22 JAAR
DUURZAAMHEIDSEXPERTISE
TEN DIENSTE VAN
UW PROJECT

CENERGIE

INTEGRAAL DUURZAAM

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Pilot Port of Antwerp

Batteries for Kieldrechtlock

Toon Possemiers
CEO

Port of Antwerp

veb

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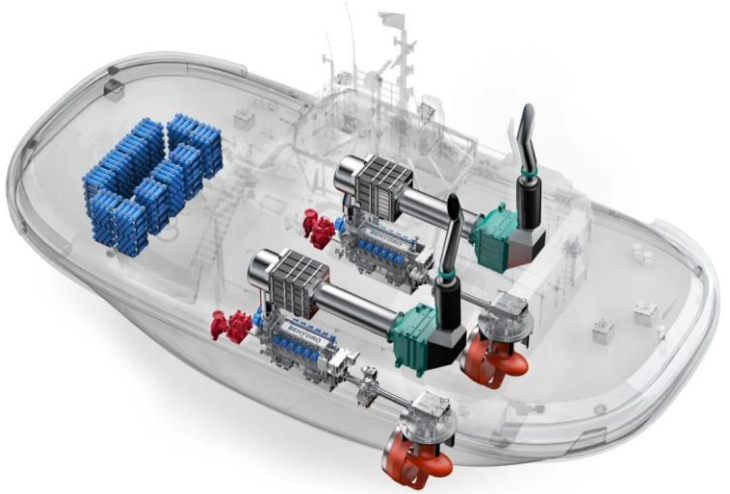
Partners: PoA, A sustainable Port

Translate the lowering of Belgian carbon emissions into 3 strategic projects

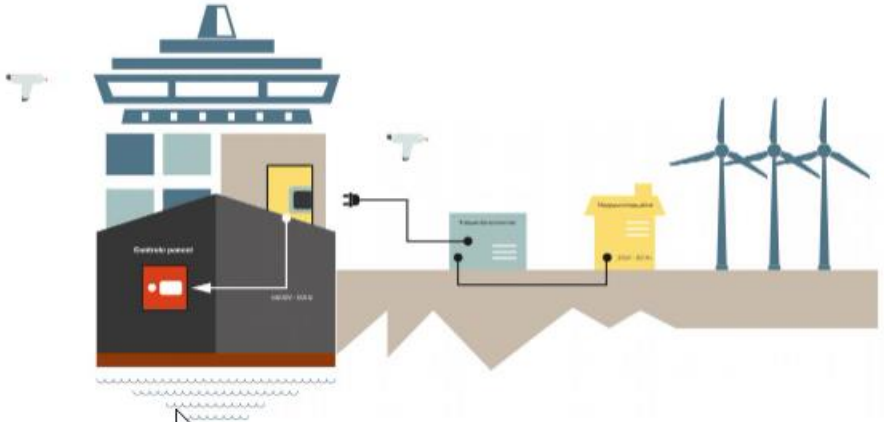
- Initiate the transition towards a **carbonless and circular economy in port area**.
- Walk the talk by **sustainably investing in existing and future maritime base infra- and superstructure**.
- **Integrate a digital ecosystem** within our port that can support transversal supply chains.

Partners: PoA, A sustainable Port



Recent initiatives

- Multi fuel port
- Hydro tug: the world's first hydrogen operated tug
- Ecluse: a steam network with residual heat
- Shore-side power



Partners: Vlaams Energie Bedrijf

"Wij ontzorgen de publieke sector naar een duurzamer en efficiënter energiebeheer en ondersteunen in het bereiken van de klimaatdoelstellingen."

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Strategic program sustainability 2017: batterytechnology

