



FLEXIBILITY POTENTIAL OF HOUSEHOLD BATTERIES FOR PORTFOLIO BALANCING

IS IT A FUTURE BUSINESS OPPORTUNITY FOR LARGE RETAIL SUPPLIERS?

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Under which market conditions would it make sense for a retail supplier and its customers to aggregate the flexibility of their batteries in order to balance supplier's portfolio?

Using real forecast and measurement data of our large retail portfolio (consumption and RES generation):

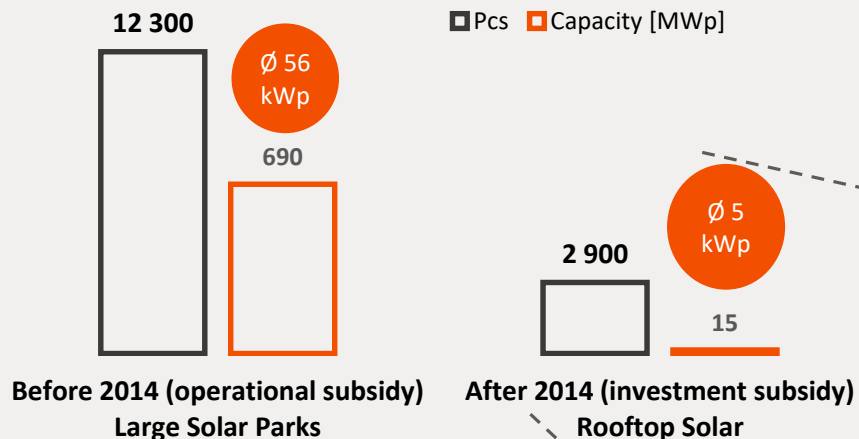
- We estimate the potential value of flexibility provided by household batteries.
- We estimate the flexibility value under current market conditions.
- We simulate how the value might change with different scenarios of battery use and with possible future changes of imbalances' prices.

CEZ SALES PV & BATTERY PORTFOLIO



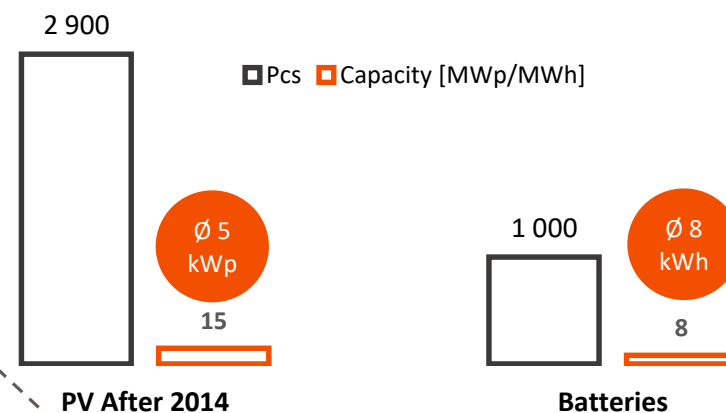
PV Portfolio

■ Pcs ■ Capacity [MWp]



HH batteries are being installed together with the small rooftop PVs.*

PV & Battery Portfolio



USUAL CUSTOMER WITH A PV & BATTERY SYSTEM IN 2019



	<i>Small</i>	<i>Large</i>
Annual Consumption [MWh]	6	14
Consumption Type	Basic	Heat Pump
PV Capacity [kWp]	4,6	6,3
Battery Capacity [kWh]	7,2	9,6
Charging Speed [kW]	3,6	4,8
Price [EUR]	14 500	18 500
Investment Subsidy [EUR]	-6 000	-6 000
Investment Cost for the Customer [EUR]	8 500	12 500
Electricity Generated [MWh]	4,46	6,1
Electricity Stored in the Battery [MWh]	1,40	1,66
Electricity Taken from the Grid [MWh]	2,36	8,73
Electricity Supplied to the Grid [MWh]	0,82	0,83
Pays for Electricity Taken from the Grid [EUR/MWh]*	190	113
Gets for Electricity Supplied to the Grid [EUR/MWh]	31	31
Annual Electricity Bill [EUR]	423	961
Annual Electricity Bill without PV & Battery [EUR]	1 140	1 582
Annual Savings due to PV & Battery [EUR]	717	621

