Co-located grey battery storage

Business case, optimization and integration

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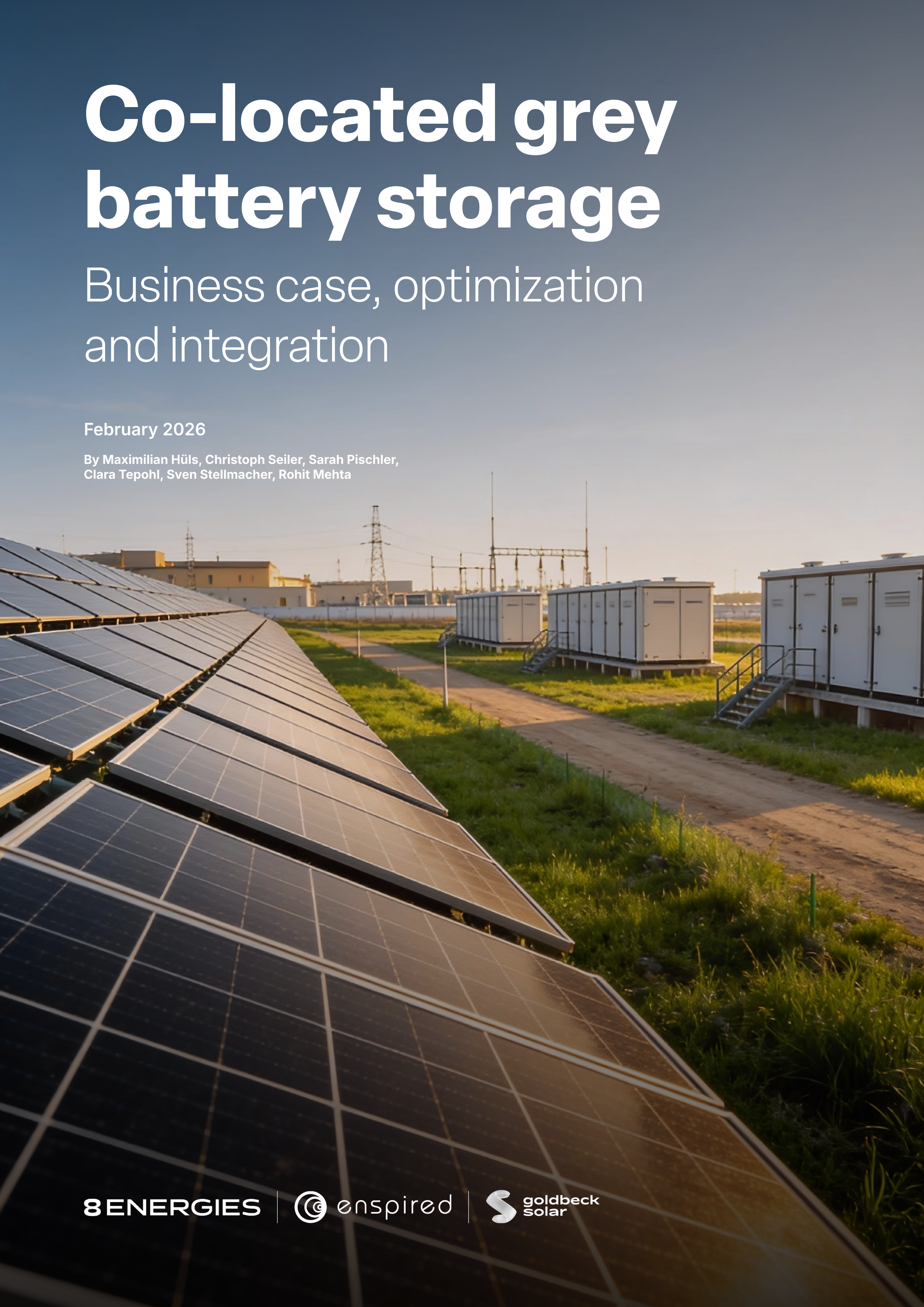

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About the authors

8ENERGIES

8Energies is a European Independent Flexibility Platform (IFP) focused on the development, construction, and operation of utility-scale stationary battery energy storage systems (BESS). The rapidly growing demand for flexibility, driven by increasing renewable penetration, higher price volatility and the declining availability of conventional dispatchable capacity, has created a strong need for flexible infrastructure. As an independent platform, 8Energies deploys storage assets operating across power and ancillary service markets, thereby providing system flexibility. By enabling fast-responding, market-based flexibility, the company contributes to the reliability and resilience of the European power system. The team combines deep experience in BESS project development with operational excellence rooted in the technology sector. Through standardized processes, a highly focused execution model, and a strong emphasis on operational scalability, 8Energies is building one of the leanest and fastest-executing IFPs in Europe.