Feasability study stationary batteries

Synergy batteries – sun

R1

Expansion of RE mix

PV

Study for potential cases

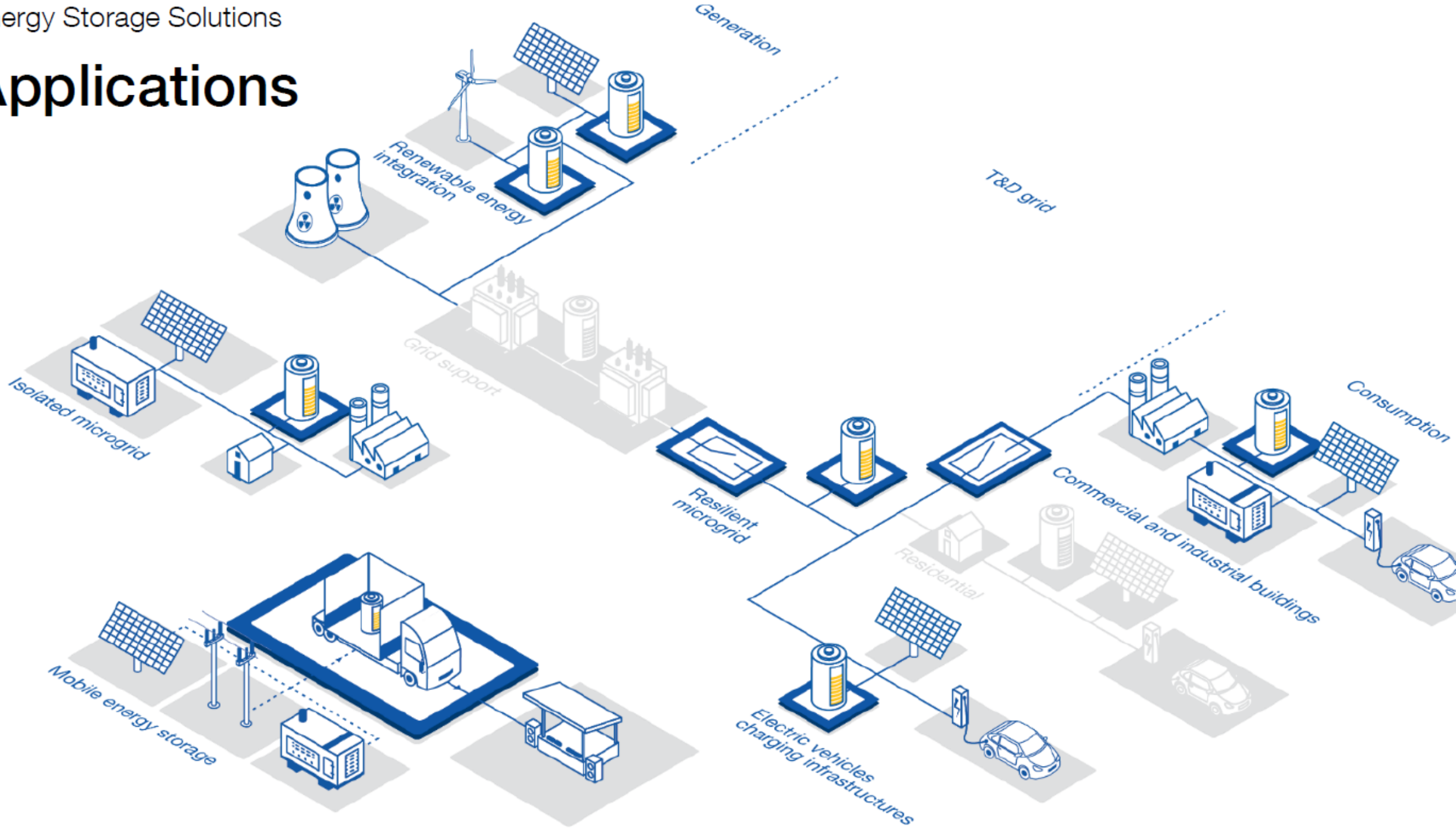
Ext companies: Mismatch use and surface

PoA: Few potential sites, only locks

Pilot Kieldrechtsluis

Energy Storage Solutions

Applications




Paal
Graauw
Emmadorp
Oude Doel
Prosperdorp
Saftingen
Lillo
Nieuw Namen
Halfeind
Kieldrechtsluis
R2
Ertbrand
Stabroek
N11
A12
Kapellen
EKEREN
N1
E19
Museum aan de Stroom
Schelde
Vliegenstal
Melseledijk
E34
Zillebeek
Sint-Gillis-Waas
N49a
N70
Antwerpen
Zwijndrecht


Haven 1718
Port of Antwerp
Kaai 1742
MPET K1742
nck Terminal
MPET kaai 1718
Deurganck Terminal Oost
Kieldrechtsluis
Sint Antoniusweg
Shipit Terminal nv
sint antoniusweg
HA Sleepbedrijf
Brabo Boatman

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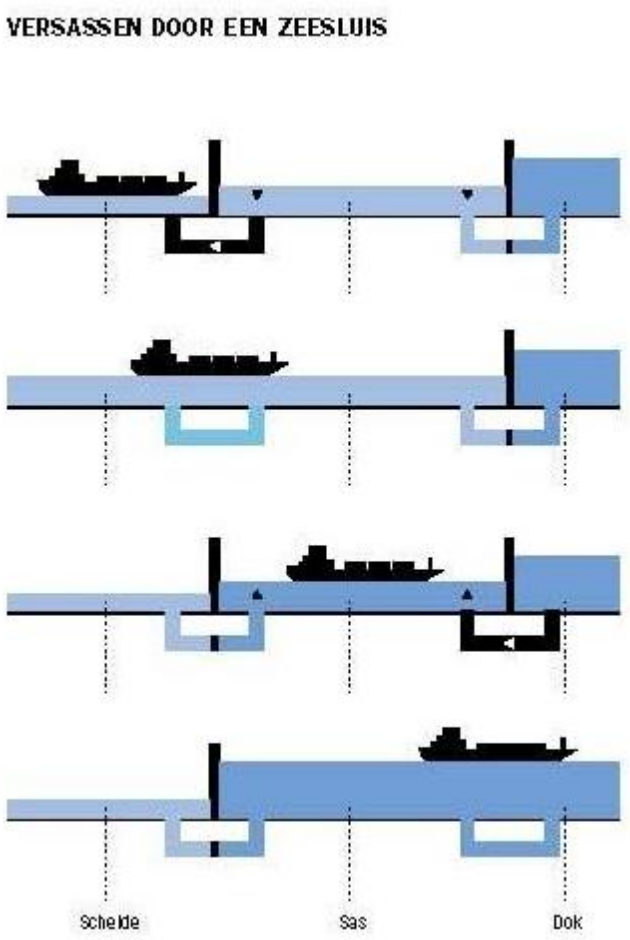
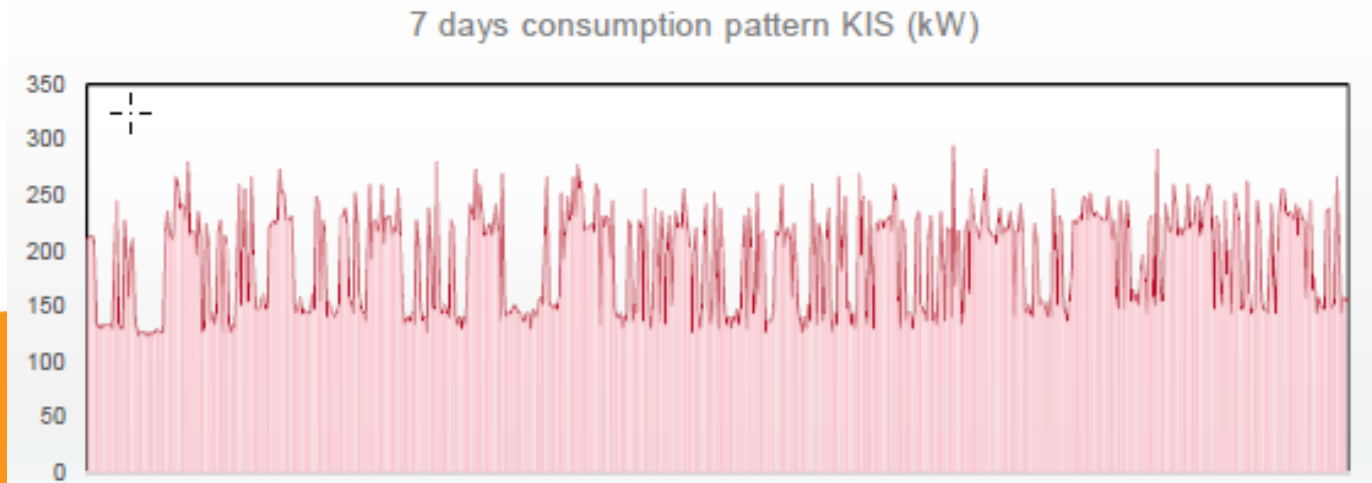
Kieldrechtlock

