MASTER IN BUSINESS ADMINISTRATION (MBA)

Trabajo Fin de Máster

Capstone project

Financial Valuation of Utility-Scale Battery Energy Storage System (BESS)

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Executive summary

This Capstone Project evaluates the financial feasibility and bankability of utility-scale Battery Energy Storage Systems (BESS) in the Spanish electricity market during a 20-year operational period. The study is framed within Spain's energy transition and the increasing need for flexible infrastructure capable of integrating large volumes of renewable energy into the grid.

The main objective is to determine under which regulatory and commercial conditions a standalone lithium-ion BESS project can become financially viable for an institutional infrastructure investor. The analysis focuses on the impact of merchant-market exposure, capacity mechanisms, public subsidies, and long-term contracted revenues in determining project viability and investment attractiveness.

The methodology combines strategic market analysis with a detailed financial valuation model. The project includes PESTEL and SWOT analyses, market and regulatory assessment, and four financial scenarios ranging from pure merchant exposure to hybrid Power Purchase Agreement (PPA) structures. Financial viability is assessed through Discounted Cash Flow (DCF) analysis, including IRR, NPV, DSCR, sensitivity analysis, and risk assessment.

The results show that a fully merchant BESS model is not bankable under current Spanish market conditions without significant public support. In contrast, scenarios incorporating capacity payments or long-term contracted revenues generate substantially stronger financial performance and lender coverage metrics. The project concludes that BESS investments in Spain present a significant long-term opportunity, although bankability remains highly dependent on regulatory certainty, stable revenue mechanisms, and continued reductions in battery-system costs.

Keywords: Battery Energy Storage Systems (BESS), energy transition, project finance, electricity markets, bankability.

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1. Introduction, industry context and strategic environment

"To what extent can a diversified Battery Energy Storage System (BESS) portfolio in Spain achieve an adjusted internal rate of return (IRR) required by infrastructure funds, considering the current high price volatility and the regulatory uncertainty regarding the implementation of the Capacity Market?"

1.1. Context: Spain's PNIEC targets and the energy transition gap

The Spanish electricity system is currently undergoing a structural transformation, defined by a rapid acceleration in renewable penetration that has overtaken the development of grid flexibility mechanisms. It is experiencing a supply shock, where the marginal cost of generation has decoupled from the value of the asset base.

As of 2024, renewable generation covered over 56,8% of the national electricity mix. This trend has accelerated in 2025, registering a growth of 2,6% with respect to 2024, further solidifying the decoupling between generation volume and capture prices [1].

To understand this decoupling, one must analyze the specific mechanics of the Iberian Electricity Market (*MIBEL*). Managed by the market operator *OMIE* (*Operador del Mercado Ibérico de Energía*), the wholesale market functions under a marginal pricing system. In this "pay-as-cleared" model, the day-ahead price for each hour is set by the most expensive technology needed to meet demand (the marginal unit). Historically, this role was fulfilled by gas (combined cycle), which established relatively high market-clearing prices that remunerated all generators.

However, the market has currently undergone an operational move toward 15-minute settlement intervals, scheduled for 30 September 2025 in accordance with EU Regulation 2017/2195 [2]. This reform increases the granularity of price signals, allowing short-term imbalances to be reflected explicitly in clearing prices. While this theoretically rewards flexibility, in the near term, it exposes the system to extreme volatility.

At the same time, the rapid deployment of renewable energy has intensified the "Zero-Marginal-Cost" effect [3]. Because solar PV and wind generation operate with very low variable costs, periods of high renewable production increasingly push electricity prices toward very low or even negative values. Market data from 2022 to 2025 reflects this transition: after the extreme price peaks of 2022 (€201,26/MWh), average electricity prices stabilized at approximately €70,67/MWh in 2025, while negative-price periods became increasingly frequent, reaching lows of −€10,00/MWh during the first months of 2025 [4].

This dynamic has intensified price cannibalization, a phenomenon whereby increasing renewable penetration reduces the market value of the electricity generated during peak solar-production hours. As midday prices collapse, the capture price achieved by solar assets falls relative to the average baseload price, increasing curtailment risk and reducing project profitability. At the same time, the widening spread between low midday prices and higher evening prices creates new opportunities for flexible technologies such as battery energy storage systems (BESS), which can store electricity during low-price periods and discharge it when demand and prices increase.

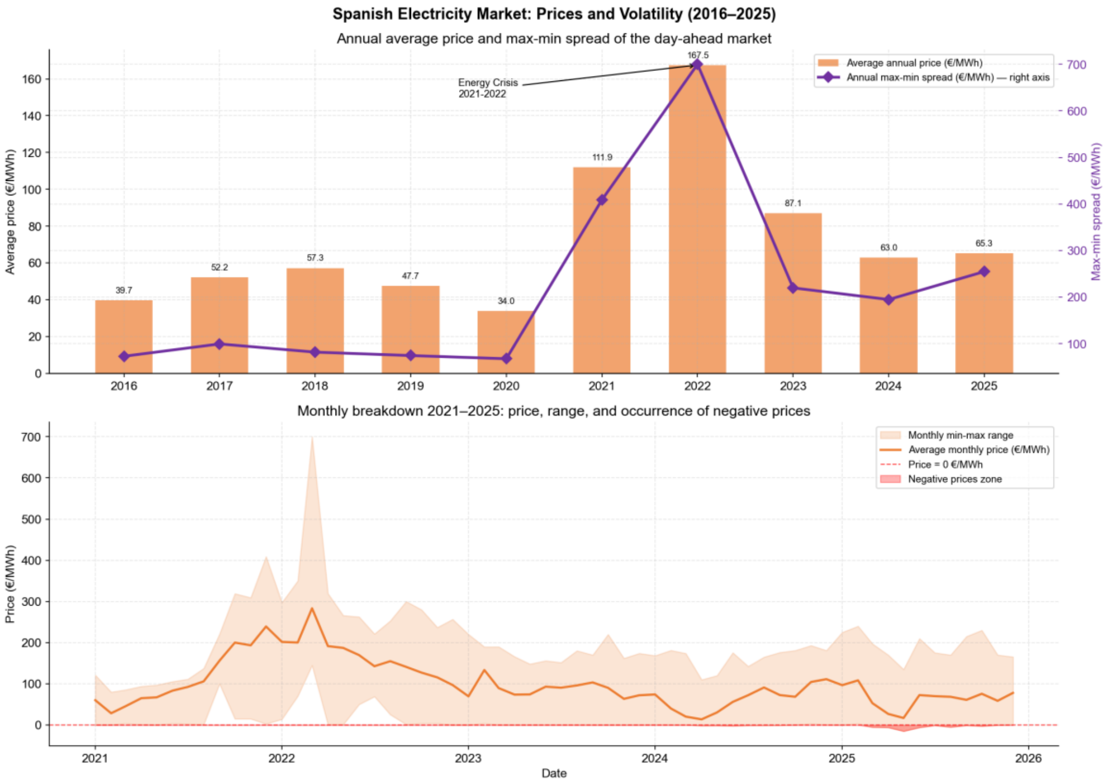

Figure 1. Spanish electricity market: prices and volatility (2016-2025). Source: The author.

This creates two critical situations for investors:

- **Valuation divergence:** a widening spread between the "baseload price" (the average price of electricity over 24 hours) and the "solar capture price" (the price a solar plant achieves when it generates).
- **Asset underutilization:** while battery-storage costs continue to decline, renewable curtailment and intraday price volatility continue to increase [5]. This reflects the growing structural need

for flexible technologies capable of shifting energy from periods of oversupply toward periods of peak demand [6].

Although Spain possesses one of Europe’s strongest solar-generation profiles, its deployment of utility-scale storage remains comparatively limited. According to *SolarPower Europe's Market Outlook (2025-2029)* [7], Germany and Italy dominate the landscape, having installed 6,2 GWh and 6,0 GWh respectively in 2024 alone. In contrast, Spain’s installed battery capacity remains negligible, with only ~190 MW of effective utility-scale BESS online as of April 2026.

