

Ramp Rates

Quantifying the impact on BESS revenues



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Agenda

1. Why do Ramp Rates Matter?
2. FlexInsight: Quantifying the impact on revenues
3. Case studies
4. Q&A

Why do Ramp Rates Matter?

01

Why do Ramp Rates Matter?



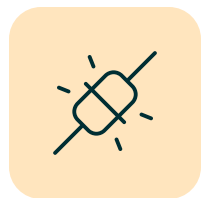
Speed

Batteries can respond to market signals almost instantaneously. But that flexibility can come with restrictions.



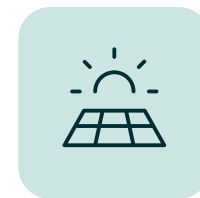
Grid stability

Rapid, simultaneous changes in battery output can exacerbate system imbalances.



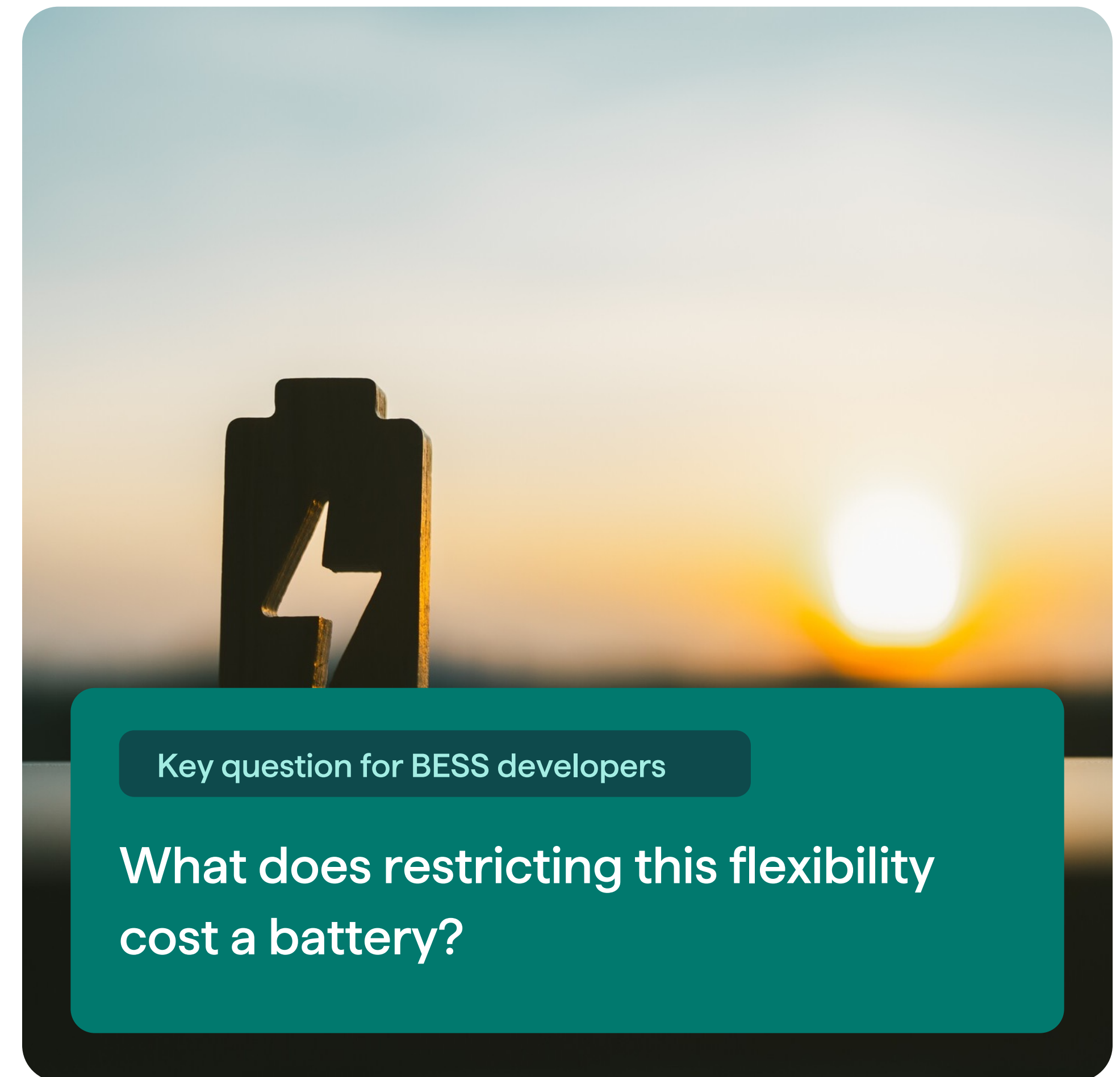
Grid connection agreements

Network operators may impose site-specific limits on how quickly imports or exports can change.



Co-location

Batteries sharing a connection with wind or solar may face additional operational constraints.

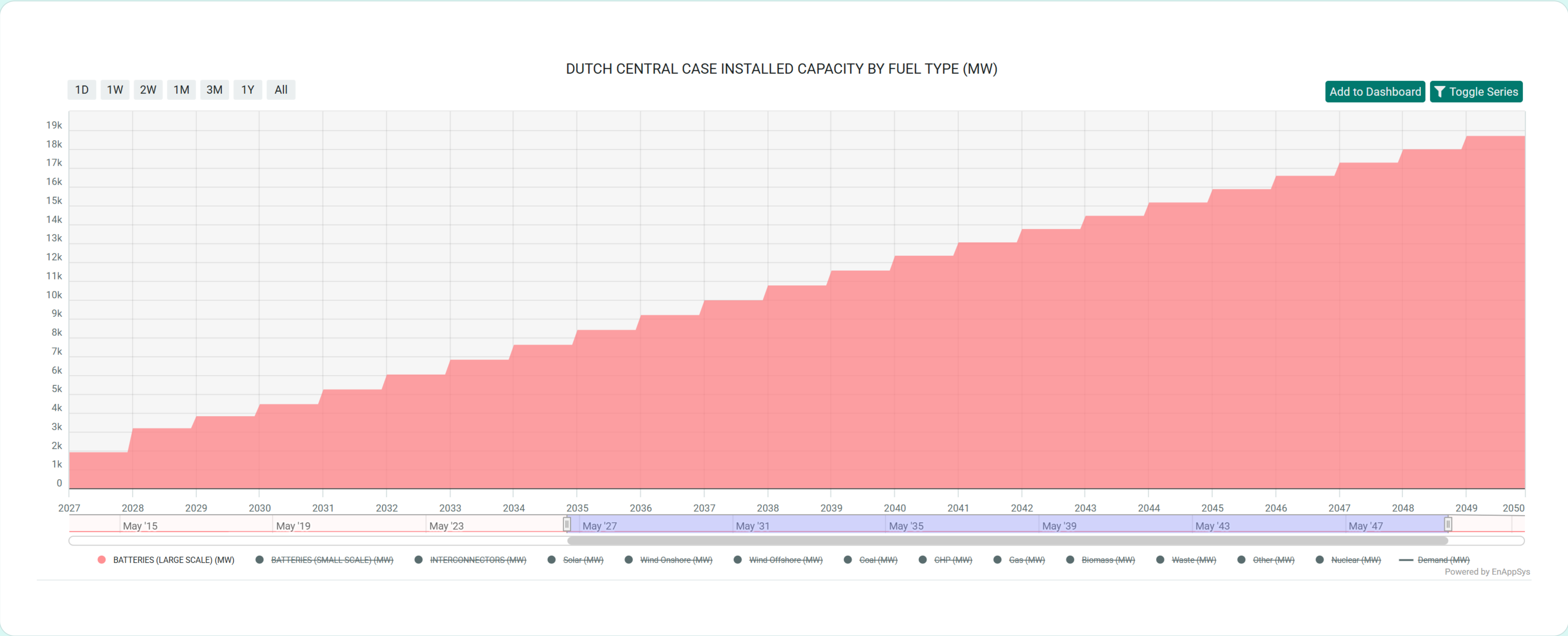


Key question for BESS developers

What does restricting this flexibility cost a battery?