- + 1,2 GWh yearly
- Variable consumption pattern
- 24/7





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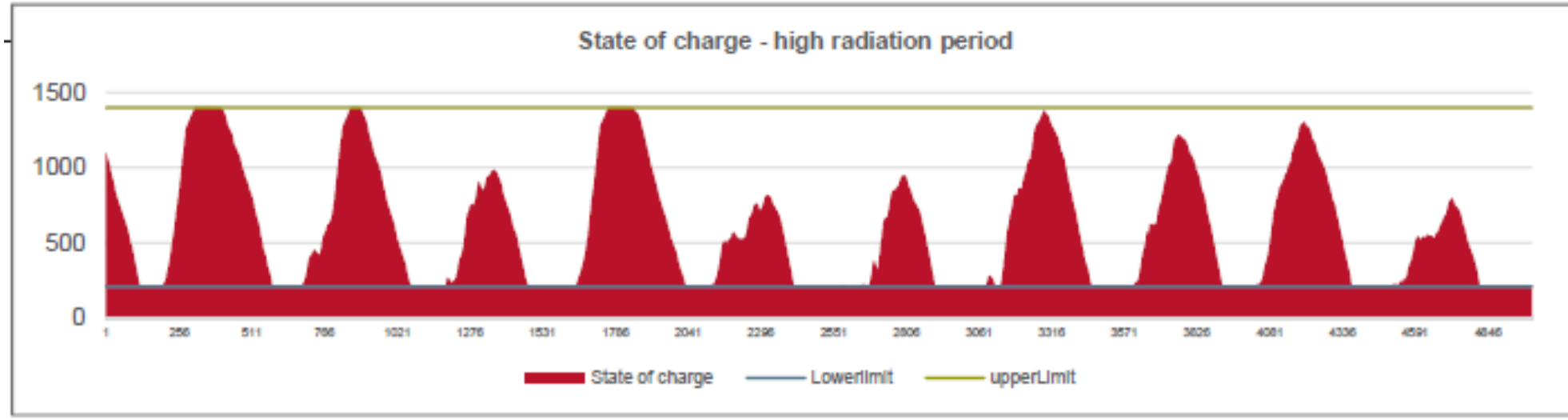
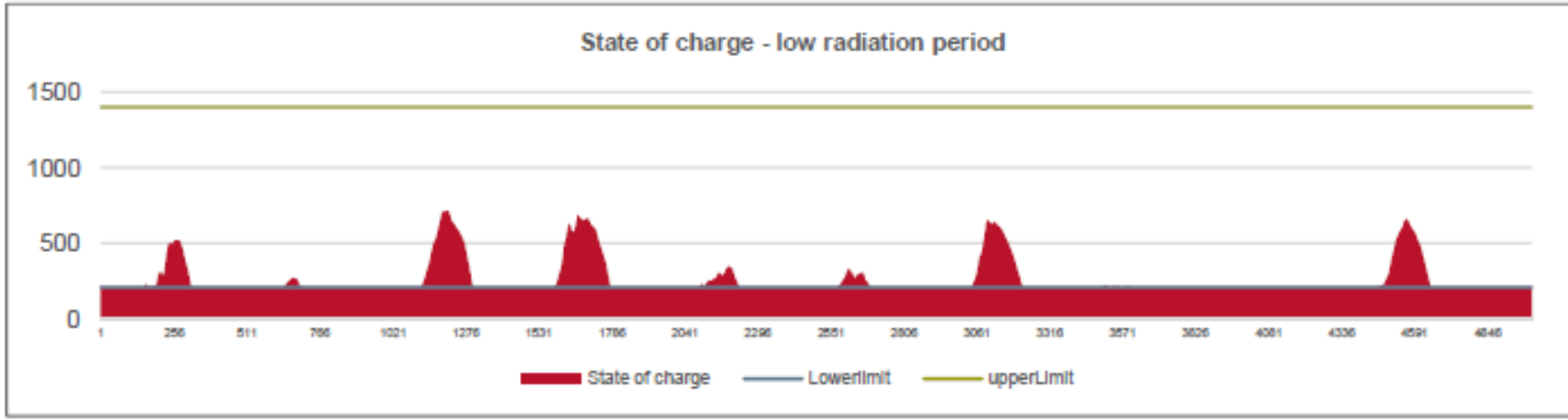
Business cases

- Peak shaving
- *Buffering of renewable energy ➔ 500 – 1.500 kWh storage*
- Back-up power

Case buffering1400 kWh - 800 kWp

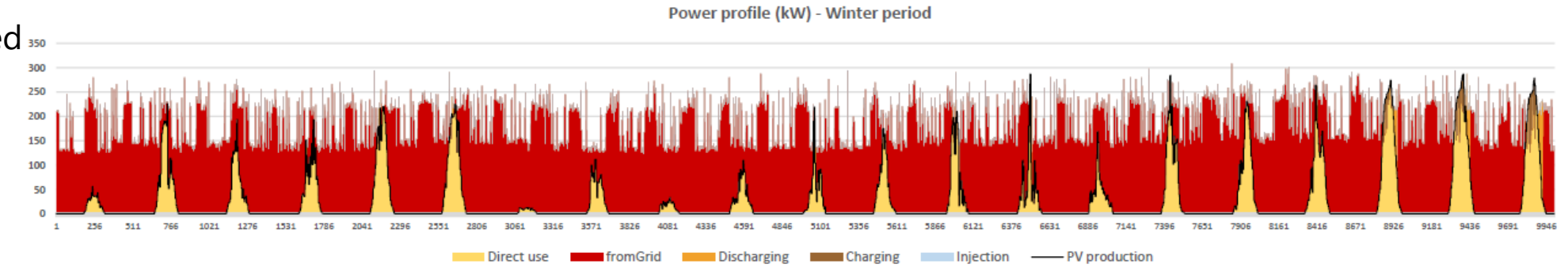
- *C-rate = 0,25*
- *SoC = 15-100%*

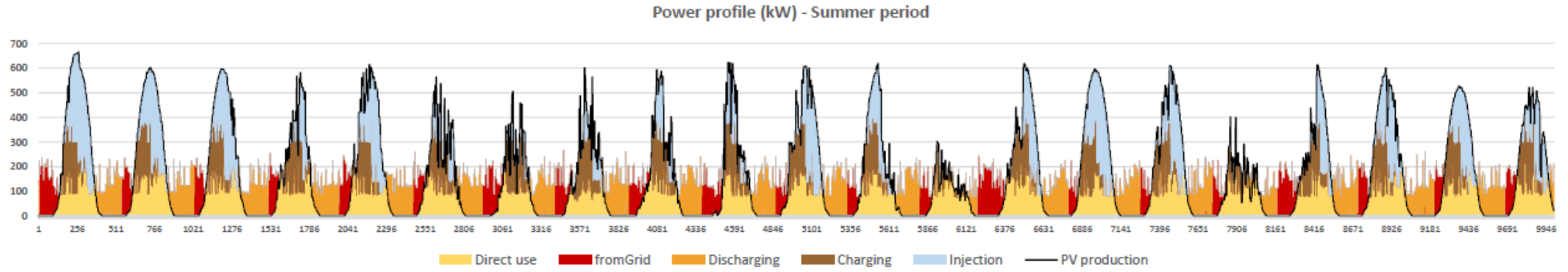




Case buffering1400 kWh - 800 kWp

- *Self consumption 80% i.o.50%*
- 45% of consumption covered by PV (i.o. 28%)
- 243 MWh stored