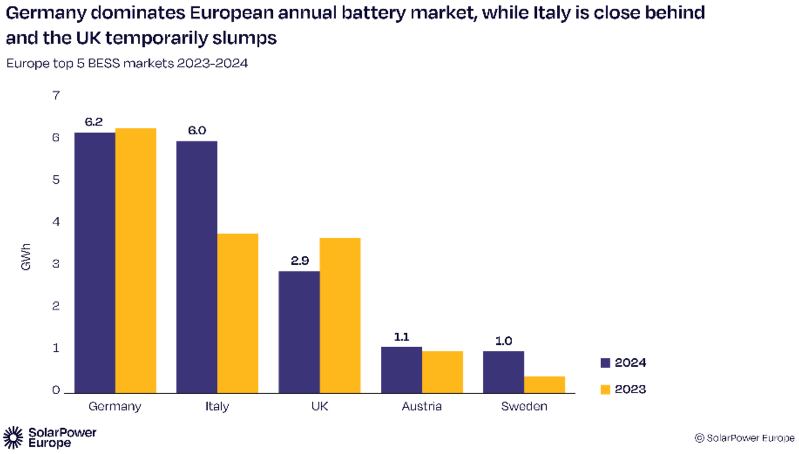

Figure 2. Annual battery storage capacity (GWh) of the top 5 European BESS markets (2023-2024). Source: SolarPower Europe.

This divergence is not merely a financial issue, but the result of a complex, multi-dimensional bottleneck holding back the Spanish market:

- **Revenue uncertainty:** From a financial perspective, the Spanish market suffers from a phenomenon in energy economics known as the "*missing money*" problem [8], a scenario where marginal market pricing fails to provide sufficient revenue to cover the high fixed CAPEX of new capacity. Unlike the UK or Italy, Spain currently lacks an active capacity market, forcing projects to rely entirely on volatile merchant revenues, which severely complicates bankability [9].

- **Administrative and permitting bottlenecks:** The permitting process in Spain is notoriously fragmented between national, regional, and municipal administrations. Securing an Environmental Impact Assessment (DIA - *Declaración de Impacto Ambiental*) and the necessary construction permits can take over three years. These bureaucratic rules severely delay Final Investment Decisions (FIDs) compared to more agile European jurisdictions.

- **Grid access constraints:** Securing grid connection rights is highly competitive and complex. Prime interconnection nodes are saturated, requiring significant infrastructure upgrades. Furthermore, the rigid "operating windows" imposed by the the National Markets and Competition Commission's (CNMC) limit the operational flexibility of these assets, creating regulatory friction that restrains foreign investment [10].

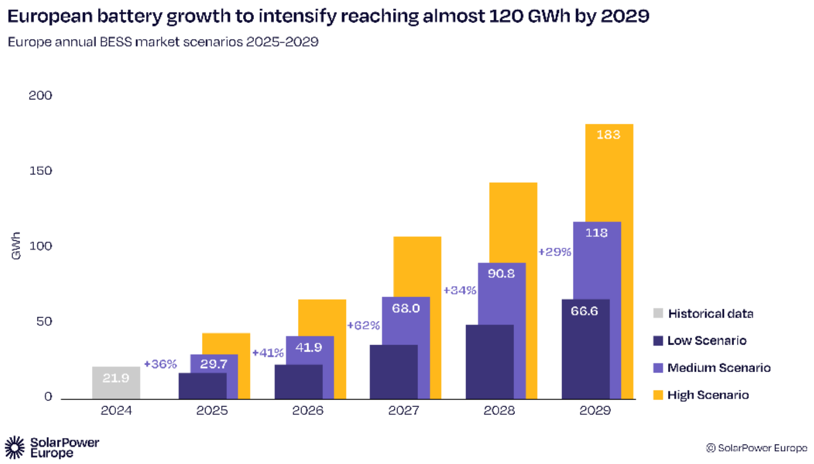

Figure 3. Projected annual BESS market scenarios in Europe (2025–2029). Source: SolarPower Europe.

While the *Plan Nacional Integrado de Energía y Clima* (PNIEC), Spain's strategic roadmap that dictates the decarbonization trajectory and sets binding capacity targets for the energy sector, establishes a target of 22,5 GW of storage by 2030, the market signals required to finance this deployment remain underdeveloped [11].

Pure arbitrage revenues, generated by the strategy of charging batteries during low-price surplus hours and discharging them during high-price peaks, often fail to cover the Levelized Cost of Storage (LCOS), which represents the total lifetime cost of the asset per MWh discharged. If arbitrage spreads remain lower than this break-even threshold, projects become unbackable, creating a bottleneck in Final Investment Decisions (FIDs).

To accelerate deployment, the Spanish administration has introduced a series of public-support mechanisms aimed at reducing early-stage investment risk. This support was formalized through the *Ministry for the Ecological Transition* (MITECO), which deployed a €700 million aid package in May 2025 for stand-alone and hybrid storage, followed by a complementary €202 million package in December

2025 [12] [13]. These injections, combined with the legislative certainty provided by Royal Decree 997/2025, contribute to lowering the effective break-even point for early movers [14].

At the same time, the investment outlook for utility-scale BESS has improved due to falling battery costs and supportive macroeconomic conditions. The Banco de España projects GDP growth of approximately 2,4% for 2026, supporting continued electricity-demand growth [15], [16]. In parallel, global battery-cell prices have fallen significantly during 2025, improving the CAPEX-to-revenue profile of new storage projects and reducing the break-even threshold required for project bankability [6].

1.2. Environmental analysis (PESTEL)

To validate the strategic context outlined in Section 2, a PESTEL analysis is conducted focusing on the specific variables affecting the bankability of BESS in Spain for the 2026-2030 period.

Political Factors (P)

- While the PNIEC sets a target of 22,5 GW storage by 2030, the regulatory mechanism to finance it is falling behind. The implementation of the Spanish capacity market is currently pending final EU Commission approval, with industry expectations for the first auctions now slipping to late 2026 or 2027. This delay forces investors to rely heavily on "bridge" subsidies, primarily the *PERTE ERHA* (Strategic Project for the Recovery and Economic Transformation of Renewable Energies, Renewable Hydrogen, and Storage) [17]. Financed by European *NextGenerationEU* funds, the *PERTE ERHA* aims to mobilize over €16,3 billion in total investments to build a clean energy transition "designed and made in Spain". Crucially for investors, the recent *REPowerEU* addendum reinforced this program with an additional 4,2 billion €, including nearly 1 billion €, specifically targeted at increasing grid flexibility and financing energy storage projects. The program deploys competitive grants across various verticals, including standalone storage, PV-hybridized systems, and pumped hydro, acting as the essential political lever to lower the break-even point and enable final investment decisions in the absence of a capacity market [17][18].
- The political urgency surrounding storage deployment was amplified by the historic Iberian blackout on April 28, 2025 [19]. Around 12:32 PM, the entire electrical system across Spain and Portugal collapsed in what became the largest European blackout in recent years. According to technical reports from *ENTSO-E*, the collapse was triggered by a unique "voltage cascade"

(*cascada de sobrevoltaje*) that initiated in the south of Spain and expanded across the peninsula in a matter of minutes. This systemic failure exposed the extreme vulnerability of operating a grid with high renewable penetration but insufficient dispatchable flexibility. Consequently, energy storage has been politically elevated from a standard market asset to a critical pillar of national security.

Economic Factors (E)

- The increasing penetration of solar generation is intensifying the separation between energy volumes and market value. As midday supply saturates demand, wholesale prices are increasingly compressed during central hours, while price volatility has risen significantly. This creates a market environment in which flexible assets can capture value through price differentials, although competition for these spreads is becoming more dynamic and uncertain.
- As capital-intensive infrastructure with a high proportion of upfront investment, BESS projects remain highly sensitive to macroeconomic conditions, particularly interest rate dynamics. According to recent statistics from the *Spanish National Bank*, although benchmark rates for corporate financing and the Euribor have moderated (stabilizing around 2,22% in early 2026 following the inflationary peaks of 2023), the cost of capital remains a decisive factor in project viability [20]. Any upward fluctuation in interest rates automatically increases the cost of bank debt (project finance). Even moderate increases in interest rates translate into higher financing costs, raising the overall cost of capital and placing pressure on required project returns. As a result, projects become increasingly dependent on wider and more consistent market spreads to remain financially attractive to investors.
- At the same time, battery technology costs have reached historically low levels, improving the underlying economics of storage systems. However, this improvement is partially offset by the perception of merchant risk in standalone projects. In practice, this leads to a divergence in financing conditions between merchant assets and vertically integrated utilities, with the latter benefiting from lower perceived risk and more favorable capital structures. [21].