BESS Buildout Boom

Large-scale BESS capacity in the Netherlands is forecast to grow dramatically over the coming decades.

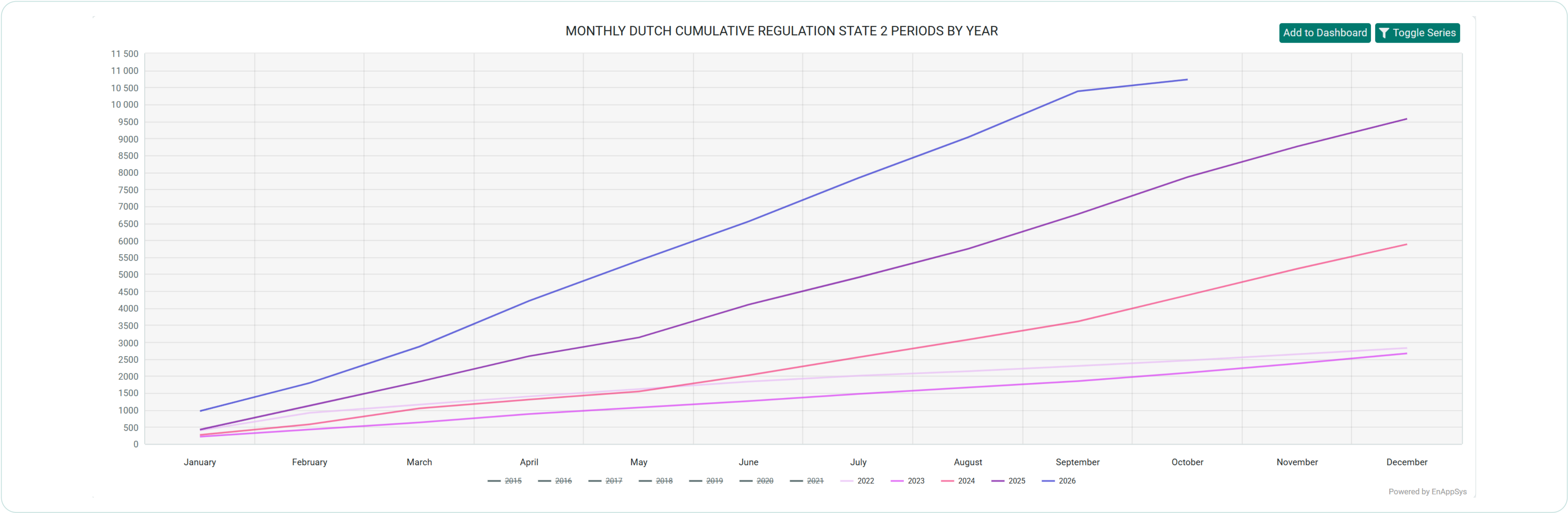


When Battery Flexibility Becomes a Problem

Batteries can react so quickly to imbalance signals that their combined response may overcorrect the system, turning a shortage into a surplus — or vice versa.

Regulation state 2 occurs when TenneT activates both upward and downward balancing energy within the same 15-minute settlement period. Its frequency has increased significantly.

A single 300 MW BESS switching from full charging to full discharging can create a **600 MW swing** in net power demand within seconds.



Ramp Rate Regulation: From Capability to Compliance

Dutch Grid Code*: Maximum ramp rate of **20%/min** of maximum active power for qualifying assets.

Previously

Technical capability

Assets needed to be capable of limiting their ramp rates, but weren't generally required to apply them in practice.



Now

Operational Compliance

Applicable assets must observe ramp-rate limits in normal operation.



Who is affected?

- BESS installations ≥ 50 MW commissioned after 1 September 2021.
- Qualifying generating units commissioned after 27 April 2019.
- Smaller BESS may also face restrictions through connection agreements or future regulation.

*Source: Dutch Grid Code 2026, Articles 2.9(3), 3.22(15), 3.25(4); TenneT clarification. Smaller BESS may also face ramp-rate constraints via other arrangements or future regulatory changes.

FlexInsight: Quantifying the impact on revenues

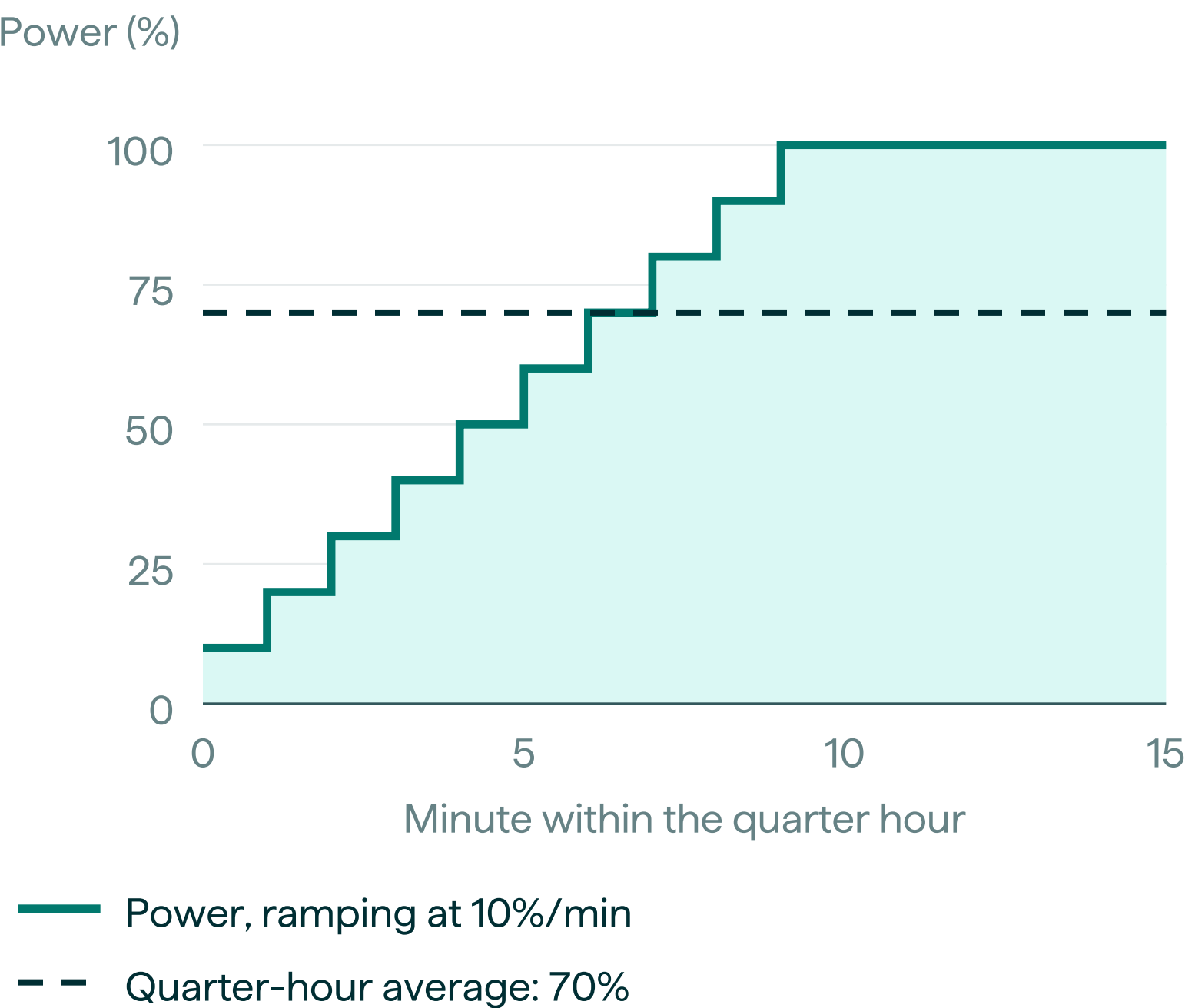
02

Montel FlexInsight

	Name	Country	Battery >	Lifetime Performance		Colocation	Grid Import Limits			Grid Export Limits		
			Energy Capacity	Daily Cycles	Degradation		Firm	Non-Firm	Firm Battery	Firm	Non-Firm	
	05PC	NL	20	1.5	fixed		10	0	0	10	0	
	10PC	NL	20	1.5	fixed		10	0	0	10	0	
	20PC	NL	20	1.5	fixed		10	0	0	10	0	
	No RR	NL	20	1.5	fixed		10	0	0	10	0	

How does FlexInsight model ramp rate limits?

