

Contents

Part I Foundry case study → day-ahead BC

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Identification

Company profile:

- Large supermarket chain
- 20 Distribution centers, high throughput, short storage time
- Sources of flexibility:
  - After questionnaire: refrigeration system
  - After audit: battery charging station, emergency generators

Refrigeration system: quantification

- Refrigeration system modelled as a battery with:
  - Pin_max (max. charging power) of 508kW
  - Pout_max (max. discharging power) of 103kW
  - E_max = 0,824MWh (4h switch off + doubling for extra deep freezing)
- Reserves BC: 6.600 €/year
- Day ahead BC:
  - theoretical: 8.500 €/year
  - more realistic: 5.500-6.500 € /year

Emergency generators: quantification

- 2 x 800 kW
- Reserves @ 11 €/MW/h
- Theoretical: 154.000 €/year
- More realistic: 100.000 €/year

Battery charging station: quantification

- Average availability of 40 batteries in the charging station
- 1/3 the batteries are charging on average
- 25% of the batteries should be full for swaps
- Average battery swap rate is every 33 minutes
- Charging power per station is 1.5kW

➔ "virtual battery" with:

- ➔ E_max (capacity) of 334.8kWh
- ➔ Pin_max (max. charging rate) of 40kW
- ➔ Pout_max (max. discharging rate) of 20kW.

Battery charging station: quantification

- Reserves BC: 1.300 €/year
- Day ahead BC:
  - theoretical: 1.800 €/year
  - more realistic: 1.200 €/year

Valorisation

1

emergency generators: 100.000 €/year
refrigeration system: 6.000 €/year
charging station: 1.200 €/year

Valorisation

1. emergency generators: 100.000 €/year
   refrigeration system: 6.000 €/year
   charging station: 1.200 €/year