Social Factors (S)

- At a macro level, there is strong public and institutional support for the green energy transition in Spain. This alignment facilitates the mobilization of ESG-oriented capital, as institutional investors increasingly seek to comply with the EU taxonomy for sustainable activities.
- However, at the local level, the rapid expansion of large-scale renewable and storage projects has generated increasing opposition, particularly in rural areas. Organized platforms such as ALIENTE (Alianza Energía y Territorio) argue that these developments can create imbalances in the distribution of costs and benefits, concentrating environmental and visual impacts in rural regions while the main benefits accrue elsewhere [22, 23].
- In this context, project viability is no longer determined only by technical or economic criteria, but also by social acceptance. Developers are therefore expected to adopt proactive stakeholder engagement strategies, including early dialogue with local communities, transparent communication of project impacts, and the design of benefit-sharing mechanisms (e.g., local employment, community investment funds, or co-ownership models). When effectively implemented, these measures can reduce permitting risks and shorten development timelines.

Technological Factors (T)

- Recent technological improvements have expanded the role of battery storage systems beyond simply buying and selling electricity at different prices. Modern BESS installations can increasingly help stabilize the electricity grid by responding rapidly to fluctuations in supply and demand, particularly in systems with high renewable energy penetration. Although these capabilities could create additional sources of revenue in the future, the regulatory framework defining how such services will be compensated in Spain is still under development.
- At the same time, the growing dependence on short-term electricity market opportunities requires batteries to operate more frequently and intensively. While this can increase revenues, it also accelerates battery degradation and reduces operational lifetime. As a result, project profitability increasingly depends on advanced energy management and forecasting software capable of balancing short-term market gains with long-term asset preservation.

Environmental Factors (E)

- The new EU Battery Regulation introduces stricter requirements regarding sustainability and transparency. From February 2027, all industrial batteries above 2 kWh must include a digital “Battery Passport” that tracks lifecycle emissions and the origin of raw materials [24]. While this adds an additional compliance layer, it also incentivizes higher standards across the value chain and may favor developers with early access to certified and traceable supply sources.
- At the system level, the increasing penetration of renewable energy has led to higher levels of curtailment, where excess generation cannot be absorbed by the grid. In this context, BESS can play a key role by storing surplus energy that would otherwise be wasted, often under very low or even negative price conditions, thereby improving overall system efficiency.
- Environmental considerations are also closely linked to land use and project siting. Approaches such as prioritizing industrial or already-developed land, minimizing physical footprint, and integrating biodiversity protection measures are becoming increasingly relevant. Beyond their environmental value, these practices contribute to improving social acceptance and reducing the risk of project delays, reinforcing the link between environmental performance and financial outcomes.

Legal Factors (L)

- At the national state level, the approval of *Royal Decree 997/2025* represents a significant step towards accelerating the deployment of energy storage. The regulation introduces measures aimed at simplifying administrative procedures and reducing permitting timelines, particularly for projects integrated into existing renewable installations. This regulatory direction is intended to facilitate faster project development and improve system flexibility in the short term [10].
- In contrast to national simplification efforts, regional governments, particularly in Northern Spain, have introduced severe zoning restrictions responding to local social pressure. Regions such as Asturias have drafted decrees suspending the authorization of standalone battery parks on rural or non-urbanizable land, while the Basque Country and La Rioja have introduced retroactive taxes and broad renewable moratoriums [25, 26]. This legal fragmentation creates a massive barrier to entry. By banning BESS in rural areas, developers are forced to site projects exclusively on scarce industrial land. This spatial limitation inflates land lease prices and grid connection costs due to high competition, negatively impacting the project's CAPEX and OPEX.

- A significant operational legal hurdle is CNMC draft resolution (RDC/DE/005/24) defining standardized "Operating Patterns" for distribution networks. This rule legally restricts storage assets to specific injection (selling) windows (00:00–10:59 and 18:00–23:59) and absorption (buying) windows (00:00–07:59 and 11:00–17:59). This rigidity limits the asset's ability to chase real-time price spikes if they occur outside these strictly regulated hours, artificially capping the revenue stack [27].

1.3. Strategic analysis (SWOT)

To synthesize the macro-environmental context and evaluate the viability of deploying battery energy storage systems in Spain, a SWOT analysis is conducted, integrating the technological profile of Lithium-Ion assets with the external competitive, regulatory, and financial realities facing an independent Infrastructure Fund in the 2026–2030 window.

1.3.1. Strengths

- BESS assets can respond within milliseconds, making them highly effective for grid balancing, renewable integration, and ancillary services. Compared to alternative flexibility technologies such as green hydrogen or gas peakers, lithium-ion batteries are currently more competitive for short-duration storage applications [28], [29].
- Unlike pumped hydro storage, which depends on complex geographical and permitting conditions, BESS projects are modular and can typically be deployed within 18–24 months. This shorter development cycle aligns well with the investment horizon and capital deployment strategy of infrastructure funds [30].

1.3.2. Weaknesses

- Financing conditions for standalone BESS projects remain more challenging than for traditional energy infrastructure with stable long-term contracts. Since revenues depend on volatile electricity markets, investors and lenders perceive these projects as higher risk and therefore demand higher returns. This places independent developers at a disadvantage compared to large integrated utilities, which generally have easier access to capital and stronger financial backing [31].

- Lithium-ion cells suffer from continuous chemical and cycle degradation. To maintain installed capacity and optimize economics, projects require significant CAPEX reinvestment or augmentation after roughly 10 years of operation, complicating long-term cash flow forecasting [32].
- The technology is highly reliant on a concentrated supply chain, with critical mineral extraction, processing, and battery manufacturing heavily dominated by Asian markets (primarily China). This creates exposure to geopolitical shocks and logistics bottlenecks [33].

1.3.3. Opportunities

- The massive penetration of solar PV has created a structural supply shock, driving midday capture prices to negative ground while evening peaks remain high. This volatility provides the foundational arbitrage opportunity for BESS.
- The transition to 15-minute settlement intervals in the *MIBEL* market increases intra-hour price granularity. This shift financially rewards fast-response technologies over traditional baseload generators [10].
- The deployment of €1,5B in "bridge subsidies" through the *PERTE ERHA* [17, 18], combined with the administrative simplification introduced by *Royal Decree 997/2025* [14], significantly lowers the break-even point and execution risk for early movers.

1.3.4. Threats

- The persistent delay in implementing the Spanish capacity market withdraws projects of a guaranteed revenue floor. This forces new assets to operate under 100% merchant risk, threatening debt service coverage ratios.
- Organized territorial resistance has led regional governments, such as Asturias, to draft moratoriums suspending the installation of battery parks on non-urbanizable land. This spatial restriction inflates land lease costs and delays permitting timelines [22, 23].
- Alternative storage technologies such as pumped hydro may become more competitive than lithium-ion batteries over the long term, particularly because they experience lower performance deterioration and longer operational lifetimes [30].

2. Consulting mandate and investment framework

2.1. Project objectives

The primary goal of this thesis is to determine the investment viability of a diversified Battery Energy Storage System (BESS) portfolio in Spain, assessing whether the risk-adjusted returns meet the fiduciary requirements of an infrastructure fund during the 2025-2030 regulatory transition. Specifically, the project aims to validate if the asset can achieve a target unlevered Internal Rate of Return (IRR) of > 8,44%.