▪ *Who is it?*

▪ *What he buys?*

▪ *How much does it cost?*

▪ *How does it perform in MWh?*

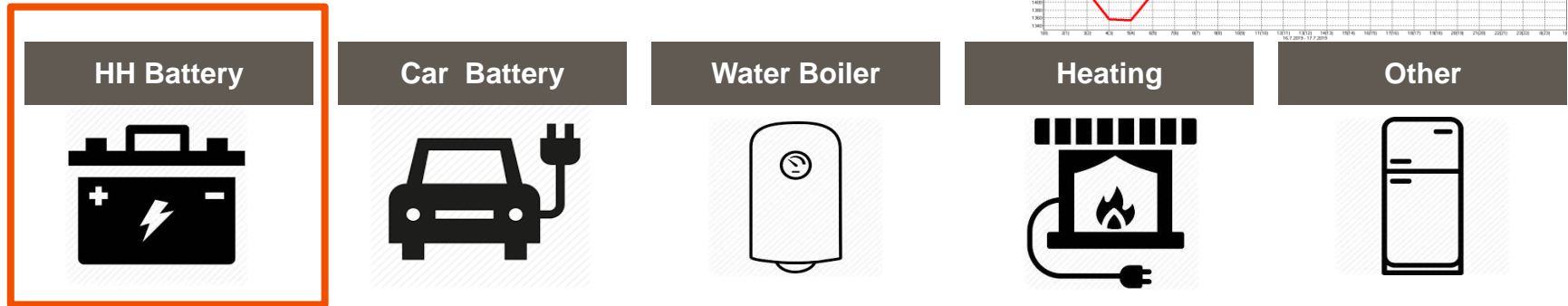
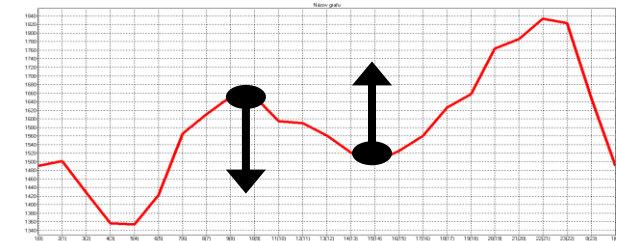
How does it perform in terms of savings?

**Customers save from 500,- to 1000,- EUR annually / Payback from 10 to 20 years.
We simulate flexibility potential of batteries using the “large customer” example.**

POTENTIAL FLEXIBILITY SOURCES IN RETAIL PORTFOLIO

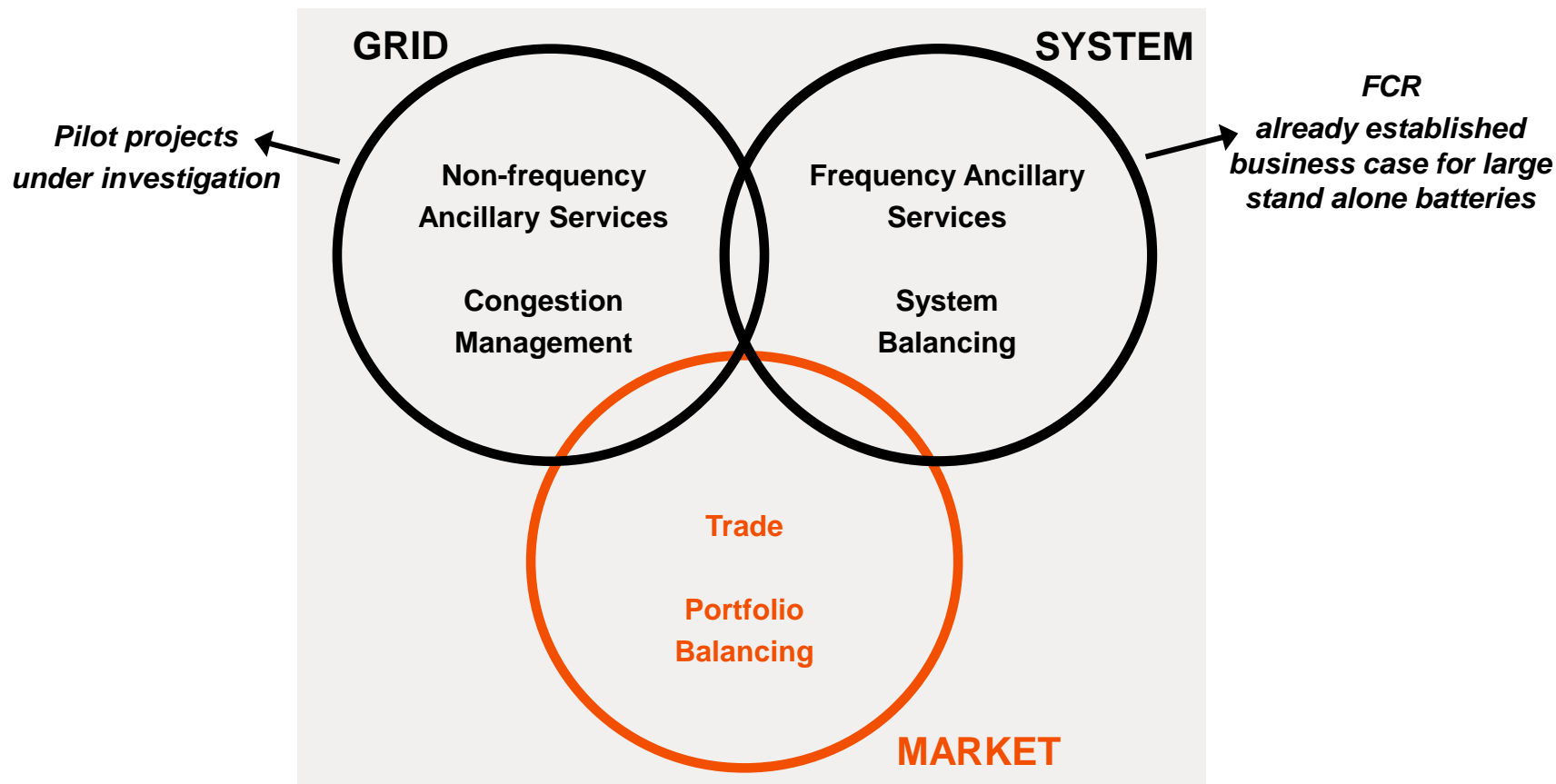


We focus on flexibility potential of HH batteries
(with a roof top PV)