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enspired is Europe's leading optimizer of battery energy storage systems (BESS), with a flexibility portfolio of over 5 GW, 80+ gridscale batteries under management, and 800 MWh live in a cross-market setup, including the biggest BESS in Germany. Through a data-driven, AI-powered optimization platform, enspired achieves the highest revenues and integrates proven solutions for navigating grid constraints. The advanced technical infrastructure is developed 100% in-house and facilitates enspired's global expansion across 12 countries in Europe and Asia with flexible and seamless adaptability to new markets and changing market conditions. As the first and only optimizer with published portfolio performance, enspired is tackling the lack of transparency in the industry by providing insight into real, independently certified revenues for live assets, establishing a reliable benchmarking standard that helps asset owners get a true understanding of what their asset is worth.

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GOLDBECK SOLAR is an international company specializing in turnkey photovoltaic and battery energy storage system (BESS) solutions. The company delivers large-scale solar projects and commercial rooftop installations worldwide. Its services cover the entire value chain, including project development and financing, construction, integration of storage technologies, technical operations, asset management, and direct clean energy sales. The photovoltaic engineering team brings over 25 years of experience in developing and building high-performance solar power plants. GOLDBECK SOLAR has been recognized multiple times for its technical excellence and engineering expertise. With strong financial capabilities and a focus on technologically and economically optimized solutions, the company supports clients in advancing toward clean energy systems while positioning itself as a global leader in the photovoltaic industry.

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Readers should obtain project-specific advice (including from legal/tax advisors and the relevant grid operator/metering parties) before implementing any co-location, cable pooling, “overbuilding”, or flexible connection arrangement described in this document. No party involved in the preparation of this paper accepts liability for actions taken based on this document without such projectspecific verification.

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01

Introduction

1.1

How grey battery storage could increase PV-project profitability in times of volatile power markets

The energy transition is in full swing. Mainly responsible for this progress is the rapid expansion of solar power in Germany. While the expansion of wind energy continues to progress steadily, the installation of photovoltaic (PV) systems exceeded expansion targets for 2025. But this success has a downside: As the market share of PV increases, more and more systems are feeding large amounts of electricity into the grid at the same time, especially at midday. This oversupply is now having a measurable impact on prices: The number of hours with negative spot prices has risen from 301 (2023) to 573 (2025) in recent years. At the same time, the solar capture rate, i.e., the ratio of the average solar price achieved to the market price, fell from around 80% in December 2023 to below 58% in December 2025. This decline in value directly affects power purchase agreement (PPA) prices and fully merchant-marketed plants and indirectly worsens the financial conditions for EEG projects.

Co-located battery energy storage systems (BESS) are a suitable option to scale electrical energy storage fast and economically. Unlike PV systems, BESS benefits from rising price volatility, as they use it to generate additional value. However, it is becoming increasingly difficult for BESS systems to obtain a grid connection. While the profits of PV parks are under pressure, they have an inefficiently used asset that can generate additional revenues: The grid connection itself. Although the grid connection capacity is designed for 24-hour utilization, the PV park only feeds in during daylight hours and even then, for many hours, only parts of the available grid connection capacity is used. This creates an ideal symbiosis:

1. A co-located battery storage system “overbuilds” the existing grid connection point (GCP) of the solar park, meaning that, in theory, the PV system and storage system together have a higher maximum grid connection capacity at the GCP than contractually agreed with the grid operator.

2. However, by configuring the battery storage system to utilize only the available capacity at the GCP that is not being used by the PV system at that time, PV and storage do not compete for feed-in capacity in practice. In this way, the grid connection point is used with maximum efficiency – without exceeding the feed-in capacity permitted by regulations or triggering revenue losses on the PV side.

3. Instead, the PV system gains an additional and predictable source of income, as the operator of the battery storage system contributes to the costs of the grid connection in return for sharing the use of the grid connection point. Overall, this results in an upside for the PV operator without any significant downside risk.

1.2

Definition of "co-located grey battery storage"

Since various forms of co-location are conceivable in theory and different definitions are used in practice, a clear definition of the term is necessary. BESS co-location refers to the installation of a BESS in close proximity to another generation or consumption facility. Of the various conceivable variants (see Fig. 1), the following will be limited to grey battery storage, as this is the most economically and technically attractive form of co-location under the current framework conditions for PV-IPPs and BESS developers.

This article focuses on a co-location model in which the battery storage system and solar plant share a common grid connection point (shared GCP) but are managed independently of each other in terms of operation and accounting and are therefore not technically linked (separate). The battery is also designed as a grey battery storage system (grey), which is charged exclusively with electricity from the public grid and whose origin is therefore not specifically certified as renewable or fossil-free.

