



industRE webinar: Flexibility potential of industrial plants

*“Demand side flexibility
business case estimation
made easy ...”*

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industRE

Using the

flexibility potential

*in energy intensive industries to
facilitate further grid integration of*

**variable renewable
energy sources**



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Using the

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Chemicals



Non-ferrous metals



Steel



Cold storage



Water treatment



industRE

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Chemicals



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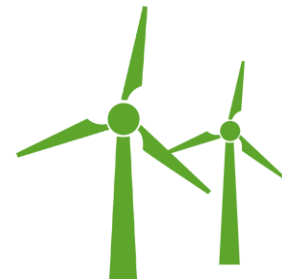


Imperial College
London



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- Part I The context: Demand Response
- Part II How calculating a demand response business case?
- Part III The need for a simplified methodology
- Part IV The simplified methodology step-by-step
- Part V On-site renewable energy business case
- Part VI Conclusions and further steps



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Part I The context: Demand Response

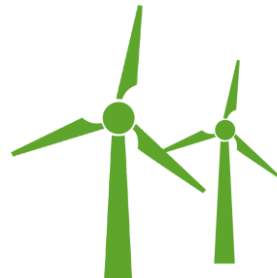
Part II How calculating a demand response business case?

Part III The need for a simplified methodology

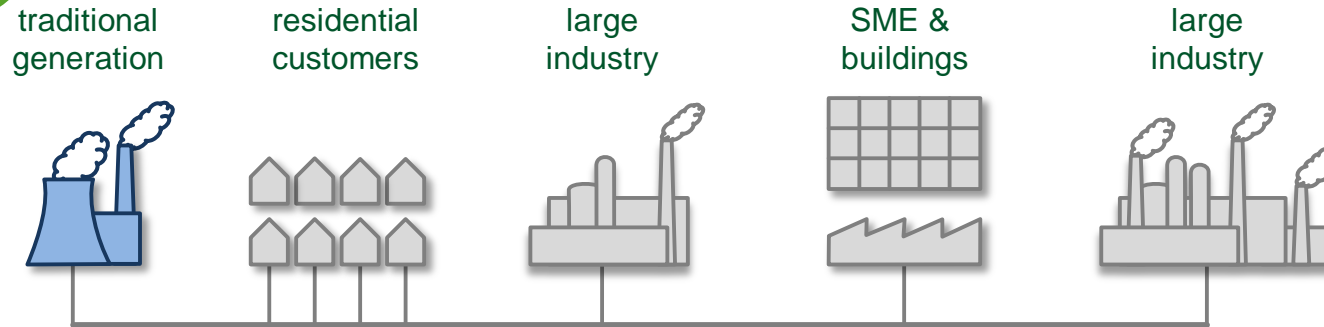
Part IV The simplified methodology step-by-step

Part V On-site renewable energy business case

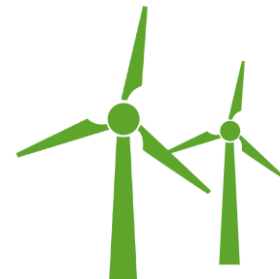
Part VI Conclusions and further steps



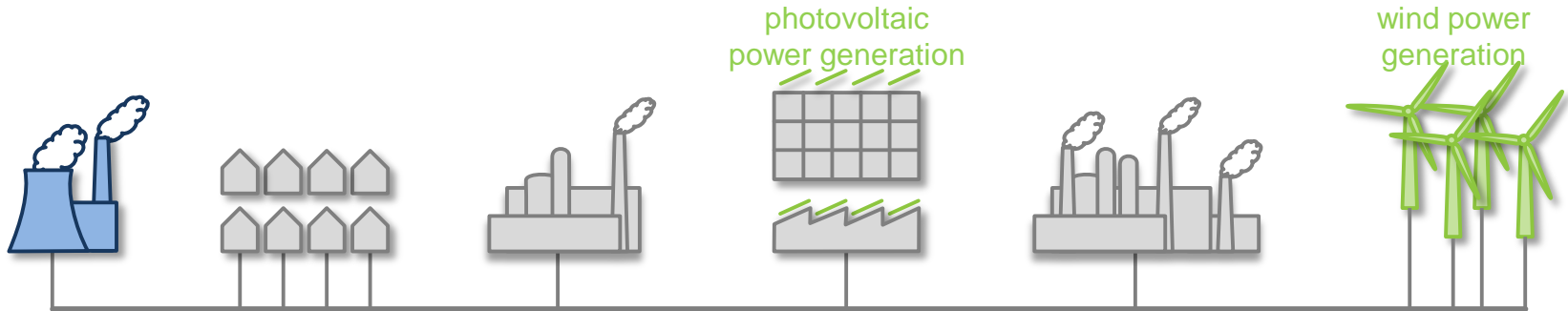
The challenge of tomorrow's electricity grid



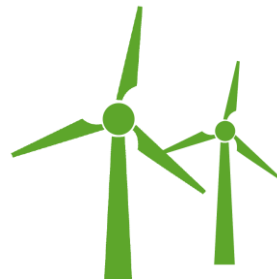
“An electricity grid with traditional generation, residential, medium sized and large industrial customers”



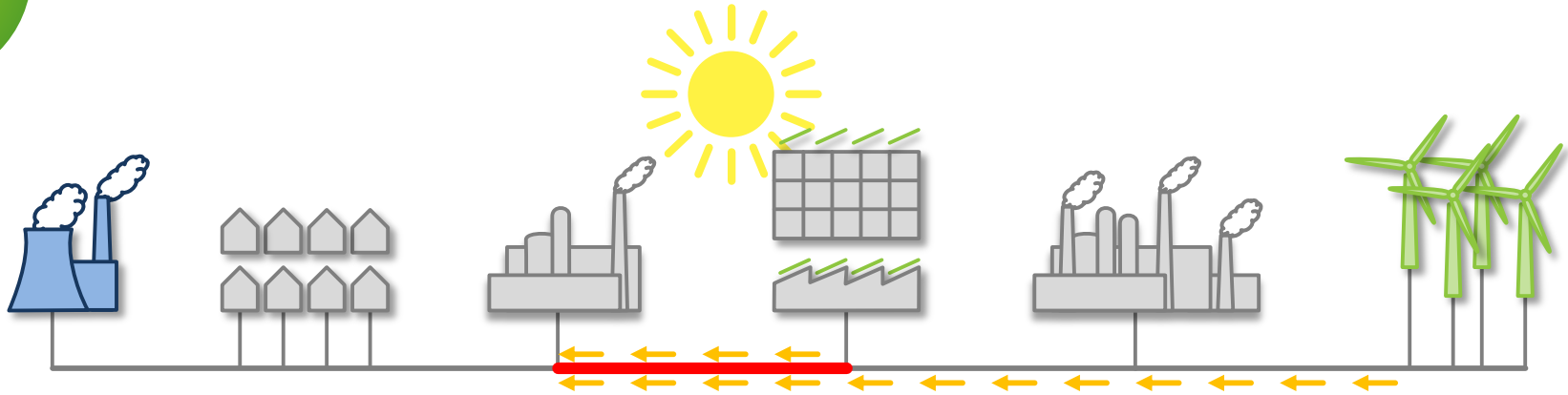
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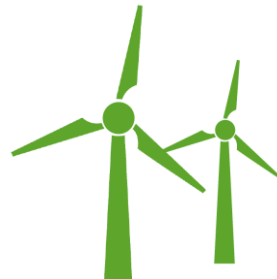
“Today, introduction and growth of renewable energy change the electricity system significantly”



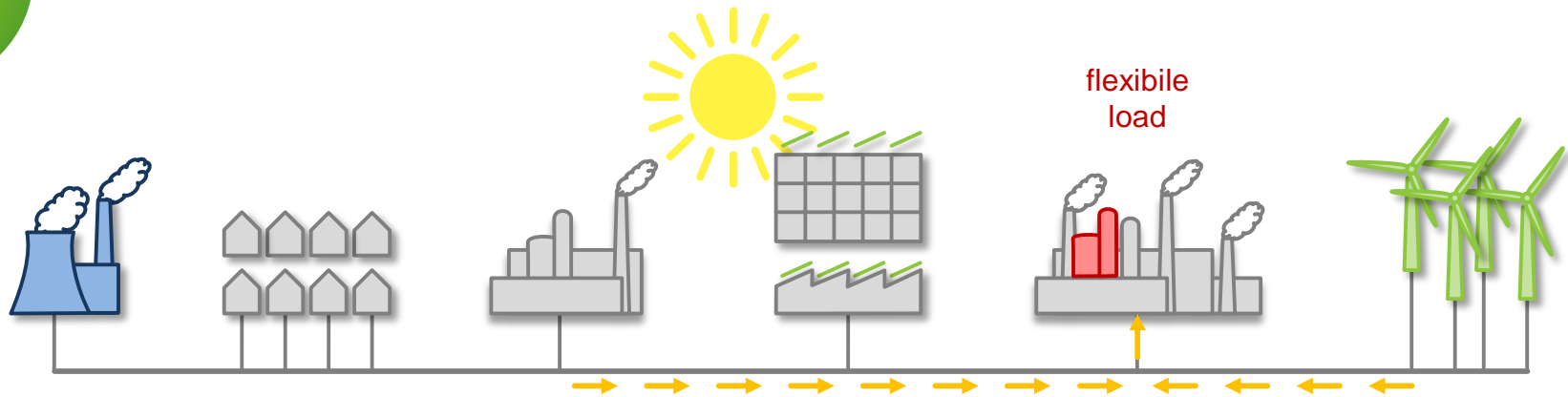
The challenge of tomorrow's electricity grid



“For example when large amounts of renewable energy are injected, grid overload situations are possible.”



The challenge of tomorrow's electricity grid



*“Activation of additional demand can help to solve this.
This is **Demand Response** or **Demand Side Management**”*



Quote (Art. 15.8) from the European Commission Energy Efficiency Directive (2012/27/EU):

“Member states shall promote access to and participation of Demand Response in balancing, reserves and other system services markets”



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Part I The context: Demand Response

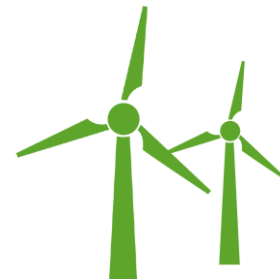
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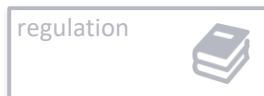
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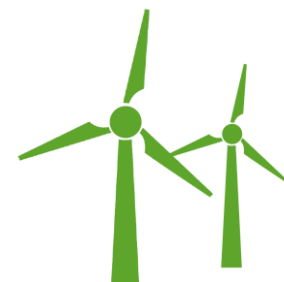
Part VI Conclusions and further steps



How can you make money with flexibility?



| Business model | | BE | FR | DE | IT | ES | UK |
|---------------------------------------|-----------------|----|----|----|----|----|----|
| Standard contract optimization | Commodity | | | | | | |
| | Network charges | | | | | | |
| Day-ahead optimization | Commodity | | | | | | |
| | Network charges | | | | | | |
| Reserve capacity | FC reserve | | | | | | |
| | FR reserve | | | | | | |
| | R reserve | | | | | | |
| Imbalance optimization | | | | | | | |
| On-site VRE optimization | | | | | | | |



What is possible from a legal point of view?

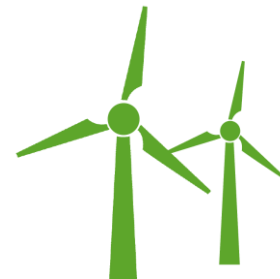


“Although EU guidelines are quite clear, implementation pace is different...”