2. **Pro*FLEX*** proved to be very efficient to estimate the flexibility value

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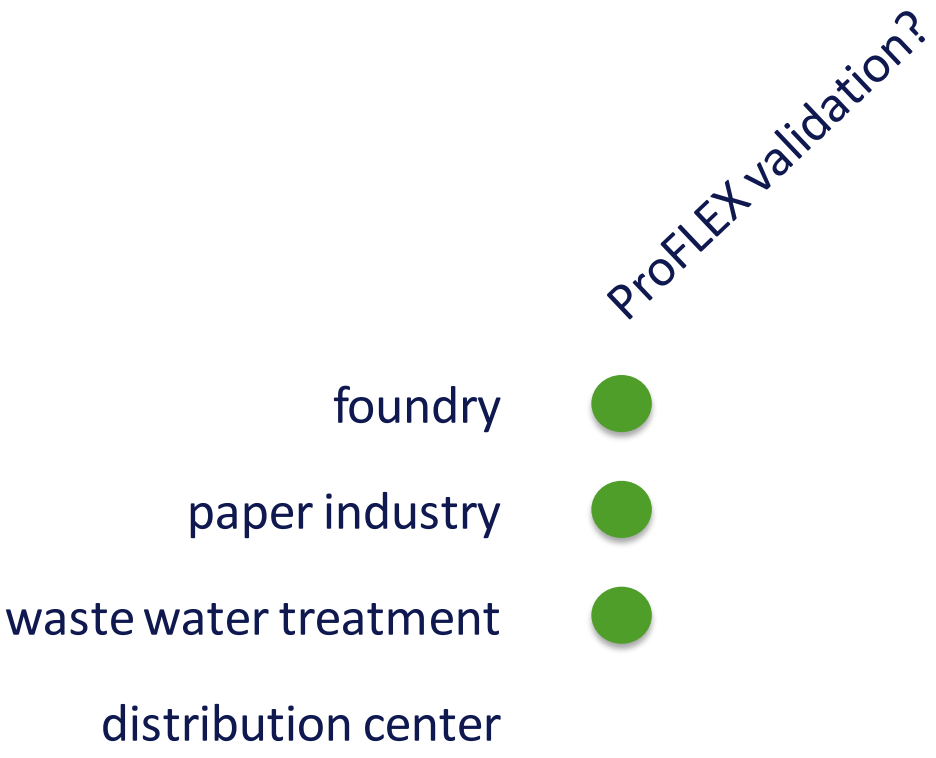
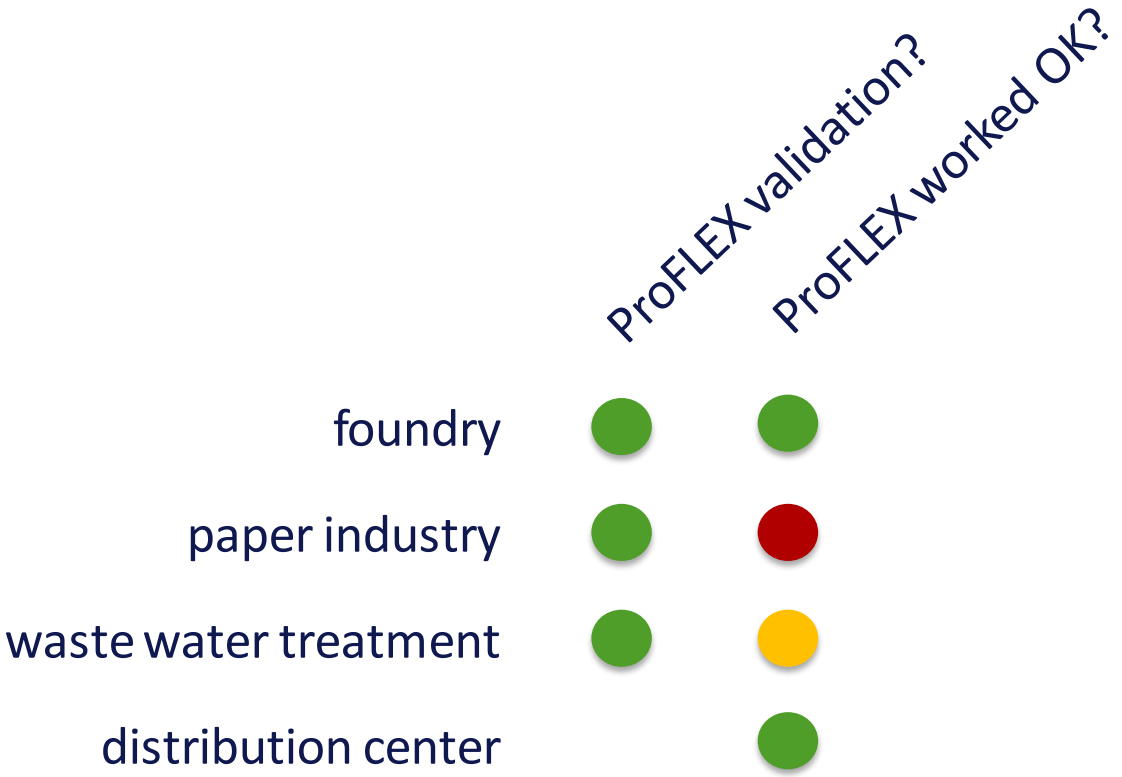
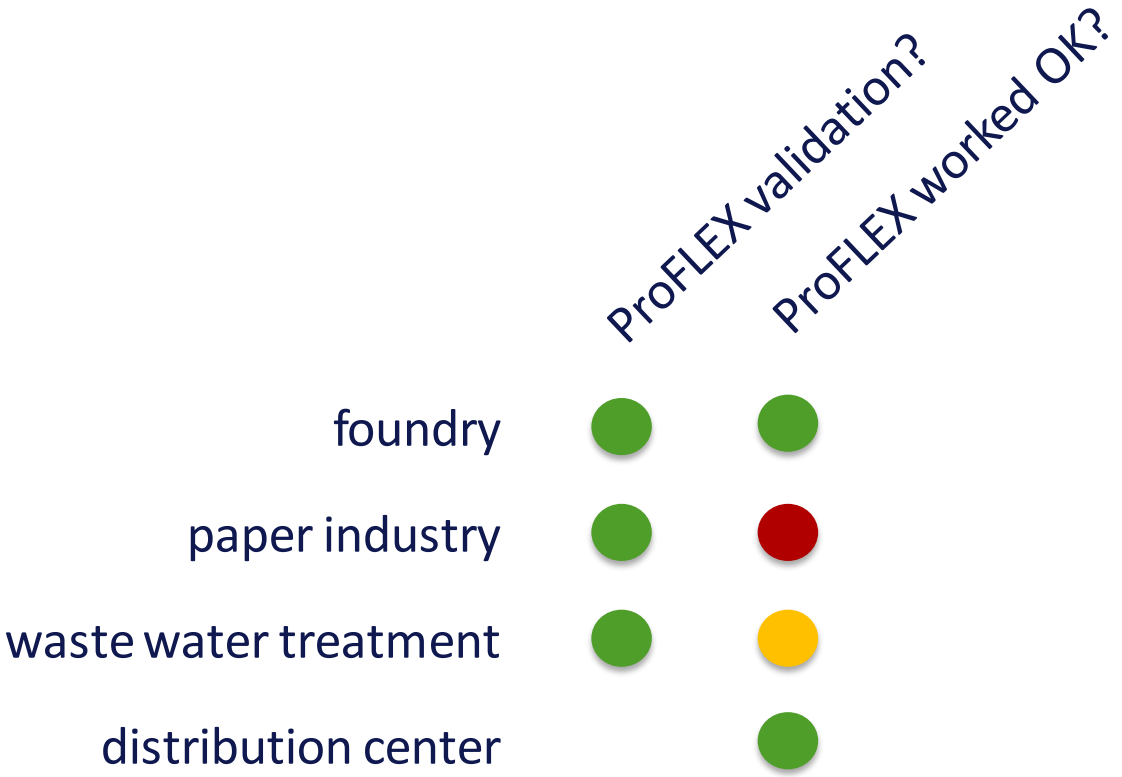
Overview validation **ProFLEX**