2.1.1. Specific objectives

To achieve these goals, the project will pursue the following objectives:

1. **Scenario-based feasibility analysis:** To assess the financial feasibility of the portfolio under four distinct regulatory scenarios, testing the project's resilience to policy delays:
    - ***Scenario A - Merchant-only****:* assumes a complete absence of government-backed capacity payments or long-term contracts. The asset relies 100% on revenue stacking from the daily wholesale market (arbitrage) and balancing services (aFRR/mFRR). It tests the project's viability in a high-volatility environment where revenue is entirely dependent on daily price spreads and grid-balancing needs*.*

    - ***Scenario B - Delayed capacity market***: models a delayed implementation of the Spanish capacity mechanism. During the initial operational years, the asset operates as a merchant plant, only receiving fixed monthly payments.

    - ***Scenario C - Target policy***: assumes full compliance with the PNIEC 2023-2030 targets. It includes active capacity payments, providing a stable, fixed revenue stream that complements merchant earnings. This represents the most favorable regulatory environment for storage deployment in Spain.

    - ***Scenario D: Fixed PPA + merchant****:* as a direct response to institutional investor requirements for bankability, this scenario incorporates a fixed-Price PPA covering the asset's entire 15-to-20-year lifespan.

2. **Valuation tool development:** To design and develop a financial valuation tool that supports the investor's final investment decision. The model evaluates the economic viability of the project under different regulatory and commercial scenarios by calculating key financial metrics, including IRR, Net Present Value (NPV), debt-service coverage ratios (DSCR), and projected cash flows.

3. **Bankability and break-even analysis:** To determine the specific "risk premium" required for the project by establishing the Maximum CAPEX per MW (break-even turnkey cost) that allows the project to remain bankable if the implementation of the Capacity Market is delayed. This objective aims to define the price below which the fund should execute the investment regardless of regulatory uncertainty.

2.2. The client's problem: capital deployment in a volatile environment

2.2.1. The merchant risk and financing gap

The target client for this consulting mandate is defined as an infrastructure or energy-transition investor seeking exposure to the Iberian power market. These investors have traditionally allocated capital to renewable energy assets with relatively predictable long-term revenues, such as solar and wind projects supported by Power Purchase Agreements (PPAs). However, the transition toward battery energy storage systems introduces a different investment profile due to the greater dependence on short-term electricity market dynamics.

Although BESS is increasingly recognized as a critical technology for renewable integration and grid flexibility, the Spanish market currently relies largely on merchant-based revenues, meaning project income depends heavily on electricity price volatility and market conditions. This creates a structural mismatch between the risk profile of standalone BESS projects and the investment criteria typically associated with long-term infrastructure capital, which generally prioritizes stable and predictable returns.

To fully grasp why the infrastructure fund struggles to authorize final investment decisions in Spain, it is necessary to contrast the Spanish merchant model with the state-sponsored mechanisms in mature markets, where the government or system operator directly acts as a client to buy "capacity" rather than just energy:

- **The United Kingdom (Capacity Market):** The UK government runs highly structured T-4 (four years ahead) and T-1 (one year ahead) auctions. Providers are awarded 15-year contracts that pay a fixed monthly premium (£/kW/year) simply for guaranteeing their asset is available to dispatch during grid stress events [34]. This guaranteed revenue floor allows funds to secure cheap debt covering up to 70-80% of the CAPEX.

- **Italy (MACSE - *Mercato della Capacità di Stoccaggio Elettrico*):** The Italian TSO (Terna) acts as the sole counterparty in a pioneering "tolling" mechanism. Through competitive auctions, Terna awards 15-year fixed-price contracts to BESS developers [35]. The investor essentially surrenders the speculative upside of the daily market to Terna, receiving in exchange a highly stable, guaranteed annual payment. This converts the BESS asset into a quasi-bond, perfectly aligning with an Infrastructure Fund's fiduciary mandate.

Because Spain lacks these contractual safety nets, the fund's investment committee is forced to apply a high "liquidity and risk premium" to their Spanish valuation models. This leads directly to the client's strategic paradox: they must choose between waiting for a Spanish mechanism like the UK/Italy or acting now under Merchant terms.

2.2.2. “First-mover" vs. "Fast-follower"

- Strategy A: Acting now. Investing immediately allows the client to capture public subsidies and secure grid interconnection nodes before saturation. Early movers may also benefit from accelerated market growth if future storage remuneration mechanisms are introduced. However, this strategy exposes investors to significant merchant risk and uncertain short-term revenues.
- Strategy B: Acting later. Delaying investment until a formal capacity remuneration mechanism is implemented could improve revenue visibility and reduce financial uncertainty. Nevertheless, this approach carries the risk of losing access to attractive project locations and available grid interconnection capacity as competition intensifies.

2.3. Financial framework and evaluation criteria

2.3.1. Revenue structure (arbitrage, ancillary services)

The project uses a value stacking approach to maximize the asset's internal rate of return. The revenue model consists of three primary streams:

- **Energy arbitrage:** Profit generated by the price spread between charging during low-price hours (midday solar surplus) and discharging during peak-price hours (evening/early morning).
- **Ancillary services:** Revenues obtained from supporting grid stability and balancing services provided to the system operator (REE) to ensure grid stability [36].
- **Capacity payments / subsidies:** Inclusion of state-sponsored de-risking through *MITECO* grants (*PERTE ERHA*) and future theoretical capacity market availability payments to provide revenue floor [17, 18].
- **Fixed PPA (power purchase agreement):** A long-term (15–20 year) contractual hedge providing a guaranteed price for a portion of the capacity to ensure debt service stability (scenario D).

2.3.2. CAPEX (capital expenditure)

The initial investment is modeled as a turnkey cost. Recent market data indicates record CAPEX deflation, with battery pack prices falling to €70–100/kWh in late 2025 [20]. The expenditure encompasses:

- **BESS equipment:** Core lithium iron phosphate modules, which have reached record lows of approximately €65/kWh [37, 38].
- **Balance of plant (BoP):** Transformers, switchgear, and civil works, which typically account for 10-15% of hardware expenses [5].
- **Grid connection:** Installation and connection costs are estimated at €43/kWh, though these can vary significantly based on local node saturation [37].
- **Maintenance:** Budgeted capital for battery cell replacement after 10–12 years to address to offset performance deterioration over time required for long-term service agreements [37].

Table 1. CAPEX estimations for 2 and 4h systems.

Category	Description	2h System (Est. €/MW)	4h System (Est. €/MW)
Development	Owner's engineering, technical feasibility studies, land securing, and site audits.	€45.000	€45.000
Construction	Hardware (LFP Modules), BoP (Inverters/Transformers), Grid Connection, ICIO (4%), and Decommissioning provision [5, 21, 31, 37].	€395.000	€715.000
Maintenance	Scheduled cell replacement after ~10 years and critical spare parts inventory [32].	€180.000	€320.000
Financing	Capitalized interest during construction (IDC) and debt arrangement fees.	*Model-dependent*	*Model-dependent*

2.3.3. OPEX (operational expenditure)

Operational expenditure includes the recurring costs required to ensure the long-term operation, safety, and commercial optimization of the asset.

- **Operations and maintenance (O&M):** Annual costs for commercial-scale BESS typically range from €13 to €22 per kW per year, covering preventative maintenance and remote monitoring [5].
- **Energy management systems:** The project includes investment in digital monitoring and optimization platforms that support real-time operational decisions and improve revenue capture across different market services [38].
- **Insurance and land lease:** Coverage for fire risks and annual site payments, which are subject to rising costs due to regional land-use restrictions and environmental zoning.
- **Personnel and H&S:** Reflecting the *Convenio Colectivo de la Industria del Metal*, we estimate a salary for an Oficial de 1ª (O&M Technician) at €25.000–€28.000 gross/year. Including Social Security and Health & Safety (H&S) compliance, the total cost per technician is approximately €36.000/year.

2.3.4. Financing

The model tests different capital structures to find the optimal "bankability" threshold:

- **Debt-to-Equity ratio:** Analysis of leverage levels (70/30) based on the presence of subsidies or theoretical capacity contracts.
- **Cost of debt:** Reflecting current benchmark rates from the *Banco de España* (approx. 2,22%) plus a merchant risk premium to account for revenue volatility in the absence of a capacity market floor.
- **WACC:** Calculation of the weighted average cost of capital to serve as the discount rate for net present value (NPV) calculations, ensuring analytical rigor for the client.

