



ICREA INGENIERÍA CREATIVA

# *Sizing DC-Coupled Utility-Scale BESS Using a Charging Reliability Metric Under High Curtailment Conditions*

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2026 PV Performance Modeling Collaborative  
Workshop  
Session 5 Modeling PV + Battery Systems

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AGENDA

## BESS sizing under curtailment conditions

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- |           |                                    |  |
|-----------|------------------------------------|--|
| <b>01</b> | <b>Introduction</b>                | <i>Curtailed PV energy and the goal of capturing it using BESS</i> |
| <b>02</b> | <b>Methodology</b>                 | <i>Case study, model used and assumptions</i>                      |
| <b>03</b> | <b>Charging Reliability Metric</b> | <i>Metric proposed</i>   |
| <b>04</b> | <b>Results Overview</b>            | <i>Comparison of different BESS capacities and optimization</i>    |
| <b>05</b> | <b>Conclusions</b>                 |  |



**[1]**

SECTION

*Introduction*

## Section 1

# Introduction

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**01**

### PV Plant

*PV Plant in Mexico.  
Installed capacity: 160 MWp  
and 145 MWac  
43 central inverters*

**02**

### Energy loss

*Although the plant has a low  
DC/AC ratio, conservative day-  
ahead schedules and grid-  
operator limits create significant  
curtailment losses.*

**03**

### Solution

*A DC-coupled BESS is proposed  
to recover curtailed energy; AC  
coupling is discarded due to  
space and intervention  
constraints.*



**[2]**

SECTION

*Methodology*

Section 2

## Methodology — Uncurtail energy calculation

- 1** **PHASE 01**  
**Measured weather and energy data QA**  
*Quality-controlled measured weather and plant output data to establish a reliable simulation.*
- 2** **PHASE 02**  
**PVsyst Digital twin model as-built engineering based**  
*PVsyst digital twin reflecting actual plant design, equipment configuration and degradation.*
- 3** **PHASE 03**  
**Pseudo sub-hourly simulation**  
*Reconstructed sub-hourly generation behavior through minute-grouped PVsyst simulations*
- 4** **PHASE 04**  
**Cross validation**  
*Simulated unrestricted generation against measured plant output and curtailment behavior.*

Section 2

## Methodology — Uncurtail energy calculation

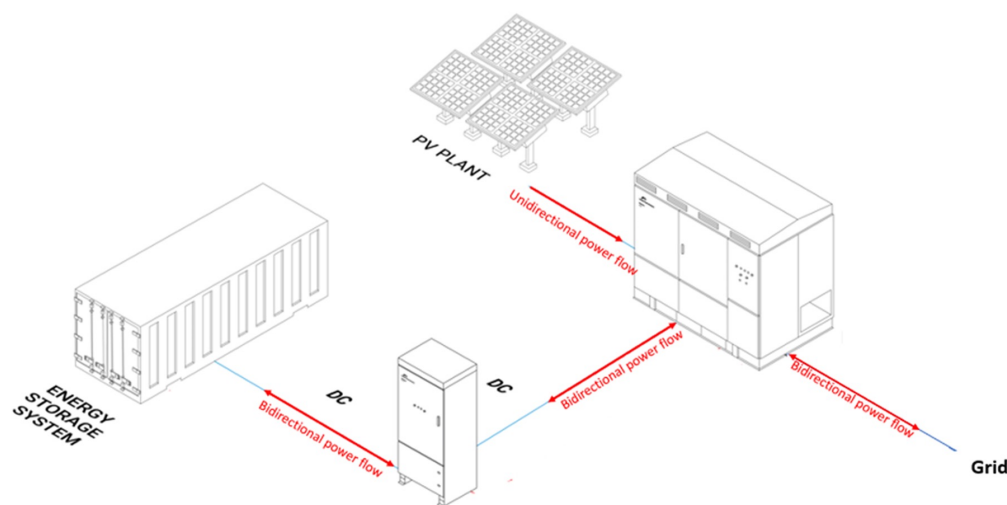


— Available power before curtailment  
— True power measured curtailed

The gap between available and delivered power defines the recoverable energy opportunity.

