



Wind Meets Storage

Co-location Assessment for Ukraine

November 2025

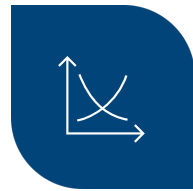
Revenue streams by market segments

MODELLED



Bilateral agreements

- **Least regulated segment** – free pricing and flexible supply structures
- **Traders** remain the main offtakers for new RES projects, typically offering:
 - ✓ packaged solution: offtake + balancing group
 - ✓ “DAM-%” pricing model
 - ✓ full buy-out of D-1 forecast
- **D-1 forecast** is required, producer is responsible for imbalances towards BRP, BRP - towards TSO
- Open operational **auction platform** is available: Ukrainian Energy Exchange (UEEX)
- Credible and reliable **counterparties** are critical
- **Wind + BESS** arrangements yet to be developed and tested



DAM and IDM

- **Organized regulated spot trading**
- **No accumulation of debts** due to escrow accounts system
- Price caps:
 - ✓ Min – 0.2 EUR/MWh
 - ✓ Max – 114...306 EUR/MWh
 - ✓ Further deregulation is declared
- Balancing group and **D-1 forecasting** is still required.
- **Not guaranteed sale**
 - ✓ **DAM** accepted volume rate **>90%**
 - ✓ **IDM** accepted volume rate **<10%**
- Challenging trading **administration**
- **Loop orders** are announced to be introduced in **2026**
- **BESS can improve WPP capture prices**



Balancing market

- Managed by TSO and not designed for free trading:
 - ✓ Obligatory bids for energy UP and DOWN which are activated on demand
 - ✓ Imbalances settlement price forming
- Hourly Price Caps
- Activation price ≠ bid price
- Non-transparent activation and pricing algorithms
- Commercial performance difficult to forecast
- Significant **payment delays**: months to a year
- **BESS mitigates wind exposure to rising imbalance costs**
- High price volatility



FCR, aFRR

- **Service contracts for TSO.**
- **Technical Certification** is required
- **Auction based sourcing.** New form of sourcing is announced – similar to balancing free-bids
- **Limited demand**, currently:
 - ✓ **FCR** – 99 MW
 - ✓ **aFRR** – 1000 MW
- Price caps - ~29 EUR/MW/h
- **2025** long-term **auctions results:**
 - ✓ **FCR** - 97% of the demand contracted until Oct 2030
 - ✓ **aFRR^{SYM}** – 87% of the demand contracted until 2032
 - ✓ **aFRR^{UP}** – 49% of the demand contracted until 2032



Curtailments optimisation

- **Not a market**
- RES is being curtailed through:
 - ✓ direct dispatch commands
 - ✓ balancing market
- No publicly available data
- BESS can charge from wind during curtailments



Other Partnership models

- Ukraine is yet to adopt the BESS framework already available in EU:
 - ✓ tolling agreements
 - ✓ revenue sharing
 - ✓ hedging agreements
- **Traders and aggregators** likely to pioneer these models