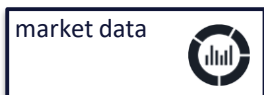
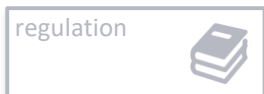


| Business model | | BE | FR | DE | IT | ES | UK |
|---------------------------------------|-----------------|----|----|----|----|----|----|
| Standard contract optimization | Commodity | ● | ● | ● | ● | ● | ● |
| | Network charges | ● | ● | ● | ● | ● | ● |
| Day-ahead optimization | Commodity | ● | ● | ● | ● | ● | ● |
| | Network charges | ● | ● | ● | ● | ● | ● |
| Reserve capacity | FC reserve | ● | ● | ● | ● | ● | ● |
| | FR reserve | ● | ● | ● | ● | ● | ● |
| | R reserve | ● | ● | ● | ● | ● | ● |
| Imbalance optimization | | ● | ● | ● | ● | ● | ● |
| On-site VRE optimization | | ● | ● | ● | ● | ● | ● |

- business case is viable in existing regulatory framework
- business case limited viability/restricted in current regulatory framework
- business case impossible in existing regulatory framework

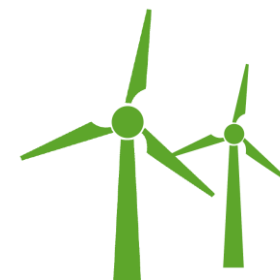


Which price data is available?

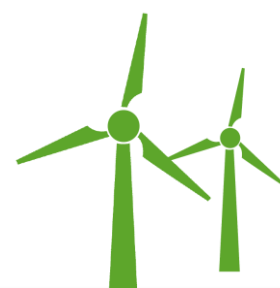
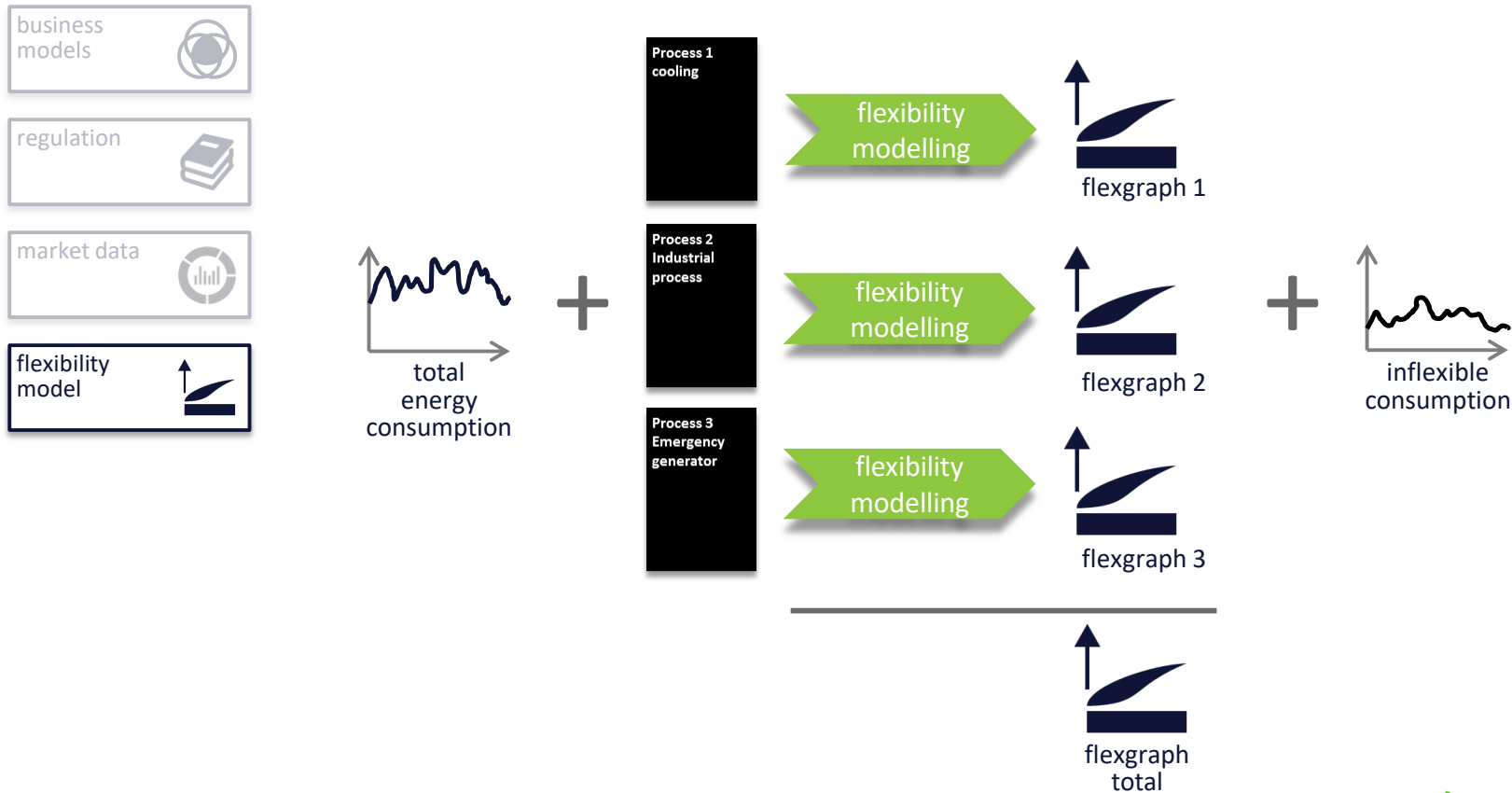


| Business model | | BE | FR | DE | IT | ES | UK |
|---------------------------------------|-----------------|----|----|----|----|----|----|
| Standard contract optimization | Commodity | ● | ■ | ● | ■ | ● | ■ |
| | Network charges | ● | ■ | ● | ■ | ● | ■ |
| Day-ahead optimization | Commodity | ● | ■ | ● | ■ | ● | ■ |
| | Network charges | ● | ■ | ● | ■ | ● | ■ |
| Reserve capacity | FC reserve | ● | ■ | ● | ■ | ● | ■ |
| | FR reserve | ● | ■ | ● | ■ | ● | ■ |
| | R reserve | ● | ■ | ● | ■ | ● | ■ |
| Imbalance optimization | | ● | ■ | ● | ■ | ● | ■ |
| On-site VRE optimization | | ● | ■ | ● | ■ | ● | ■ |

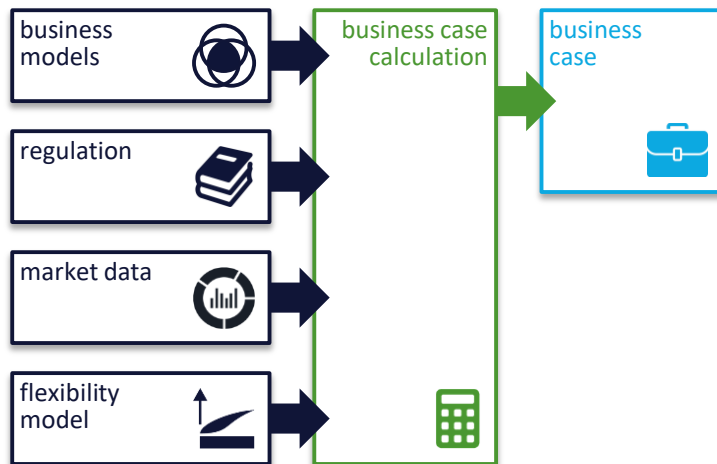
public price data available
 bilateral price data estimates available
 (bilateral) price data not available



How much flexibility is available?



Calculate the business case



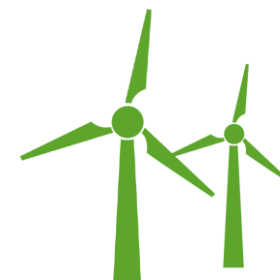
| Business model | | BE | FR | DE | IT | ES | UK |
|---------------------------------------|-----------------|-------|--------|--------|----------|-------|-------|
| Standard contract optimization | Commodity | ● PP | ● PP | ● PP | ● PP | ● PP | ● PP |
| | Network charges | ● PP | ● PP | ● PP | ● PP | ● PP | ● PP |
| Day-ahead optimization | Commodity | ● PP | ● PP | ● PP | ● PP | ● PP | ● PP |
| | Network charges | ● PP | ● PP | ● PP | ● PP | ● PP | ● PP |
| Reserve capacity | FC reserve | ● C | ● C | ● C | ● - | ● - | ● C |
| | FR reserve | ● - | ● C/PP | ● C/PP | ● - | ● - | ● C |
| | R reserve | ● C | ● C | ● C/PP | ● - | ● - | ● C |
| Imbalance optimization | | ● DIP | ● DIP | ● PP | ● DIP/PP | ● DIP | ● DIP |
| On-site VRE optimization | | ● DS | ● DS | ● DS | ● DS | ● - | ● DS |

PP Price profile optimization method (energy + peak)

DS Dual supplier optimization method (supplier + own production + peak)

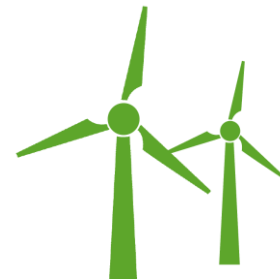
DIP Dual imbalance price optimization

C Total costs optimization method (capacity only)



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Skills for creating a flexibility model ...



A flexibility model is the result of a 2 stage process:

selection stage:

- identification of flexibility during a site survey or audit
- requires good top-level understanding of industrial processes with focus on energy flows

modelling stage:

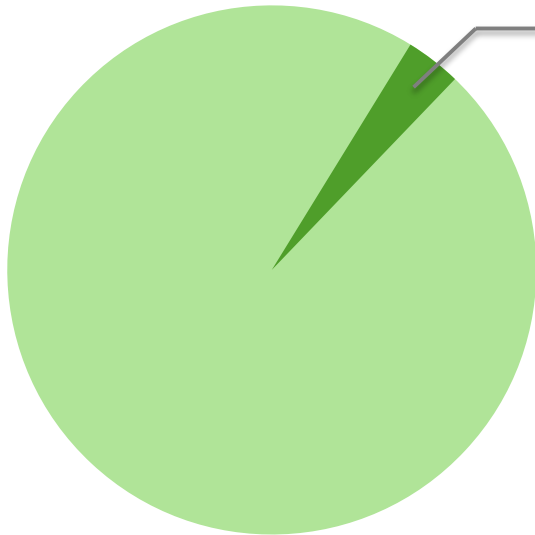
- construction of a mathematical model which describes production process and constraints from energy consumption point of view
- requires understanding of modelling and optimization techniques

➔ The combination of skills is not so obvious

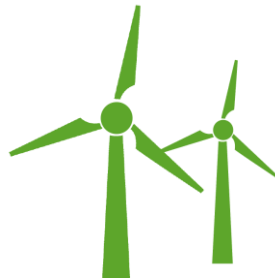


Business case calculation complexity ...

business case calculation

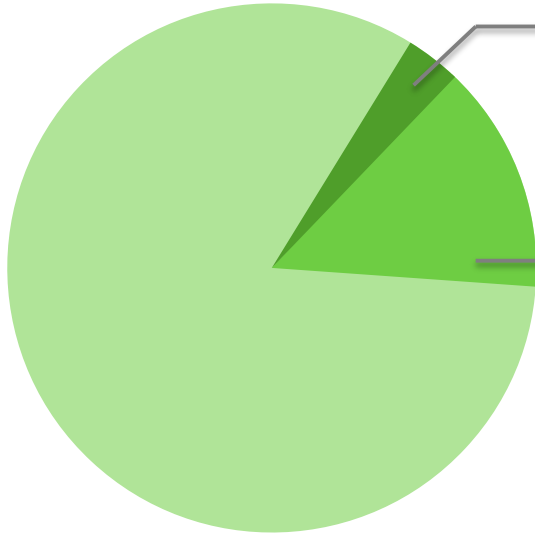


$$\begin{aligned} 16,3 \text{ kWh} \times 1000 \times 43,8 \text{ €/kWh} &= 714 \text{ k€} \\ 2 \text{ MW} \times 3,18 \text{ €/MWh} \times 365 \times 24 &= 55,7 \text{ k€} \\ 55,7 / 714 \times 100 &= 7,8\% \end{aligned}$$



Business case calculation complexity ...

