

Project Accumulator GmbH

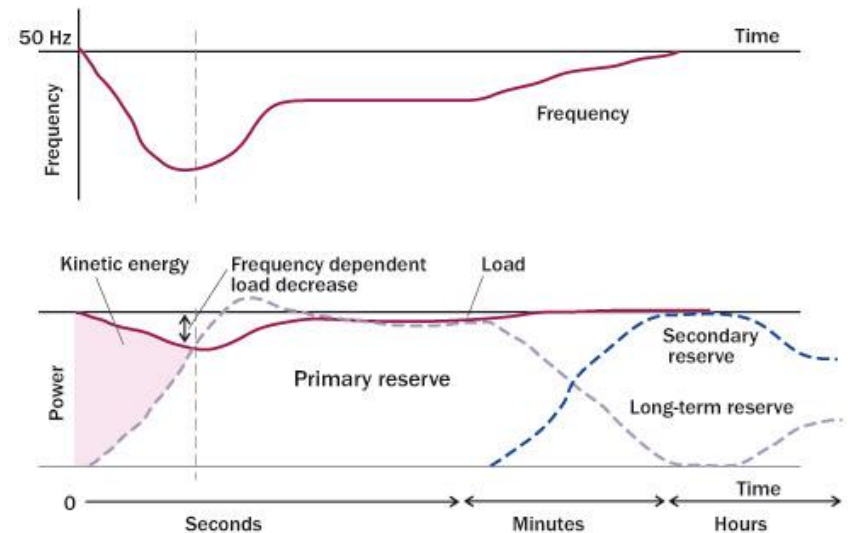
Trading with primary control power via a lithium ion battery



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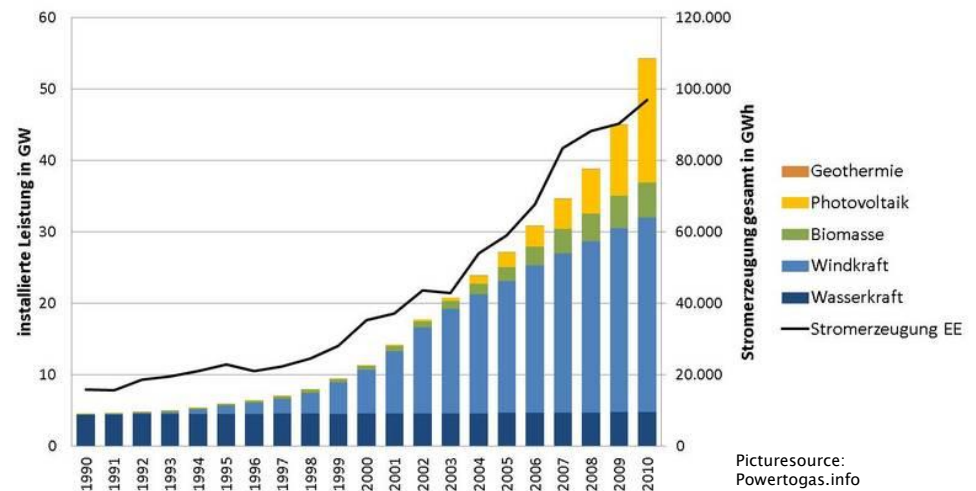
Background – What is the control power

- Purpose: Balance between production and consumption to ensure the security of supply for the consumer
- Variants:
 - positive reserve capacity
 - negative reserve capacity
- Types:
 - **Primary reserve**
 - Secondary reserve
 - Minute reserve
- Payment:
 - Provision of resources: demand rate (Bereitstellung: Leistungspreis) by primary reserve
 - delivery on call: working price (Abruf: Arbeitspreis) additional by secondary/minute reserve
- Primary reserve:
 - tendering procedure on reserve capacity market once a week
 - minimum product size: 1 MW



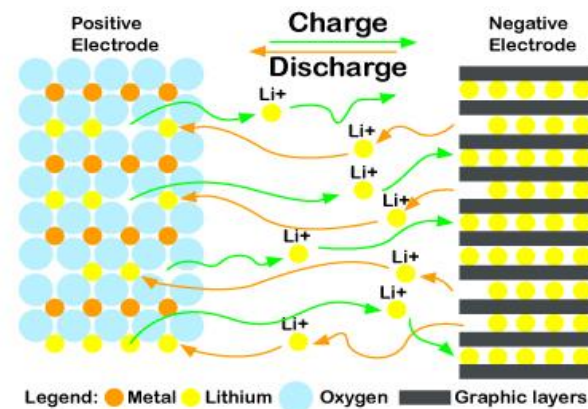
Background – Why you should invest in control power