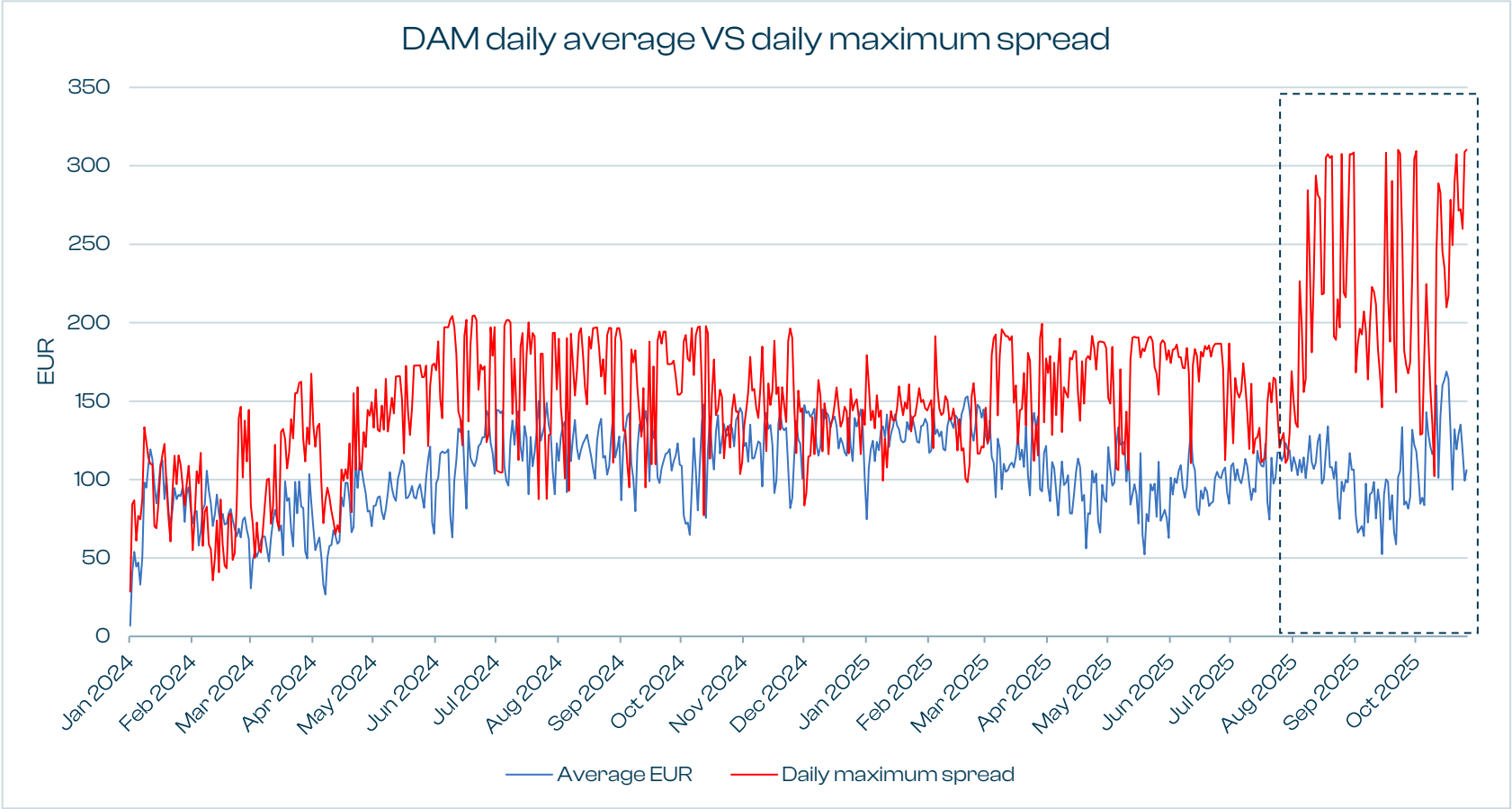
**NOT
MODELLED**

Other Revenue Streams

Spot Prices

Intra-day price volatility – key driver for BESS economics

- **Price caps adjustment** from Aug 1st 2025 triggered **38%** average high-low daily **spread increase**
- Which adds +5...7 % IRR to BESS return



Average DAM price spreads, EUR/MWh

	Night / Morning		Day / Evening	
	max	2h	max	2h
Jan 2024	68	41	52	28
Feb 2024	32	24	65	34
Mar 2024	42	41	92	74
Apr 2024	51	50	97	95
May 2024	57	46	145	139
Jun 2024	31	18	172	169
Jul 2024	26	11	154	153
Aug 2024	29	20	168	164
Sep 2024	58	52	145	143
Oct 2024	83	75	127	124
Nov 2024	80	67	105	83
Dec 2024	79	60	87	74
Jan 2025	84	75	97	83
Feb 2025	70	64	114	107
Mar 2025	62	61	154	147
Apr 2025	69	64	163	161
May 2025	52	46	154	151
Jun 2025	8	(1)	169	166
Jul 2025	28	21	132	128
Aug 2025	27	18	226	213
Sep 2025	73	71	205	187
Oct 2025	62	56	209	188

Model Assumptions

WPP

/ WTGs capacity	100 MW
/ Grid allowed capacity	100 MW
/ Balancing group efficiency	0%
/ Yearly positive imbalances	21% (of production volume)
/ Yearly negative imbalances	11% (of production volume)

BESS

/ CAPEX	155,000 EUR/MWh (0.5c)
	140,000 EUR/MWh (0.25c)
/ OPEX	2.5% of CAPEX per year
/ Availability	98%
/ RTE	86,9% (0.5c)
/ DoD	95%
/ Capacity degradation	cycle and calendar (suppliers' curve)
/ EOL	10,000 cycles (~14 years at 2 cycles/day)
/ Augmentation strategy	2 phases during 35 years
/ Financing	100% equity in 2029
/ COD	2030