+	<ul style="list-style-type: none"> High charging power Easy to simulate availability 	<ul style="list-style-type: none"> Very high charging power Higher number of natural charging cycles with flexibility potential 	<ul style="list-style-type: none"> Large penetration in customer portfolio Higher number of natural charging cycles with flexibility potential 	<ul style="list-style-type: none"> Large hourly power Large availability (probably) Large penetration in customer portfolio 	<ul style="list-style-type: none"> Great pool of options ?
-	<ul style="list-style-type: none"> Closed API for electricity supplier Additional cycles shorten lifetime Limited availability due to consumer use case 	<ul style="list-style-type: none"> Closed API for electricity supplier Additional cycles shorten lifetime Harder to simulate availability 	<ul style="list-style-type: none"> Low charging power Smart control must be installed (e.g. IOT thermostat) Harder to simulate availability (must be done individually) 	<ul style="list-style-type: none"> Smart control only rarely in place (e.g. heat pump combined with PV) Harder to simulate availability 	<ul style="list-style-type: none"> Hard to standardize ?

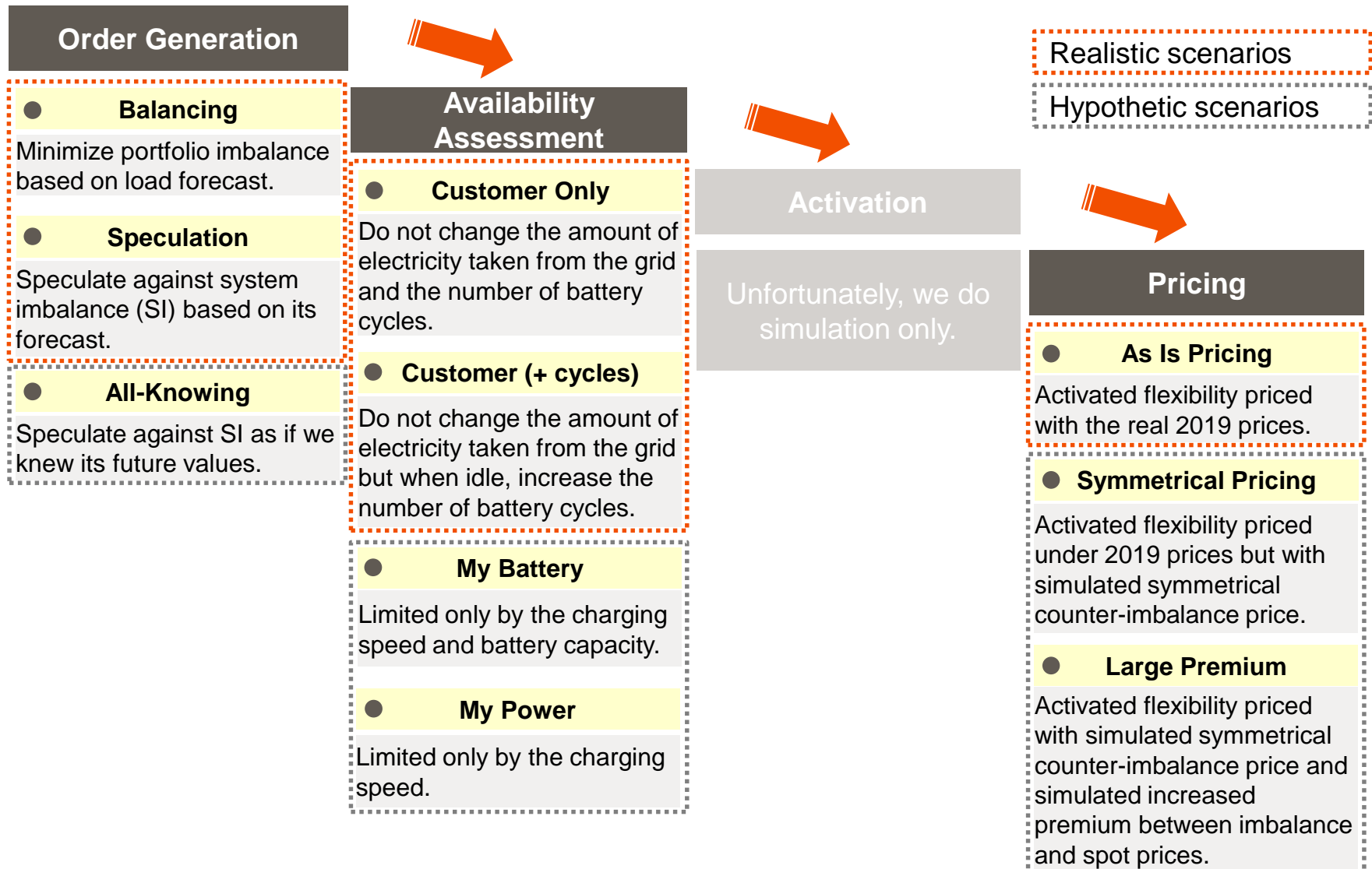
SERVICES THAT CAN BE DELIVERED BY FLEXIBILITY



We focus on portfolio balancing and speculation, i.e. we trade against the prices of imbalances that offer the largest market premium.