business case calculation


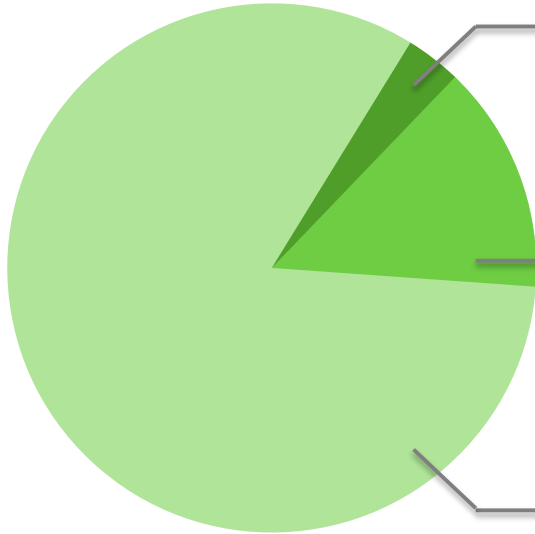
$16,3 \text{ kWh} \times 1000 \times 43,8 \text{ €/MWh} = 714 \text{ k€}$
 $2 \text{ MW} \times 3,18 \text{ €/MWh} \times 365 \times 2,4 = 55,7 \text{ k€}$
 $55,7 / 714 \times 100 = 7,8 \%$



| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|----|-----------------|--|---|---|---|---|---|---|---|---|----|----|----|----|----|
| 1 | Case File | http://www.sclab.nl | | | | | | | | | | | | | |
| 2 | Part Number | http://www.sclab.nl/.../partnumber/... | | | | | | | | | | | | | |
| 3 | Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 4 | Scenario Method | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 5 | Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 6 | Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
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| 12 | Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 13 | Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 14 | Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
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Business case calculation complexity ...

business case calculation

$16,36 \text{ kWh} \times 1000 \times 43,8 \text{ €/MWh} = 714 \text{ k€}$
 $2 \text{ hW} \times 3,18 \text{ €/MWh} \times 365 \times 24 = 55,7 \text{ k€}$
 $53,7 / 714 \times 100 = 7,5 \%$



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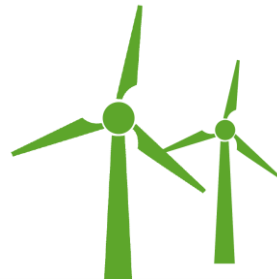


$$\sum_{\tau=t}^{t+T-1} s(\tau)[V\beta(\tau) - Q(\tau) - X(\tau) - Y(\tau)] \\
 + \sum_{\tau=t}^{t+T-1} [(X(\tau) + Y(\tau))(\gamma b(\tau) - \gamma l(\tau))] \\
 0 \leq s(\tau) \leq s_{\max}, \quad \forall \tau \\
 \sum_{\tau=t}^{t+T-1} \gamma \beta(\tau) \leq N_{\max}$$



Accuracy of the business case value

“Building up interest in demand response is for many companies a long, time consuming, multi-stage process...”

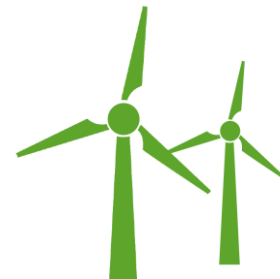


Accuracy of the business case value

“Building up interest in demand response is for many companies a long, time consuming, multi-stage process...”



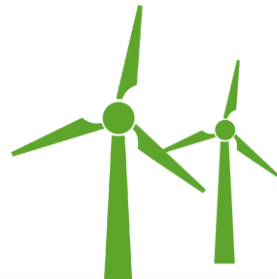
... but an order of magnitude business case estimation is enough to plant a seed”



Requirements of a simplified methodology

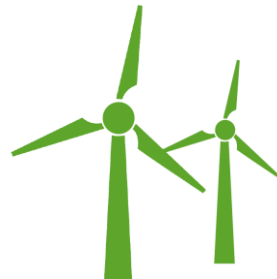
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Being cost effective and time efficient



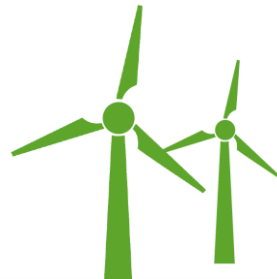
Requirements of a simplified methodology

- 1 Being cost effective and time efficient
- 2 Order of magnitude accuracy estimation is good enough



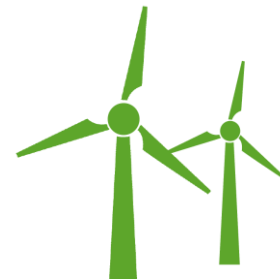
Requirements of a simplified methodology

- 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















































Contents

- Part I The context: Demand Response
- Part II How calculating a demand response business case?
- Part III The need for a simplified methodology
- Part IV The simplified methodology step-by-step**
- Part V On-site renewable energy business case
- Part VI Conclusions and further steps

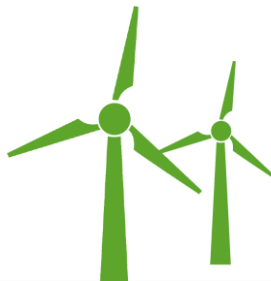


The naïve approach ...

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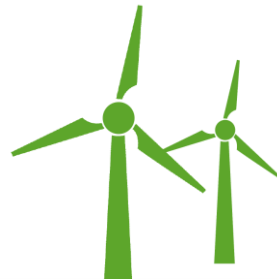


“Database with many precalculated business cases”



A smarter approach ... in 4 steps

- 1 map
- 2 normalize
- 3 select
- 4 scale



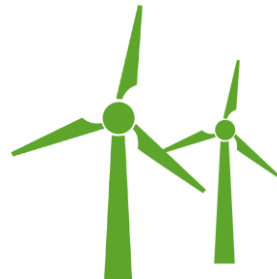
A smarter approach ... in 4 steps

1 map

2 normalize

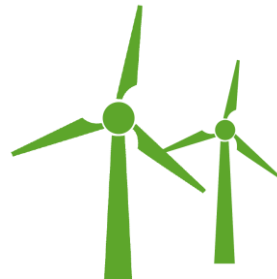
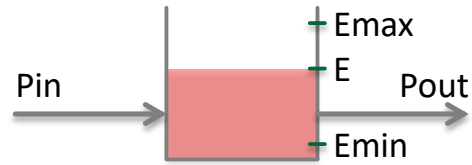
3 select

4 scale



Example: generic battery model

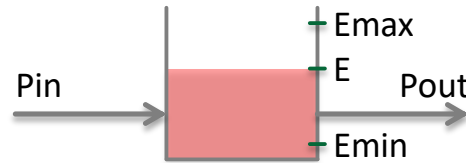
generic
battery model



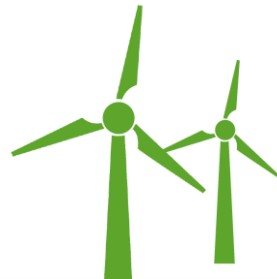
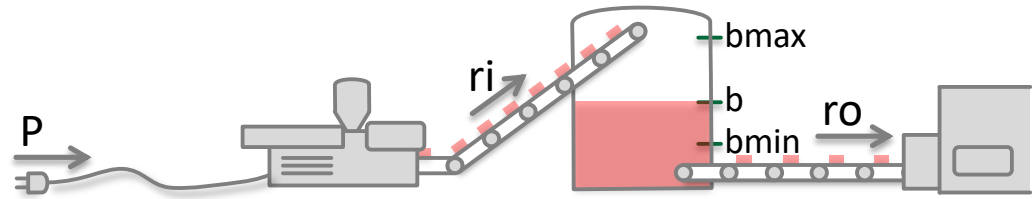
Example: generic battery model



generic
battery model



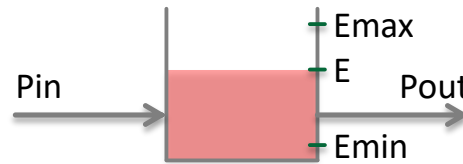
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industrial process



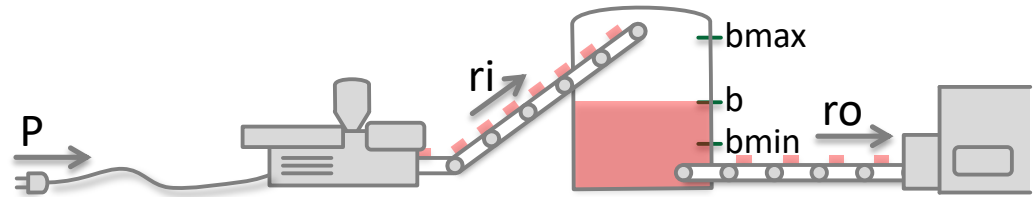
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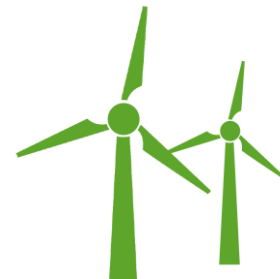
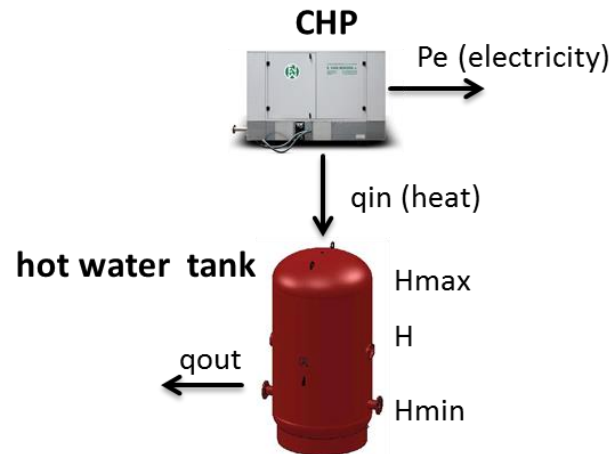
generic
battery model



buffered
industrial process



CHP with a hot
water storage tank



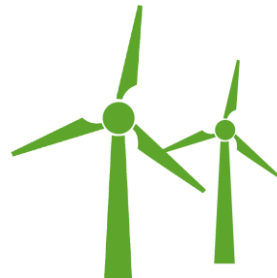
A smarter approach ... in 4 steps

1 map

2 **normalize**

3 select

4 scale



Some properties scale very well ...

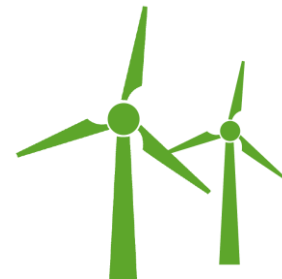
2 normalize

1x



*“If you can earn **20€/year** by trading electricity on the day-ahead market with **1 car battery** ... “*

*$P_{in} = 2 \text{ kW}$
 $P_{out} = 2 \text{ kW}$
 $E_{max} = 1 \text{ kWh}$*



Some properties scale very well ...

2 normalize

1x



20x

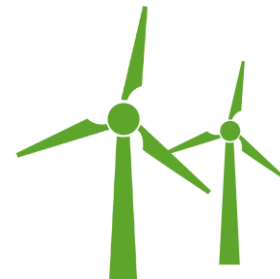


*“If you can earn **20€/year** by trading electricity on the day-ahead market with **1 car battery** ... “*

*Pin = 2 kW
Pout = 2 kW
Emax = 1 kWh*

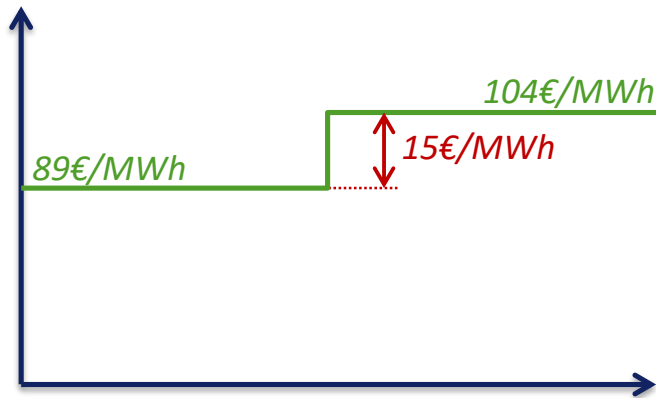
*“... you can earn **400€/year** with **20 car batteries!**“*

*Pin = 40 kW
Pout = 40 kW
Emax = 20 kWh*

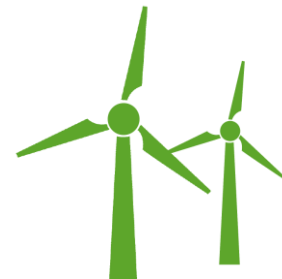


Some properties scale very well ...