- Energy policy (Energiewende) leads to an expansion of renewable energies in Germany
- Renewable energies cause variations in the electrical power grid
- Control power is also needed in case of power plant breakdown, power supply failure, forecast error
- The fluctuating input of renewable power plants requires control energy to stabilize / balance the grid
- **The demand and the price of control power goes up**



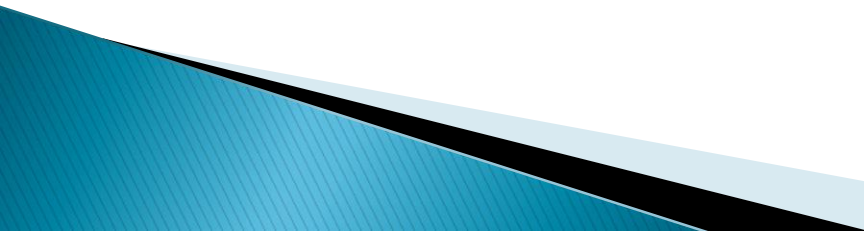
The Company – Domain and technology

- Electrical energy power storage company (GmbH)
- The purpose of the company is to trade with a 12 MWh electrical power storage in Germany
- Domain: primary reserve
 - fully automated within 30 seconds by frequency oscillations ($\pm 10\text{mHz}$)
 - duration: maximum 15 minutes
 - Batteries are perfect for this fast requests
- Grid connection at the 10 kV / 20 kV medium-voltage level
- Suitable energy storages are lithium ion batteries with the necessary battery management system and an inverter