FLEXIBILITY SIMULATION SCENARIOS



FLEXIBILITY SIMULATION SCENARIOS

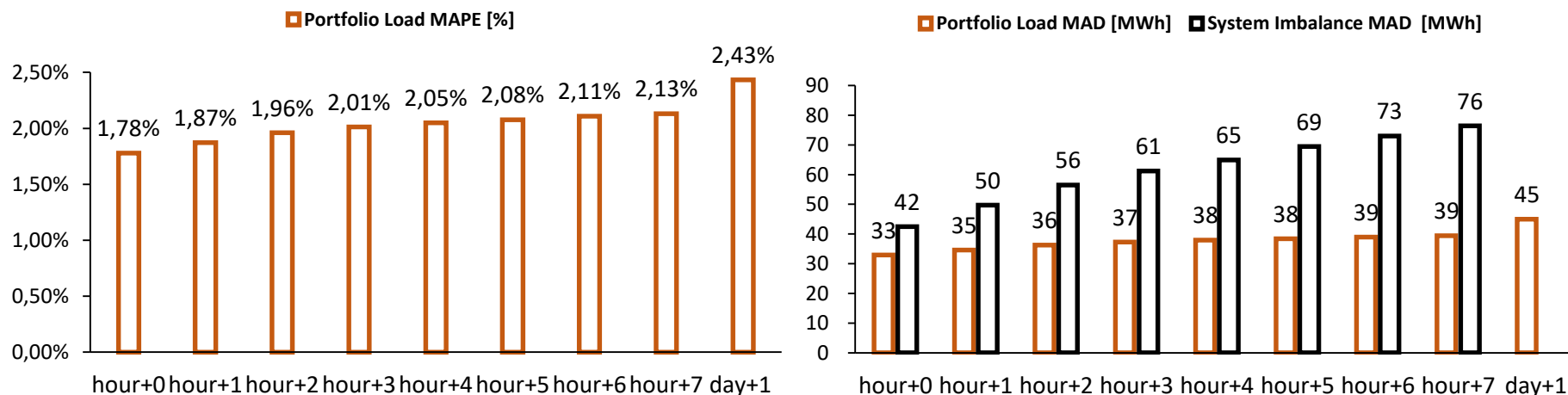


Order Generation

Balancing	Speculation	All-Knowing
<ul style="list-style-type: none"> Minimize portfolio imbalances. Based on load forecasts for hour+0, hour+1, ..., h+7. Initial flexibility activated primarily in hour+1 and hour+0 (only 50 % of the forecast). If supported by the forecast, then rebound activated in hour+3,..hour+7. Otherwise left to the hour+7. 	<ul style="list-style-type: none"> Speculate against SI. Based on SI forecasts for hour+0, hour+1, ..., h+7. Initial flexibility activated primarily in hour+1 and hour+0 (only 50 % of the forecast). If supported by the forecast, then rebound activated in hour+3,..hour+7. Otherwise left to the hour+7. 	<ul style="list-style-type: none"> Speculate against SI. As if we knew the exact SI value for hour+0, hour+1, ..., h+7. Initial flexibility activated primarily in hour+1 and hour+0 (only 50 % of the forecast). If supported by the forecast, then rebound activated in hour+3,..hour+7. Otherwise left to the hour+7.

Forecast Errors in 2019

(Our forecasts are based on a combination of linear ARIMAX, non-linear and neural network models)



FLEXIBILITY SIMULATION SCENARIOS

Availability Assessment (6.3 kWp Rooftop Solar & 9.6 kWh Battery & 14 kWh Annual Consumption Profile)

Customer Only

- Fully respect the primary load shifting business case of the customer.
- Do not change the amount of electricity taken from the grid.
- Do not change the number of battery cycles.
- Only shift battery charging if excess customer generation is forecasted for the following 7 hours.
- Only shift battery discharging if excess customer consumption is forecasted for the following 7 hours.

Customer (+ cycles)

- Respect the primary load shifting business case of the customer.
- Do not change the amount of electricity taken from the grid.
- Shift battery charging if excess customer generation is forecasted for the following 7 hours.
- Shift battery discharging if excess customer consumption is forecasted for the following 7 hours.
- Add battery cycles in idle hours, i.e. in the hours when the battery is not used by the customer.