2 normalize

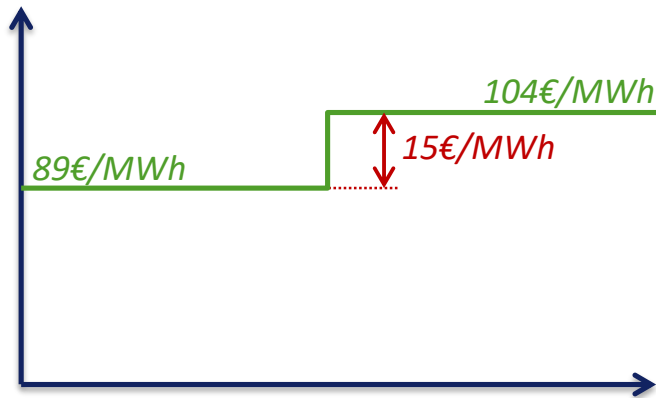


*“If you can earn **2.000€/year** by shifting electricity consumption from day to night ... “*

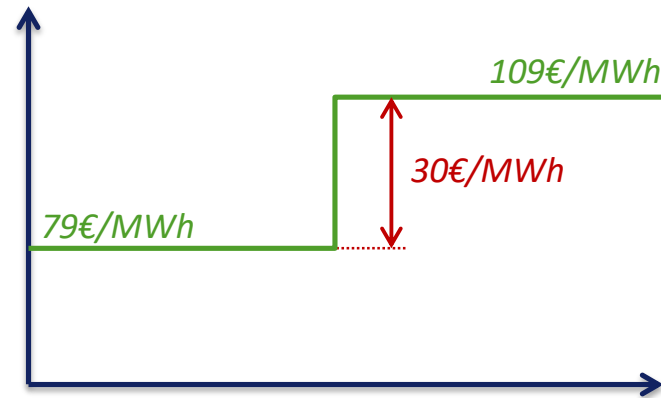


Some properties scale very well ...

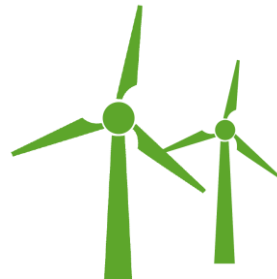
2 normalize



*“If you can earn **2.000€/year** by shifting electricity consumption from day to night ...”*

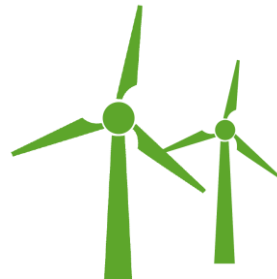


*“... you can earn **4.000€/year** in case the **price difference doubles** ...”*

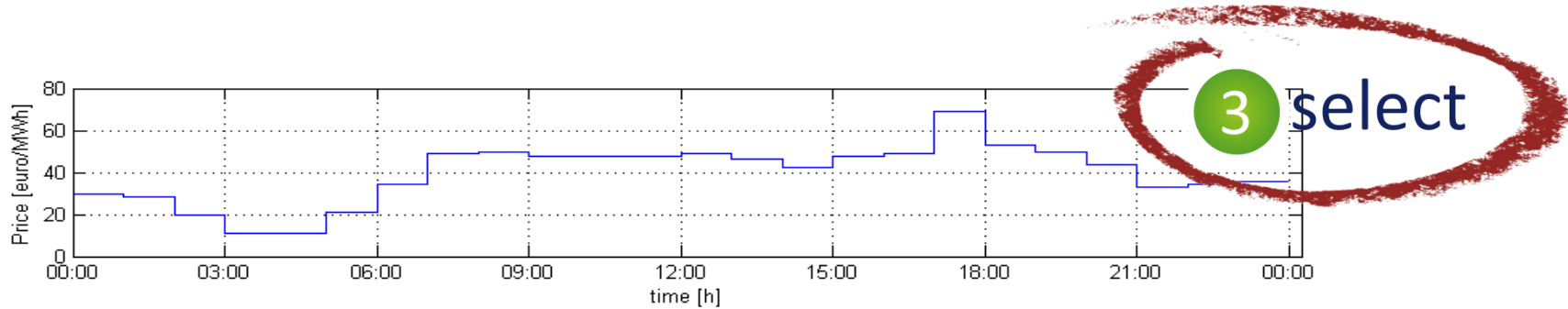


A smarter approach ... in 4 steps

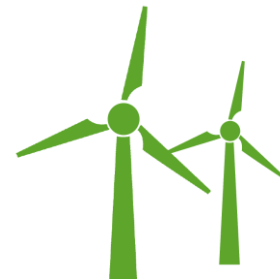
- 1 map
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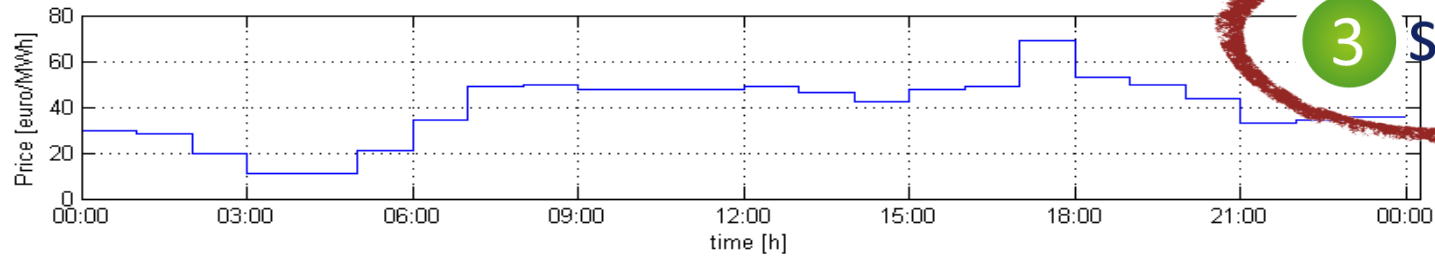
Making money with a “reference battery” on the day ahead market



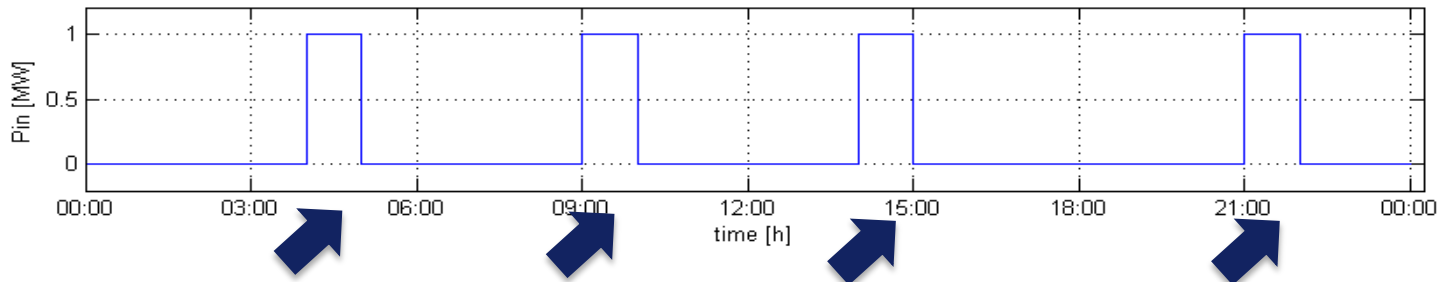
“Day ahead electricity price for 1 day ...”



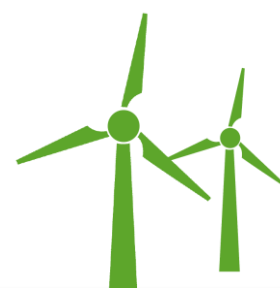
Making money with a “reference battery” on the day ahead market



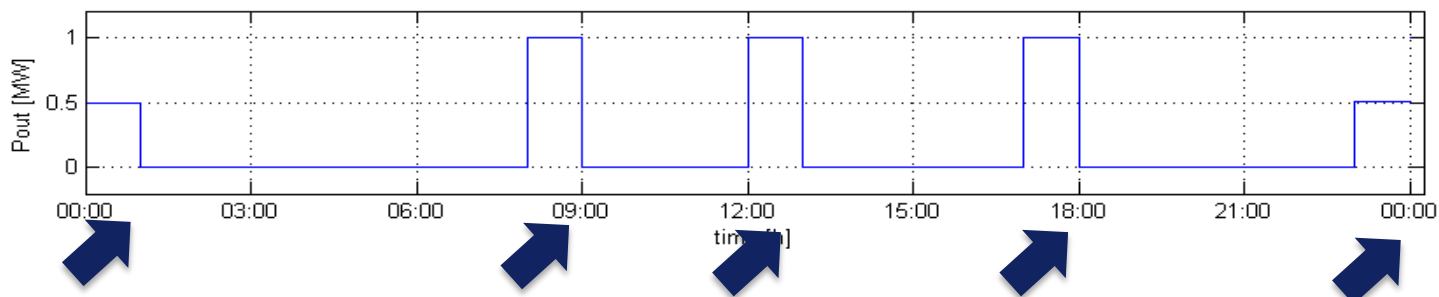
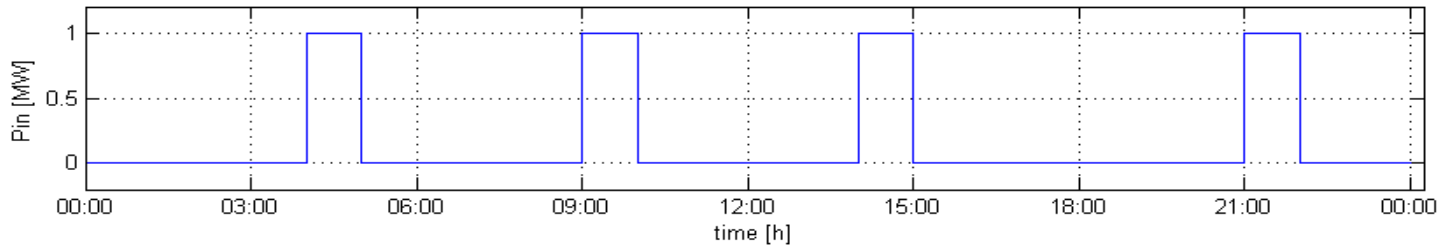
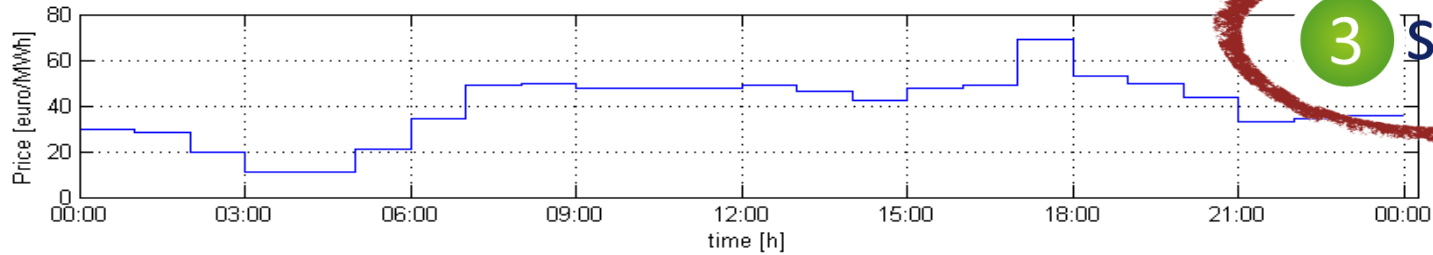
3 select



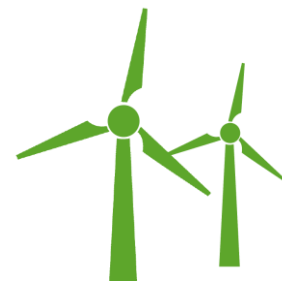
“Buy electricity when cheap ...”