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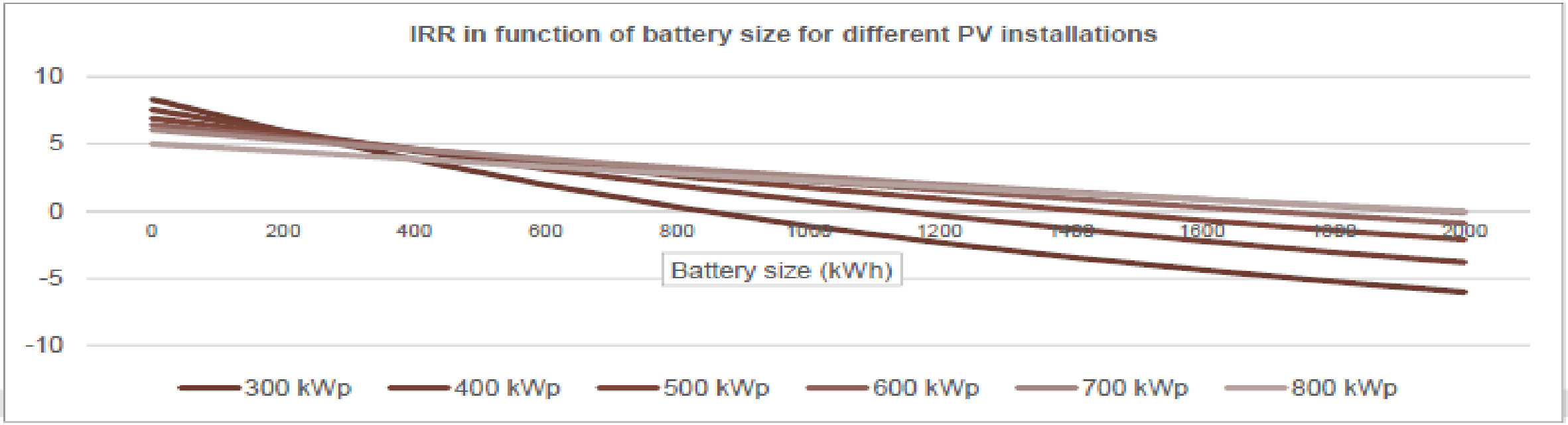
Case buffering 1400 kWh - 800 kWp



Buffering alone will not be feasable. Need for extra income.

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Balancing markets

Risk of imbalances

- Balancing Service Porviders:
  - Offer capacity
  - Decrease consumption
  - Increase consumption
- Automatic or controlled and proportional reaction
- Possible income

Situation at 15/10/2020 from 10:02 to 11:00

Quarter	Minute	Quality status	NRV (MW)	SI (MW)	α (€/MWh)	MIP (€/MWh)	MDP (€/MWh)	SR (€/MWh)	SI < -I C (MW)	Price (€/MWh)
11:00 > 11:15	11:00	Non-validated	-204,131	315,503	2,21	0,00	**11,01**			8,8
10:45 > 11:00	10:59	Non-validated	-193,152	217,751	3,21	59,00	**11,01**			7,8
10:45 > 11:00	10:58	Non-validated	-194,998	216,737	3,18	59,00	**11,01**			7,8
10:45 > 11:00	10:57	Non-validated	-198,225	217,671	3,20	59,00	**11,01**			7,8
10:45 > 11:00	10:56	Non-validated	-203,650	219,216	3,24	59,00	**11,01**			7,7
10:45 > 11:00	10:55	Non-validated	-212,447	221,198	3,29	59,00	**11,01**			7,7
10:45 > 11:00	10:54	Non-validated	-222,801	227,546	3,45	59,00	**11,01**			7,5
10:45 > 11:00	10:53	Non-validated	-232,451	238,772	3,76	59,00	**11,01**			7,2
10:45 > 11:00	10:52	Non-validated	-241,047	251,550	4,14	59,00	**11,01**			6,8
10:45 > 11:00	10:51	Non-validated	-248,225	265,177	4,58	59,00	**11,01**			6,4
10:45 > 11:00	10:50	Non-validated	-253,615	265,934	4,61	0,00	**11,01**			6,4
10:45 > 11:00	10:49	Non-validated	-259,725	281,167	5,17	0,00	**11,01**			5,8

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Demand site management

- Frequency Containment Reserves R1
  - Automatic reaction within 30 seconds
- Frequency restoration reserve R2
  - Controlled by Elia
  - Activated within 7,5 min
- Replacement reserve R3
  - Controlled manually
  - Activated within 15 min

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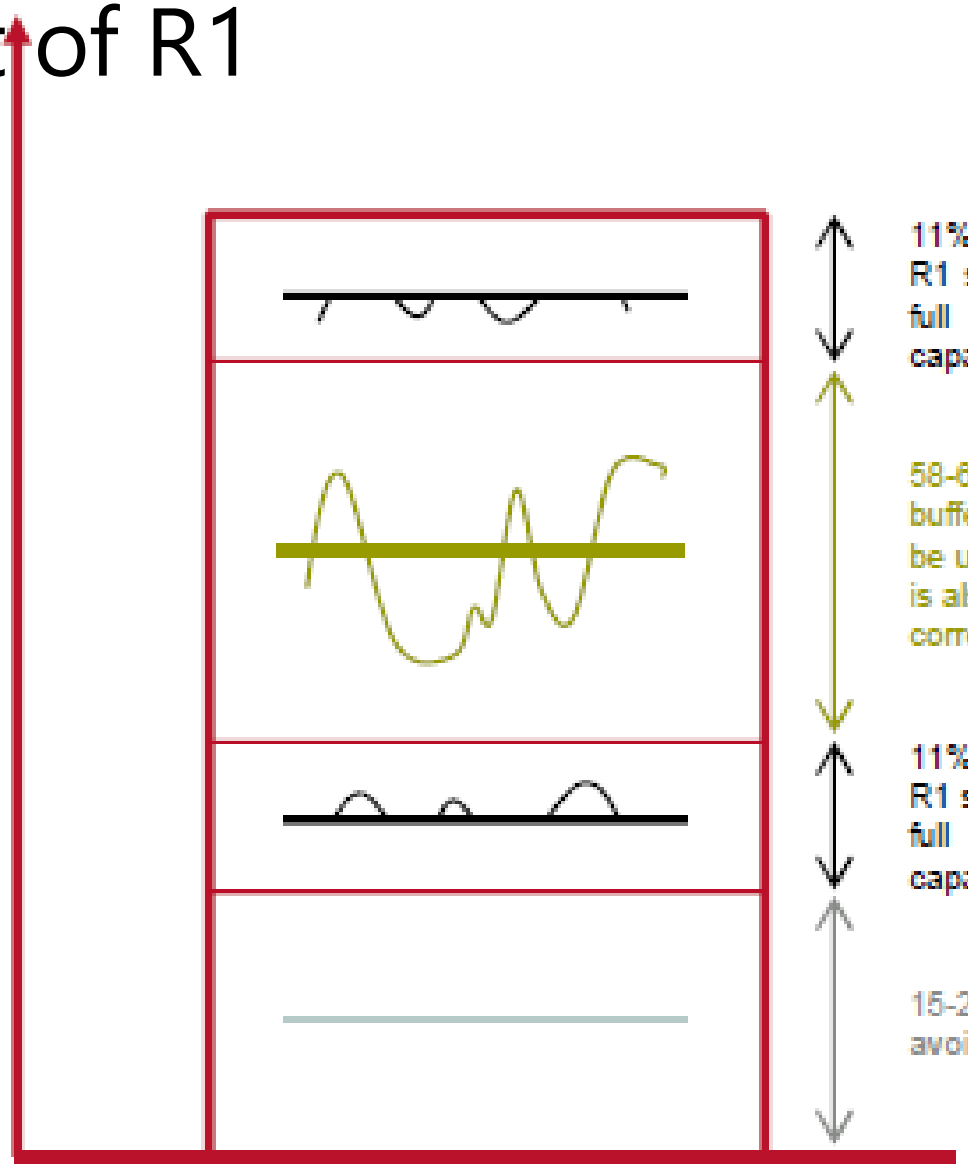
Potential impact of R1