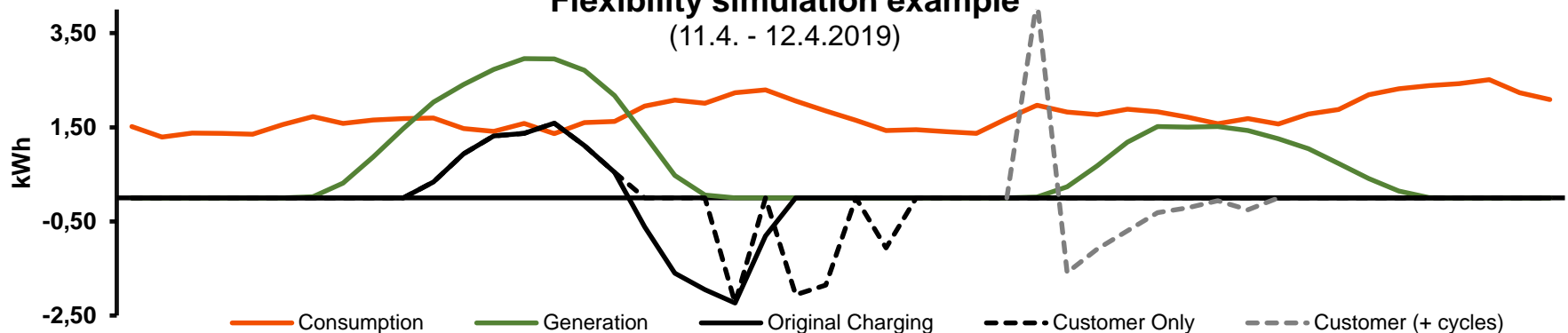
My Battery

- Limited only by the charging speed and battery capacity.
- Flexibility activated based on hour+1 forecast up to the charging speed if battery capacity and charging level permit.

My Power

- Limited only by the charging speed.
- Flexibility activated based on hour+1 forecast up to the charging speed.

Flexibility simulation example (11.4. - 12.4.2019)



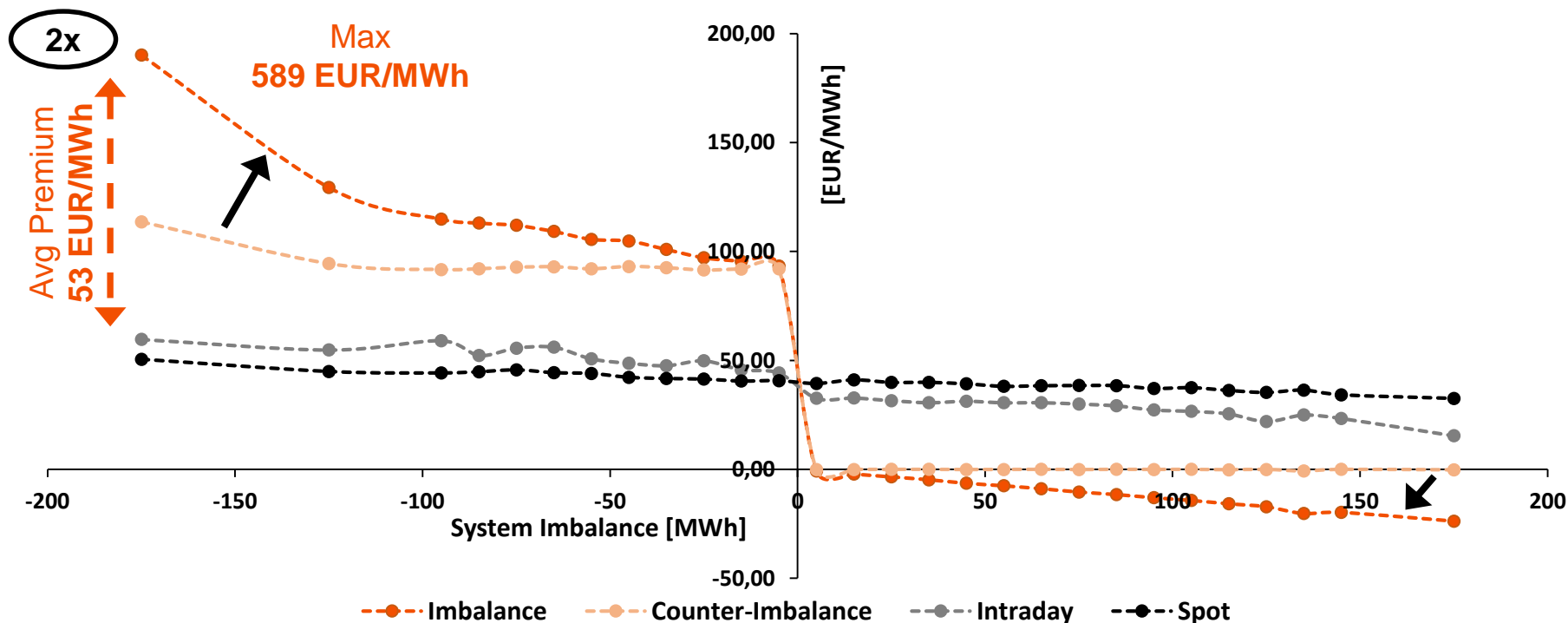
FLEXIBILITY SIMULATION SCENARIOS



Pricing		
As Is Pricing	Symmetrical Pricing ↗↘	Large Premium 2x
<ul style="list-style-type: none"> Activated flexibility priced with the real 2019 imbalances' prices. 	<ul style="list-style-type: none"> Activated flexibility priced with 2019 imbalances' prices but with simulated symmetrical counter-imbalance price. 	<ul style="list-style-type: none"> Symmetrical pricing. Simulated 2 x premium imbalance vs spot prices (53 → 106 EUR).