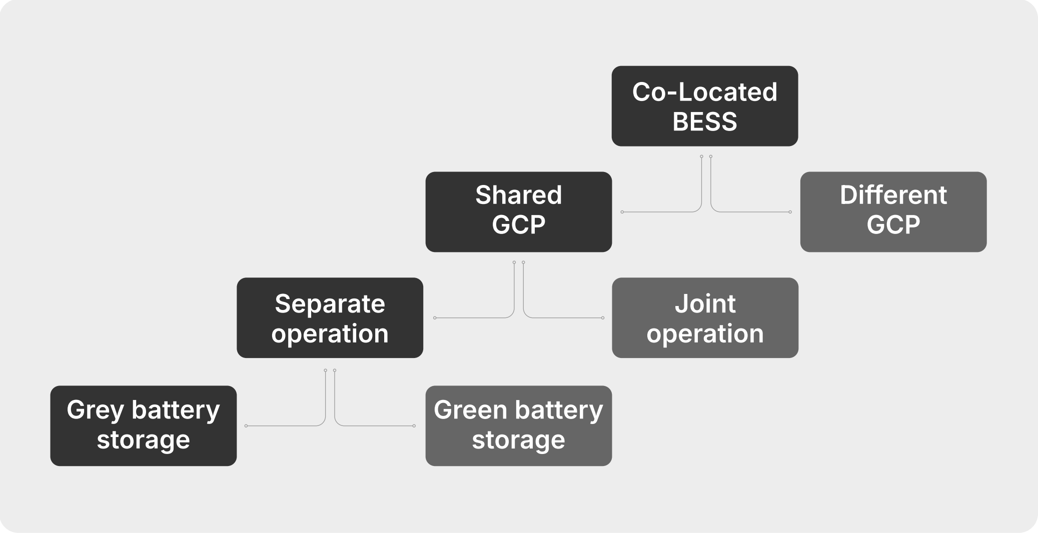

Figure 1: Definition of the term co-located grey battery storage

1.3

Objective of this white paper

The aim of this white paper is to develop a detailed concept for asset managers, IPPs, and grid operators, showing how grey battery storage can be implemented as a co-location approach at existing and newly built PV facilities.

In the first part (business case), 8Energies, a leading project developer and IFP of battery storage systems, models various scenarios to quantify the significance with which a co-located grey battery storage system increases the IRR of a PV project. In the second part, enspired, a specialist for the fully automated optimization of BESS and other power assets across available markets, provides insight into the commercialization of co-located grey battery storage. In the third part, GOLDBECK SOLAR, an established EPC and O&M for PV and BESS, explains the practical implementation of a co-located grey battery storage system, including an appropriate hardware component concept.

02

Business Case
Co-located grey battery storage

2.1
Modes of collaboration between PV IPPs and BESS developers

In order to combine the advantages of the inverted market incentives of PV and BESS in a successful partnership, a collaboration model must first be selected. The first decisive factor is whether the battery system is planned for an existing, already constructed PV project.

If this is not the case, the most common form of implementation is "cable pooling," which involves pooling all dual-use infrastructure, such as cables and substations, in a separate special purpose vehicle (SPV) in which the PV IPP and the BESS developer hold proportional shares (A). In addition, a substation usage agreement is often concluded to regulate the use of the infrastructure. Since the beginning of 2025, it has been possible to build over a GCP in Germany in accordance with Sections 8a EEG 2023 and 17 (2b) EnWG. The contractual terms of the usage agreement often stipulate a primary-secondary logic that regulates which of the two assets may feed into the GCP with priority when there are simultaneous market incentives for providing feed-in capacity that cumulatively exceeds the total GCP capacity.

If the PV plant has previously been constructed and an additional co-located grey battery storage facility is now to be built, there are essentially two ways to implement this. The first option would be to create a carve-out of the existing dual-use infrastructure, such as cable routes and substations (B). Once the infrastructure has been removed from the PV IPP's existing PV SPV and transferred to a joint SPV in which the BESS developer also holds a stake, a substation usage agreement can be drafted as described above. There is also a leaner option, which requires less operational effort from the PV IPP but slightly worsens the risk profile for the BESS developer. In this case, the developer enters into a direct substation usage agreement with the PV SPV without holding any stake in the dual-use infrastructure assets (C). This results in a structural risk for the battery storage project developer, as there are no direct ownership rights to the dual-use infrastructural assets in case of insolvency of the PV IPP, for example.

2.2
Compensation schemes for dual-use grid connection points

After explaining the various PV-BESS co-location models, the next step is to explain how they can be compensated.

Cost advantage through cable pooling: For PV projects to be constructed (A), the financial advantage of co-location lies primarily in sharing the infrastructure costs. By pooling the infrastructure, which affects both the PV system and the battery storage facility, in a separate

SPV, both parties can bear the costs in proportion to the size of their project. With an example dimensioning of 1:1:0.5 (GCP:PV:BESS), the PV IPP would bear two-thirds of the infrastructure costs and the BESS developer one-third of the infrastructure costs. This can have a significant impact on CAPEX and thus on the project IRR expected by both parties (see 2.3). Assuming that financing for the PV park has not yet been finalized, the cost advantage can be directly taken into account in the financing of the PV project. This means that no adjustments to the financing structure would be necessary and a co-located BESS project would be a cost advantage without significant additional expense. However, there is a limiting factor in that newly constructed PV projects are often built with co-located green energy storage, which makes the feed-in profile disadvantageous for co-located grey battery storage. This significantly limits the selection of co-located grey battery storage projects in project development.