2.3.5. Taxes

- **Corporate income tax:** Applied at the standard Spanish rate of 25% for general entities [40].
- **Tax loss carryforwards (TLCFs):** Known in Spain as *Bases Imponibles Negativas (BINs)*. During the 3-year development phase and the first operational year (high depreciation/interest), the project will generate tax losses. These losses are tracked in the model and deducted from future profits once the asset becomes cash-flow positive, optimizing the project's NPV.
- **Local taxes:** Inclusion of the Impuesto sobre Bienes Inmuebles de Características Especiales (BICES).
- **Tax shield:** Modeling of interest expense deductions and depreciation to optimize after-tax cash flows.

2.3.6. Financial evaluation metrics and key performance indicators (KPIs)

To evaluate the viability of the BESS project across the defined regulatory scenarios, the valuation tool will calculate a specific set of financial ratios and performance metrics. These indicators provide the investment committee with the quantitative basis required to authorize a Final Investment Decision (FID) by measuring profitability, risk, and operational efficiency.

- **Net present value (NPV):** Measures the value created by the project by discounting future cash flows to the present day using the Weighted Average Cost of Capital (WACC) [41, 42]. A positive

NPV indicates that the project generates returns above the investor's required rate of return [41].

- **Internal Rate of Return (IRR):** Evaluates the expected profitability of the investment on both a project basis and an equity basis [40]. The analysis compares how different revenue structures and financing conditions affect investor returns [42].
- **Debt Service Coverage Ratio (DSCR):** Assesses the project's ability to meet debt repayment obligations through a given period [40]. In merchant-based scenarios, maintaining an adequate DSCR is particularly important due to higher revenue volatility [43, 44].
- **Energy-to-Power (E/P) Ratio:** Defines the storage duration of the system and influences the project's commercial strategy. Different configurations may favor either short-duration balancing services or longer-duration energy arbitrage opportunities [42, 43].
- **Payback Period and Return on Investment (ROI):** Evaluate the time required for the project to recover the initial investment and measure the overall return generated throughout the asset's operational life [41].

2.4. Scope and limitations

- **Geographic scope:** The analysis is strictly limited to the Spanish Peninsular System, excluding non-peninsular territories (Canary/Balearic Islands) due to their distinct regulatory regimes.
- **Technological scope:** The technical analysis focuses exclusively on Lithium-Ion technology, as it represents the current bankable standard. Emerging technologies (Flow batteries, Hydrogen) are out of scope.
- **Time horizon:** The financial model will cover a 20-year operational life.
- **Data limitations:** While the thesis applies institutional data, forecasts regarding the specific clearing price of the future capacity market remain speculative and will be modeled as sensitivity variables.

3. Market and competitive analysis

3.1. Supply-side analysis: competitive landscape

To precisely model the revenue potential of a new battery energy storage system, it is necessary to first analyze the supply-side dynamics. The Spanish storage market is transitioning from an early stage into active deployment. As of early 2026, the system officially entered the battery era with approximately 192 MW of utility-scale storage actively connected to the grid [45].

However, the threat of saturation is imminent. The national pipeline exceeds 9.000 MW across more than 560 projects, with over 1.058 MW already holding the final Authorization for Construction (AAC) [45]. This influx of capacity is driven by distinct strategic groups, each possessing different structural advantages.

3.1.1. Integrated utilities

The early deployment phase is mainly led by Spain's major integrated utilities. The primary competitive advantage of this group is a lower WACC. Because these entities can finance BESS projects directly from their corporate balance sheets, they are not reliant on securing high-interest, non-recourse project finance from commercial banks.

Strategically, this group focuses heavily on hybridization. By installing batteries at their existing solar and wind sites, they sidestep saturated grid-access and accelerate administrative permitting. For instance, market leaders such as Iberdrola and Naturgy have acted as first-movers in the utility-scale segment, commissioning multi-megawatt hybrid and standalone projects across the peninsula and the Canary Islands [46, 48, 49]. Furthermore, their corporate size allows them to efficiently absorb early-stage public funding, capturing millions in European subsidies (FEDER) to significantly de-risk their initial capital expenditure [47].

3.1.2. Independent power producers (IPPs)

Lacking the diversified balance sheets of the integrated utilities, this group relies heavily on external project finance. To achieve bankability, their core supply-side strategy is to avoid merchant risk by locking in long-term contracts.

A defining market movement for this group is the negotiation of hybrid PPAs. By securing a fixed price for both solar generation and battery dispatch capacity, as demonstrated by recent landmark agreements between IPPs and utility off-takers combining massive solar displays with long-duration storage, these developers secure the predictable cash flows required by institutional lenders [50].

3.1.3. Market aggregators

As the Spanish storage market expands, specialized aggregators and market representatives are becoming increasingly relevant. These entities optimize battery participation across wholesale and balancing markets through digital trading and dispatch platforms, allowing asset owners to maximize revenues from multiple market services. For infrastructure investors without internal energy trading capabilities, aggregators reduce operational complexity, although their services represent an additional operating cost [52].

3.2. Demand-side dynamics

The Spanish electricity market is becoming increasingly decoupled from fossil fuel prices as renewable penetration expands. While geopolitical tensions continue to drive upward pressure on peak-hour prices when gas sets the margin, the expansion of renewables has reduced fossil fuel influence on just 15% of total hours [53]. This increased spread is the fundamental driver for BESS arbitrage profitability.

3.2.1. The "Duck Curve" and the frequency of sub-zero pricing

The Duck Curve provides a visual representation of the net load on the system, showing a significant contraction in net demand during daylight hours due to solar oversupply. By late 2025, Spanish solar capacity reached nearly 41 GW, leading to consistent midday surpluses [54].

- **Negative pricing volatility:** Spain recorded 477 hours of negative pricing in 2025, representing a near 100% increase compared to 2024 [55].

- **Negative marginal charging costs:** During these periods, market clearing prices reached lows of €-15,0/MWh [56]. For a BESS operator, this provides an opportunity for negative marginal cost charging, where the asset receives credit for absorbing excess energy, eliminating the primary variable cost of storage operations.

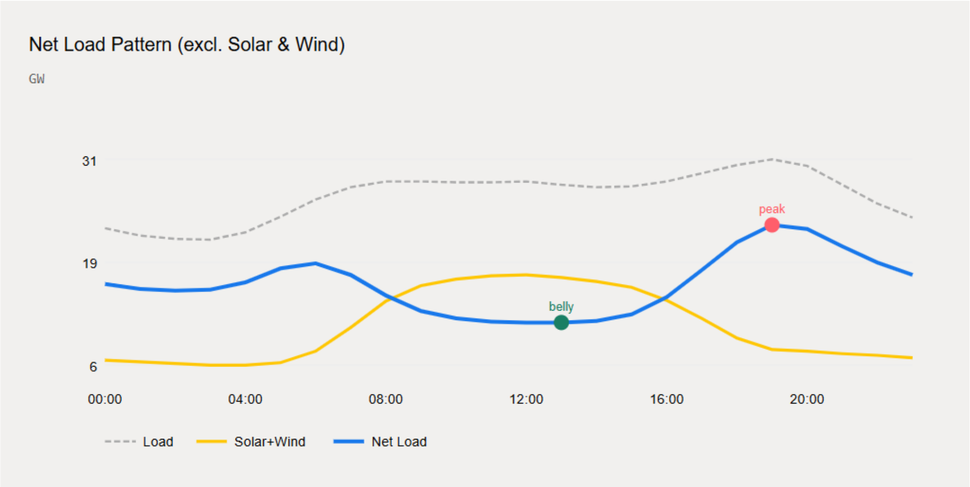

Figure 4. Daily net load pattern and renewable generation in Spain. Source: Electricity Maps (2025) [55].

3.2.2. Price cannibalization

As renewable penetration intensifies, market spots price cannibalization, in which the high correlation of solar generation profiles drives midday prices toward zero, significantly diluting the capture price for standalone solar producers.