Overview validation **ProFLEX**



Overview validation **Pro*FLEX***



Important remarks:

- If **Pro*FLEX*** does not work for a particular case, it does not mean it can not be used for the whole sector
- **Pro*FLEX*** can become more versatile with the introduction of new reference models

Pro*FLEX* observations …

1

Multi commodity normalized business case graphs are missing …

- Paper industry and wastewater treatment business case
- Will become even more important in the future (e.g. power to gas context)

Pro*FLEX* observations …

1 Multi commodity normalized business case graphs are missing …

- Paper industry and wastewater treatment business case
- Will become even more important in the future (e.g. power to gas context)

2 Complex processes with lots of constraints are difficult …

- Complex paper industry and combined wastewater treatment business are difficult
- But still satisfactory results can be achieved

Pro*FLEX* observations …

3

The mapping step is not always as easy as it seems …

- Recognizing the “virtual battery” in an industrial process requires some experience and engineering skills

Pro*FLEX* observations …

3 The mapping step is not always as easy as it seems …

- Recognizing the “virtual battery” in an industrial process requires some experience and engineering skills

4 Works very well to get the order of magnitude right in simple or simplified cases…

- Quick comparison of the emergency generator case with the other sources of flexibility in the distribution center cases

Pro*FLEX* observations …

5

Clever combination of several simplified cases worked fine …

- The variable temperature ranges and losses during operations and weekend days are not compatible with **Pro*FLEX***
- Clever “pro rata” scaling gives pretty good results

Pro*FLEX* observations …

5 Clever combination of several simplified cases worked fine …

- The variable temperature ranges and losses during operations and weekend days are not compatible with **Pro*FLEX***
- Clever "pro rata" scaling gives pretty good results

6 As long as the process matches the reference process well, accuracy is very good …

- There are definitely processes which match perfectly well on a "virtual" battery model
- E.g. Foundry and waste water treatment cases

Contact information

- More materials, webinars, reports available on www.industre.eu
- Stay tuned for more case study results