Making money with a “reference battery” on the day ahead market

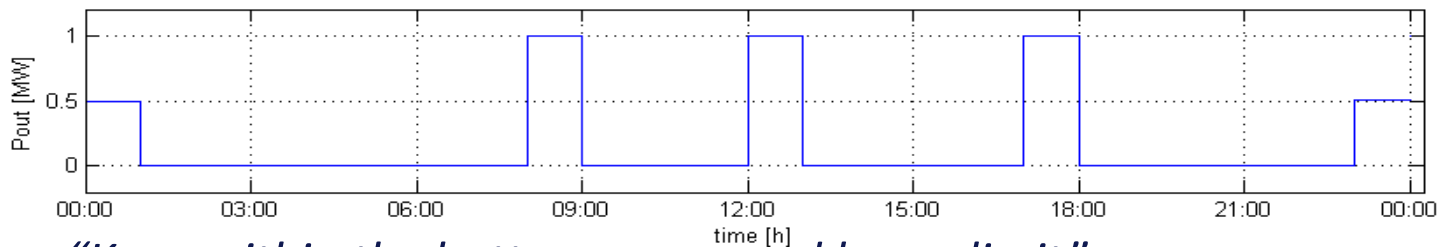
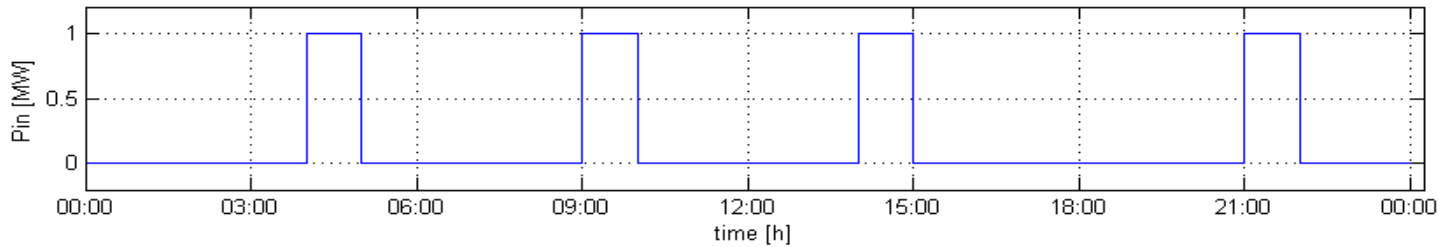
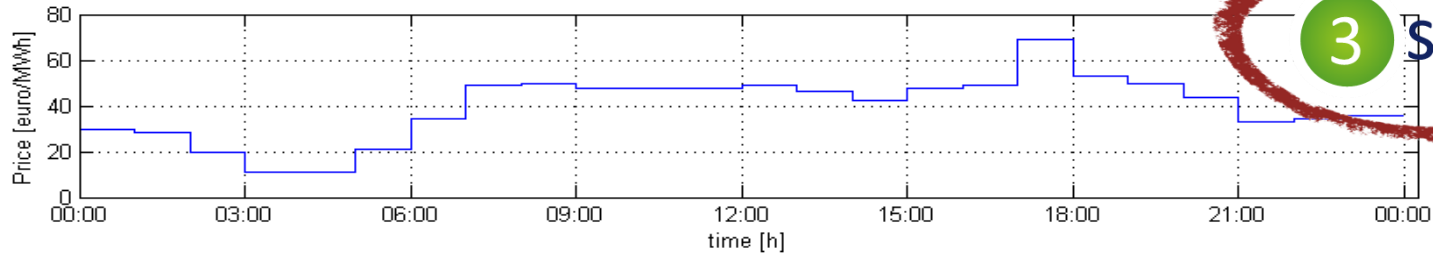


“Well electricity when expensive ...”

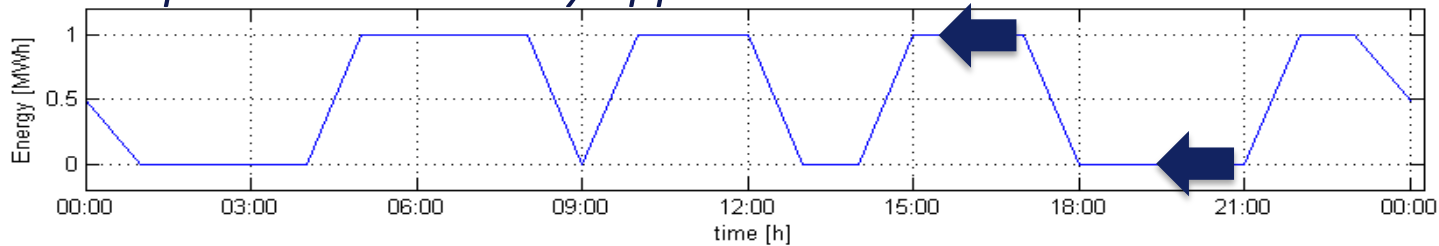


Making money with a “reference battery” on the day ahead market

3 select

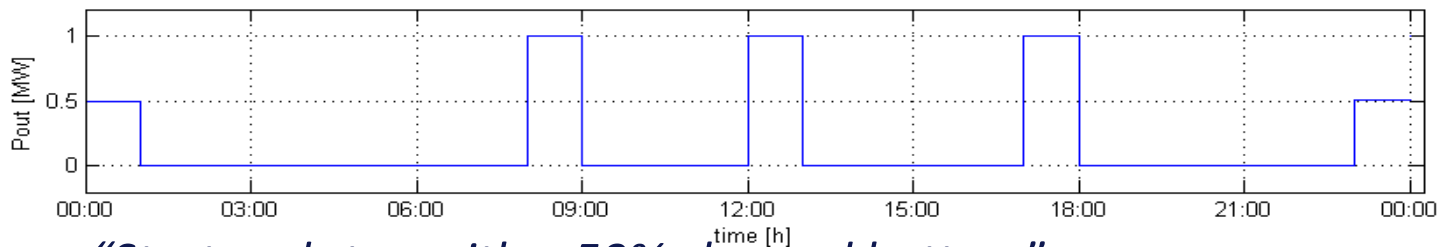
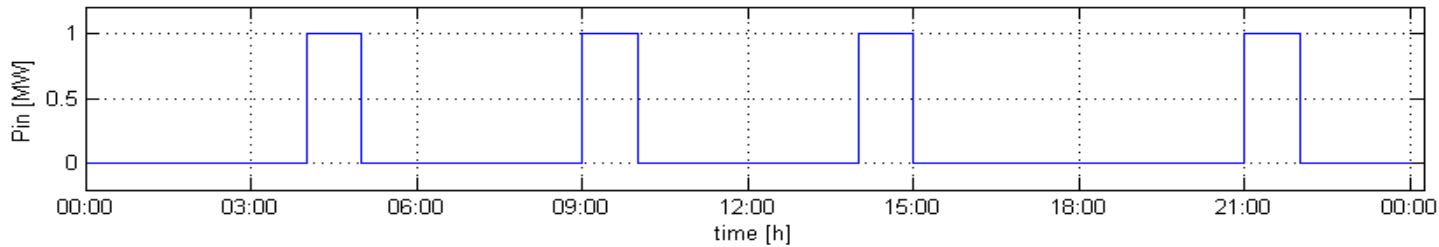
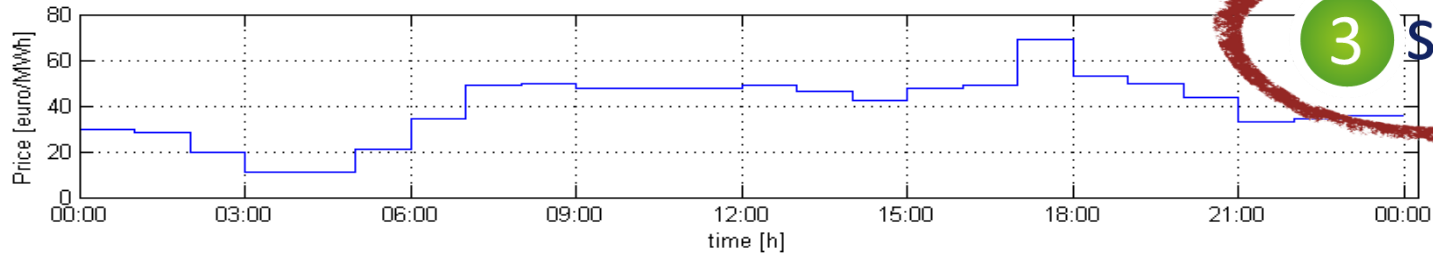


“Keep within the battery upper and lower limit”

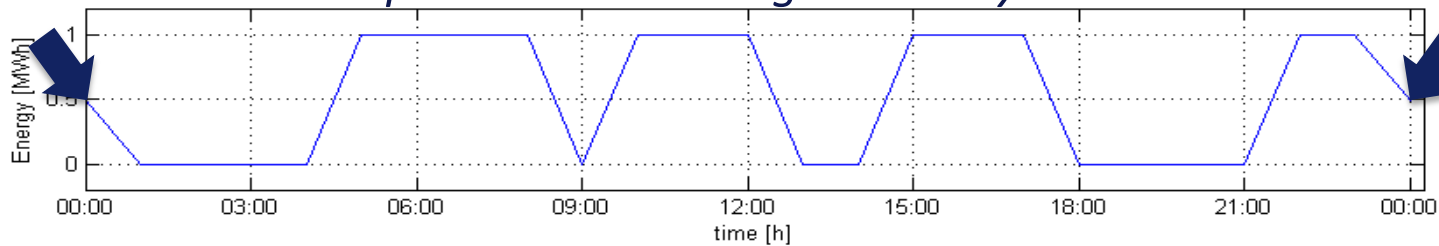


Making money with a “reference battery” on the day ahead market

3 select



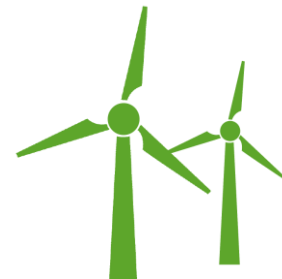
“Start and stop with a 50% charged battery”