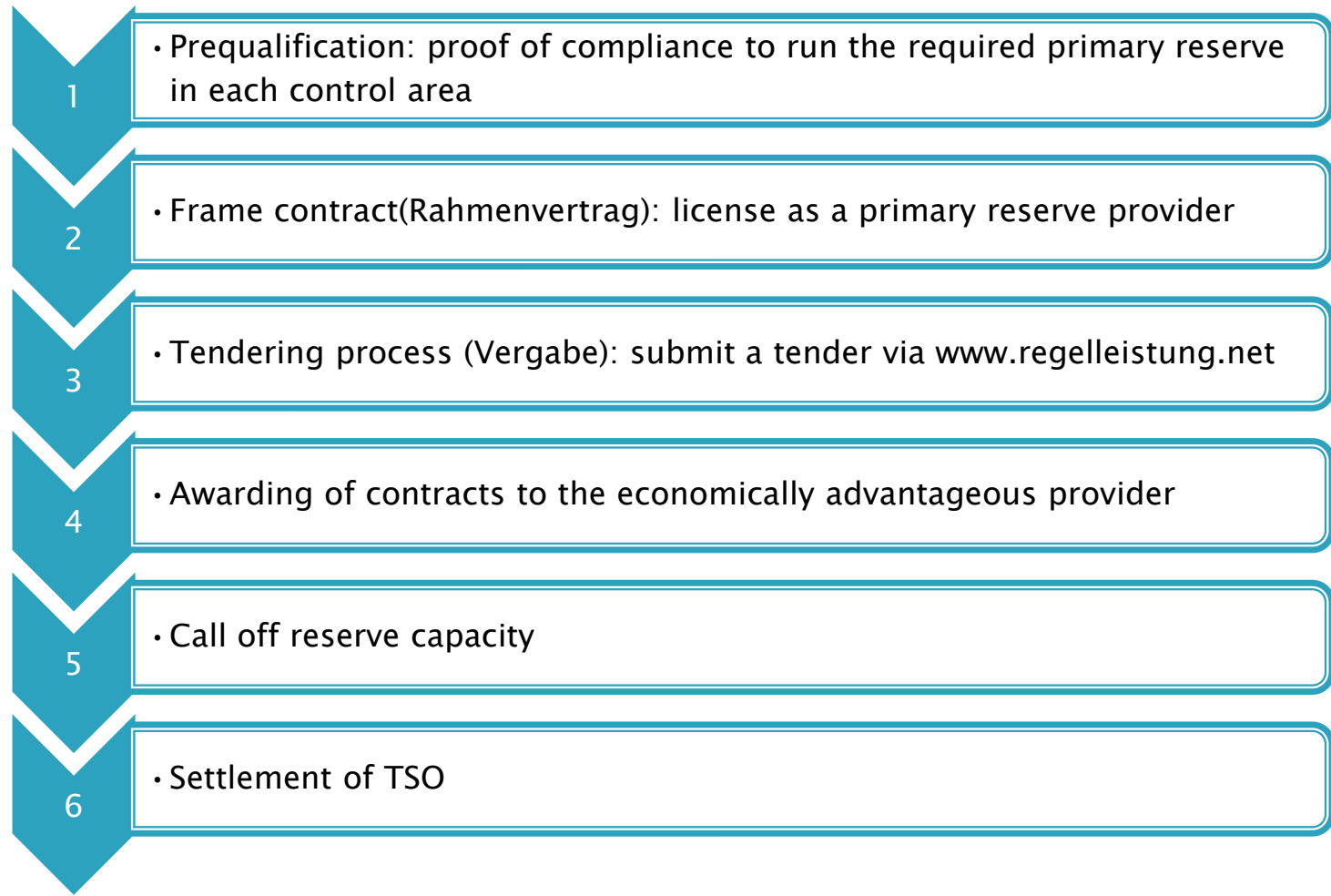


Picturesource: Snupeel.com

Market overview: prices and competitors

- At the end of 2014 Lithium ion batteries cost around 110 €/kWh, our storage will be 12 MWh
 - The annual average for primary control power in 2014 was 3500 €/MW/Week, with this price we will be in the Market 50 weeks a year
 - We trade primary control amounting to +/- 5 MW
 - The storage level will be around 6 MWh, so we are able to deliver 5 MW for one hour non-stop in each direction, which will be more than enough
 - The annual average of the ratio of positive and negative primary control power adds up to 50/50, therefore we only have to take our storage losses into consideration
 - Currently there are 21 competitors qualified for Primary reserve on the market
 - At the moment the total demand is 670 MW (Germany / Partly Netherlands / Partly Swiss)
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Necessary regulatory steps for trading with primary reserve



Cost calculation – Investment

	Unit price (€)	Quantity (pc.)	Total investment (€)	Depreciation time (a)	Depreciation cost
Infrastructure					
Cost of land	150 €	1.000	150.000 €		
Building	500.000 €	1	500.000 €	20	25.000 €
Foundation	25.000 €	1	25.000 €		
Planning	75.000 €	1	75.000 €	10	7.500 €
SUM			750.000 €		32.500 €
Facilities					
Battery (1 kWh)	110 €	12.000	1.320.000 €	10	132.000 €
Battery- Managment	200.000 €	1	200.000 €	10	20.000 €
Battery shelf	50.000 €	1	50.000 €	10	5.000 €
Inverter/Rectifier station	500.000 €	1	500.000 €	10	50.000 €
Grid connection	200.000 €	1	200.000 €	10	20.000 €
Assembly	200.000 €	1	200.000 €	10	20.000 €
Control system	25.000 €	1	25.000 €	10	2.500 €
Office	10.000 €	1	10.000 €	10	1.000 €
Office equipment	10.000 €	1	10.000 €	4	2.500 €
Unique battery load (6 MWh)	0,25 €	6.000	1.500 €		
SUM			2.515.000 €		253.000 €
Unexpected					
			200.000 €		
Total			3.465.000 €		285.500 €

Cost calculation – Balance of Dept./Credit

Balance of Dept./Credit				
Total investment			3.465.000 €	
Own capital funds		25%	866.250 €	
Bank loan		75%	2.598.750 €	
Year	Balance of dept	Intrest rate (%)	Interest costs p.a	Repayment p.a.
1	2.598.750 €	4,00%	103.950 €	173.250 €
2	2.425.500 €	4,00%	97.020 €	173.250 €
3	2.252.250 €	4,00%	90.090 €	173.250 €
4	2.079.000 €	4,00%	83.160 €	173.250 €
5	1.905.750 €	4,00%	76.230 €	173.250 €
6	1.732.500 €	4,00%	69.300 €	173.250 €
7	1.559.250 €	4,00%	62.370 €	173.250 €
8	1.386.000 €	4,00%	55.440 €	173.250 €
9	1.212.750 €	4,00%	48.510 €	173.250 €
10	1.039.500 €	4,00%	41.580 €	173.250 €
11	866.250 €	4,00%	34.650 €	173.250 €
12	693.000 €	4,00%	27.720 €	173.250 €
13	519.750 €	4,00%	20.790 €	173.250 €
14	346.500 €	4,00%	13.860 €	173.250 €
15	173.250 €	4,00%	6.930 €	173.250 €