Cost advantage through cable pooling + revenue stream through GCP utilization fee: In the case of already constructed PV projects where the grid connection infrastructure has been carved out (B), a similar logic applies. Here, the SPV costs would similarly be distributed and the BESS developer would contribute to the SPV in proportion to the relative size of the BESS. The resulting cost advantage may be sufficient for a PV IPP to decide in favor of a co-located battery storage project. This depends on how high the share of infrastructure costs is in relation to the project CAPEX. For larger projects where this share is less significant, a fee for utilizing the GCP infrastructure can be charged to make the carve-out worthwhile for the PV IPP. This reduces the CAPEX (cable pooling) of the existing PV project and creates an additional revenue stream (GCP utilization fee). Both have a positive effect on the profitability of the PV project and an increase in IRR is possible (see 2.3).

Revenue stream through GCP utilization fee: For PV projects that have already been constructed but which, for structural reasons, do not wish to carve out assets from already financed projects (C), a continuous fee can be charged for the utilization of the grid connection point and its infrastructure. In principle, the amount of such a fee is freely negotiable up to the threshold value at which the target return of the BESS developer is not achieved or the value of the GCP infrastructure is significantly exceeded. Due to the structural risk that the PV SPV could be acquired or go bankrupt, which in turn would affect the contractual stability of the substation usage agreement, this threshold is usually significantly undershot in practice. Nevertheless, the GCP utilization fee creates an additional revenue stream for an existing PV project, which can significantly influence the IRR (see 2.3).

2.3

Influence of co-located grey battery storage on PV project profitability

To demonstrate how strongly the various compensation schemes influence the PV business case, this study calculated how much the PV project IRR can be increased, depending on the BESS CAPEX and BESS revenue forecast, using real-world BESS and PV business cases. Since both variables affect the economic viability of the co-located BESS project, they limit the amount of the GCP utilization fee that can be paid without making the BESS project economically unviable.

The study examined a 20 MWp PV project yet to be built with an EEG+merchant remuneration structure (A) and an already built 20 MWp PV project with an EEG remuneration structure (B,C). In addition, a dimensioning factor of 1:1:0.5 (GCP:PV:BESS) and a c-rate of 0.5 were assumed for the co-located grey battery storage system, giving it a capacity of 10 MW and 20 MWh, respectively. Furthermore, this study makes best-case, base-case, and worst-case CAPEX and revenue assumptions for the BESS project, which are based on real project data. A bankable revenue forecast for a fully merchant cross-market traded BESS project was used to calculate the three revenue cases. Real project data for 10 MW and 20 MWh BESS projects in Germany was used for the CAPEX structure.

This study seeks to determine the relative change in the project IRR of the PV project over a period of 15 years, as this is often the period covered by guarantees for the BESS asset, meaning that the GCP utilization fee can be paid over this period. It is important to note that this study only collects indicative values, which are intended to give an idea of the significance of the increase in profitability. Explicitly, this study does not attempt to model exact changes, as these would require a much more in-depth and highly individualized modeling approach.

For the PV project that is still to be built (A), it is not possible to differentiate between different cases, as the advantage lies purely in sharing the costs of the dual-use infrastructure: cost advantage through cable pooling. With a co-located BESS project at a 20 MWp PV project with an EEG+merchant remuneration structure, the model showed that the project IRRs could be increased by approximately 29%. For an example project with an 8% IRR over 15 years, this would mean an increase to approximately 10% IRR.

For PV projects that have already been built (B,C), on the other hand, it was possible to examine the potential increase in profitability depending on CAPEX and revenue forecasts of the grey battery storage:

For the cost advantage through cable pooling + revenue stream through GCP utilization fee, there is a relative IRR increase of approximately 6-24%. Therefore, in the case of a PV project with an IRR of 15% over 15 years, the project IRR would increase to approximately 16% in the worst case and 19% in the best case. In the worst-case revenue scenario, it was not economically viable to pay a continuous fee for the use of the GCP in the worst-case and base-case CAPEX scenarios, meaning that the IRR increase corresponds to the cost advantage through cable pooling, which was 6%.

Revenue/CAPEX	**Worst Case** High CAPEX	**Base Case** Mid CAPEX	**Best Case** Low CAPEX
Worst Case Bearish Revenue Forecast	6%*	6%*	7%
Base Case Mid Revenue Forecast	10%	14%	17%
Best Case Bullish Revenue Forecast	19%	22%	24%

Figure 2: Relative IRR increase resulting from cost advantage through cable pooling + revenue stream through GCP utilization fee

In the case of an additional revenue stream through GCP utilization fees, this results in an IRR range of 0-21% IRR increase. In an example project with 15% IRR over 15 years, this would mean a maximum increase up to approximately 18% IRR. In the worst-case revenue scenario, it was not economically viable to pay a continuous fee for the use of the GCP in the worst-case and base-case CAPEX scenarios, resulting in an IRR increase of 0%.

Revenue/CAPEX	**Worst Case** High CAPEX	**Base Case** Mid CAPEX	**Best Case** Low CAPEX
Worst Case Bearish Revenue Forecast	0%*	0%*	2%
Base Case Mid Revenue Forecast	5%	9%	12%
Best Case Bullish Revenue Forecast	15%	18%	21%

Figure 3: Relative IRR increase resulting from revenue stream through GCP utilization fee

To conclude, co-located grey battery storage can significantly improve the profitability of existing PV projects, and for projects yet to be built, it can potentially even transform unprofitable PV projects into profitable ones.