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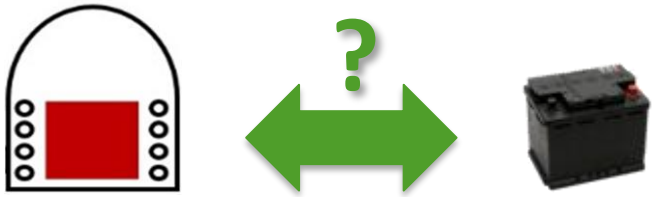
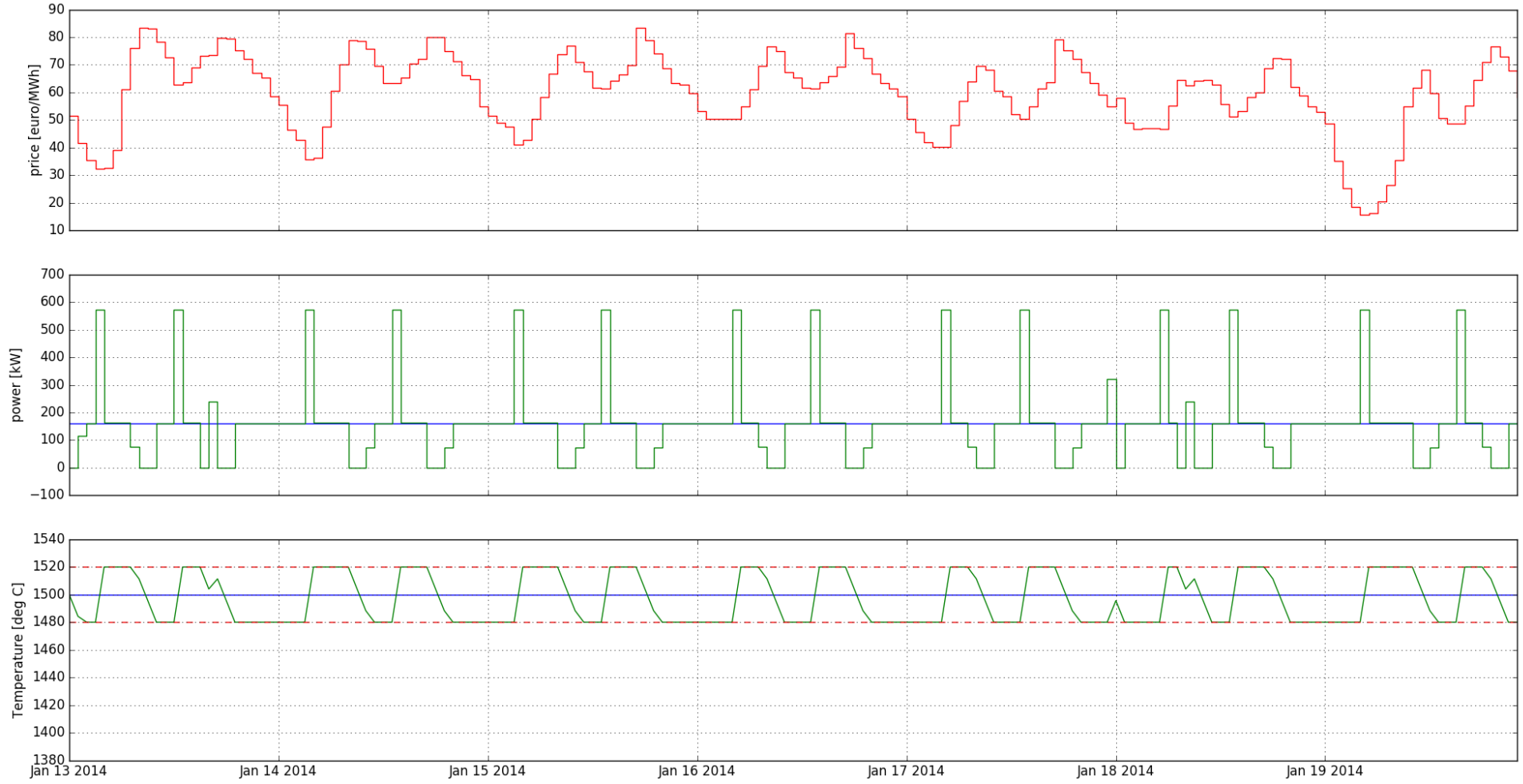
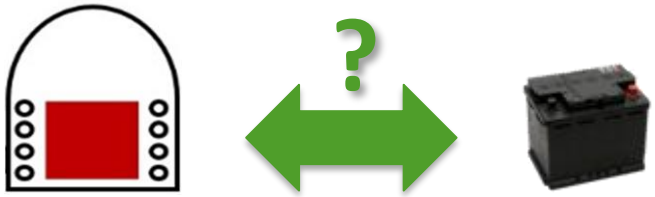
Backup slides