Cost calculation – Calculation of costs – Income

Calculation of costs

Battery Capacity:	95%	maintenance:	5% of total investment	insurance:	2% of total investment
Battery efficiency:	90%	personal cost:	150000 €	insurance price increase:	1% per year
normal energy Price:	0,25 €/kWh	labour cost increase:	3% every 2 years		
energy price increase	2% per year				

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
maintainance	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €
labour costs	150.000 €	150.000 €	154.500 €	154.500 €	159.135 €	159.135 €	163.909 €	163.909 €	168.826 €	168.826 €
insurance	69.300 €	69.993 €	70.693 €	71.400 €	72.114 €	72.835 €	73.563 €	74.299 €	75.042 €	75.792 €
efficiency losses	65.625 €	66.938 €	68.276 €	69.642 €	71.035 €	72.455 €	73.904 €	75.382 €	76.890 €	78.428 €

	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €	173.250 €
	173.891 €	173.891 €	179.108 €	179.108 €	184.481 €	184.481 €	190.016 €	190.016 €	195.716 €	195.716 €
	76.550 €	77.316 €	78.089 €	78.870 €	79.659 €	80.455 €	81.260 €	82.072 €	82.893 €	83.722 €
	79.997 €	81.596 €	83.228 €	84.893 €	86.591 €	88.323 €	90.089 €	91.891 €	93.729 €	95.603 €

Income/Revenue

sold pos. performance:	5 MW	pos. performance revenue:	3500 €/MW/Week	sold weeks/year:	50 weeks
needed performance through losses:	5,8 MW	neg. performance revenue	3500 €/MW/Week	ratio pos./neg. performance:	50%
efficiency losses:	0,8 MW	revenue increase	1% per year	daily average on call duration:	1 h
sold neg. performance:	5,0 MW			days of marketing:	350 days

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
pos. Performance	437.500 €	441.875 €	446.294 €	450.757 €	455.264 €	459.817 €	464.415 €	469.059 €	473.750 €	478.487 €
neg. Performance	437.500 €	441.875 €	446.294 €	450.757 €	455.264 €	459.817 €	464.415 €	469.059 €	473.750 €	478.487 €

	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	483.272 €	488.105 €	492.986 €	497.916 €	502.895 €	507.924 €	513.003 €	518.133 €	523.315 €	528.548 €
	483.272 €	488.105 €	492.986 €	497.916 €	502.895 €	507.924 €	513.003 €	518.133 €	523.315 €	528.548 €