Prices

- / **Historic prices on DAM and Balancing market**
(June 2024 - May 2025)
- / **BESS capture prices:**
 - cost of Positive imbalance: -45 EUR/MWh
 - cost of Negative imbalance: 120 EUR/MWh
 - effective arbitrage spread: 147 EUR/MWh

BESS Dispatch schedule

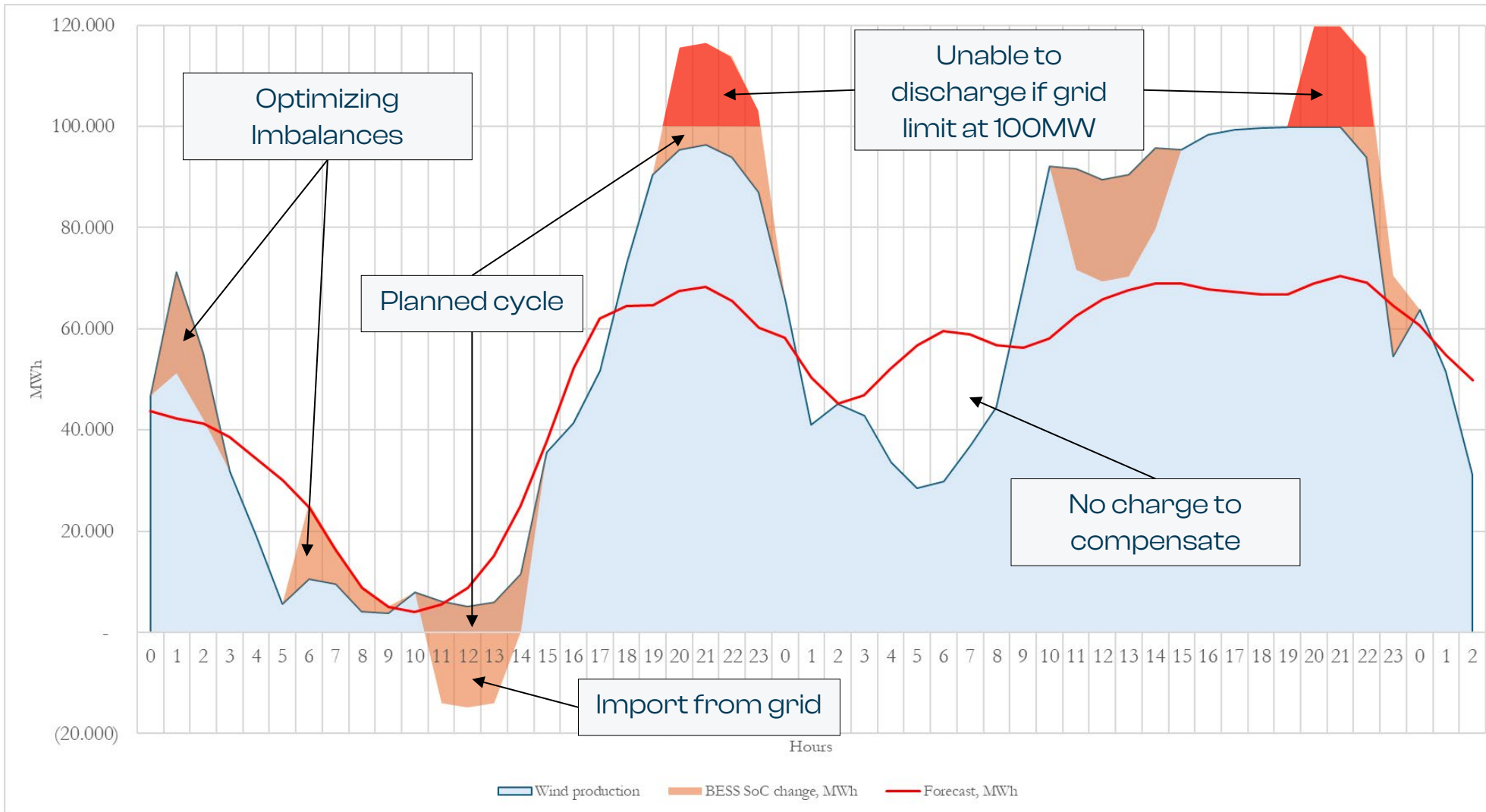
/ Manual input by months and hour

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	I-			P+	P+	I+	I+	I-	I-	I-	I-	I-	P+	P+				P-	P-	I-	I-	I-	I-	I-
Feb	I-		I+	P+	P+	I+	I+	I-	I-	I-	I-	I-	P+	P+				P-	P-	I-	I-	I-	I-	I-
Mar	I-	I+	I+	I+	I+	I+	I+	I-	I-	I-	I-	I-	P+	P+					P-	P-	I-	I-	I-	I-
Apr	I-	I+	I+	I+	I+	I+	I+	I-	I-	I-	I-	I-	P+	P+							P-	P-	I-	I-
May	I-	I+	I+	I+	I+	I+	I+	I-	I-	I-	I-	I-	P+	P+							P-	P-	I-	I-
Jun	I-	I+	I+	I+	I+	I+	I+	I-	I-	I-	I-	I-	P+	P+							P-	P-	I-	I-
Jul	I-	I+	I+	I+	I+	I+	I+	I-	I-	I-	I-	I-	P+	P+							P-	P-	I-	I-
Aug	I-	I+	I+	I+	I+	I+	I+	I-	I-	I-	I-	I-	P+	P+							P-	P-	I-	I-
Sep	I-	I+	I+	I+	I+	I+	I+	I-	I-	I-	I-	I-	P+	P+							P-	P-	I-	I-
Oct	I-			P+	P+	I+	I+	I-	I-	I-	I-	I-	P+	P+					P-	P-	I-	I-	I-	I-
Nov	I-			P+	P+	I+	I+	I-	I-	I-	I-	I-	P+	P+				P-	P-	I-	I-	I-	I-	I-
Dec	I-			P+	P+	I+	I+	I-	I-	I-	I-	I-	P+	P+				P-	P-	I-	I-	I-	I-	I-

**Example with the best result: 1-cycle arbitrage + Imbalance Optimization*

I-	Discharge to Negative IB
I+	Charge from Positive IB
P-	Planned discharge
P+	Planned charge

BESS+Wind hourly calculation



/ Real WPP hourly data allows to see real SoC and energy volumes



Optimal BESS size

- / 10-20MW (10-20% of WPP nominal power)
- / 2-hours duration

Optimal use-case