Section 2

## Methodology — BESS system



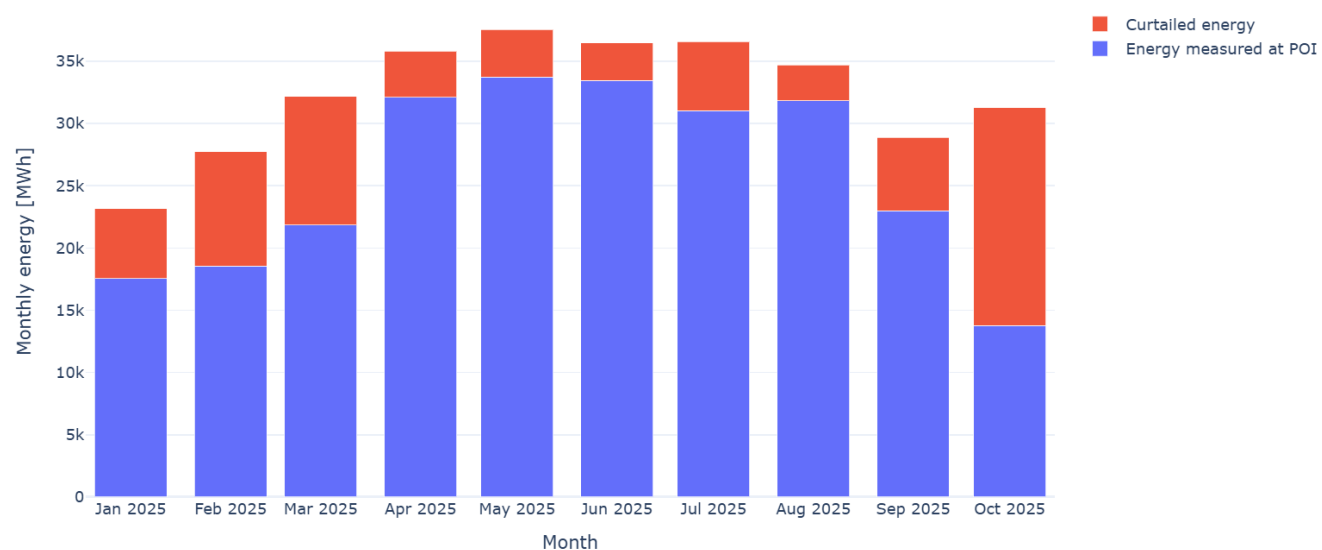
*Assumption: One BESS is installed per inverter. During curtailment, BESS-equipped inverters stop exporting and prioritize charging from their available DC power.*

- Power: 2.4 MW
- Capacity: 5 MWh
- SOC: 100%
- Day charge, Nigh discharge

Source: Power Block Control Solutions for Storage and Hybrid Plants, Power electronics

Section 2

# Methodology — Case study



*Curtailement losses vary over time, driven by changing operational constraints, grid limits, oversupply conditions, and dispatch instructions from the system operator.*

Fuente: [ICREA, 2026]



**[3]**

SECTION

# *Charging Reliability Metric*

Section 3

# Charging Reliability Metric

01

## Charging Reliability

Share of valid days when the BESS reaches full SOC using only curtailed energy.

$$CR_N = \frac{\sum I(SOC_{max,d,N} = SOC_{full})}{D_{valid}} \times 100$$

02

## Capacity utilization

Recovered energy relative to one full usable BESS cycle per valid day.

$$CU_N = \frac{E_{POI,N}}{D_{valid} \cdot N \cdot E_{cycle,POI}} \times 100$$

03

## Marginal recovery

Additional recovered energy from one extra BESS, expressed relative to the first BESS unit.