- C-rate = 0,85
- 80% battey capacity
- 25% power available for buffer
- 75% power available for R1



11% of total energy necessary to deliver R1 services downwards for 10 minutes at full capacity with 75% of battery power capacity of a 0.85c battery

58-63% of total energy available for buffering and 25% of power capacity can be used to optimize in this range. This 25% is alse used to keep the battery in the correct range for R1

11% of total energy necessary to deliver R1 services upwards for 10 minutes with at full capacity with 75% of battery power capacity of a 0.85c battery

15-20 % of battery capacity reserved to avoid deep cycles and garantee live span

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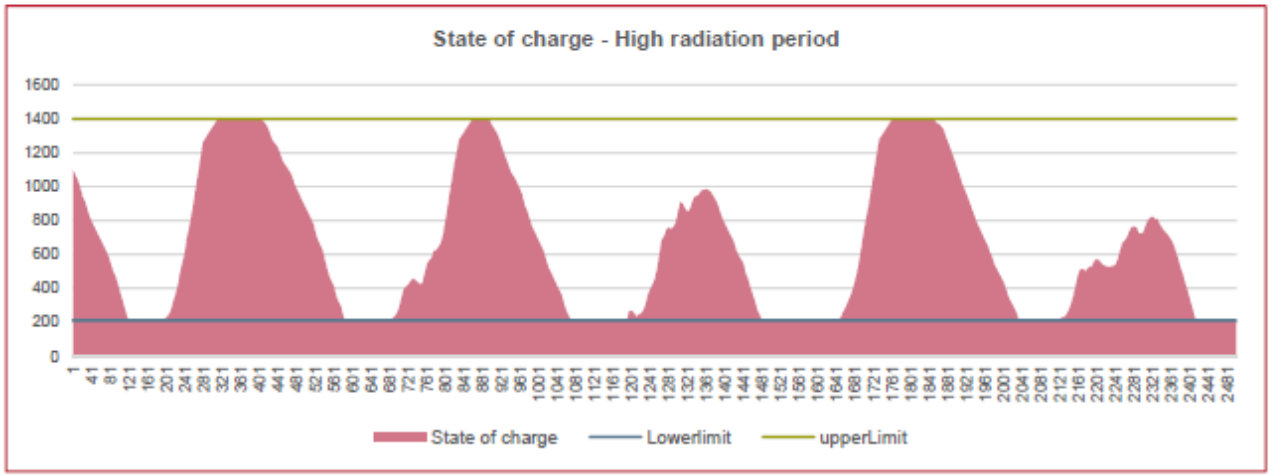
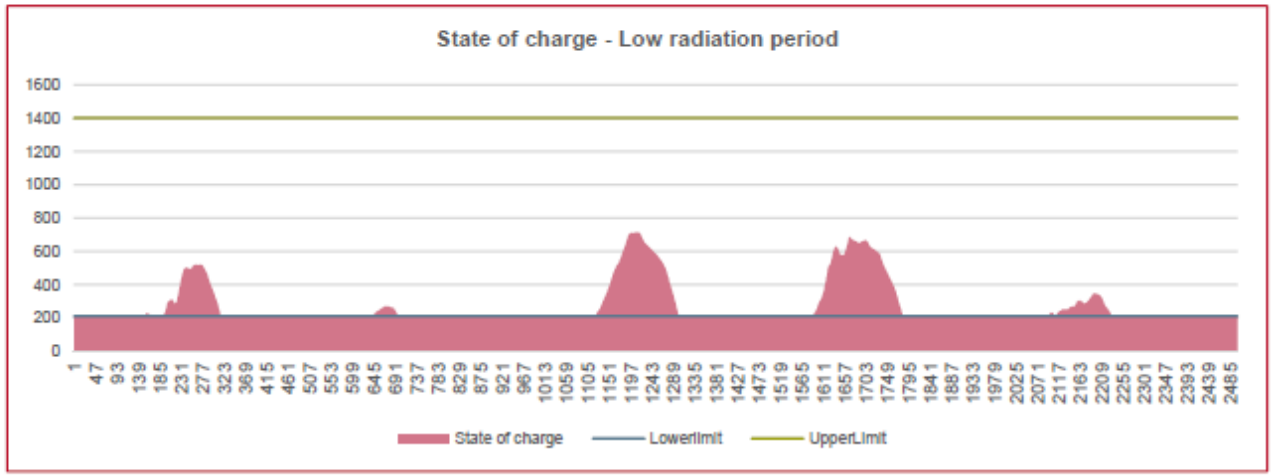
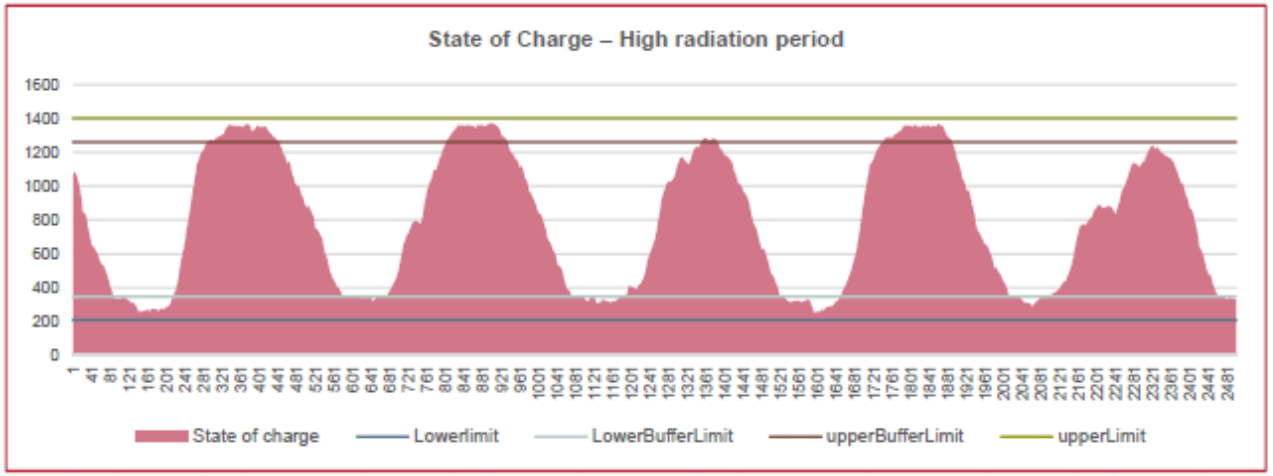
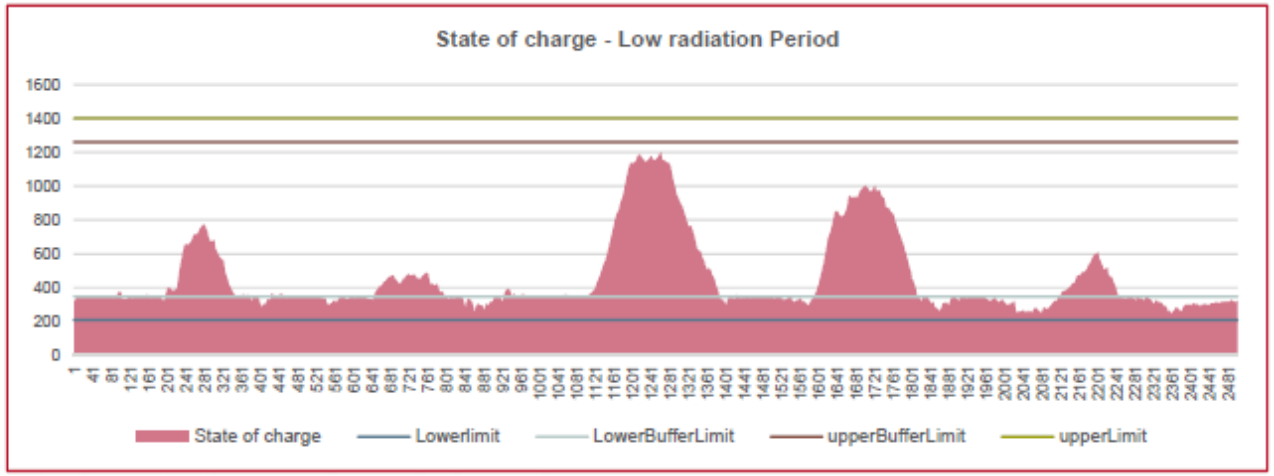
Simulation without R1:



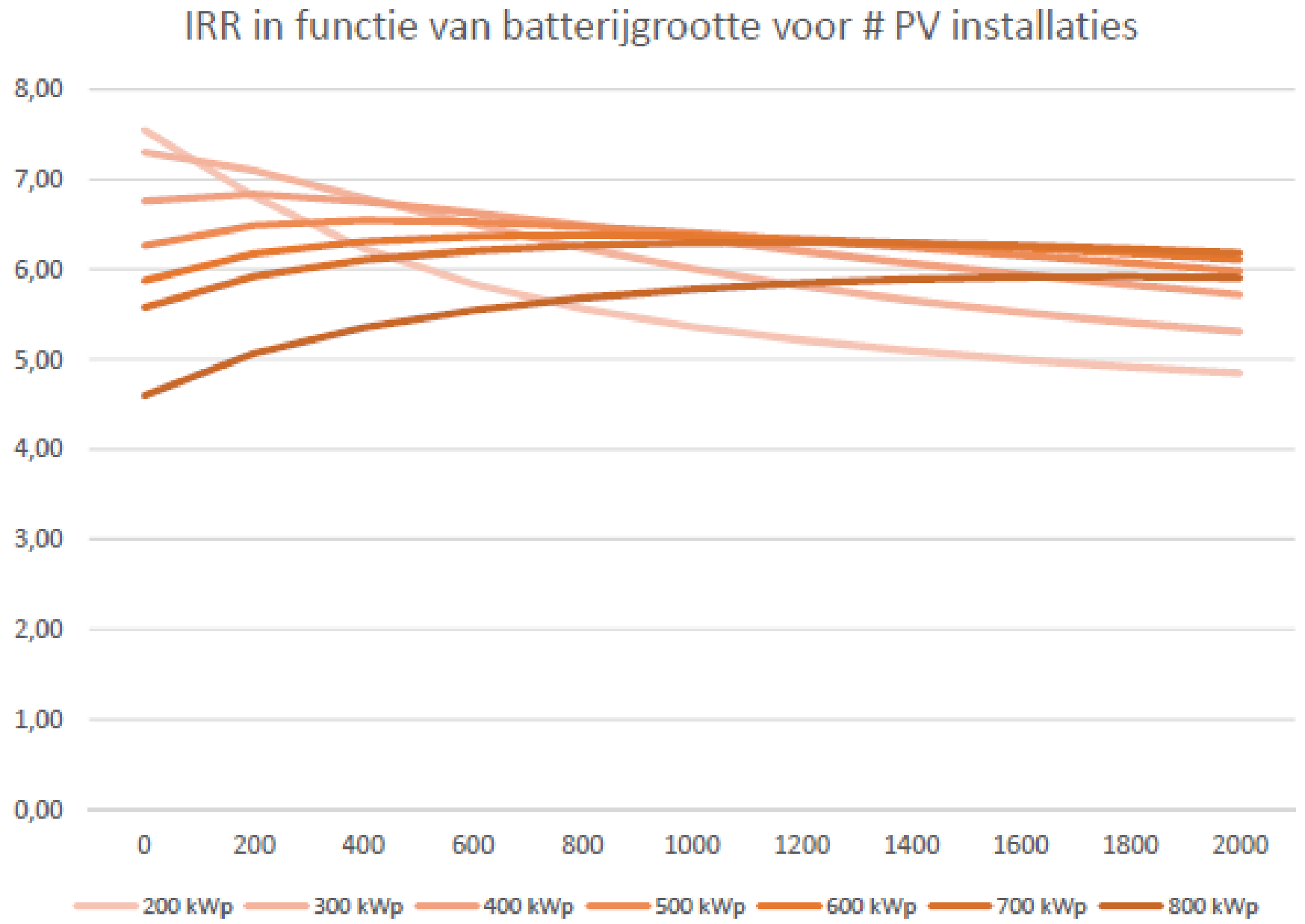


Simulation with R1:





- Life span ⇔ full cycles
- 72% buffering (i.o. 80%)
- Need for aggregator



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Direct consumption of solar PV:

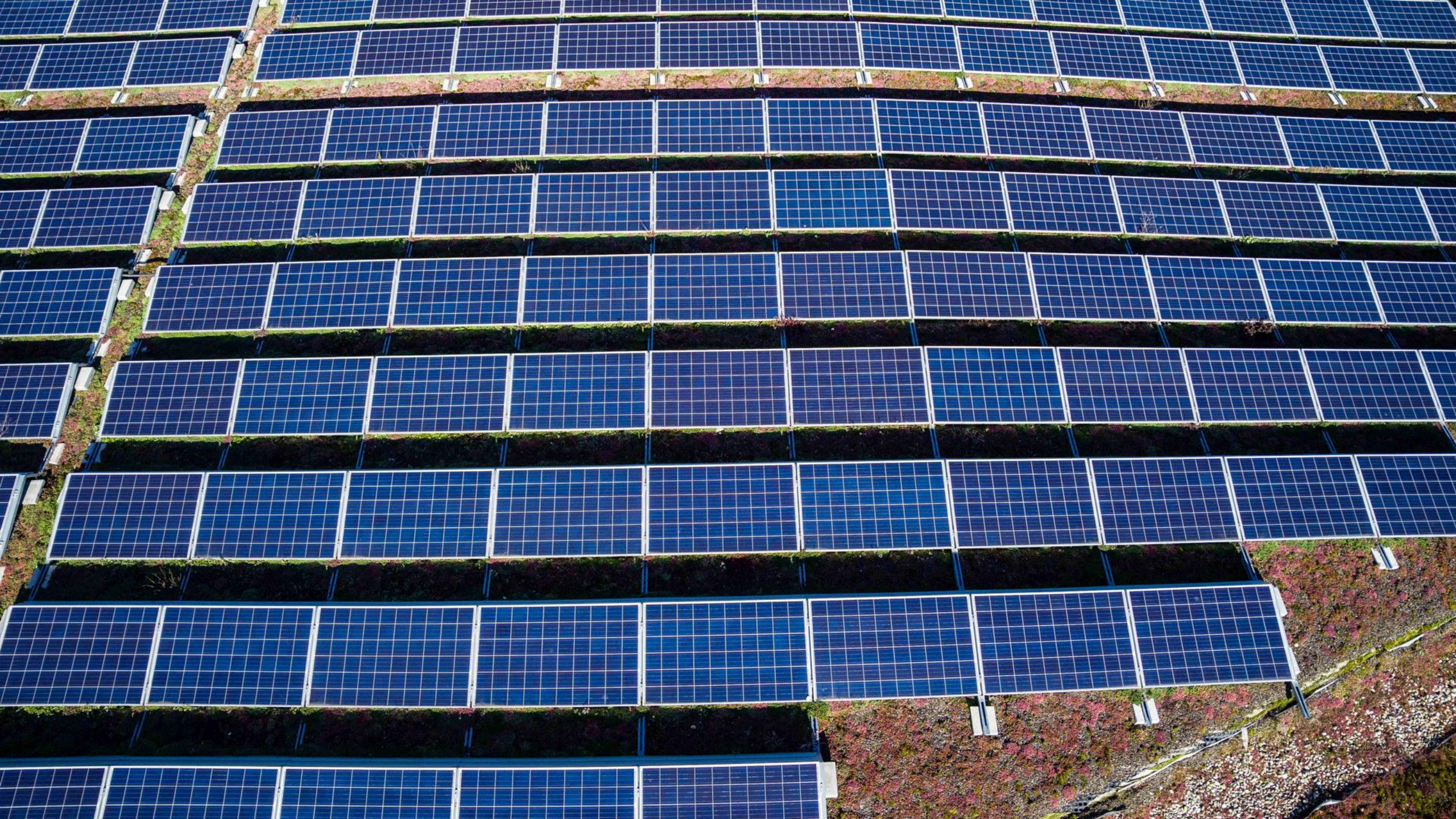
Battery size kWh \ PV size (kWp)	100	200	300	400	500	600	700	800	900	1000
0	99,97	95,07	84,97	74,65	66,29	59,62	54,20	49,71	45,91	42,65
200	100,00	99,16	91,50	81,07	72,14	64,91	59,03	54,12	49,99	46,45
400	100,00	99,94	95,40	85,75	76,80	69,23	63,02	57,82	53,45	49,73
600	100,00	99,99	97,65	89,34	80,64	73,02	66,56	61,14	56,57	52,68
800	100,00	99,99	98,88	92,16	83,90	76,37	69,82	64,22	59,47	55,43
1000	100,00	100,00	99,43	94,31	86,64	79,33	72,77	67,10	62,19	58,00
1200	100,00	100,00	99,69	95,92	88,97	81,92	75,47	69,79	64,79	60,44
1400	100,00	100,00	99,82	97,11	90,96	84,21	77,92	72,24	67,22	62,76
1600	100,00	100,00	99,89	98,02	92,64	86,21	80,11	74,47	69,46	64,97
1800	100,00	100,00	99,91	98,60	93,97	87,91	81,98	76,45	71,45	66,94
2000	100,00	100,00	99,94	98,90	94,93	89,27	83,49	78,07	73,09	68,60

IRR 15 jaar (%):

	100	200	300	400	500	600	700	800	900	1000
0	5,26	7,55	7,31	6,76	6,27	5,87	5,58	4,60	4,67	4,70
200	4,76	6,81	7,10	6,84	6,49	6,18	5,92	5,07	5,12	5,13
400	4,56	6,23	6,80	6,76	6,55	6,31	6,10	5,35	5,40	5,41
600	4,45	5,84	6,50	6,63	6,53	6,37	6,21	5,55	5,59	5,61
800	4,38	5,57	6,24	6,49	6,48	6,38	6,27	5,68	5,73	5,75
1000	4,33	5,37	6,01	6,34	6,41	6,37	6,29	5,78	5,83	5,86
1200	4,30	5,21	5,82	6,20	6,33	6,34	6,30	5,85	5,91	5,94
1400	4,27	5,09	5,66	6,07	6,24	6,29	6,29	5,89	5,96	6,00
1600	4,25	5,00	5,52	5,95	6,16	6,24	6,27	5,92	6,00	6,04
1800	4,23	4,92	5,41	5,83	6,07	6,18	6,23	5,92	6,01	6,07
2000	4,22	4,85	5,31	5,72	5,98	6,11	6,18	5,91	6,01	6,07

Self reliance (% of consumption self-produced):

	100	200	300	400	500	600	700	800	900	1000
0	7,02	13,35	17,90	20,97	23,28	25,12	26,64	27,93	29,01	29,95
200	7,02	13,93	19,28	22,77	25,33	27,35	29,02	30,40	31,59	32,62
400	7,02	14,04	20,10	24,09	26,96	29,17	30,98	32,48	33,78	34,92
600	7,02	14,04	20,57	25,09	28,31	30,76	32,72	34,35	35,75	37,00
800	7,02	14,04	20,83	25,88	29,46	32,18	34,32	36,07	37,59	38,92
1000	7,02	14,04	20,95	26,49	30,42	33,42	35,77	37,69	39,30	40,72
1200	7,02	14,04	21,00	26,94	31,24	34,52	37,10	39,20	40,94	42,44
1400	7,02	14,04	21,03	27,28	31,94	35,48	38,30	40,58	42,48	44,07
1600	7,02	14,04	21,04	27,53	32,53	36,32	39,38	41,83	43,90	45,62
1800	7,02	14,04	21,05	27,70	32,99	37,04	40,29	42,95	45,15	47,00
2000	7,02	14,04	21,05	27,78	33,33	37,61	41,04	43,85	46,19	48,17



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Outdoor energy system

- Batteries
- Convertor
- BMS
- Cooling
  - Liquid cooled battery module
  - Liquid cooled rack