- **Inter-temporal value arbitrage:** BESS assets mitigate this dilution by decoupling energy production from market injections. By absorbing energy during zero-value periods and discharging during evening peaks (20:00–22:00), which reached €255/MWh in 2025, the asset captures the displaced value of the solar peak. This trend is fundamentally reshaping the market toward hybridized configurations as a prerequisite for long-term bankability [56].

3.2.3. Volatility spreads

BESS profitability is a function of the daily price spread rather than absolute average prices. In 2025, the average daily price swing in the Spanish market reached €98/MWh [56].

- **Margin resilience:** Elevated gas prices during peak hours serve to expand the arbitrage spread by raising the market ceiling, while solar saturation maintains a consistent floor near zero.
- **Arbitrage magnitude:** Maximum single-day price deltas reached €228/MWh in 2025, providing sufficient margin for 4-hour BESS systems to achieve capital recovery through high-intensity arbitrage cycles [56].

3.3. Market depth: TAM, SAM, and SOM analysis

The global battery energy storage system sector is expected to experience sustained growth through 2030, with market estimates projecting a total industry value of approximately $120–150 billion USD by the end of the decade [44, 57]. This growth is being driven by increasing renewable penetration, electrification, and the need for grid flexibility across major energy markets.

Within this broader context, Spain represents a significant investment opportunity due to the storage targets established in the PNIEC 2023–2030, which sets an objective of 22,5 GW of storage capacity by 2030 [11]. Industry estimates suggest that approximately 10–12 GW of this target could correspond to BESS, excluding pumped hydro technologies [58]. Based on current European industry benchmarks, achieving this deployment could require cumulative investments of several billion euros through 2030.

For the purposes of this valuation, the target infrastructure investor is assumed to develop a portfolio of approximately 100 -200 MW of installed BESS capacity, equivalent to roughly 2–3% of the projected standalone BESS market in Spain. Under the assumptions developed in the financial model, including revenues from wholesale arbitrage, balancing services, and potential capacity payments, this portfolio could generate estimated annual operating revenues of approximately €12–18 million. These assumptions form the basis for the scenario and valuation analyses developed in the following section.

4. Financial plan and feasibility

4.1. Valuation methodology and key assumptions

The primary methodological instrument is the purpose-built BESS financial model, an integrated Microsoft Excel workbook. The model architecture follows a separation of assumptions, calculations, and outputs across ten interconnected worksheets (INPUTS, ASSUMPTIONS, OPS, DEP, DEBT, FS, SUBSIDIES, SUMMARY, RATIOS, and the Arbitrage Calculator). All input parameters are sourced from primary data: OMIE 2025 annual price statistics, REE P47/P48 balancing market auction results (2023–2025), ECB/Bloomberg financial market data (April 2026), INE inflation forecasts, IDAE and CNMC regulatory publications, and industry CAPEX benchmarks from publicly available BESS cost studies.

Financial analysis employs the discounted cash flow (DCF) methodology, computing both the unlevered project IRR and the levered equity IRR for each scenario. The discount rate (WACC = 8,44%) is derived via the Capital asset pricing model (CAPM) using updated Spanish sovereign rate data. Debt is structured under a project-finance annuity model with a 15-year tenor (18 years under Scenario D) and a 70% gearing ratio (75% under Scenario D). Public subsidy impacts are evaluated through a dedicated sensitivity module that allows toggleable activation of CAPEX grants and soft-loan instruments, with the minimum subsidy thresholds for bankability derived analytically.

The regulatory and accounting analysis relies on primary legislative sources, specifically the *Ley de Sociedades de Capital* (*Real Decreto Legislativo 1/2010*) [59], the *Ley del Impuesto sobre Sociedades (Ley 27/2014)* [60], the *Plan General de Contabilidad (Real Decreto 1514/2007)* [61], and the energy sector regulatory framework including *Royal Decrees 1183/2020* [62], *148/2021* [63], and *CNMC Circular 3/2020* [64], supplemented by authoritative sources including IDAE regulatory guidance and BOE publications for equity risk premium data.

4.1.2 The project

The project subject to analysis is a 100 MW / 400 MWh utility-scale BESS to be developed, constructed, and operated in Spain, structured as a stand-alone Special Purpose Vehicle (SPV). It represents a significant capital commitment of €68,908 million all-in CAPEX (€181,25/kWh). financed through a combination of senior project debt (70% gearing, 15-year tenor, all-in rate of 4,70%) and equity. The system uses lithium iron phosphate (LFP) cells, selected for their superior thermal stability, cycle durability (2,2%/yr degradation), and declining cost trajectory. At a 4-hour duration, the system qualifies for the MITECO 85% de-rating factor under the Spanish capacity adequacy framework, yielding

85 MW of firm capacity eligible for capacity market payments. The project is intended to generate revenues through three stacked mechanisms: (1) intraday OMIE wholesale arbitrage (charging during midday solar-glut hours, discharging during the evening peak); (2) automatic and manual frequency restoration reserves (aFRR / mFRR) procured by Red Eléctrica de España (REE); and (3) a capacity mechanism payment under the PNIEC's storage adequacy programme and/or a long-term fixed-price power purchase agreement (PPA), depending on the scenario.

The project achieves Commercial Operation (COD) in 2029, following 18 months of permitting (2025–2026) and 18 months of construction (2027–2028), with operations extending to 2048. A cell augmentation event is modelled at Year 11 (2039), when the battery's State-of-Health (SoH) is expected to decline to approximately 80% of initial capacity, triggering a replacement CAPEX of 20% of initial investment (€13,78 million). PNIEC's *PERTE ERHA* funding instrument and IDAE soft-loan programs provide a potential public support layer, with the financial model explicitly quantifying the subsidy impact on returns across each scenario.

4.1.3 Model architecture

The valuation model is structured as an integrated Excel-based project finance tool designed to assess the financial viability and bankability of standalone BESS projects under different regulatory and commercial conditions. The workbook separates assumptions, operational calculations, financing structures, subsidy mechanisms, and financial outputs across worksheets to ensure transparency, consistency, and scenario flexibility.

The model architecture combines technical operating assumptions with project-finance methodology. Revenue projections are based on a revenue stacking framework integrating wholesale market arbitrage, balancing services (aFRR and mFRR), and, depending on the scenario, capacity payments or long-term contracted revenues through a fixed-price PPA. These revenue streams are linked to operational parameters including system duration, round-trip efficiency, degradation, availability, and daily cycling assumptions.

On the cost side, the model incorporates detailed CAPEX and OPEX structures, including battery equipment, grid connection, financing costs during construction, operational maintenance, land lease, insurance, and future cell augmentation requirements. Financing is modelled through a senior project-finance structure with scenario-dependent leverage, debt tenor, and interest-rate assumptions.

The model integrates projected income statements, balance sheets, and cash-flow statements over the full operational life of the asset, enabling the calculation of project and equity cash flows. Financial viability is evaluated using discounted cash flow analysis and a range of investor and lender metrics, including NPV, Project IRR, Equity IRR, DSCR, and LLCR.

Given the uncertainty associated with long-term merchant electricity markets, the model is designed primarily as a scenario-based valuation and sensitivity framework rather than as a deterministic forecasting tool. Dedicated modules evaluate the impact of changes in electricity price spreads, subsidy support, financing conditions, and capacity remuneration mechanisms on overall project bankability.

A detailed description of the worksheet structure and model implementation is included in Appendix II.

4.1.4 Regulatory and accounting framework (Spain)

The project is structured as a Spanish special purpose vehicle and therefore operates under the national corporate, tax, accounting, and energy-sector regulatory framework. The valuation incorporates the principal regulatory and fiscal mechanisms that materially affect project cash flows, financing structure, and shareholder returns.

At the corporate level, the model applies the standard Spanish corporate income tax rate of 25% under the Ley del Impuesto sobre Sociedades [60]. Tax calculations incorporate depreciation, interest deductibility, and tax-loss carryforward provisions. In addition, Article 274 of the Ley de Sociedades de Capital requires Spanish companies to allocate 10% of annual net profit to a legal reserve until it reaches 20% of share capital, slightly constraining shareholder distributions during the first profitable operational years [59].