Illustrative example: 10%/min ramp-rate restriction.

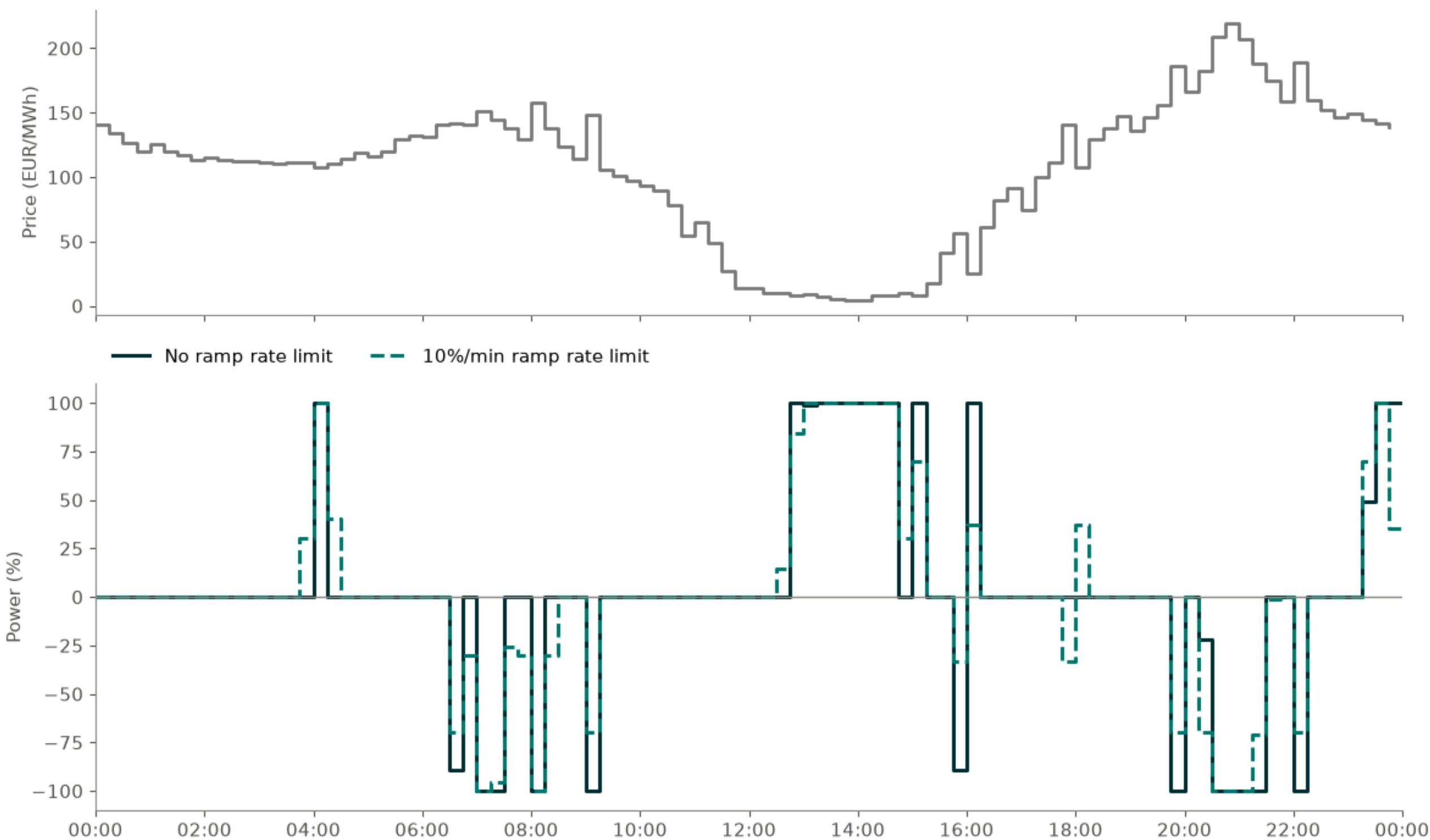


Revenue impact

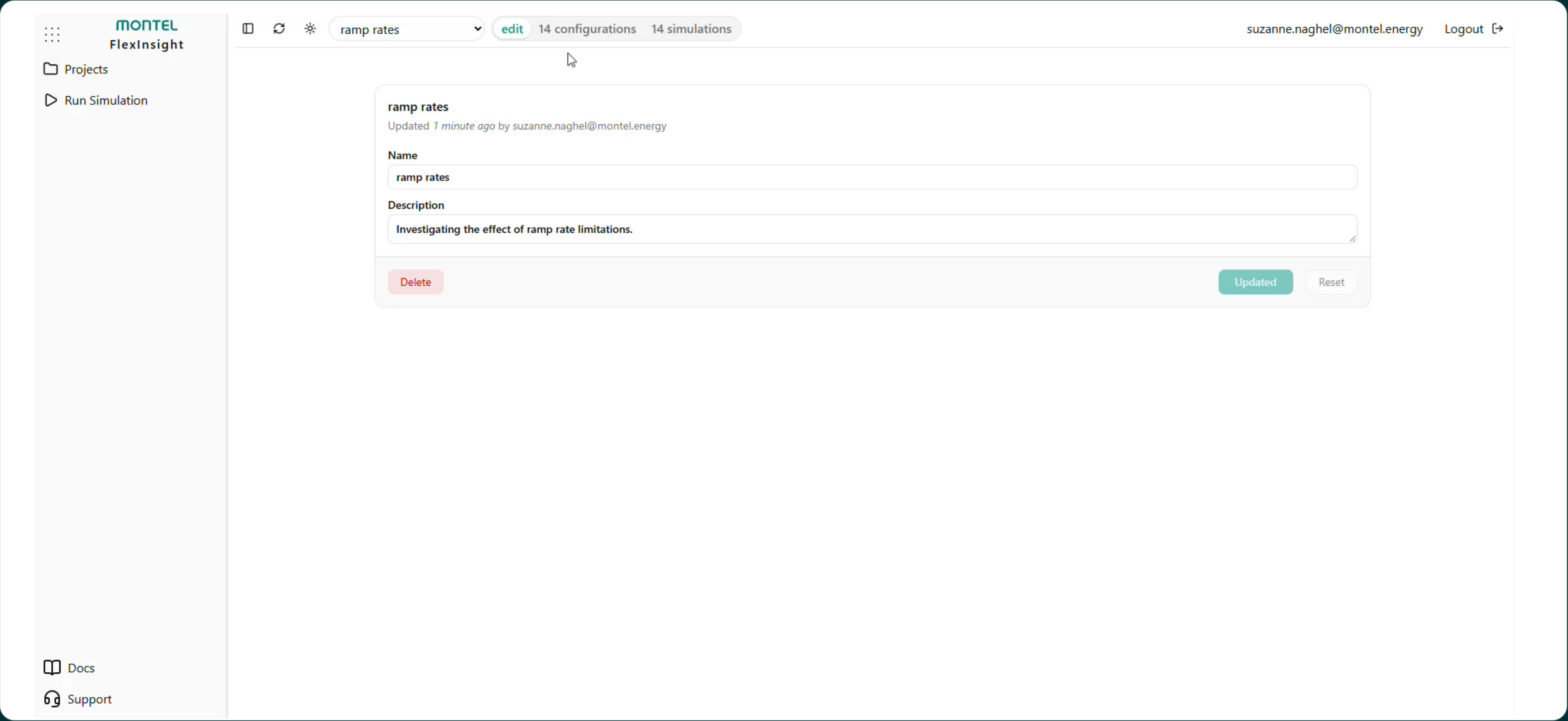
-1.7%

2-hour BESS • Day-ahead optimisation • 21 May 2026

2h BESS Day-Ahead optimisation 21/05/2026



Montel FlexInsight: Running multiple scenarios

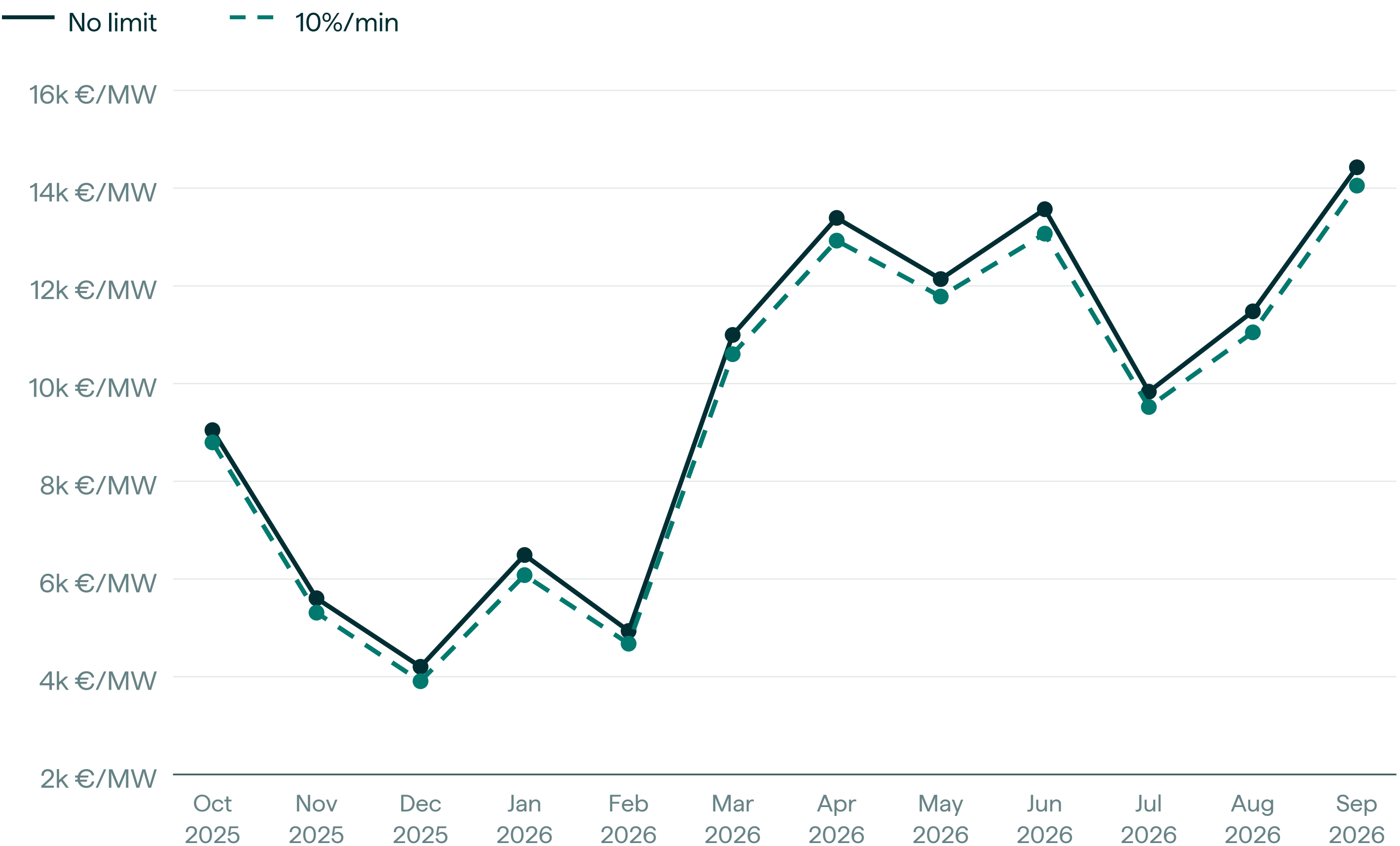


Case studies

03