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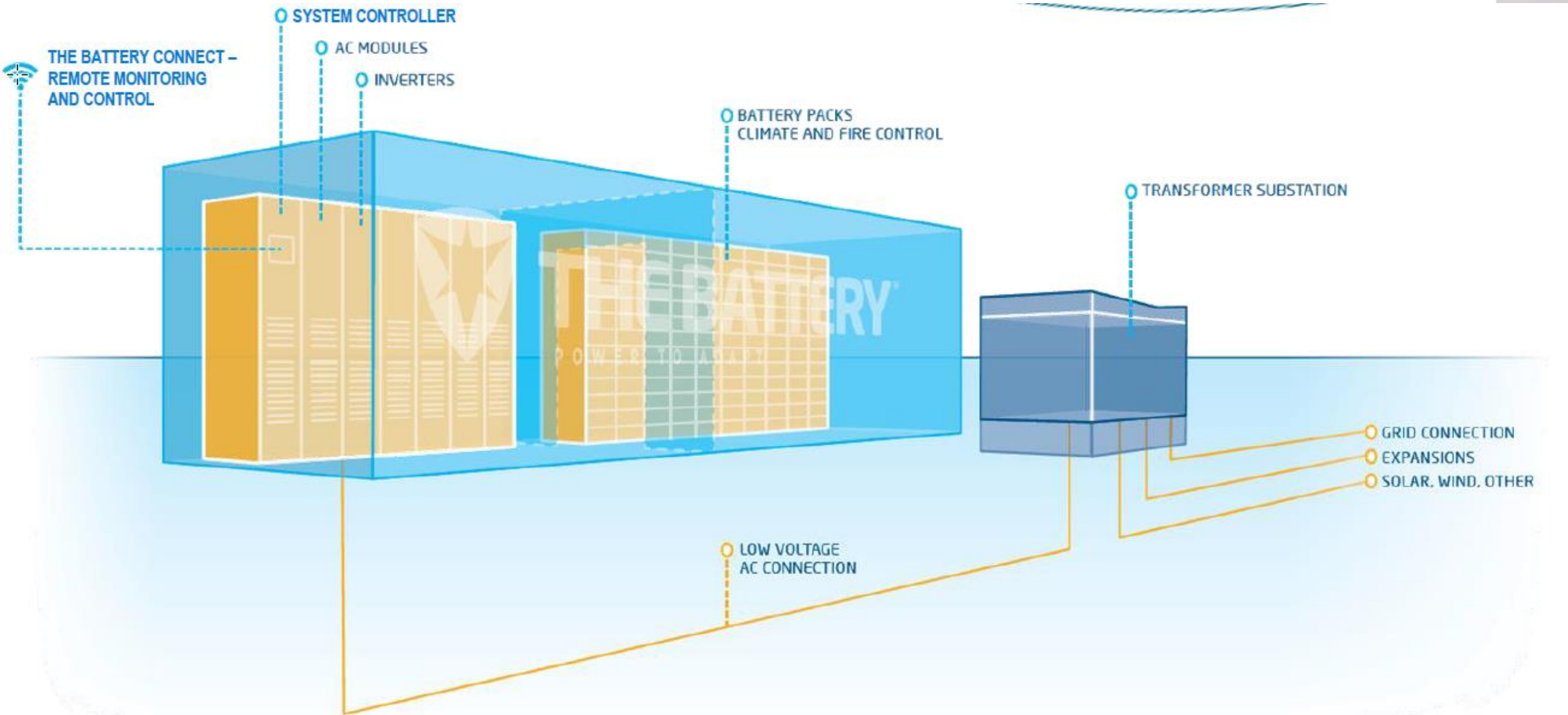

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Air filter

Air Entry (front door)

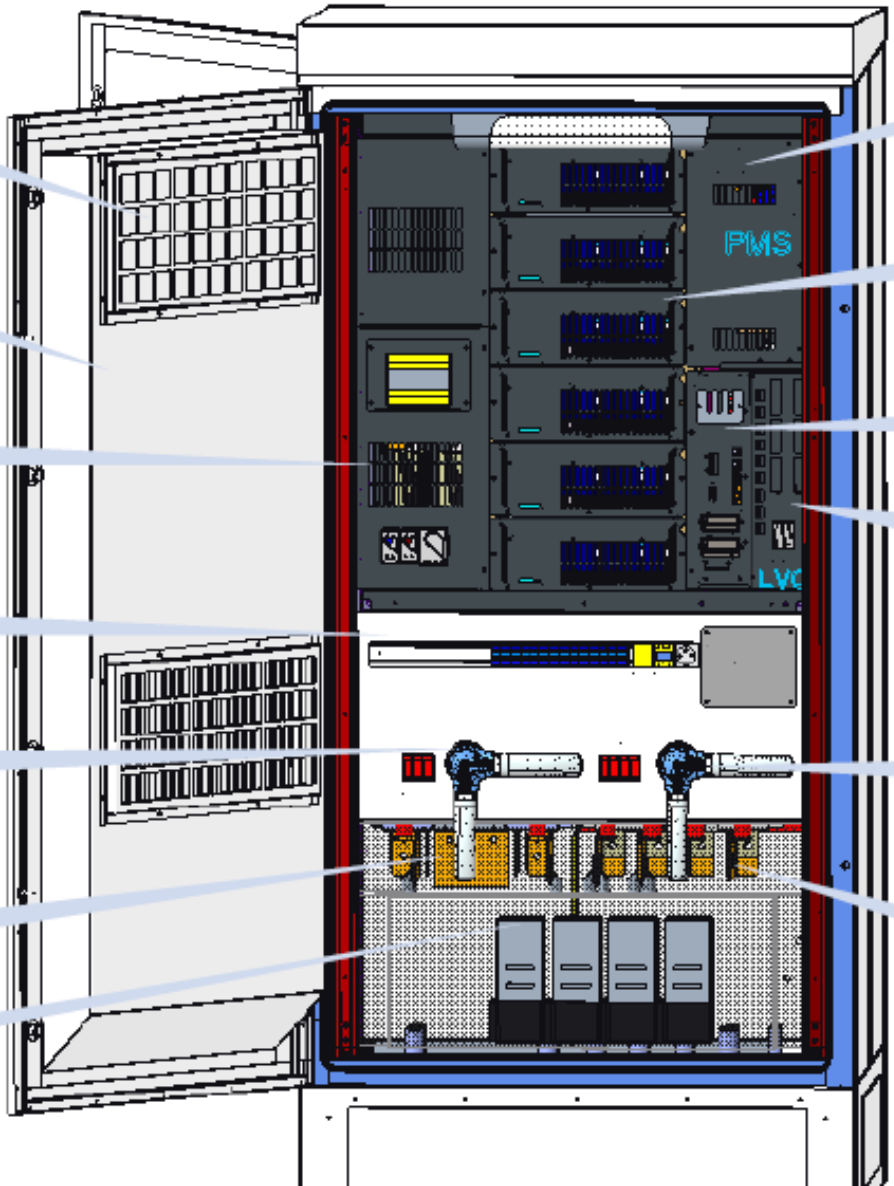
Power DC fuses

Control fuses

DC switch

DC Connections

Heater



PMS + EIS devices

Power module 50 kVA

Control (up to 6 modules)

Communication IoT
(I/O, Ethernet,...)

AC switch

AC Connections

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Grid connection

High Voltage ⇔ Low Voltage

- High Voltage
  - Investment in equipement

- Low Voltage
  - Investment in cabling + converter

4 motors of the lock and 2 of the bridges on LV

No space in HV cabine

➔ Low voltage

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Lessons learned

- PV = easy
- Batteries = easy
- Combination of PV, batteries and consumer ≠ easy

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Dank u voor uw aandacht.