03

Optimization

Profitable commercial optimization of grey co-location

3.1

The priority question in the optimization of grey co-location

As grey co-location gains traction in Germany as an accelerator of BESS grid access and an economically beneficial setup for the grid operator, the question arises of how this co-located setup, where grid access for the battery is variably restricted by the RES (renewable energy system) production, can be optimized in the market. This section on optimizing co-location provides the answers and presents enspired's approach, complete with examples.

In a strict PV-priority setup, the PV cannot be curtailed, and the battery is forced to operate around the grid limit. Differences between forecast and actual production cause variable grid restrictions for BESS, making it challenging to participate in ancillary service markets, where the capacity to deliver energy needs to be guaranteed a day in advance. This substantially reduces achievable PnL (profit and loss). In a BESS-priority setup, the PV can always be curtailed, and the optimization of the battery takes priority, but this approach entails lost PV revenues and mirrors a standalone BESS case.

Commercially, the superior solution is a form of joint optimization, where a reduction of PV generation is applied only if the battery's market earnings clearly exceed the value of PV generation, i.e., can offset the cost of reducing production. In this case, the solution is not to determine the best scenario for a BESS in a primary or secondary role, but to pursue the commercial optimum of the entire site. Market signals are typically inverted enough for BESS and PV to co-exist profitably on the same connection point. This means the value of the business case is maximized by optimizing the battery's trading activities and the PV's production profile.

3.2

Dispatch profiles, capacity allocation, and bidding in the optimization of grey co-location

In BESS optimization, the battery is optimized continuously throughout the day and can participate in DA (day-ahead) and IDA (intraday) auctions, ancillary services (AS), and intraday continuous trading for revenue stacking. The required data input for co-location includes the PV production profile, as well as the battery's real-time SoC (state of charge), general system configurations (grid access, power, capacity), and warranty terms. From those specifications, the trading model deduces optimized bids and a dispatch schedule for the battery, as well as signals for when and how to reduce PV production.

This can be illustrated with a conservative example of a standard case commonly seen in Germany – a 1:1:1 setup, where a 10 MW grid access point has connections to:

A) PV with a 10 MW peak and an existing PPA paying 42€/MWh, with the possibility of reducing production

B) BESS with 10 MW/20 MWh and 2 cycles per day

The optimization snapshots below, dated 14 June 2025, display a rich PV curve and typical price conditions for summer, including a significant aFRR down capacity price spike. These trends are reflected in the optimization profile. The individual steps can be observed in Figure 4, followed by a commentary on the optimization activities.

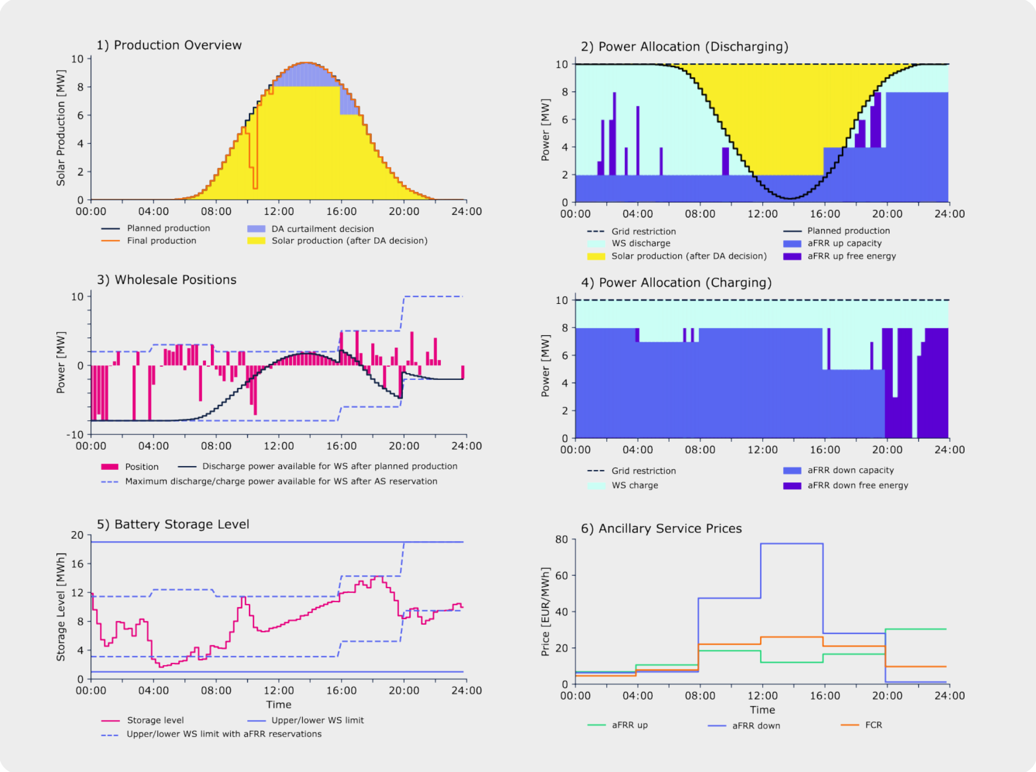

Figure 4: Optimization schedule of PV and BESS co-location setup

3.2.1 BESS optimization

Large volumes are traded in aFRR down throughout the day (Fig. 4.4), as this direction is not limited by the PV production. Small volumes are placed into aFRR up throughout the day, with larger volumes committed in the evening due to favorable prices (Fig. 4.6) and the absence of grid restrictions from the PV (Fig. 4.2). There is no participation in FCR due to limited additional revenue potential.