- / 1-cycle arbitrage +
- / Imbalances optimisation (charging and discharging hours separated)

Project IRR

BESS power, MW	5	10	15	20	30	40	50
BESS dispatch scenario							
Imbalances optimization only	18%	16%	14%	12%	9%	6%	6%
1-cycle arbitrage	15%	15%	14%	14%	13%	12%	11%
1-cycle arbitrage + IB	22%	20%	19%	18%	16%	15%	14%
2-cycles arbitrage	17%	16%	16%	15%	14%	14%	13%
2-cycles arbitrage +IB	19%	18%	17%	17%	16%	15%	14%

**2h BESS duration; historic prices (June 2024 - May 2025) are fixed for all years; grid limit at 100MW*

Modelling Results

If BESS charging from grid is not allowed (not in the base-case)

- / Negative impact on BESS IRR will be **-2%** if BESS charging only from wind energy
- / Regulation allows BESS to import from the grid, but additional CAPEX may be required

If Double grid tariffs are applied (not in the base-case)

- / Currently, co-located BESS would be charged with the grid tariffs on the full imported electricity volume.
- / This would result in a minor IRR reduction around **-0.6%**
- / It is recommended to align legislation with stand-alone BESS, applying the tariff only to consumed volumes

Other Price scenarios' impact on Project IRR

Price Scenarios	BESS power, MW	
	10	20
Base case: Historic prices (Jun 2024 - May 2025) remains fixed	20%	18%
High case: DAM evening prices are adjusted +20%, and remains fixed	25%	22%
Low case: DAM evening prices are adjusted +20% plus negative trend: -25% by 2030	18%	16%
Stress case: Historic prices (Jun 2024 - May 2025) plus negative trend: -25% by 2030	14%	12%