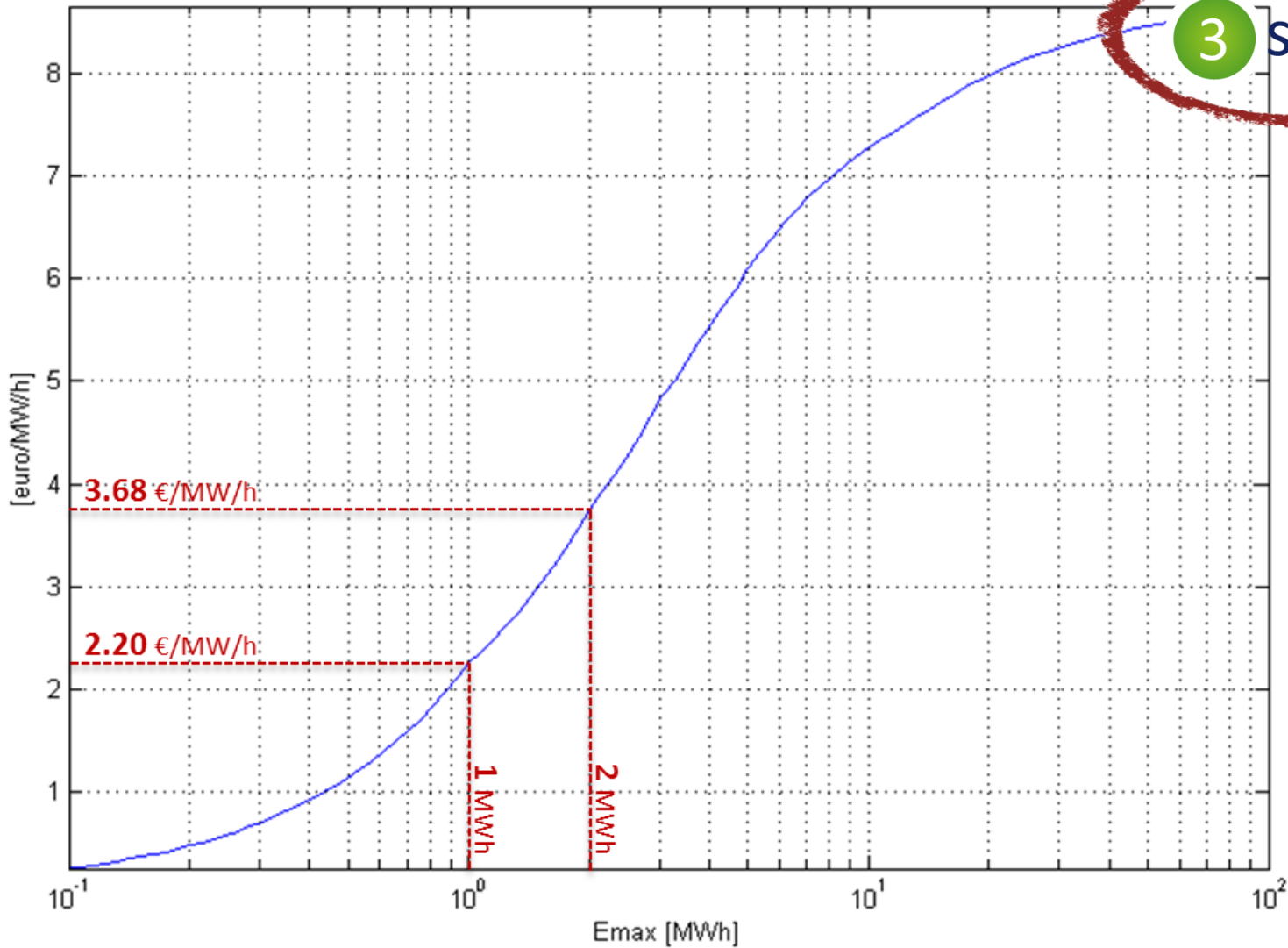
3 select

- For 1 day in this example: profit = 66,16€
- For whole year: profit = 19.240€/year
- ... or an average profit of **2,2€/MW/h**
- In case you double the battery size, but not the Pin and Pout, unfortunately this doesn't scale very well

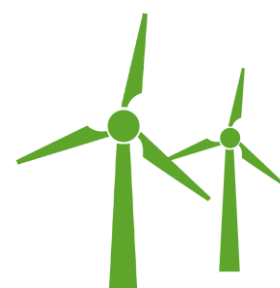
“But why not putting it in a graph?”



Part IV: The simplified methodology step-by-step
The normalized business case graph

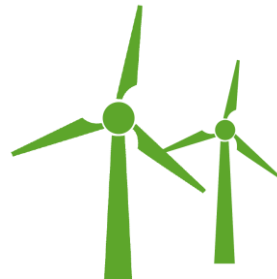


3 select



A smarter approach ... in 4 steps

- 1 map
- 2 normalize
- 3 select
- 4 scale**



Scale back to the real process parameters



1x



20x

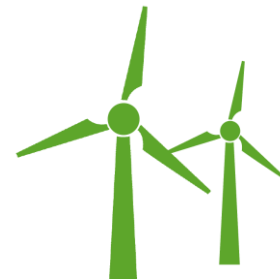


*“If you can earn **20€/year** by trading electricity on the day-ahead market with **1 car battery** ... “*

*Pin = 2 kW
Pout = 2 kW
Emax = 1 kWh*

*“... you can earn **400€/year** with **20 car batteries!**“*

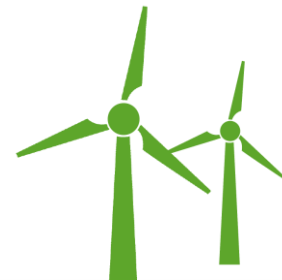
*Pin = 40 kW
Pout = 40 kW
Emax = 20 kWh*



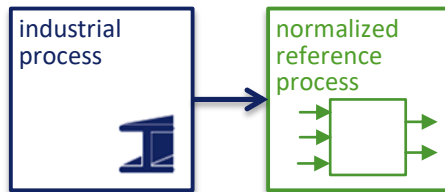
Summary



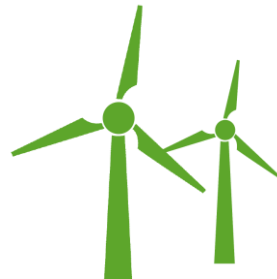
“Starting point is an industrial process ...”



Summary

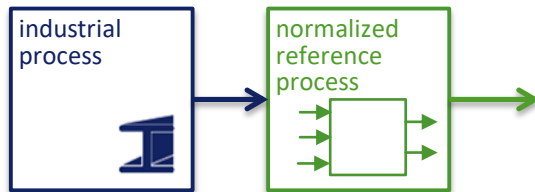


“ ... which will be mapped on a reference process ... ”

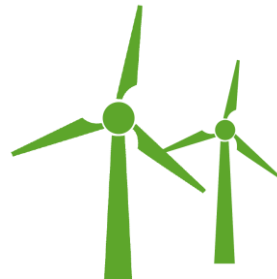


Summary

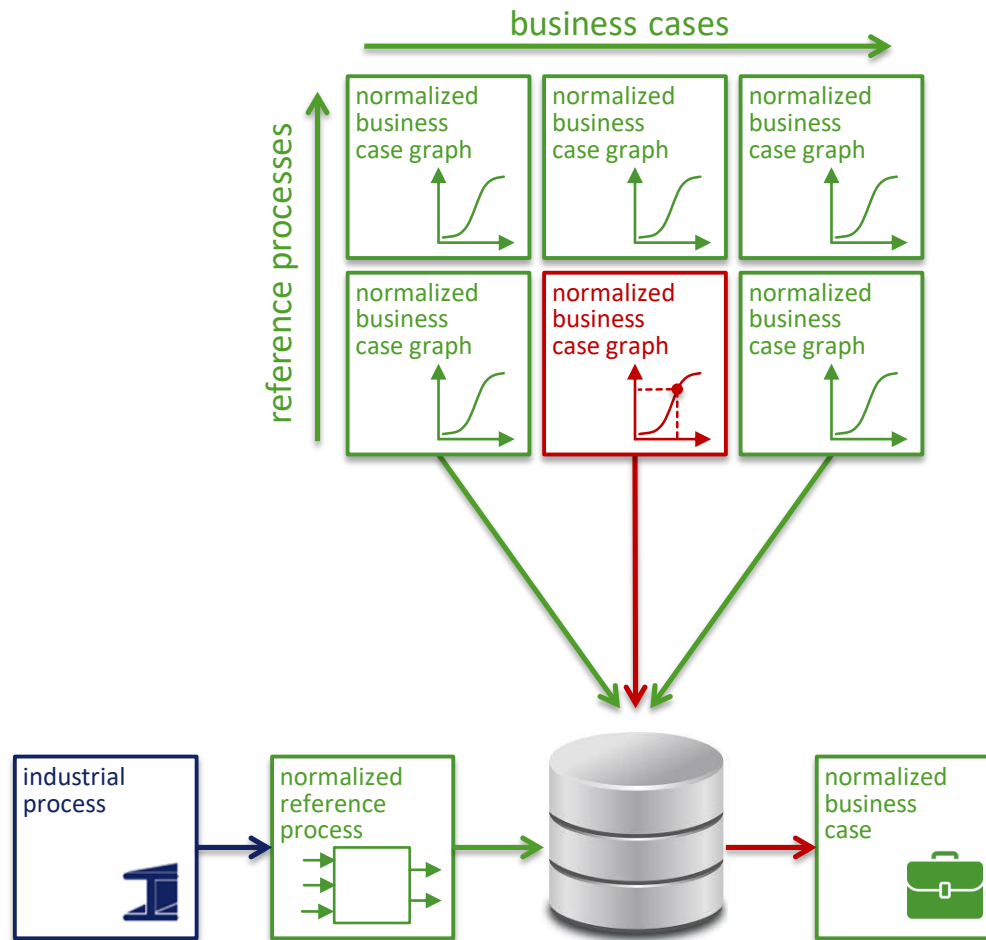
2 normalize



“ ... which is normalized to an 1MW equivalent ... ”

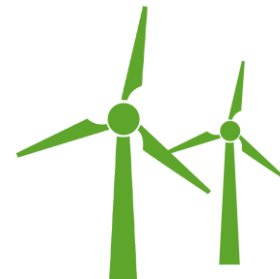


Summary

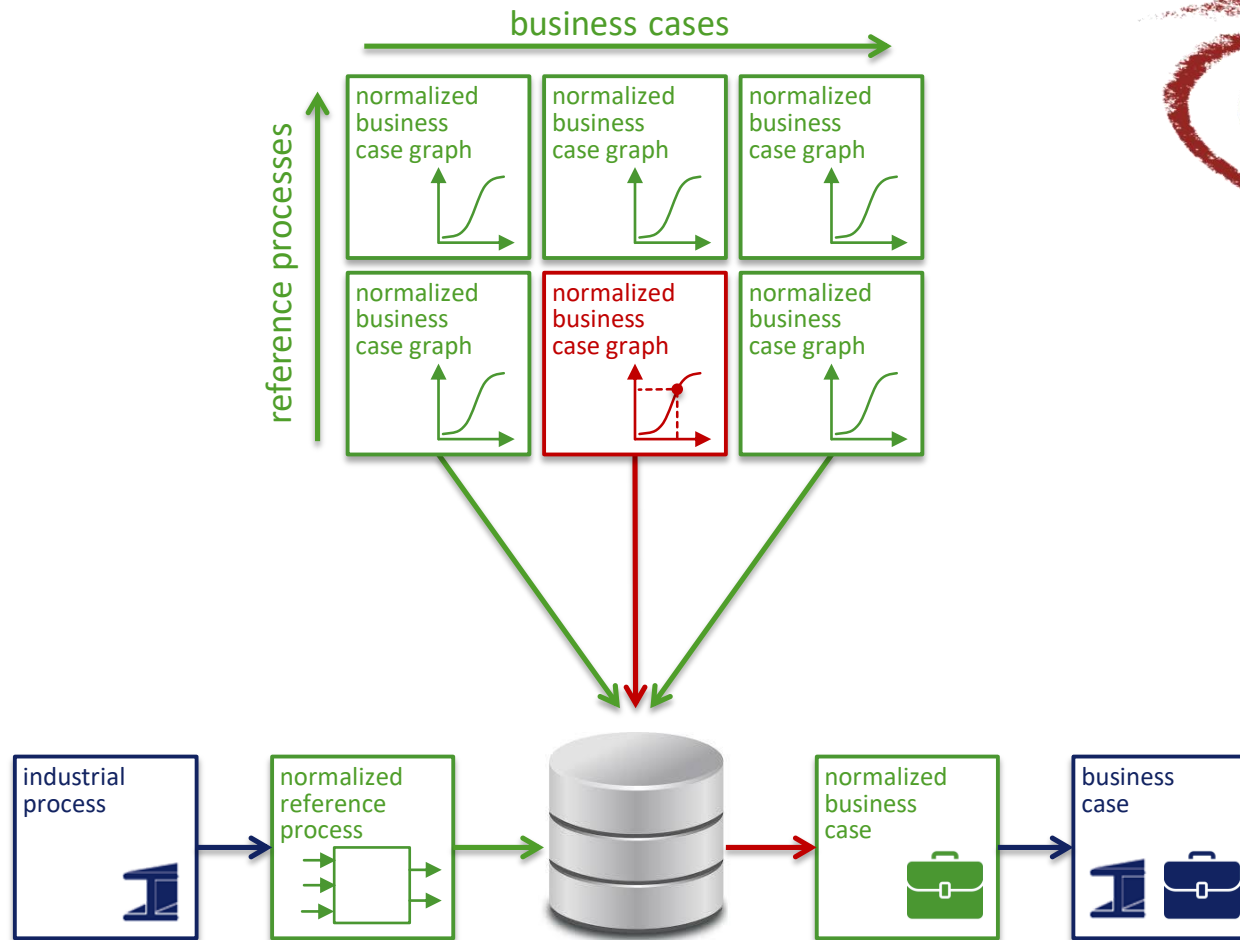


3 select

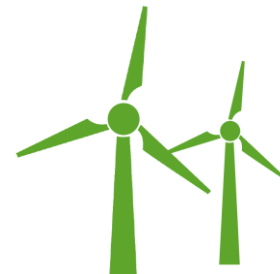
“ ... select the correct normalized business case graph and value ... ”



Summary

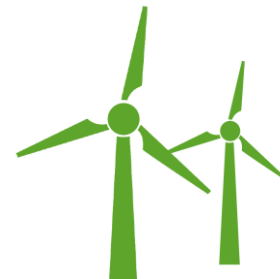


“ ... and scale back to the correct business case value.”