3.2.2 PV production profile optimization

The day-ahead decision (in the ancillary service auction) to reduce the PV production enables the leveraging of aFRR up capacity, meaning the revenue loss from the opportunity cost payment is compensated by the battery's aFRR up earnings.

3.2.3 Final dispatch

aFRR energy activations (not shown) and anticipated charging from RES require SoC management, including a reduction in PV production (Fig. 4.1, orange line; Fig 4.3 sell positions ignore the discharge restriction from the planned production between 10:00-11:00 and at 11:45). The wholesale (WS) positions within the remaining limits capture price spreads (not shown) throughout the day. An adjustment on the day-ahead curtailment decision is made: Instead of reducing PV production to accommodate aFRR up capacity commitments (while financially sound), it can be more profitable not to adjust production and buy the positions back in the market instead, effectively charging the BESS with "excess" energy (Fig. 4.1, blue segment; Fig. 4.3, wholesale positions adhere to the PV's afternoon discharge power restriction). From a grid perspective, curtailment versus charging the battery from the PV is a neutral operation.

3.3

Battery sizing and revenue scenarios

Battery sizing is a common pain point in co-location. For a 10 MW PV, backtests were compared for a variety of battery sizes, ranging from 5-10 MW and 1-3 hours, that are either standalone or co-located, between July 2024 and July 2025. Findings show that the restrictions imposed by the co-located PV have only a minor impact on the earning potential of the BESS. Generally speaking, the revenue reduction depends strongly on curtailment costs and how these relate to ancillary services and market prices. In the example and assuming perfect foresight, the revenue reduction for fully integrated hybrid systems is less than 3.5%. For smaller assets, the impact is even less pronounced. Even assuming forecast deviations, the revenue reduction for co-location is around the 4% mark, with smaller assets again less affected.

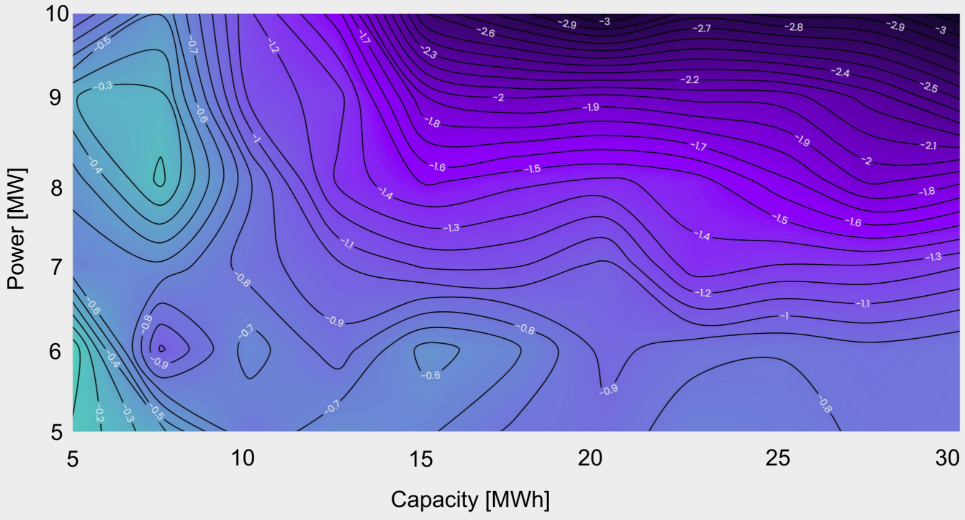

Figure 5: Revenue deviations between standalone and co-located BESS in %

Reference setup: 10 MW grid access, 10 MWp PV production

3.4

PPA models and opportunity costs

As PPA prices are no longer sufficient to finance RES, an alternative strategy is needed to make renewables economically viable in the future. Co-location with BESS unlocks additional opportunities for revenue capture, and the PV owner's earnings will not suffer from a co-located setup if opportunity costs for curtailment are managed correctly. While a range of different PPAs can be modelled in the optimization, structures that support free BESS marketing offer the highest upside potential. The two examples below illustrate how PPAs can impact revenue.

3.4.1 Option A: Profile PPA

In a profile PPA, the delivery profile is fixed (e.g., 6 MW from 8:00-20:00), and the battery can shift the PV production to deliver this profile. In this scenario, the PPA price is higher (e.g., 72€/MWh instead of 42€/MWh), but the battery has limited optimization potential.