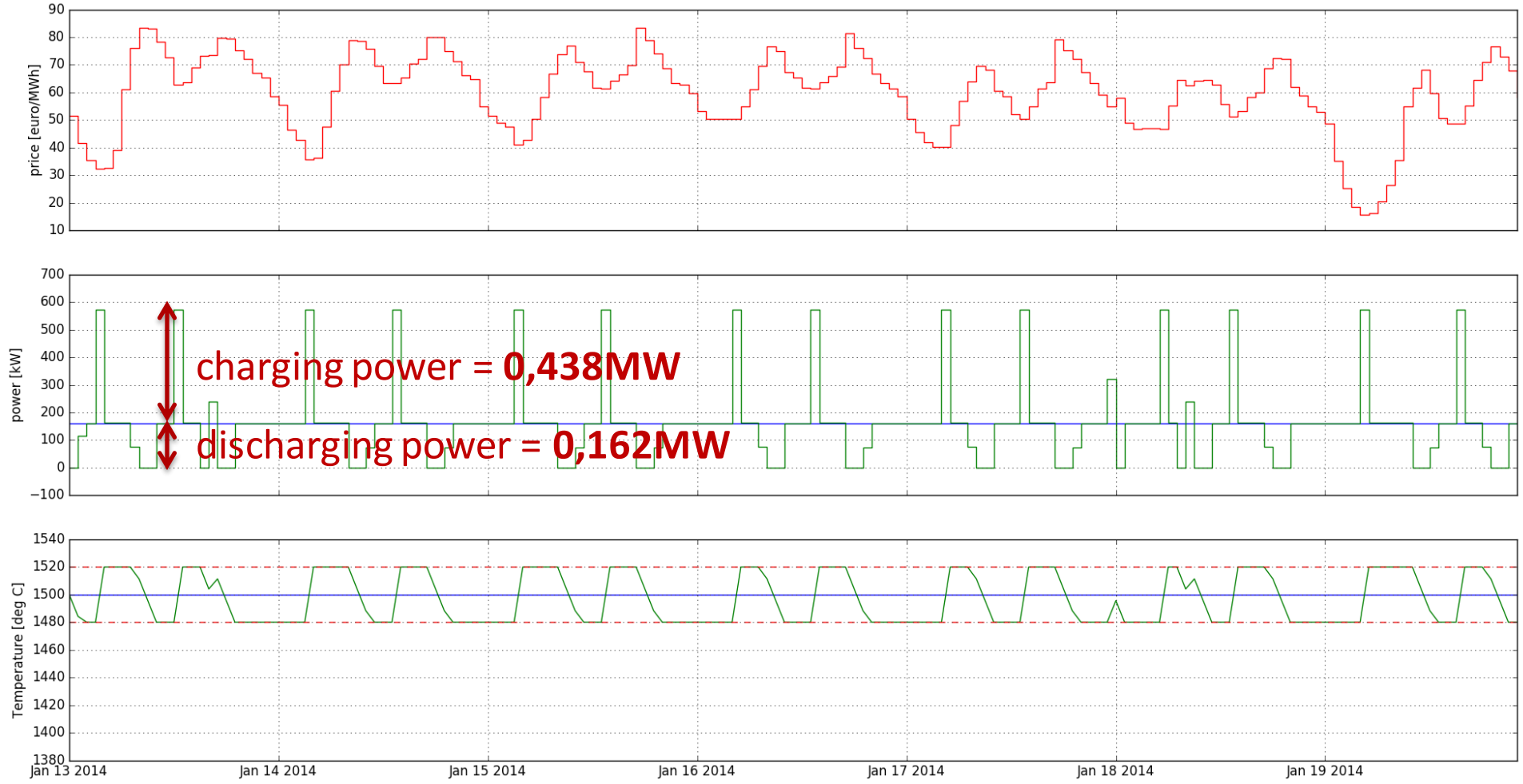
Mapping induction furnace on a battery





Mapping induction furnace on a battery





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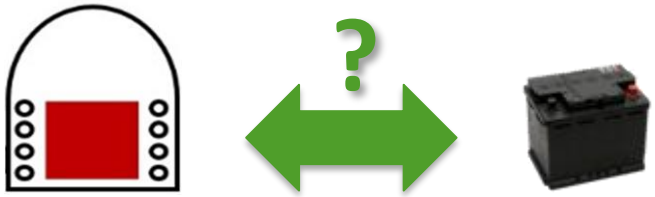


price [euro/MWh]

power [kW]

charging power = **0,438MW**

discharging power = **0,162MW**

0,412MW

1h

battery size = **0,412MWh**

Temperature [deg C]

Jan 13 2014 | Jan 14 2014 | Jan 15 2014 | Jan 16 2014 | Jan 17 2014 | Jan 18 2014 | Jan 19 2014