What does a ramp rate limitation cost a battery?

Modelled revenue 10MW/20MWh battery (day-ahead + intraday + imbalance)



Annual revenue loss

-4.4%



Stand-alone 10 MW / 20 MWh battery



10%/min ramp rate limit



Optimised across day-ahead, intraday and imbalance

Where in the strategy does the ramp rate limits bite?



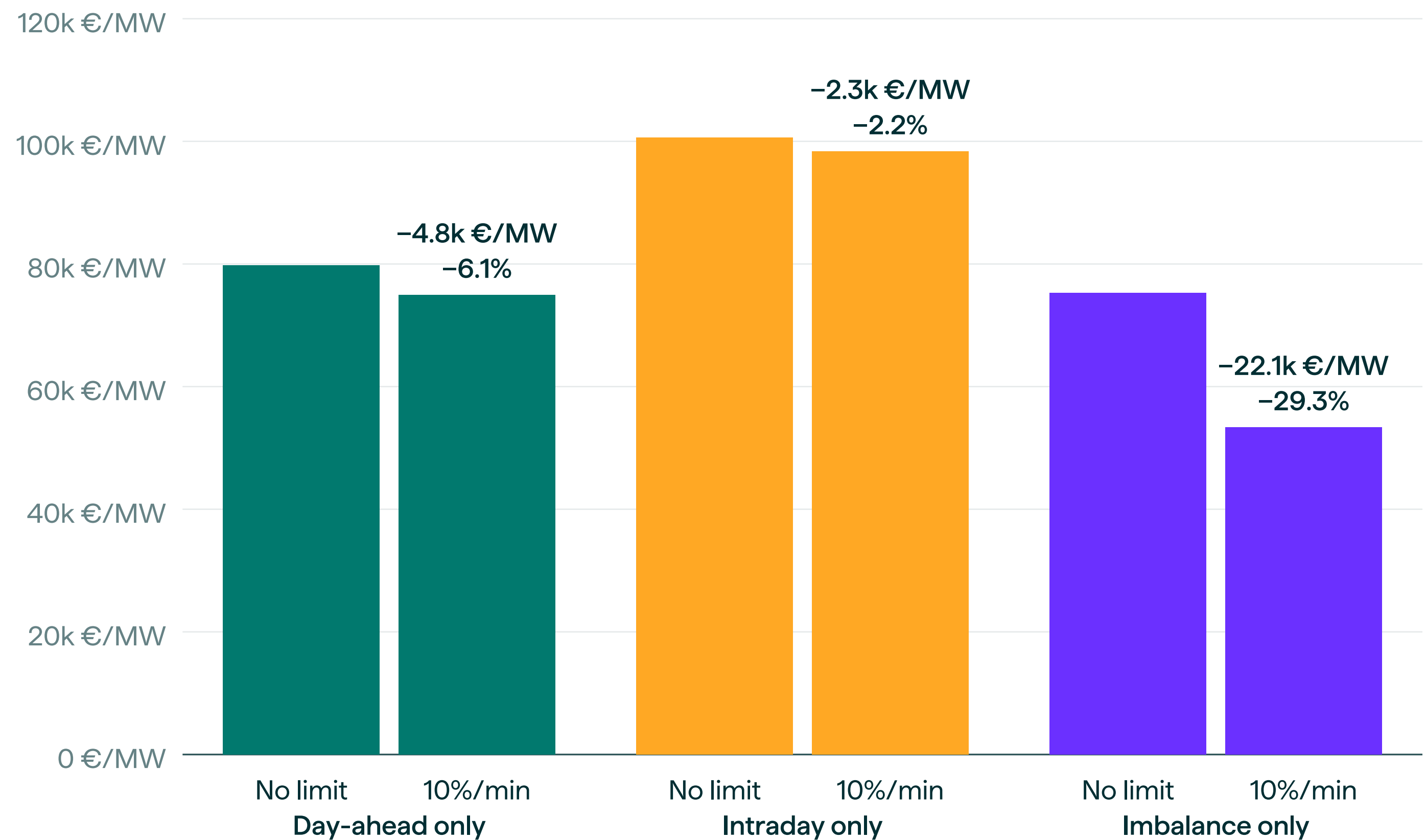
Imbalance takes the biggest revenue hit:

balancing needs a quick response, which is dampened by a ramp rate restriction

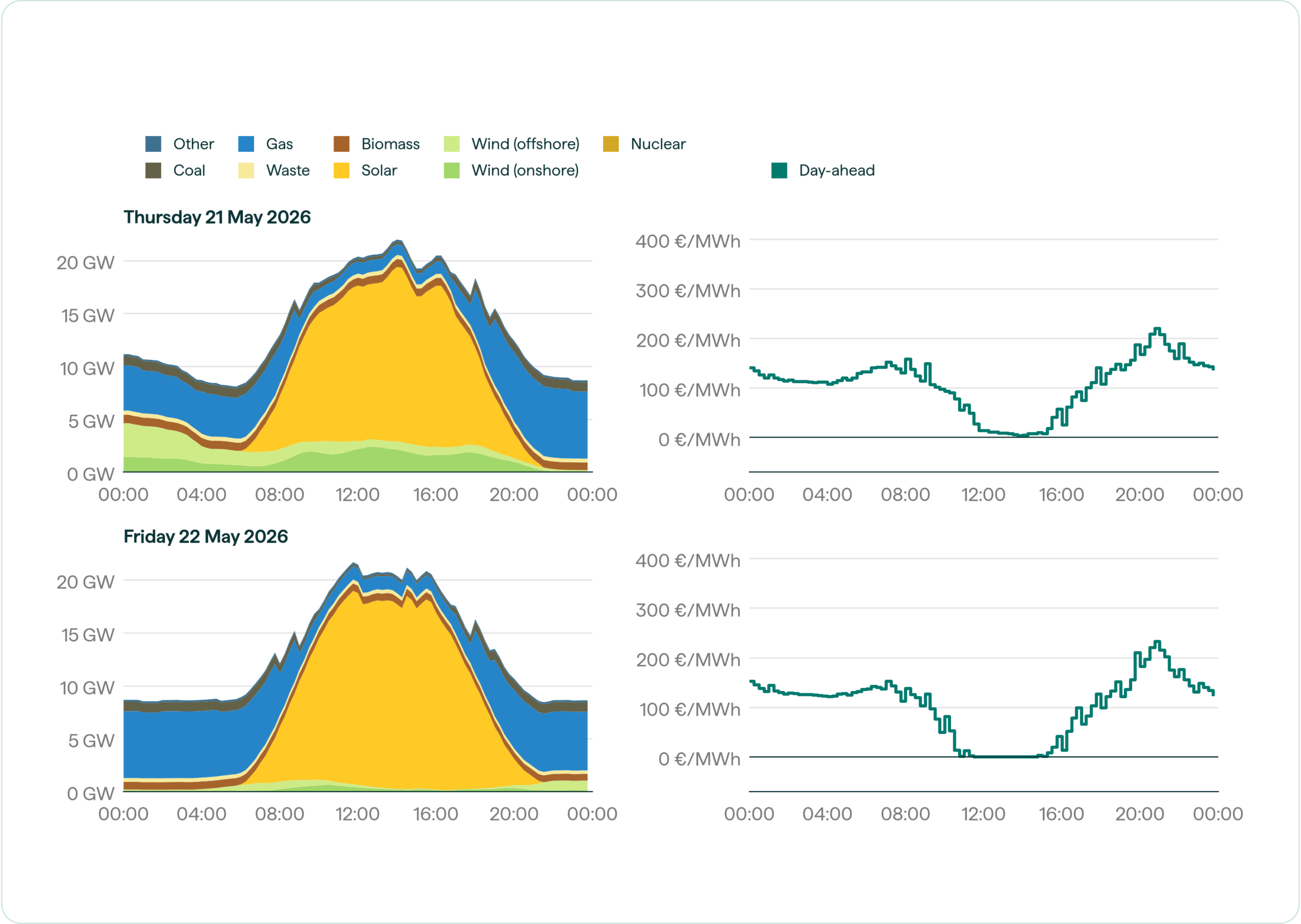
Each optimisation done per single market, no limit vs 10%/min

Revenue of a single-market optimisation, 10 MW / 2h battery

■ Day-ahead ■ Intraday ■ Imbalance



When does a ramp rate limit cost the most?



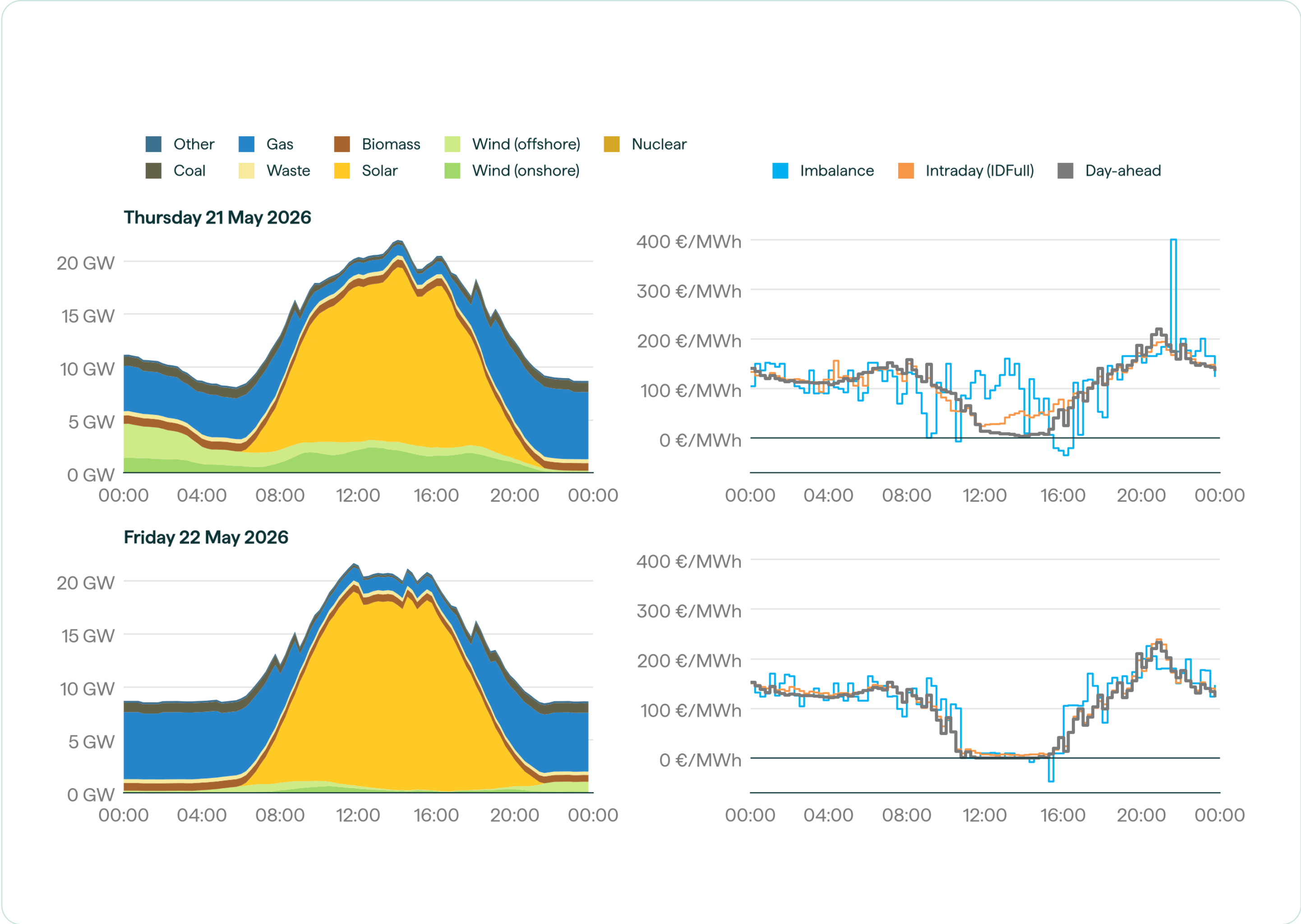
–1.7%

loss from 10%/min on day-ahead only

–2.0%

loss from 10%/min on day-ahead only

When does a ramp rate limit cost the most?