3.4.2 Option B: Pay-as-produced PPA and free BESS optimization

In this setup, the PV sells power at fixed price (e.g., 42€/MWh) and can be curtailed, while the battery is optimized across all markets (AS, WS). The PV curtailment creates opportunity costs. Opportunity costs refer to the internal "costs" of unproduced MWhs. In this example, this cost equates to the 42€/MWh the PV would have earned, as well as any other costs the PV owner incurs due to non-production. The battery takes priority over the PV production only if opportunity costs are offset by revenues or if corrections are necessary to avoid constraint violations.

3.5

The commercial case for fully integrated co-location

Making grey co-location viable as a business case requires flexibility from both assets. Even in a PV-priority setup, a certain degree of control over the solar production should be negotiated to increase BESS profitability through participation in ancillary services, which is vital for revenue stacking. In co-location, the ideal strategy consciously refrains from approaching the optimization as a matter of which asset has priority over the other and instead considers the costs for different operations, leveraging additional opportunities that arise from treating both assets as a unit with hybrid flexibility. The outcome is what is referred to as the commercial optimum or, in simpler words, maximum revenue.

Disclaimer

Due to the dynamic nature of algorithmic trading, the optimization strategy presented in this paper is subject to change and further improvements.

04

EPC

Successful integration of a grey battery storage facility at an existing PV park

4.1

Analysis of the existing system and design of the BESS

The integration of a BESS into an existing PV park first requires an assessment of local conditions and the existing infrastructure, followed by the correct selection and design of the components for the BESS system. Key elements include a battery system, inverters, transformers, cable systems, medium-voltage (MV) route, grid connection point with transfer station or substation, a hybrid park controller, and a measurement concept approved by the grid operator.

Starting from the existing grid connection point, the engineering team assesses the existing infrastructure – either a substation or a transfer station – for the addition of further metering points. While this is often possible in substations, it can become a bottleneck in existing transfer stations that are part of the PV park, making the construction of an additional transfer station necessary, which significantly increases infrastructure costs. In coordination with the grid operator, a metering concept must be established that considers the operation of both PV and BESS, and complies with applicable laws and regulations, including §5(4) Stromsteuergesetz and §118(6) Energiewirtschaftsgesetz.

Based on the agreed metering concept and the grid connection point, potential additional synergies through existing infrastructure can be evaluated. In particular, cable pooling in the medium-voltage route can offer significant cost savings but must be assessed on a case-by-case basis.

When selecting the core BESS components – battery storage, inverter, and transformer – integrated container solutions or the combination of multiple containers are the preferred design to reduce the number of components on-site. Experienced engineers must assess component compatibility and consider the potential for future storage capacity expansion. The component suppliers should be evaluated through a comprehensive lifecycle analysis, considering cost, lifespan, failure probability, O&M costs, service quality, and spare parts availability.

To enable efficient progress, detailed information and specifications from the existing plant are required. Reviewing this documentation early and clarifying any outstanding questions in advance is essential to avoid delays.

4.2

Implementation of a robust control system for the hybrid park

Every form of co-location requires a robust communication and control infrastructure. This chapter outlines the smooth integration of BESS co-location into an existing PV park regulation concept as implemented by experienced EPCs.

A full analysis of the existing communication and SCADA (Supervisory Control and Data Acquisition) infrastructure is required to verify compatibility. The existing PV plant includes a park controller responsible for grid-compliant active and reactive power regulation based on utility requirements. Inverters and transformers are integrated through an established SCADA system and communication bus. The direct marketer typically communicates with the plant through a dedicated router or secured communication line. Sensors, meters, and plant telemetry are already integrated into the supervisory control chain. The plant operates under a single controller (single-primary) regulation scheme. Successful retrofitting requires open communication interfaces and complete documentation of the existing control system.

For the subsequent addition of a BESS, a BESS-specific controller (Secondary 2) must be added to interface with the Energy Management System (EMS). In this setup, the existing PV park controller becomes Secondary 1, while the BESS controller is operated as Secondary 2. Both Secondaries are controlled by a Primary power park controller, which is to be added to the substation of the shared grid connection.