Normalizing to a 1MW battery

2 normalize

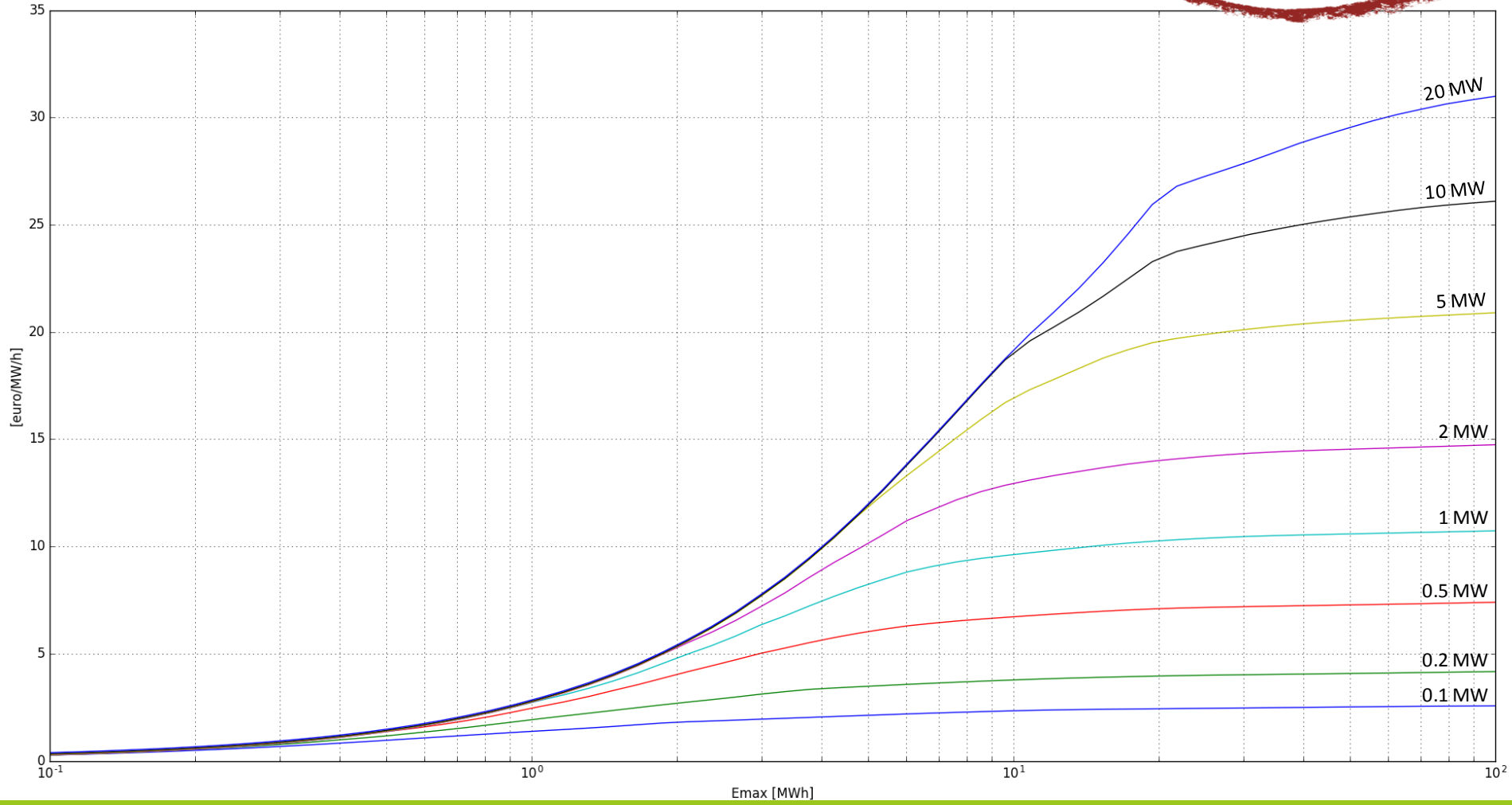
Pin_max = **0,438** MW
Pout_max = **0,162** MW
Emax = **0,412** MWh