The model also incorporates the principal taxes associated with utility-scale infrastructure development in Spain. These include ICIO (construction tax), typically ranging between 2% and 4% of construction costs, AJD (stamp duty on financing documentation), which varies between 0% and 1.5% depending on the autonomous community, IBI (property tax), applied at an assumed rate of 0,70% of cadastral asset value, and IAE (economic activity tax). For modelling purposes, IAE is estimated at approximately €0,72/kW/year based on standard municipal schedules applicable to electricity generation and storage activities [65, 66, 67]. VAT (IVA) at the standard 21% rate applies to most construction-phase CAPEX components. Although recoverable through the Spanish Tax Authority (AEAT), the model assumes a reimbursement lag of approximately 6–12 months, generating a temporary working-capital requirement during construction [68].

From a regulatory perspective, the valuation reflects the current Spanish framework governing grid access and storage operations. Under *Royal Decree 1183/2020*, developers are required to post a refundable financial guarantee ("aval") of €40,000 per MW to secure grid access rights [62]. In the model, this guarantee is treated as a recoverable financial asset rather than depreciable CAPEX, affecting construction-phase liquidity requirements and the project balance sheet.

The valuation also incorporates the regulatory treatment of grid-connected storage under *RD 148/2021* and *CNMC Circular 3/2020*, which exempt BESS facilities from certain electricity system charges and network access tolls during charging periods [63, 64]. These exemptions materially improve arbitrage margins and therefore have a direct impact on project profitability and debt-service capacity.

Finally, the accounting treatment follows the principles established under the *Spanish Plan General de Contabilidad* (PGC), particularly regarding depreciation schedules, financing costs during construction, and the treatment of long-term financial obligations within the SPV structure [61].

A detailed description of the regulatory, accounting, and fiscal treatment applied in the model is included in Appendix III.

4.2. Revenue modeling scenarios

All four scenarios share a common technical and financial baseline: COD in 2029, installed capacity of 100 MW / 400 MWh, round-trip efficiency (RTE) of 85%, annual degradation of 2,2%, 97% availability, and a 20-year operational life. Total project CAPEX is estimated at €68,9 million, financed under a standard project-finance structure with 70% gearing, a 15-year debt tenor, and an all-in cost of debt of 4,70%, unless modified at scenario level.

Balancing-service revenues are based on historical REE P47/P48 auction averages for the 2023–2025 period, assuming aFRR remuneration of €25.000/MW/year and mFRR remuneration of €16.000/MW/year. Revenue differentiation across scenarios is therefore driven primarily by varying enrolment levels, commercial structures, and regulatory assumptions rather than changes in balancing-market pricing.

- ***Scenario A: Merchant-Only***

Scenario A represents a fully merchant exposure strategy with no capacity-market support or long-term contractual hedge. Revenues are generated exclusively through wholesale market arbitrage and participation in balancing services. The model assumes a net arbitrage spread of €33,88/MWh, based on charging during low-price midday solar hours and discharging during evening peak periods.

Balancing market participation remains high, with 80% enrolment in both aFRR and mFRR services, generating approximately €2,0 million and €1,3 million annually, respectively. Operational intensity is comparatively moderate at 1,2 cycles/day, reflecting the greater dispatch flexibility available under a pure merchant strategy.

This scenario represents the lowest bankability case within the valuation framework. Although the project benefits from high operational flexibility and strong exposure to intraday volatility, revenues remain highly sensitive to future spread compression as renewable penetration increases. The absence of contracted revenues or capacity payments significantly weakens debt-service resilience and results in the lowest lender metrics across the four scenarios.

- ***Scenario B: Delayed Capacity Market***

Scenario B assumes a two-year delay in the commencement of Spanish capacity mechanism payments relative to COD. During the first operational year, the asset operates under merchant conditions identical to Scenario A before receiving capacity payments from 2030 onwards.

The model assumes capacity remuneration of €50.000/MW/year applied to the project's 85 MW de-rated firm capacity, generating approximately €4,25 million annually once activated. Due to the operational constraints associated with balancing-service participation and capacity obligations, the arbitrage spread decreases to €28,76/MWh, while balancing-service enrolment falls to 70%. Operational intensity increases to 1,5 cycles/day as the battery simultaneously participates in arbitrage and ancillary-service markets.

The two-year capacity payment delay (2029 to 2030 start) reflects a realistic interpretation of PNIEC implementation timelines. Spain's PNIEC 2023–2030 commits to 22,5 GW of storage by 2030, with the Capacity Mechanism under development by MITECO and the CNMC. Historically, Spanish electricity market regulatory reforms have experienced implementation delays of 12–36 months relative to legislative announcements. The model's Base Case accordingly assigns a probability-weighted mid-case by assuming capacity contracts are awarded through a competitive CNMC auction in 2030, one auction cycle after COD.

- ***Scenario C: Target Policy***

Scenario C represents the optimal policy execution case: capacity market payments start at COD (2029) under the assumption that the PNIEC targets are implemented on schedule and a CNMC capacity auction is cleared before COD.

The scenario maintains the €50.000/MW/year capacity payment assumption while increasing balancing-market participation to 90% enrolment in both aFRR and mFRR services. This higher operational utilization raises daily cycling intensity to 1,8 cycles/day, representing the upper operational range assumed within the model. Due to the prioritization of balancing obligations and reduced dispatch flexibility, the net arbitrage spread remains at €28,76/MWh.

This scenario represents the highest regulatory support case and produces the strongest overall financial performance under the base assumptions. The combination of early capacity payments, elevated balancing-service participation, and stable operational utilization materially improves project cash-flow stability, allowing the assets to achieve the strongest debt-service metrics and the lowest dependence on public subsidy support.

- ***Scenario D: Fixed PPA + Merchant***

Scenario D evaluates a partially contracted commercial strategy combining long-term fixed-price revenues with residual merchant exposure. Under this structure, 80% of annual energy output is sold through a 20-year fixed-price PPA at €85/MWh, while the remaining 20% continues to participate in merchant arbitrage markets at an assumed spread of €30/MWh.

The contracted revenue structure materially improves financing conditions within the model. Gearing increases from 70% to 75%, the all-in cost of debt declines from 4,70% to 4,20%, and debt tenor extends from 15 to 18 years. However, the operational rigidity associated with PPA commitments reduces balancing-service participation to 40% and limits dispatch flexibility relative to the merchant-oriented scenarios. The daily cycle count is 1,4 cycles/day, and the arbitrage spread on the non-PPA 20% is €30/MWh (slightly below Scenario A's €33,88/MWh due to the constrained dispatch flexibility).

The PPA fixed price of €85/MWh is calibrated within the range indicative of Spanish BESS-to-industrial-offtaker PPA negotiations in 2024–2025 (€80–€95/MWh all-in). This scenario produces the most stable cash-flow profile from a lender perspective. Although exposure to merchant volatility is partially sacrificed, the contracted revenue floor significantly improves financing efficiency and reduces refinancing and liquidity risk, resulting in the strongest overall bankability profile among the four commercial structures analyzed.

4.3. Scenario conclusions

Table 2 summarizes the key financial performance metrics across all four scenarios, without and with subsidies.

Table 2. Summary of key financial returns by scenario - without and with subsidies.