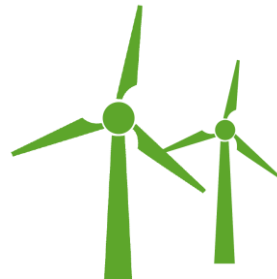
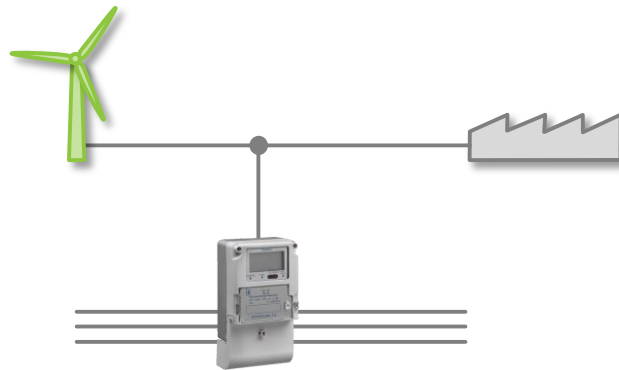


Contents

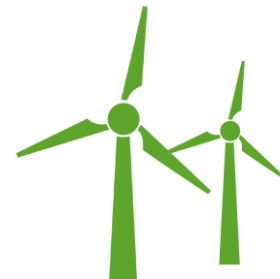
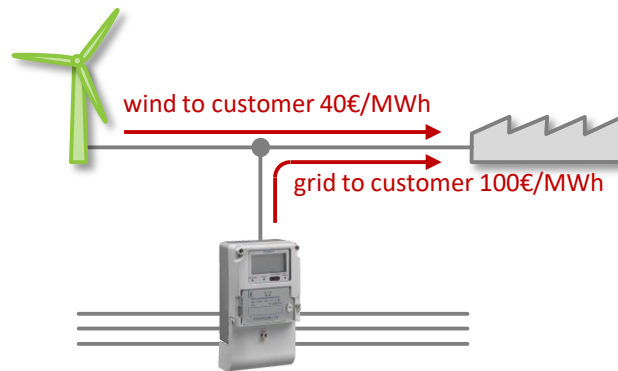
- Part I The context: Demand Response
- Part II How calculating a demand response business case?
- Part III The need for a simplified methodology
- Part IV The simplified methodology step-by-step
- Part V On-site renewable energy business case
- Part VI Conclusions and further steps



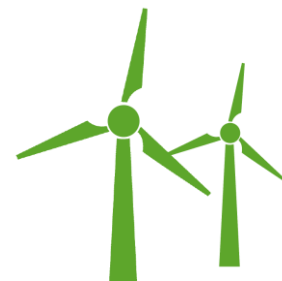
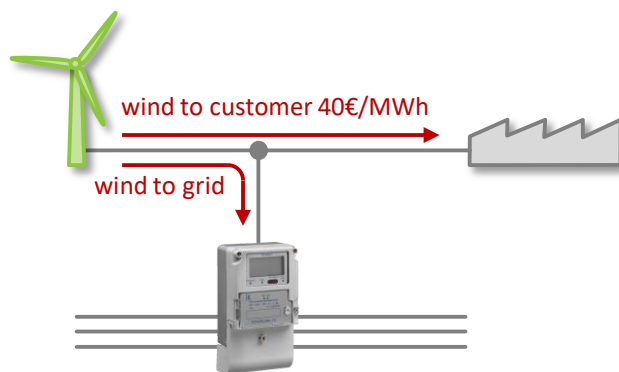
Configuration



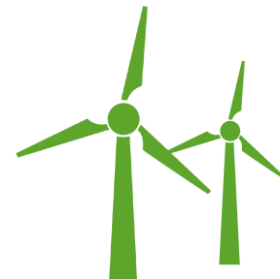
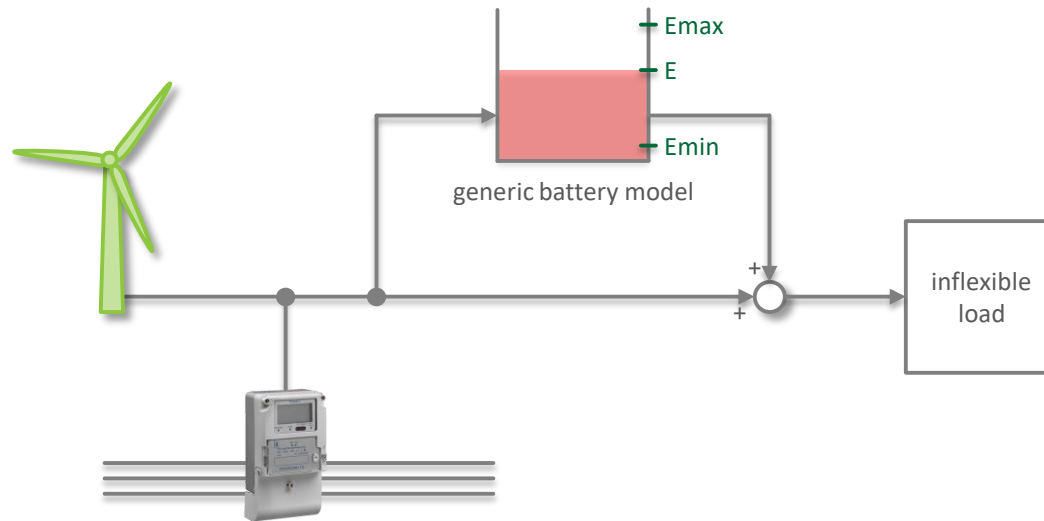
At low wind conditions



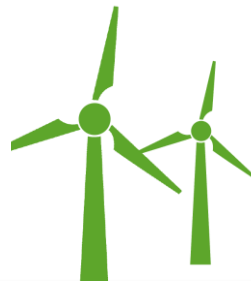
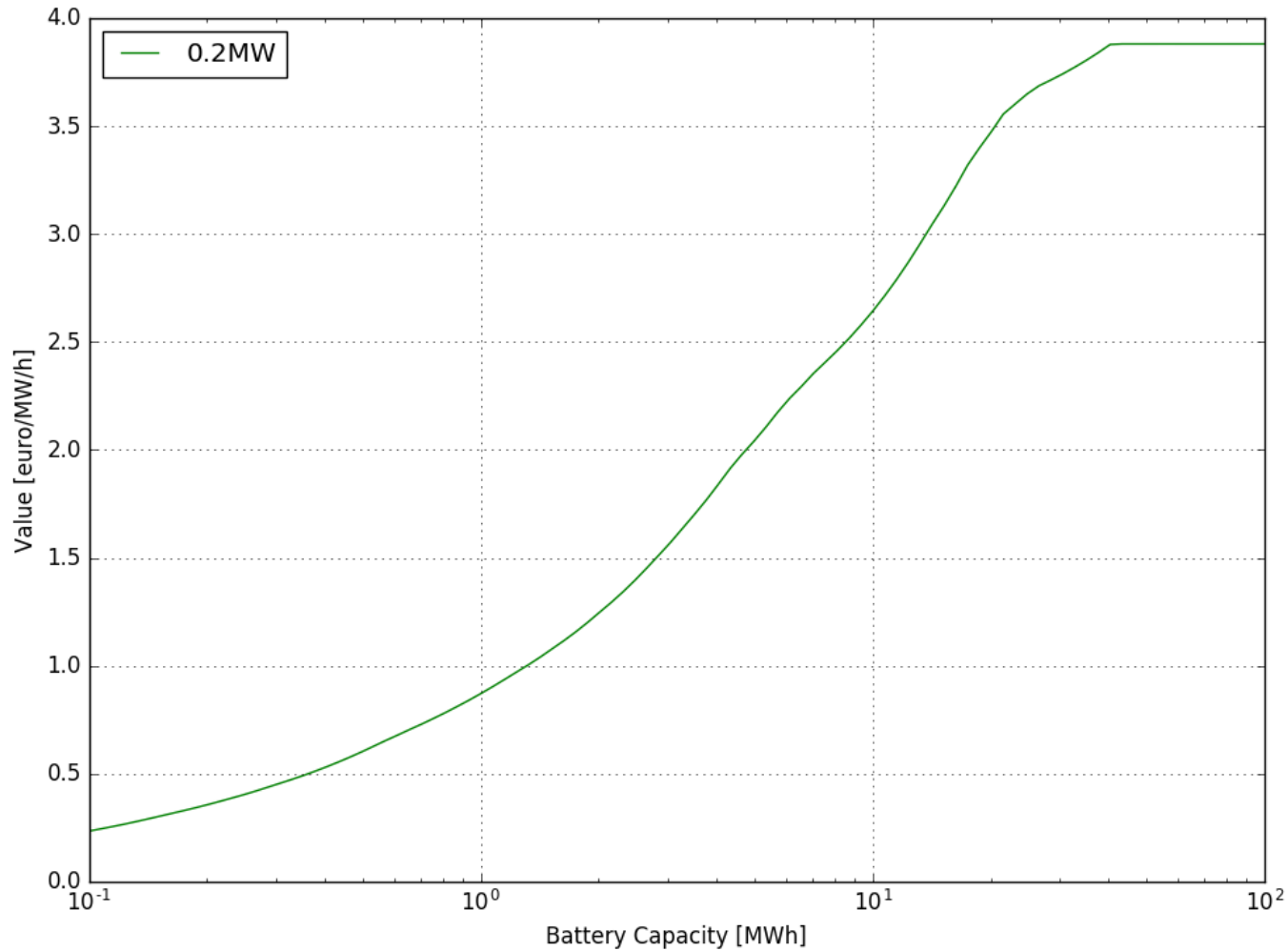
At high wind conditions