Electricity Prices in 2019

(Average prices as function of the system imbalance)

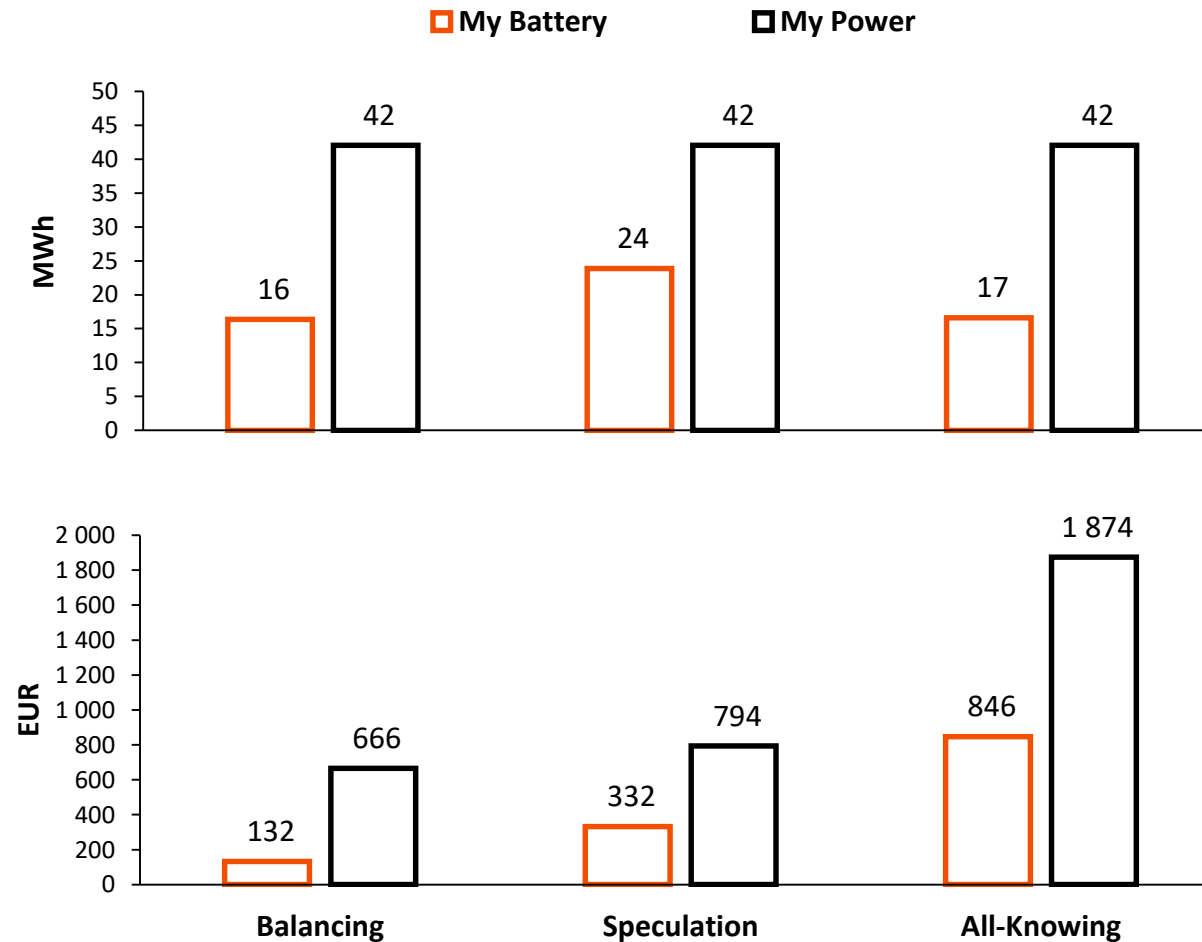




RESULTS OF 2019 SIMULATION (ANNUAL DATA)

Hypothetic Availability Scenarios: “My Battery” & “My Power”

(Activated flexibility in MWh and its value in EUR)