$$MR_N = \frac{E_{POI,N} - E_{POI,N-1}}{E_{POI,1}} \times 100$$



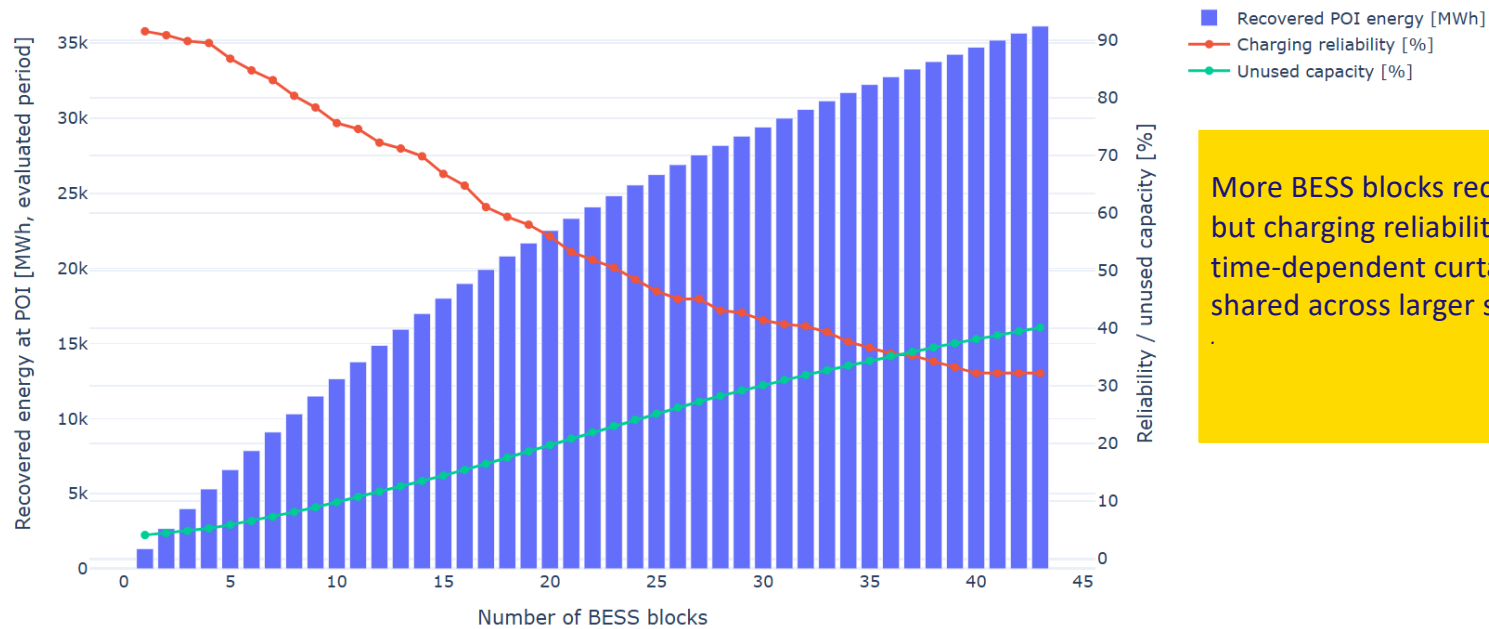
**[4]**

SECTION

# *Results Overview*

Section 4

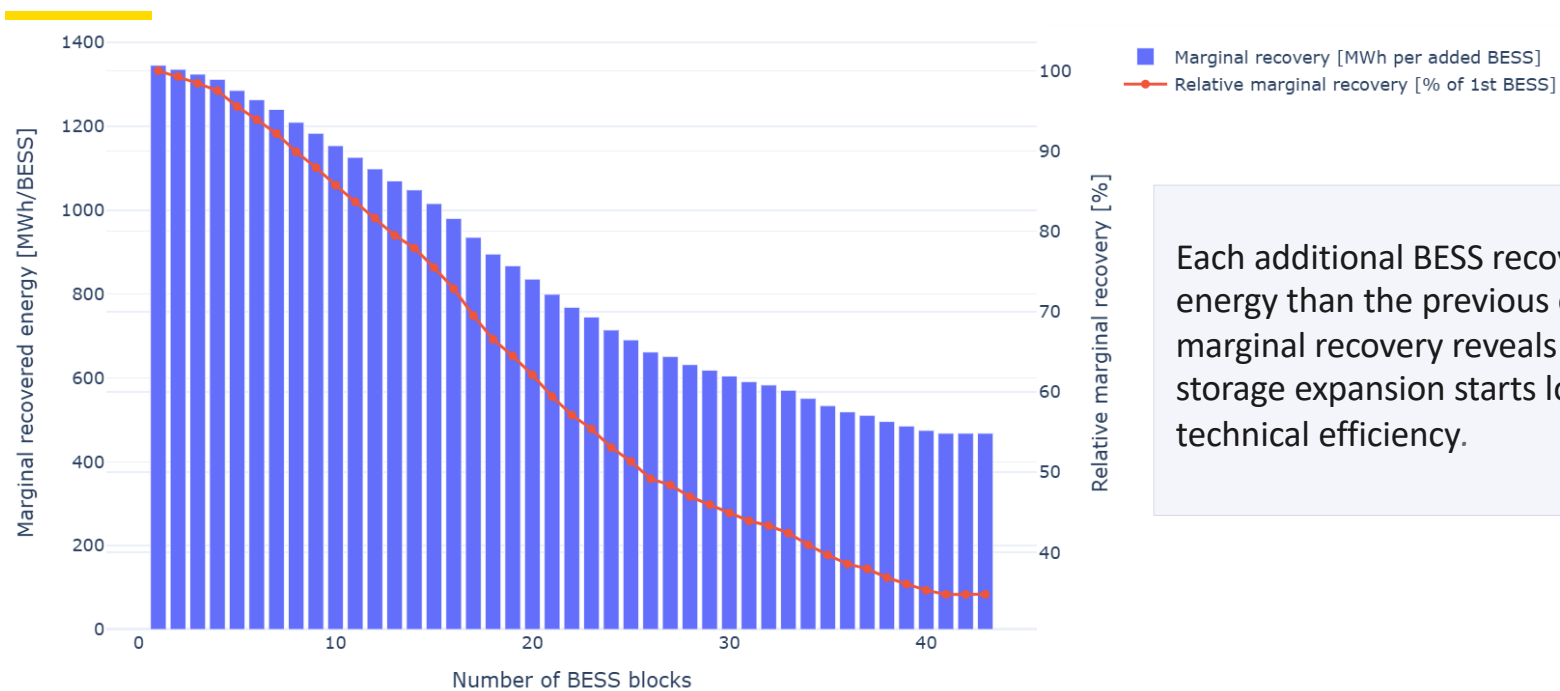
# Results Overview



More BESS blocks recover more energy, but charging reliability drops as the same time-dependent curtailment resource is shared across larger storage capacity.

Section 4

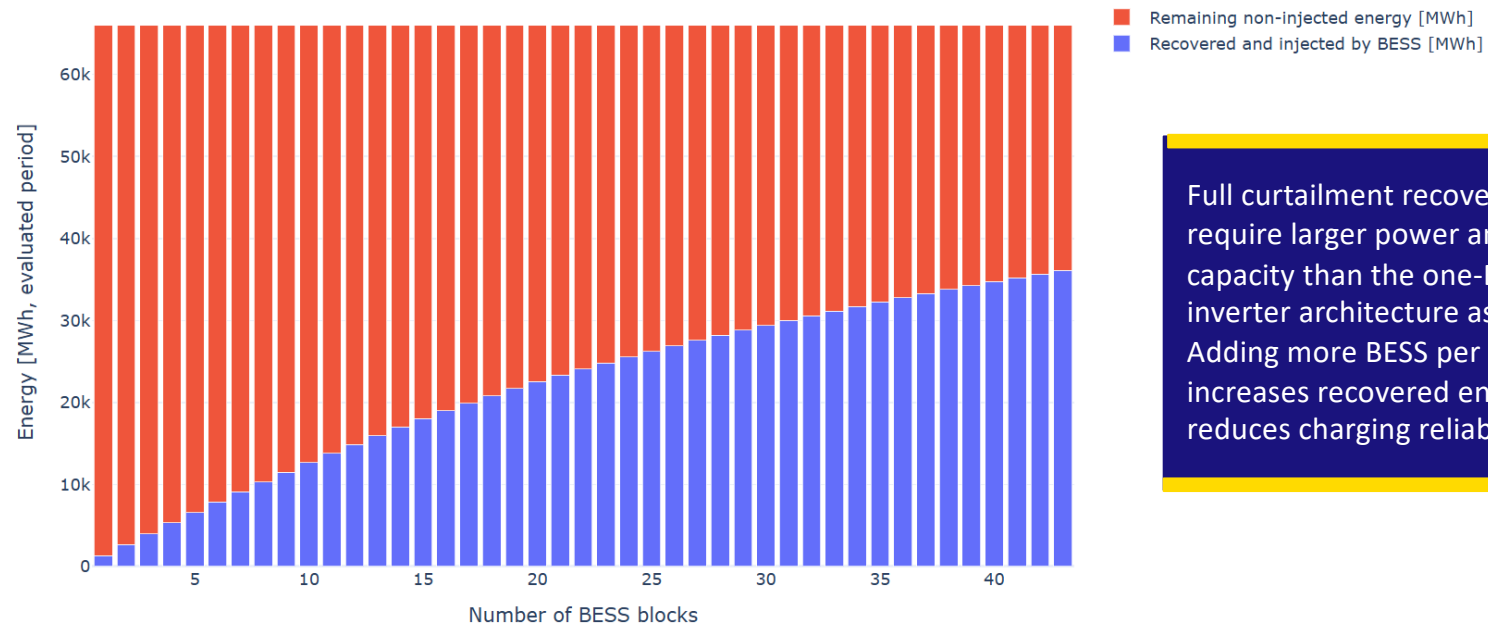
# Results Overview



Each additional BESS recovers less energy than the previous one; marginal recovery reveals where storage expansion starts losing technical efficiency.

Section 4

# Results Overview



Full curtailment recovery would require larger power and energy capacity than the one-BESS-per-inverter architecture assumed here. Adding more BESS per inverter increases recovered energy, but reduces charging reliability.



**[5]**

SECTION

*Conclusions*

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Section 5

## Conclutions

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1

*Curtaiment losses cannot be estimated from plant design alone.*

2

*Additional work is required to estimate curtaiment before operation.*

3

*Charging Reliability reveals the sizing trade-off.*

4

*Without CAPEX/OPEX, the technical optimum can be selected from the CR curve.*



*Thank you.*

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*Ingeniería que respalda su decisión.*

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