On-site VRE with the generic battery model

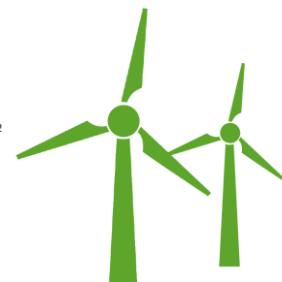
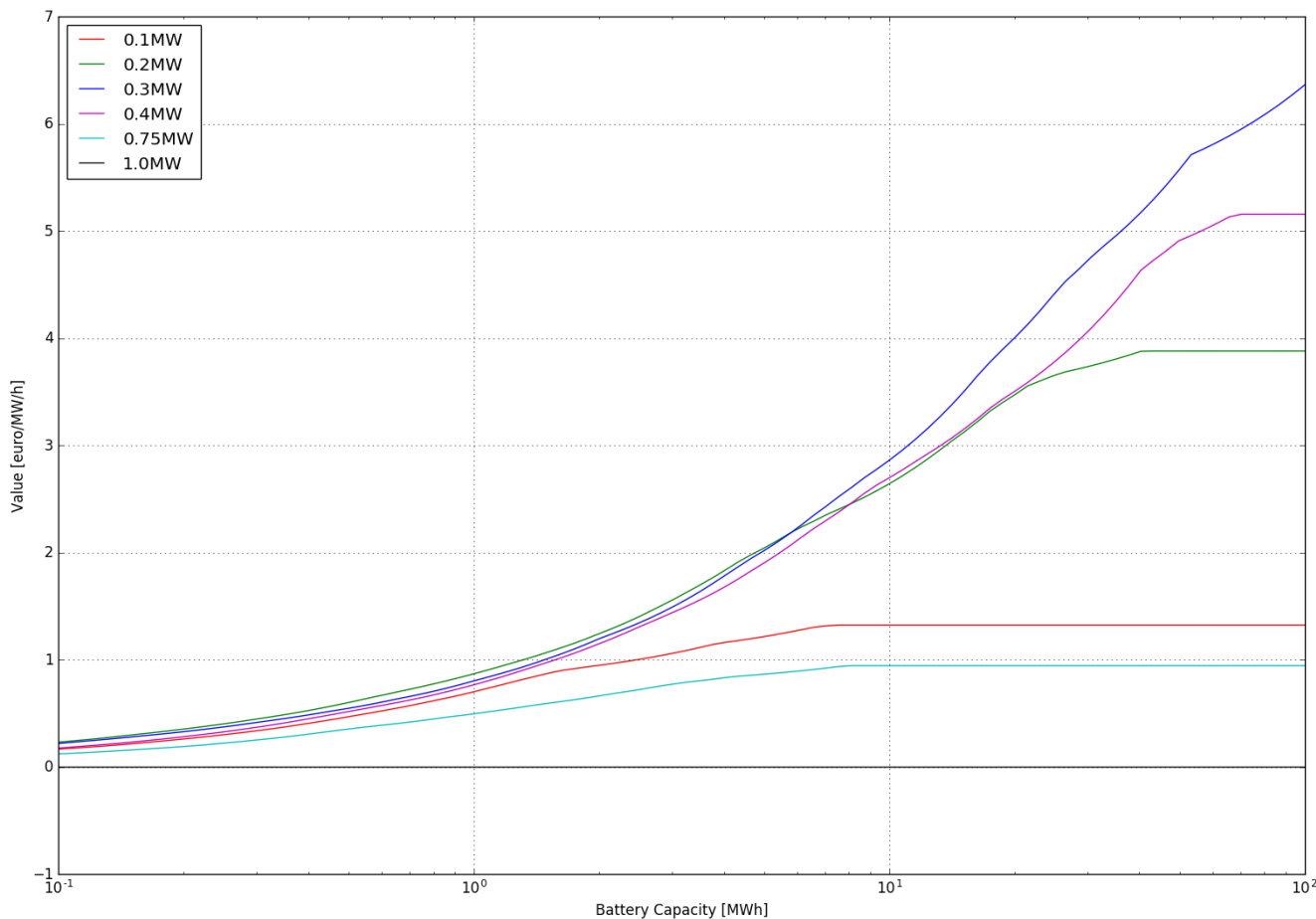


On-site VRE normalized business case graph



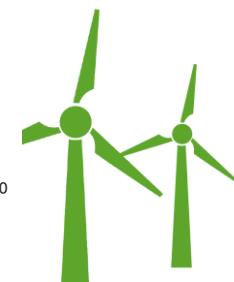
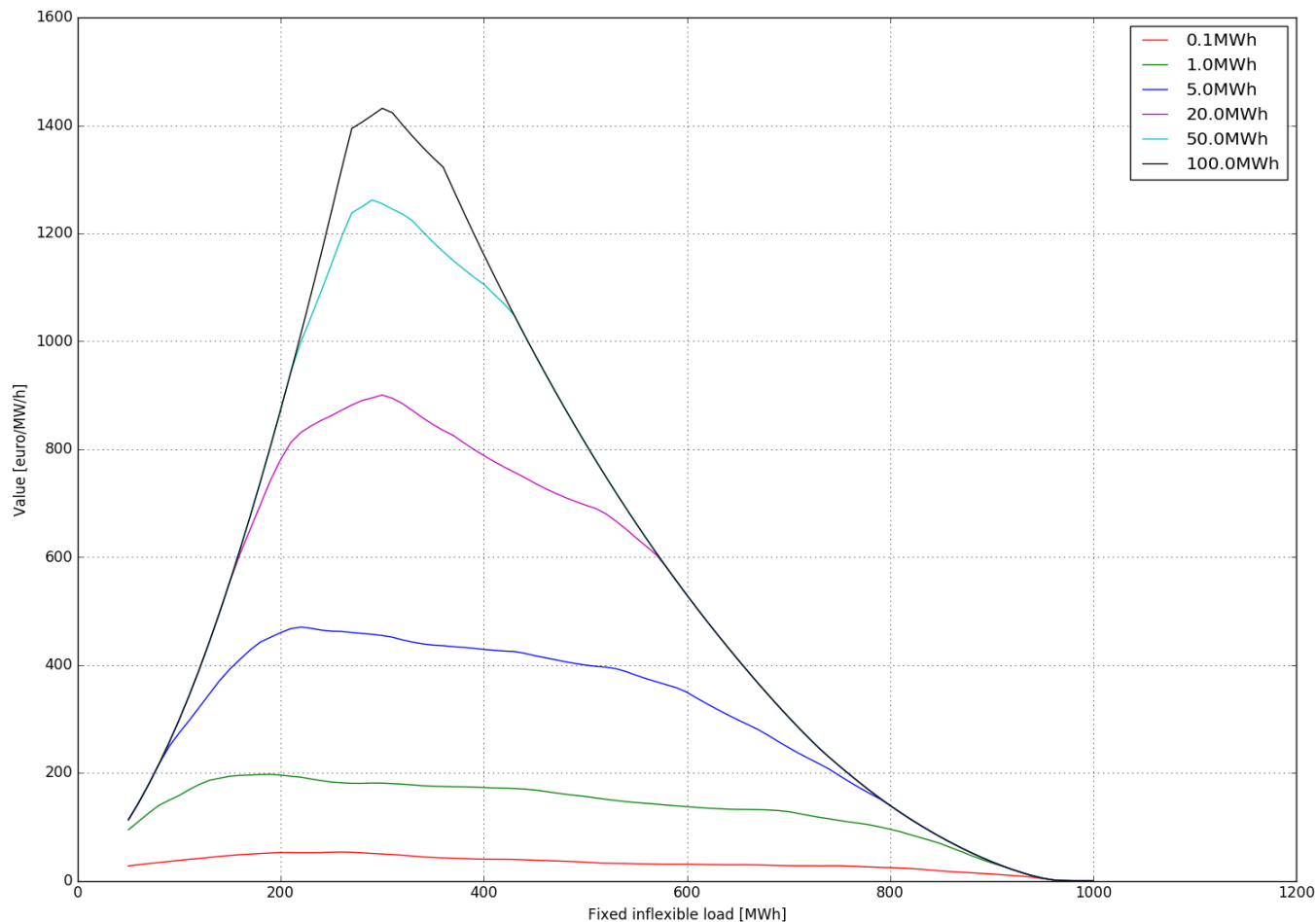
On-site VRE normalized business case graph

“ ... for different values of the fixed inflexible load.”



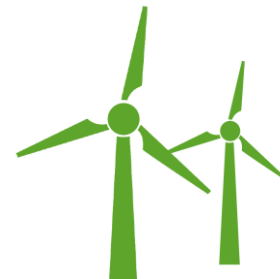
On-site VRE normalized business case graph

“ ... and if you plot it differently,
you even see that there are optimal ratio's ...”



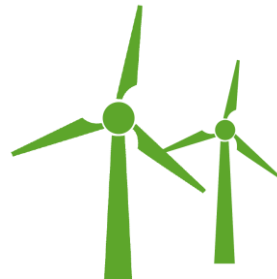
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Have the requirements been met?

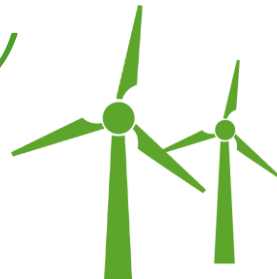
- 1 Being cost effective and time efficient
- 2 Order of magnitude accuracy estimation is good enough
- 3 No specific modelling and optimization knowledge and tools needed



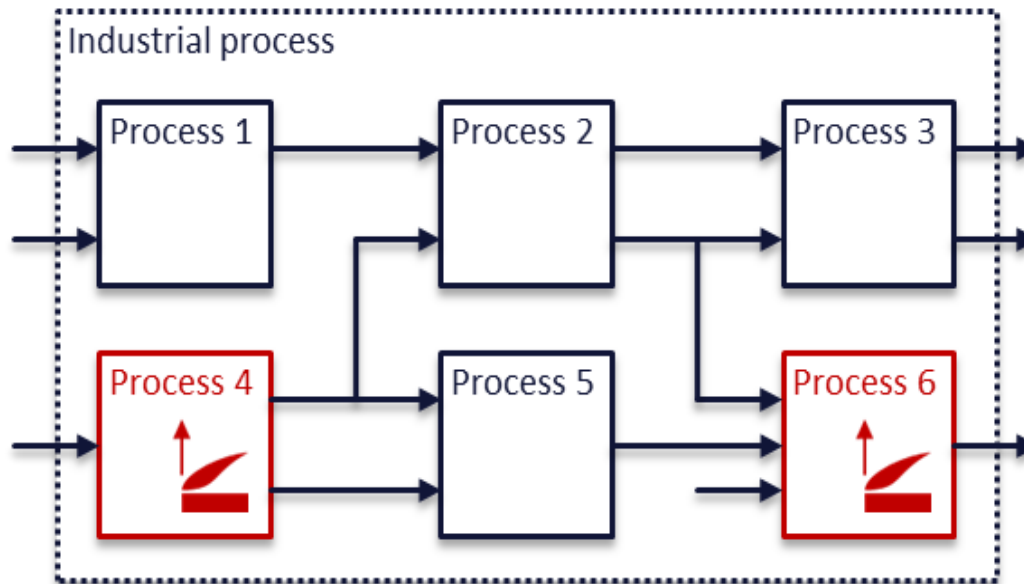
Have the requirements been met?

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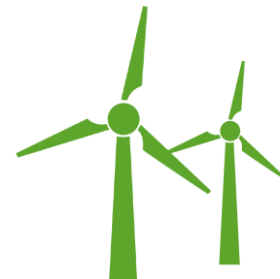
“ Under the condition that the industrial process can be mapped on a relevant reference process, the approach is very straightforward “



Does this really work for complex cases?

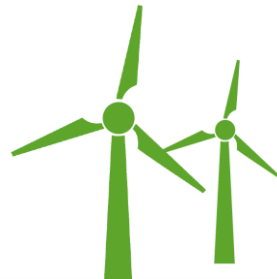


$$\text{BC value} \leq \text{BC4 value} + \text{BC6 value}$$



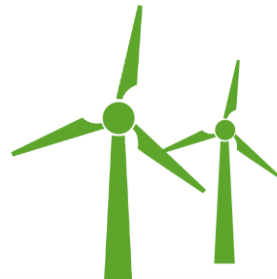
Next steps with the methodology

- Methodology will be tested and refined (if needed) during a **number of case studies**
- Case studies will take place **Q4-2016 till Q2-2017** in the **6** target countries



Call for interest

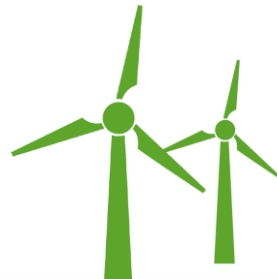
- This webinar is a **first information session**, showing you the potential of the methodology
- Mid 2017, a **hands-on workshop** will be organized → we'll keep you informed!
- Bringing this methodology to the market is **part of the IndustRE project**



Call for interest

Are you:

- An **engineering company** or **consultancy agency** with experience in **energy services**?
- **BRP, BSP** or **aggregator**?
- Interested in extending your portfolio with cost effective **demand response** business case advise?
- **Energy intensive industry** who wants to understand demand response opportunities yourself?

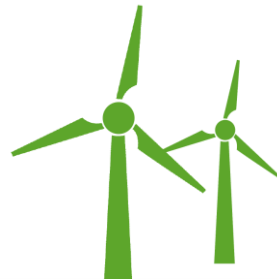


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**We would like to
hear from you!**



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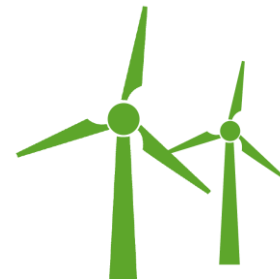
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