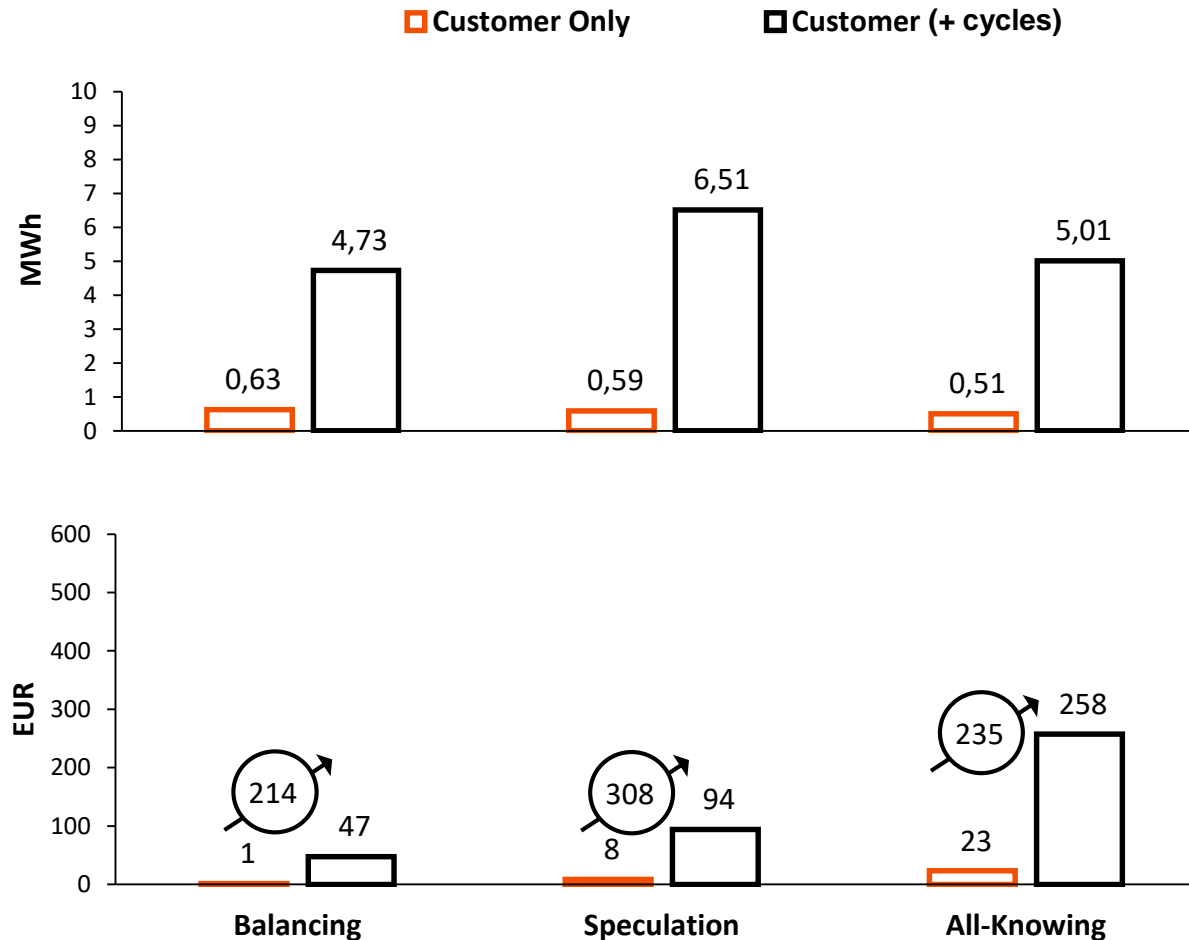


RESULTS OF 2019 SIMULATION (ANNUAL DATA)



Realistic Availability Scenarios: “Customer Only” & “Customer (+ cycles)”

(Activated flexibility in MWh and its value in EUR)



No
No. of added
battery cycles.

No. of natural
cycles is only 170.

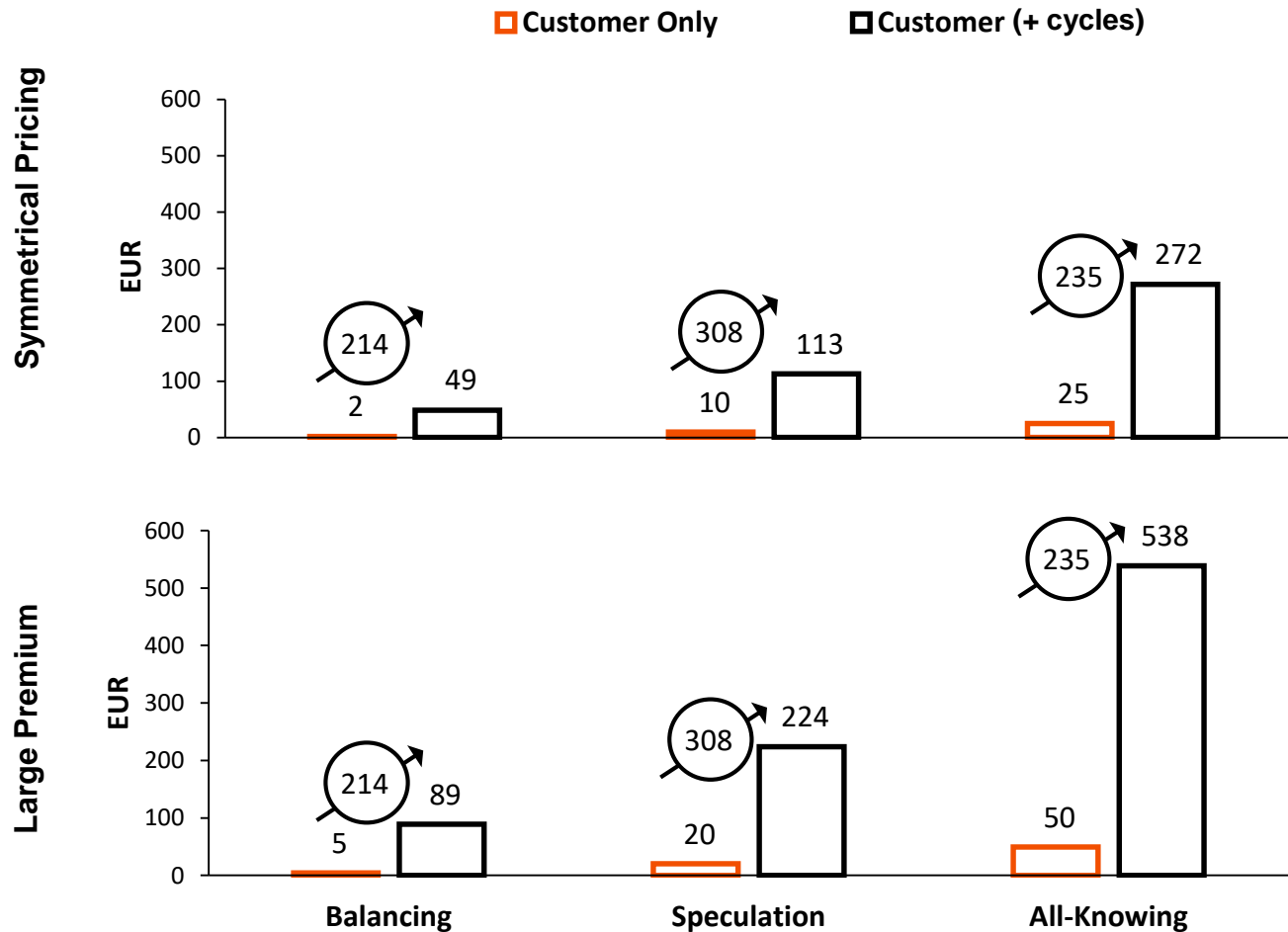
200 added cycles
cost ~75 EUR
but perception of
the customer
might be much
more pessimistic.