Cost calculation – Summary

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Depreciation										
Building	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €
Planning	7.500,00 €	7.500,00 €	7.500,00 €	7.500,00 €	7.500,00 €	7.500,00 €	7.500,00 €	7.500,00 €	7.500,00 €	7.500,00 €
Battery	132.000,00 €	132.000,00 €	132.000,00 €	132.000,00 €	132.000,00 €	132.000,00 €	132.000,00 €	132.000,00 €	132.000,00 €	132.000,00 €
Battery Management	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €
Battery shelf	5.000,00 €	5.000,00 €	5.000,00 €	5.000,00 €	5.000,00 €	5.000,00 €	5.000,00 €	5.000,00 €	5.000,00 €	5.000,00 €
Inverter/Rectifier	50.000,00 €	50.000,00 €	50.000,00 €	50.000,00 €	50.000,00 €	50.000,00 €	50.000,00 €	50.000,00 €	50.000,00 €	50.000,00 €
Grid connection	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €
Assembly	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €	20.000,00 €
Control system	2.500,00 €	2.500,00 €	2.500,00 €	2.500,00 €	2.500,00 €	2.500,00 €	2.500,00 €	2.500,00 €	2.500,00 €	2.500,00 €
Office	3.500,00 €	3.500,00 €	3.500,00 €	3.500,00 €	1.000,00 €	1.000,00 €	1.000,00 €	1.000,00 €	1.000,00 €	1.000,00 €
Financing										
Interest Payment	103.950,00 €	97.020,00 €	90.090,00 €	83.160,00 €	76.230,00 €	69.300,00 €	62.370,00 €	55.440,00 €	48.510,00 €	41.580,00 €
Repayment	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €
Costs										
maintainance	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €
labour costs	150.000,00 €	150.000,00 €	154.500,00 €	154.500,00 €	159.135,00 €	159.135,00 €	163.909,05 €	163.909,05 €	168.826,32 €	168.826,32 €
insurance	69.300,00 €	69.993,00 €	70.692,93 €	71.399,86 €	72.113,86 €	72.835,00 €	73.563,35 €	74.298,98 €	75.041,97 €	75.792,39 €
efficiency losses	65.625 €	66.938 €	68.276 €	69.642 €	71.035 €	72.455 €	73.904 €	75.382 €	76.890 €	78.428 €
Revenue/Income										
pos. Performance	437.500,00 €	441.875,00 €	446.293,75 €	450.756,69 €	455.264,25 €	459.816,90 €	464.415,07 €	469.059,22 €	473.749,81 €	478.487,31 €
neg. Performance	437.500,00 €	441.875,00 €	446.293,75 €	450.756,69 €	455.264,25 €	459.816,90 €	464.415,07 €	469.059,22 €	473.749,81 €	478.487,31 €
Sum										
	-145.875,00 €	-132.200,50 €	-122.971,68 €	-109.188,26 €	-97.484,96 €	-83.591,51 €	-74.416,67 €	-60.412,09 €	-51.268,82 €	-37.152,05 €

Cost Calculation – Summary

	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Depreciation										
Building	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €	25.000,00 €
Planning	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Battery	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Battery Management	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Battery shelf	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Inverter/Rectifier	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Grid connection	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Assembly	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Control system	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Office	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Financing										
Interest Payment	34.650,00 €	27.720,00 €	20.790,00 €	13.860,00 €	6.930,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Repayment	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Costs										
maintainance	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €	173.250,00 €
labour costs	173.891,11 €	173.891,11 €	179.107,84 €	179.107,84 €	184.481,08 €	184.481,08 €	190.015,51 €	190.015,51 €	195.715,98 €	195.715,98 €
insurance	76.550,31 €	77.315,82 €	78.088,97 €	78.869,86 €	79.658,56 €	80.455,15 €	81.259,70 €	82.072,30 €	82.893,02 €	83.721,95 €
efficiency losses	79.997 €	81.596 €	83.228 €	84.893 €	86.591 €	88.323 €	90.089 €	91.891 €	93.729 €	95.603 €
Revenue/Income										
pos. Performance	483.272,18 €	488.104,90 €	492.985,95 €	497.915,81 €	502.894,97 €	507.923,92 €	513.003,16 €	518.133,19 €	523.314,52 €	528.547,67 €
neg. Performance	483.272,18 €	488.104,90 €	492.985,95 €	497.915,81 €	502.894,97 €	507.923,92 €	513.003,16 €	518.133,19 €	523.314,52 €	528.547,67 €
Sum										
	229.956,43 €	244.186,44 €	253.256,71 €	267.600,98 €	276.629,50 €	464.339,00 €	466.392,04 €	474.037,73 €	476.041,38 €	483.804,17 €

Evaluation

- Total cumulated sum over 20 years: 2.721.682 €
- Life-cycle of 20+ years with a lithium ion battery is very realistic
- Possible options:
 - Different storage technology
 - Different storage size / more or less primary power
 - Used buildings or existing space in a big transformer station
 - Secondary reserve / Long term reserve (more competitors, provision of resources + working price)
- Our battery storage system is a relatively „save“ way to invest in primary control power in comparison to a much bigger investment for example into a pumped storage hydro power station
 - A pumped storage hydro power station can only trade 10 % of the total power for primary control power (50 MW total power -> 5 MW possible for primary power)

**Thank you for your
attention**



Sources

- General informations:
- <https://www.regelleistung.net/ip/action/static/ausschreibungPrI>
- Results/Prices:
- <https://www.regelleistung.net/ip/action/ausschreibung/public>
- Competitors:
- <https://www.regelleistung.net/ip/action/static/provider>
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