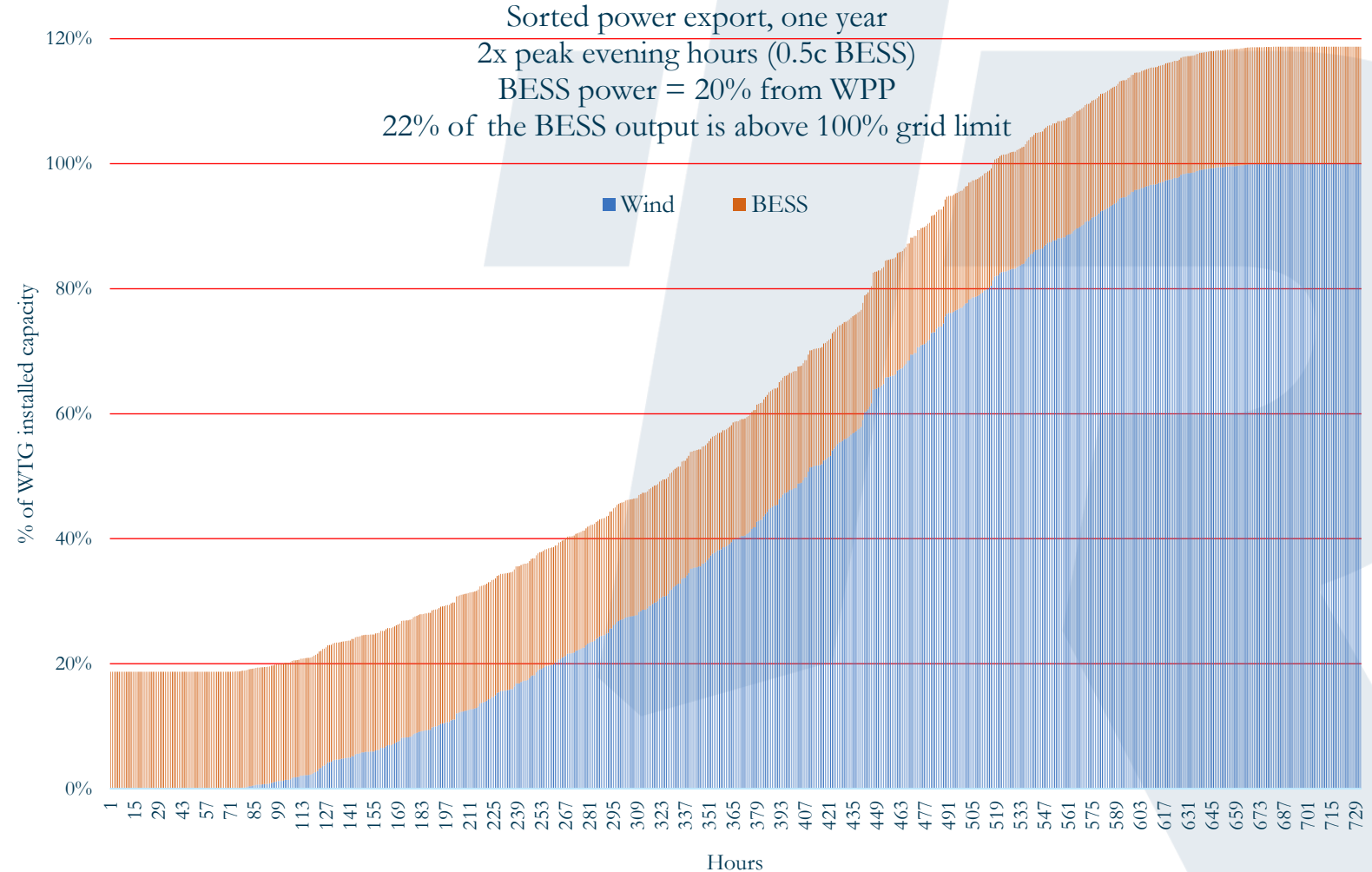
**2h BESS*

Modelling Results: sensitivities

Grid limit effect

BESS may compete with wind production in the evening

- / BESS unable to sell in the evening because wind production is also high
- / This effect may reduce BESS IRR by 3...6% depending on the wind daily profile
- / Impact increases with BESS size
- / Contracted Grid Capacity above WTG nominal power is not standard practice and comes at a cost
- / Justified additional grid capacity cost is 30,000 EUR/MW for 10MW BESS
- / If additional grid capacity is available at a reasonable cost, adding more WTGs could be smarter





Thank you
for your
attention!