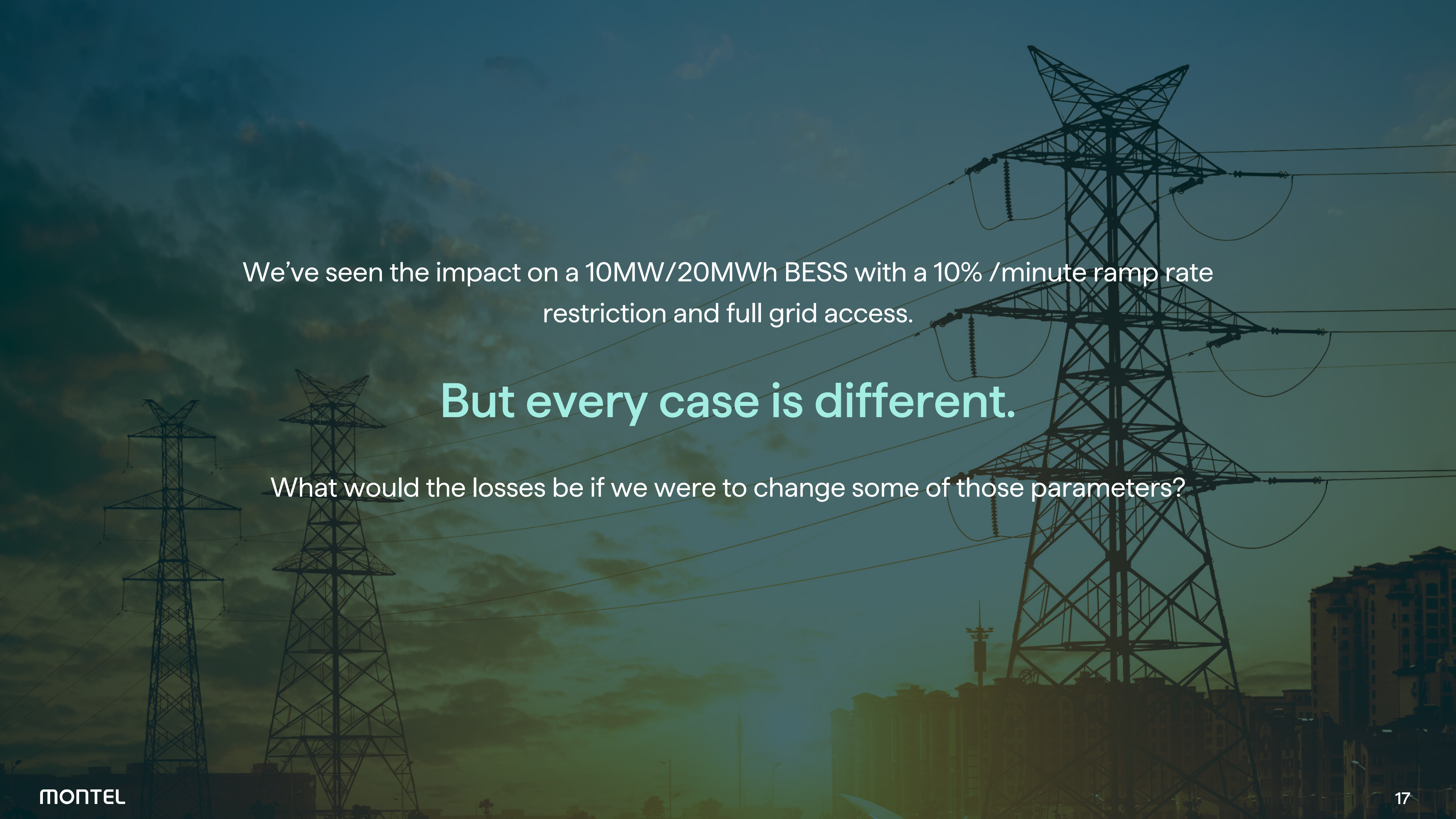


–6.9%

loss from 10%/min on **full optimization**
volatile intraday and imbalance prices

–2.5%

loss from 10%/min on **full optimisation**
calm, short-term prices track day-ahead



We've seen the impact on a 10MW/20MWh BESS with a 10% /minute ramp rate restriction and full grid access.

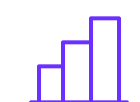
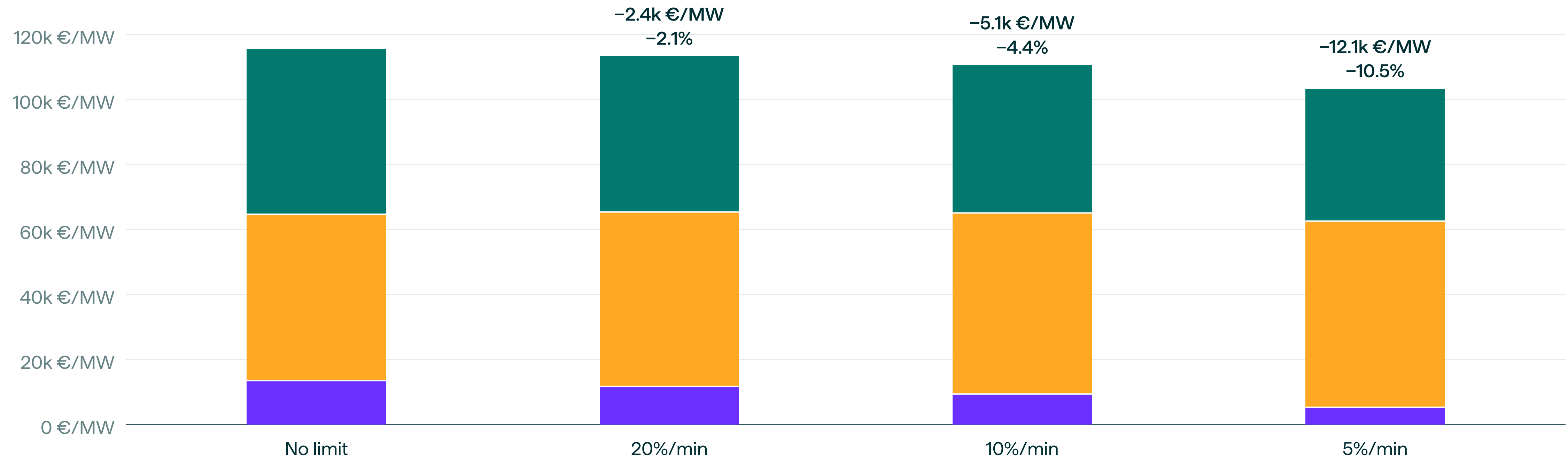
But every case is different.

What would the losses be if we were to change some of those parameters?

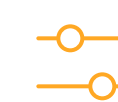
What if... my ramp rate limit is stricter or looser?