scale factor = 2,283

Pin_max = **1** MW
Pout_max = **0,336** MW
Emax = **0,941** MWh

Normalized BC graph generic battery model

3 select



Normalized BC graph generic battery model

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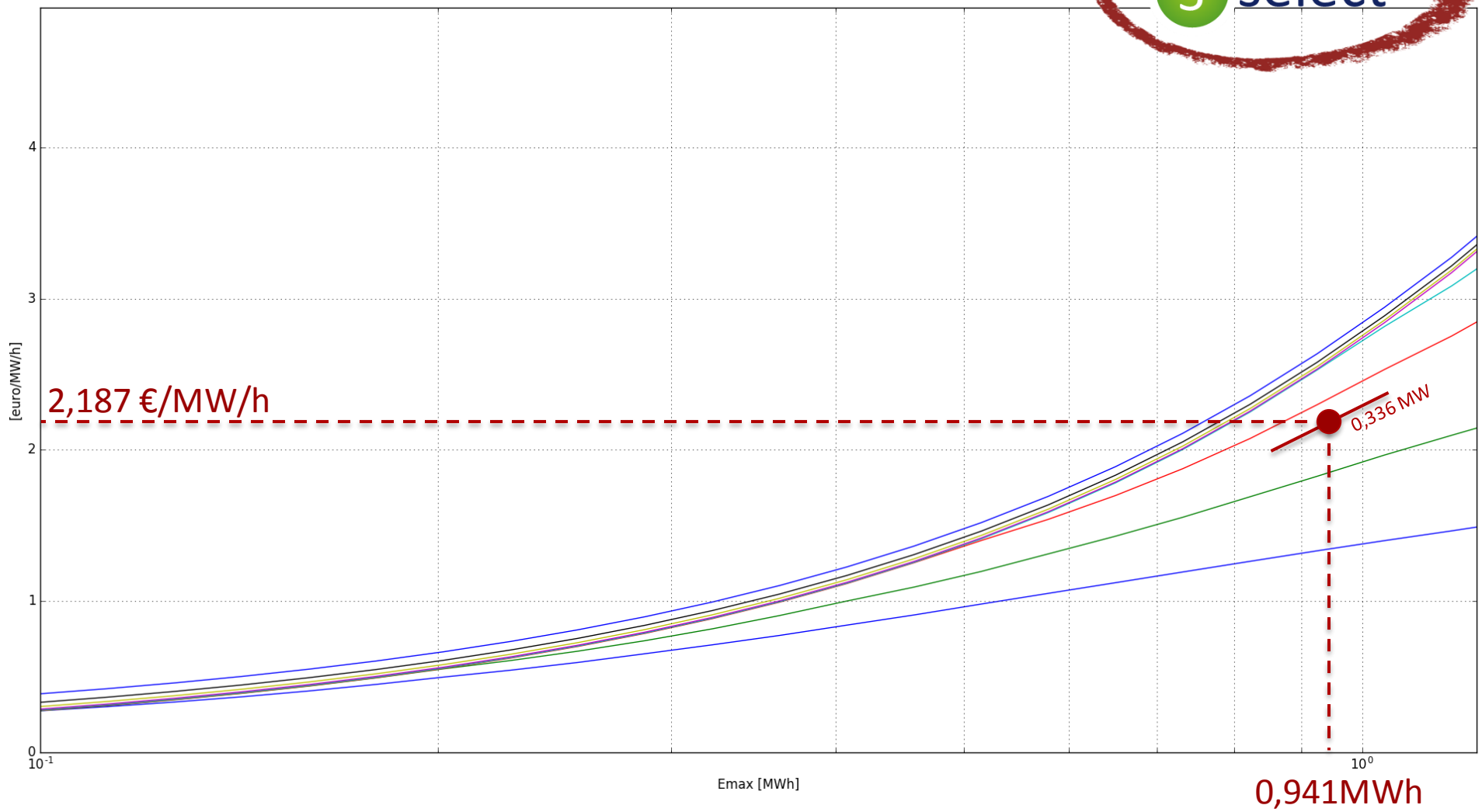

Scaling back to a the original values

Normalized values:

Pin_max = **1** MW

Pout_max = **0,336** MW

Emax = **0,941** MWh

Value = **2,187** €/MW/h

scale factor = 2,283

Actual values:

Pin_max = **0,438** MW

Pout_max = **0,162** MW

Emax = **0,412** MWh

Value = **0,958** €/h

Scaling back to a the original values

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scale factor = 2,283

Actual values:

Pin_max = **0,438** MW

Pout_max = **0,162** MW

Emax = **0,412** MWh

Value = **0,958** €/h

An added value of 0,958 €/h corresponds to **8.392** €/year
while the result of the full optimization was **8.472** €/year.