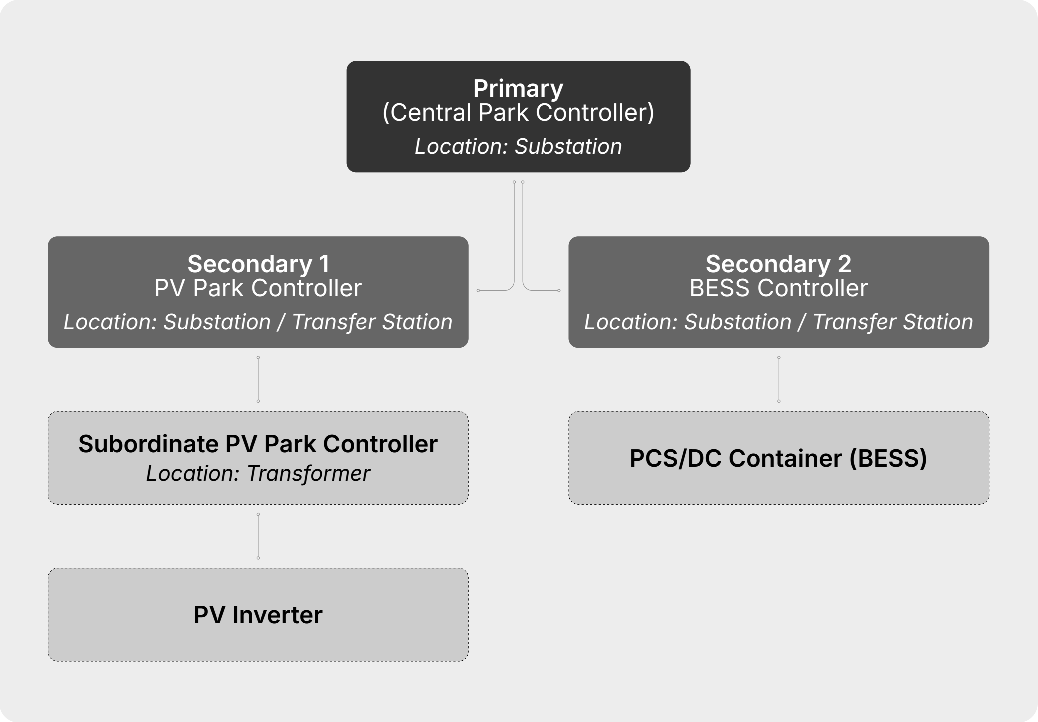

Figure 6: Hardware setup for co-located grey battery storage at an existing PV-park

The Primary controller receives commands from the grid operator or direct marketer. It distributes all plant level commands (active power, reactive power, curtailment, grid operator requirements) to both Secondaries. The existing PV park controller (Secondary 1) continues to manage all PV-related equipment, while the new BESS controller (Secondary 2) manages charging and discharging through the PCS.

A dedicated industrial router must be installed to provide a separate communication channel for the direct marketer, one per direct marketer. Additional interface hardware, such as gateways or protocol converters, may be required depending on the protocols used by the existing system (e.g., Modbus TCP, IEC 60870-5-104, Sunspec). The BESS DC container and PCS must be integrated into the same hierarchical control structure using the appropriate communication standards. On the software side, the Primary must be extended to manage setpoint distribution across both Secondaries. SCADA software may require expansion to visualize, monitor, and log BESS-related operating data. Cybersecurity features such as firewall rules, VPN access, and network segmentation must be updated. Control logic, setpoint arbitration, and safety interlocks must be adapted to ensure coordinated PV–BESS operation. Commissioning tools for the BESS must also be integrated into the site's operational workflow.

Since each existing PV plant varies in documentation quality and interface openness, the integration process can be complex. A structured plan needs to be in place to ensure seamless connection between the existing PV plant control system and the BESS system.

4.3

Successful execution and commissioning phase

While detailed analysis and planning lay the foundation for a cost-effective project, practical execution during construction and commissioning is often marked by unexpected challenges and, in cases of inexperienced site and project management, significant delays. For a smooth integration and commissioning, close coordination of requirements and responsibilities by an experienced EPC is advisable. Schedules must be aligned, lead times and specifications correctly considered, and both commissioning and coordination with the grid operator must be carried out on time despite the increased complexity. Coordination issues or the rejection of responsibilities between the different stakeholders can lead to additional costs, delays in commissioning, and avoidable revenue losses.

05

Conclusion

Co-located grey battery storage turns an increasingly underutilized asset in PV parks, the grid connection point, into a scalable profitability lever at a time when PV capture rates are falling and negative-price hours are rising. By “overbuilding” a shared GCP while keeping PV and BESS operationally and financially separable, PV owners can monetize unused capacity through cost sharing (cable pooling) and/or predictable GCP utilization fees, often with meaningful IRR uplift, ranging from a ~29% relative increase for new-build setups to ~6–24% (and up to ~21% in fee-only structures) for existing plants, depending on BESS CAPEX and revenue assumptions.

Maximizing site value in co-located grey storage projects is not a question of PV-priority versus BESS-priority, but of joint, market-driven optimization. PV curtailment should occur exclusively in situations where incremental BESS market revenues demonstrably exceed the PV opportunity costs. This dynamic dispatch logic enables effective revenue stacking across wholesale and ancillary service markets, while empirical backtests indicate that co-location-related revenue dilution remains limited under realistic assumptions. As a result, overall asset value can be increased without materially impairing the PV business case.

The successful integration of a grey co-location BESS into an existing PV park requires a holistic EPC approach combining rigorous upfront analysis, compliant metering and grid concepts, and carefully selected, future-proof components. Leveraging existing infrastructure where feasible can unlock significant cost synergies, while robust control, communication, and cybersecurity architectures are essential for stable hybrid operation. Ultimately, experienced engineering, clear documentation, and disciplined execution during construction and commissioning are decisive to mitigate risks, avoid delays, and ensure reliable, regulation-compliant PV–BESS performance over the full project lifecycle.

With these collaboration, optimization, and implementation principles in place, the developed co-location setup extends beyond a project-specific solution. It represents a scalable and replicable blueprint that can be transferred across PV portfolios and geographies, enabling faster BESS deployment, more efficient grid utilization, and structurally improved PV economics.