Revenue loss of a 10 MW / 2h battery, by ramp rate limit

■ Day-ahead ■ Intraday ■ Imbalance



With a harsher ramp rate, imbalance revenues take even more of a hit

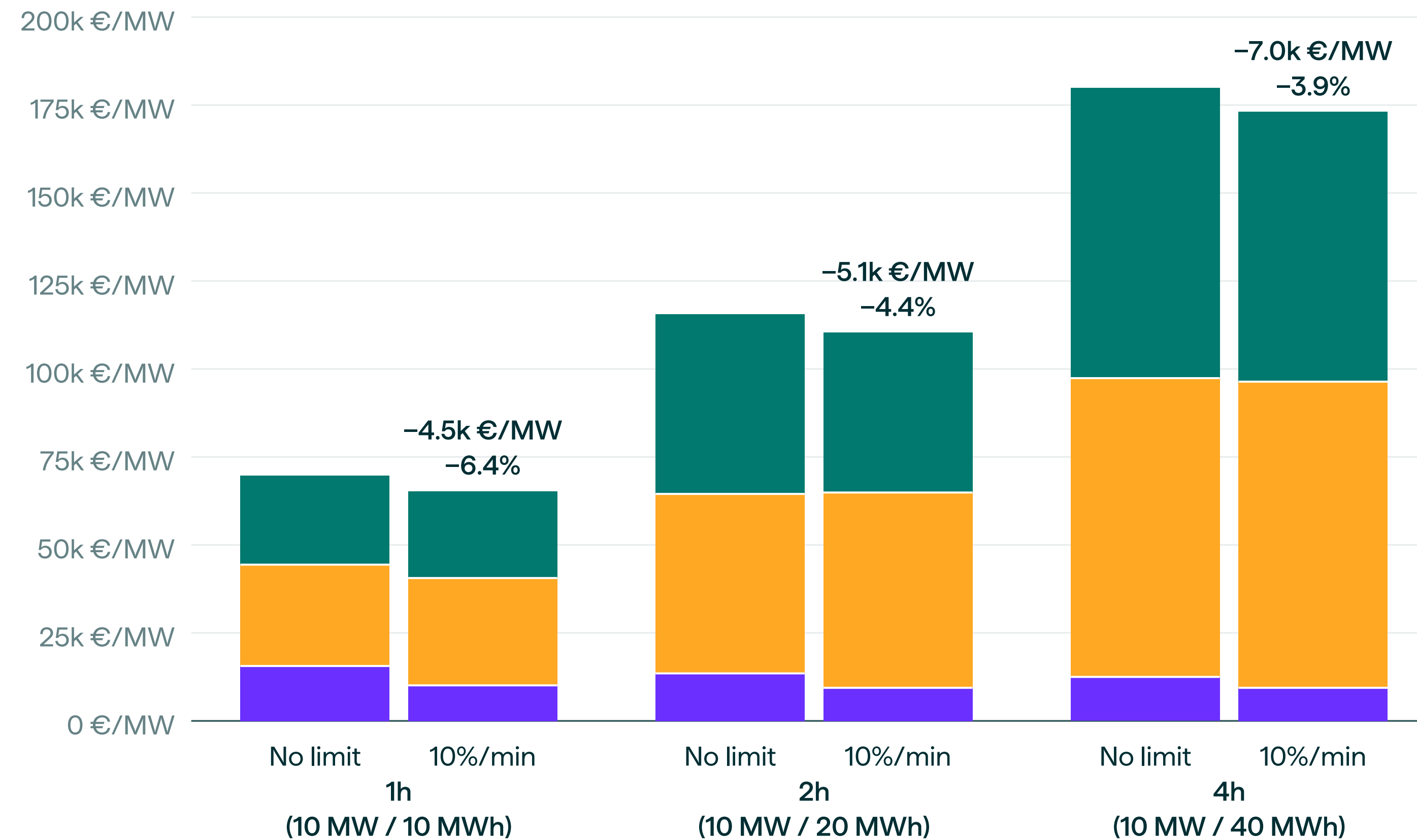


The optimisation model is able to mitigate this to an extent by allocating more of the BESS to markets that are less impacted.

What if... my battery has a different duration?

Revenue loss with 10%/min: 1h vs. 2h vs. 4h battery

■ Day-ahead ■ Intraday ■ Imbalance



A longer duration battery loses less in relative terms because the unrestricted has a lower imbalance share of the total profit

A shorter duration BESS is already able to capture most imbalance spikes, longer duration BESS are more dependent on DA and ID.

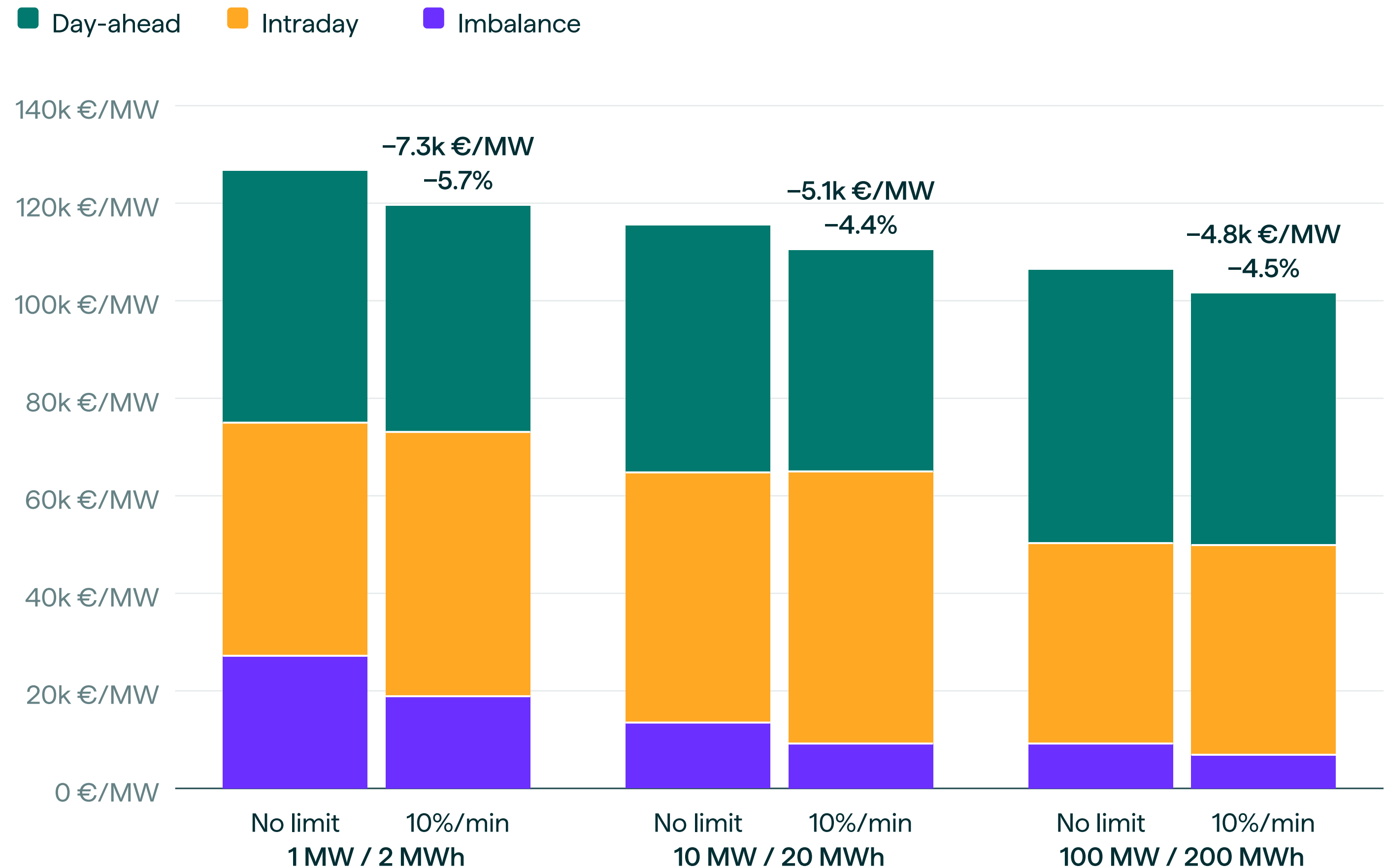
What if... my battery is a different size?

In FlexInsight, size does matter: bigger batteries are optimized differently than smaller ones, taking into account market depths.

A larger BESS has to be optimised more conservatively, accounting for limited market share of the balancing market.

As seen before, the configuration whose unrestricted revenue depends most on imbalances, loses the most.