RESULTS OF 2019 SIMULATION (ANNUAL DATA)



Realistic Availability Scenarios: “Customer Only” & “Customer (+ cycles)”

Improved by hypothetical pricing scenarios (Activated flexibility value in EUR)

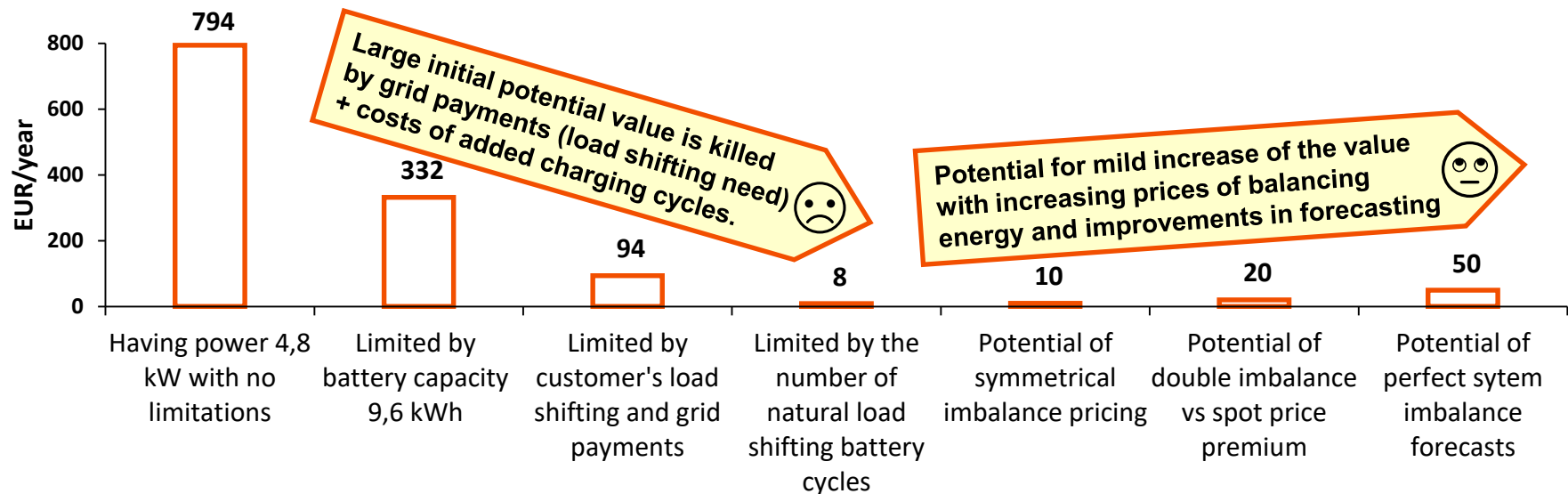


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CONCLUSION: FLEXIBILITY POTENTIAL OF HOUSEHOLD BATTERIES FOR BALANCING AND MARKET SPECULATION



Could the value of other sources of flexibility be higher?

- **Car Batteries: Higher** due to higher number of natural charging cycles with available flexibility and due to much higher charging power?
- **Water Boilers: Comparable or lower** due to lower charging power partly compensated by higher number of natural charging cycles but with no added cycles possible?
- **Heating/Heat Pumps: Higher** due to large availability and large available power?