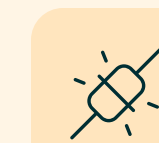
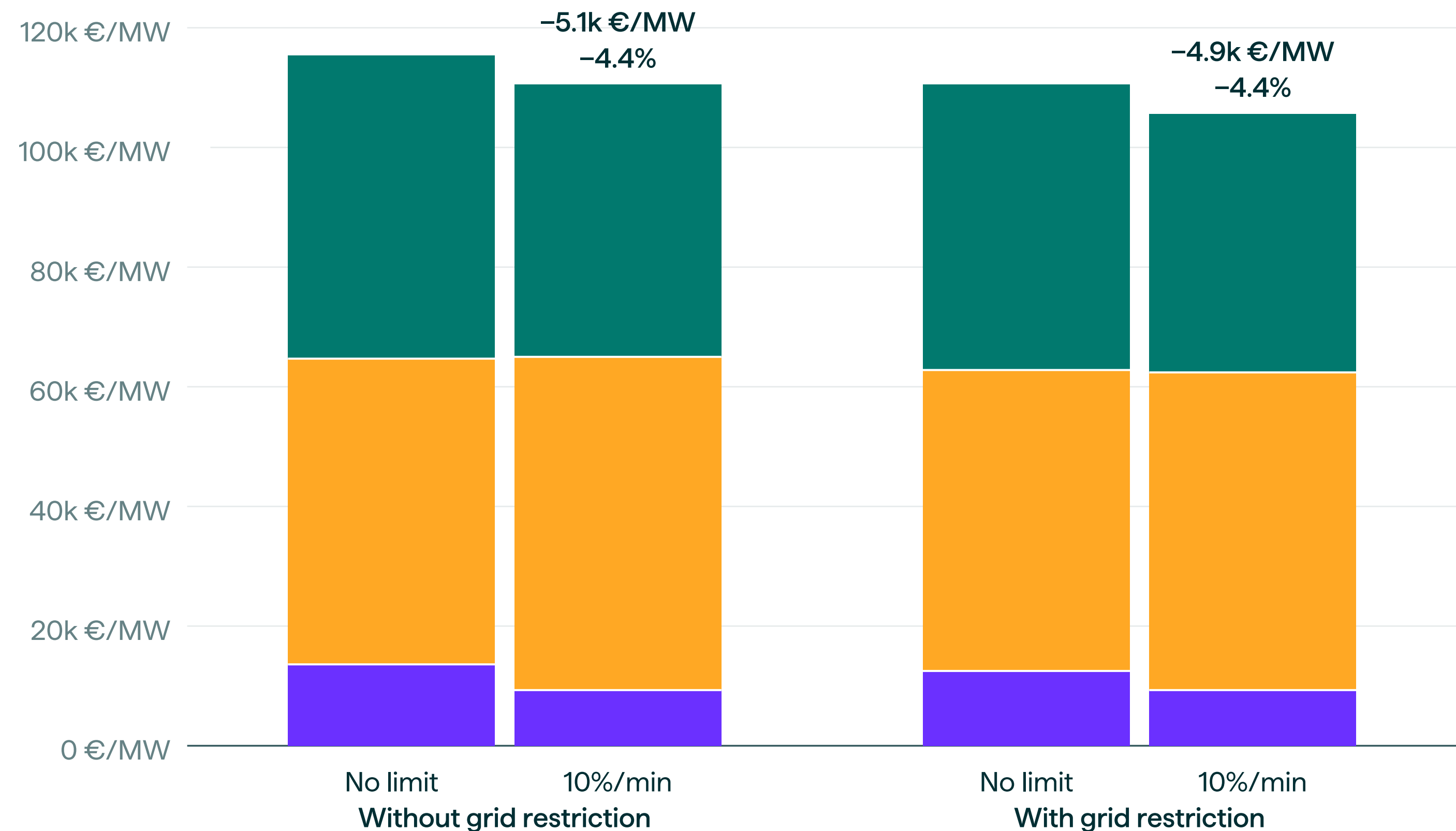
Revenue loss with 10%/min: 1 MW vs. 10 MW vs. 100 MW battery



What if... my battery has curtailed grid connections?

Revenue loss with 10%/min: with and without grid restriction

■ Day-ahead ■ Intraday ■ Imbalance

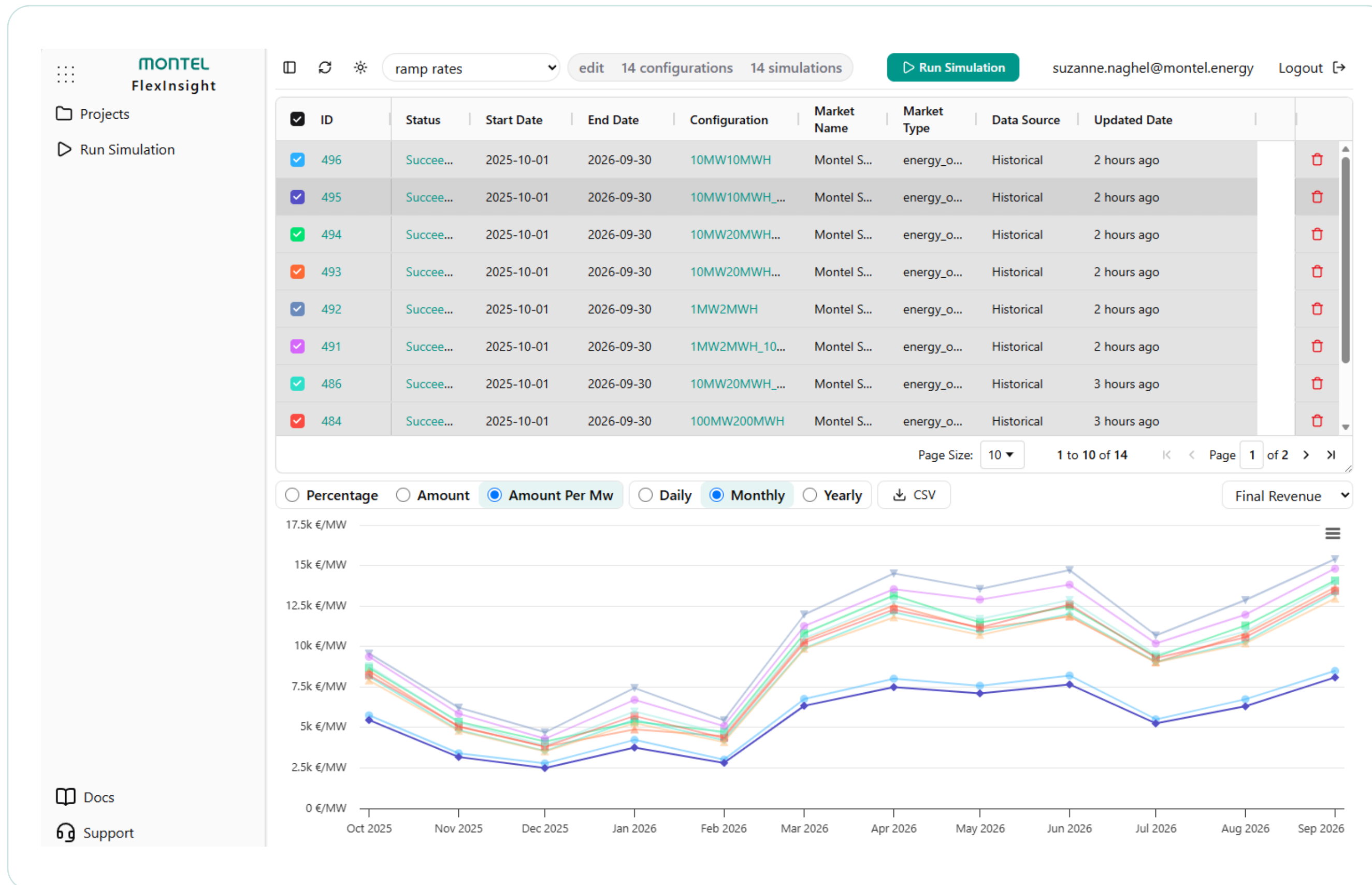


25% curtailment on grid export/import.

In this case, relative loss stays the same

In absolute terms, the already restricted battery has less to lose.

What if... my specific case wasn't covered in this presentation?



Discover FlexInsight yourself

- 1 Build your own battery configuration**
co-location, grid restrictions and ramp rates
- 2 Run simulations**
Against historical prices or Montel's long term curve scenarios
- 3 Compare runs side by side**
Gain insights on sensitivities

Conclusion



Impact depends on how the battery earns its money

The more a battery relies on fast intraday and imbalance opportunities, the more a ramp rate limit costs.



Imbalance is hit hardest

Shifting energy between cheap and expensive hours is hardly affected. Reacting to short price swings is.



Not a simple calculation

Optimise across all markets, together with the project's other restrictions. Future costs depend on how short-term price swings evolve.

Don't leave ramp rates out of your business case.

They change how your battery can operate in the market.

Any Questions?

Thank you