		Scenario A — Merchant Only		Scenario B — Delayed Capacity Market		Scenario C — Full PNIEC		Scenario D — Fixed PPA + Merchant	
Metric	**Lender Threshold**	**No Subsidy**	**With Subsidy**	**No Subsidy**	**With Subsidy**	**No Subsidy**	**With Subsidy**	**No Subsidy**	**With Subsidy**
Project IRR (Ungeared)	≥ 8%	2,6%	9,9%	9,6%	16,7%	12,6%	20,46%	12,0%	19,9%
Equity IRR (Levered)	≥ 12%	0,03%	12,75%	15,9%	30,1%	24,9%	43,3%	23,6%	42,1%
NPV at WACC (M€)	> 0	(25,5)	—	6,1	—	22,4	—	18,3	—
Payback Period (years)	≤ 10 yrs	15,5	↓	8,5	↓	7,1	↓	7,6	↓
Min. DSCR (Year 1)	≥ 1,20×	1,0×	1,35×	1,9×	2,51×	2,2×	3,03×	2,0×	2,69×
Avg. EBITDA Margin	> 50%	~60%	—	~74%	—	~78%	—	~76%	—
Avg. Annual Revenue (M€)	—	8,6	—	13,5	—	15,7	—	14,8	—
Bankability Rating	—	**Difficult**	**Conditional**	**Conditional**	**Bankable**	**Bankable**	**Bankable**	**Fully Bankable**	**Fully Bankable**

Scenario A — Merchant-Only: Conclusions

Without subsidies

Scenario A is financially non-viable under the base assumptions. The project IRR of 2,6% remains significantly below the WACC of 8,44%, producing a negative NPV of −€25,5 million and an equity IRR close to zero. In addition, the minimum DSCR of 1,16× falls below the standard lender covenant of 1,20×, while the 15,5-year payback period is the longest among all scenarios.

The main weakness of this scenario is its high dependence on merchant arbitrage revenues, which represent approximately 55–65% of annual income. As a result, project performance is highly sensitive to compression in OMIE price spreads caused by increasing renewable penetration and future storage saturation. Under these conditions, the project lacks sufficient revenue stability to support a conventional project-finance structure without external support.

With subsidies

Public support improves Scenario A, primarily through the reduction of upfront capital intensity and debt-service requirements. The model indicates that a minimum CAPEX grant of approximately 28% is required for the project IRR to reach the WACC threshold, while an 18% grant is sufficient to restore DSCR above lender covenant levels.

Under the combined 35% PERTE ERHA grant and 50% IDAE soft-loan structure, project IRR increases to 9,9%, equity IRR rises to 12,8%, and minimum DSCR improves to 1,35×. Although the project becomes technically bankable under this support structure, the margin of safety remains limited relative to the other scenarios. Under the maximum scenario (45% GBER grant + 75% soft loan), project IRR rises to approximately 12,48%, providing a more comfortable margin of safety.

In both cases, the grant operates by reducing net CAPEX (from €68,9 million to €55,0 million at 35% grant), which proportionally reduces senior debt (€48M → €38,5M), annual debt service saving of €1.2M/yr, and annual insurance and IBI costs. The equity investment also falls, amplifying the equity IRR improvement relative to the project IRR improvement via the leverage effect.

Scenario B — Delayed Capacity Market: Conclusions

Without subsidies

Scenario B represents the most realistic base-case regulatory environment for COD in 2029. The project achieves a positive NPV of €6,1 million, a project IRR of 9,6%, and an equity IRR of 15,9%, exceeding both the WACC and the minimum institutional return threshold. The payback period falls to 8,5 years, supported by the introduction of capacity payments from 2030 onwards.

However, the first operational year remains exposed to merchant-only conditions, creating a temporary deterioration in lender metrics. The Year-1 DSCR of 1,13× falls slightly below the standard lender covenant due to the absence of capacity payments during the initial operational phase. As a result, the scenario remains highly sensitive to additional regulatory delays. A further postponement of capacity remuneration would materially reduce both IRR and NPV, potentially pushing returns below the cost of capital.

Overall, Scenario B represents a minimum-viability investment case rather than a fully robust one. While technically financeable, the project maintains limited resilience against adverse market or regulatory developments.

With subsidies

Public support significantly strengthens Scenario B by improving both debt-service resilience and return stability. Under the combined 35% grant and 50% soft-loan structure, project IRR increases to 16,7% while minimum DSCR improves to 2,51×. Equity IRR rises to 30,1%, substantially exceeding institutional return requirements.

In this context, subsidies function less as a pure return-enhancement mechanism and more as a tool for increasing lender comfort and reducing exposure to regulatory timing risk during the early operational years.

Scenario C — Full PNIEC: Conclusions

Without subsidies

Scenario C delivers the strongest standalone financial performance among the four regulatory cases. The project achieves a project IRR of 12,6%, an NPV of €22,4 million, and an equity IRR of 24,9%, supported by immediate capacity payments from COD and high participation in balancing-service markets. The payback period decreases to 7,1 years, while EBITDA margins remain consistently above 78% during the first operational years.

Despite these strong financial results, Scenario C also carries high regulatory execution risk. Its viability depends on the successful implementation of the Spanish capacity mechanism before 2029 and on the maintenance of the assumed remuneration framework throughout the project life. In addition, the elevated operational intensity of 1,8 cycles/day increases long-term degradation pressure and reduces operational flexibility relative to the lower-intensity scenarios.

With subsidies

Under the combined 35% PERTE ERHA grant and 50% IDAE soft-loan structure, Scenario C becomes highly financeable across all lender and investor metrics. Project IRR increases to 20,5%, equity IRR rises to 43,3%, and minimum DSCR reaches 3,03×.

At this stage, the project becomes effectively de-risked from a financing perspective. Subsidies further strengthen already robust operating economics, while reduced CAPEX and financing costs materially improve cash-flow coverage and leverage capacity.

Scenario D — Fixed PPA + Merchant: Conclusions

Without subsidies

Scenario D produces the highest equity IRR of all scenarios at 23,6%, driven by the combination of revenue certainty (80% of output contracted at €85/MWh, eliminating 80% of merchant price volatility); higher gearing (75%) reducing the equity contribution from €20,6M to €17.2M, amplifying equity returns; lower debt cost (4,20% versus 4,70%) reducing annual debt service; and longer debt tenor (18 years versus 15 years) reducing annual amortization. The project IRR of 12,0%, while lower than Scenario C's 12,6%, is achieved with substantially lower risk, as 80–90% of annual revenues are contractually fixed at €85/MWh regardless of OMIE spot conditions. The minimum DSCR of 2,14× and average DSCR of 2,26× are the strongest of all scenarios.

The principal trade-off of this structure is reduced exposure to merchant upside, as operational flexibility and balancing-market participation are partially constrained by the fixed-dispatch obligations embedded in the PPA structure. In addition, the scenario remains dependent on the credit quality of the offtaker, as the financing advantages assumed in the model rely on an investment-grade counterparty.

With subsidies

Public support further enhances an already strong financing structure. Under the combined subsidy scenario, project IRR increases to 19,9%, minimum DSCR improves to 2,69×, and equity IRR reaches 42,1%, representing the highest levered return among all scenarios.

However, the relative impact of subsidies is smaller than in Scenarios A and B because the project is already financially robust under the base commercial structure. In this case, contracted revenues remain the primary driver of long-term bankability.

4.4. Discounted cash flow (DCF) analysis and IRR calculation

The model employs a standard project-finance DCF framework in which two separate IRR calculations are performed per scenario: the project (ungeared) IRR and the equity (levered) IRR. The project IRR is calculated on the unlevered free cash flow series, where the Year-0 outflow equals the total CAPEX, and the annual inflow equals EBITDA less taxes paid on a tax-equity basis.

The equity IRR is calculated on the levered equity cash flow series: Year-0 equity investment, and annual flows equal net profit plus D&A less principal repayment less capex (augmentation at Year 11). Both series reflect the Year-11 augmentation CAPEX as a negative flow: this represents the most significant mid-life cash strain, producing a negative FCF in Year 11 across all scenarios due to the €13.782k cell replacement CAPEX, partially offset by operating cash generation.

Discount rate (WACC) derivation

The valuation applies a standardized WACC of 8.44% across all scenarios to maintain comparability between regulatory and commercial structures. The discount rate was derived using a project-finance approach combining the cost of equity and the after-tax cost of debt under the assumed capital structure.

The cost of equity was estimated using the Capital Asset Pricing Model (CAPM), based on:

- Spanish 10-year sovereign bond yield of 3,49% (April 2026)
- equity risk premium of 5,50%
- relevered beta reflecting the higher volatility and merchant exposure associated with standalone BESS infrastructure assets in Spain.

An additional project-specific risk adjustment was incorporated to account for regulatory uncertainty, merchant revenue exposure, and long-term electricity market volatility.

The model assumes a pre-tax cost of debt of 4,70%, corresponding to project-finance lending conditions for partially merchant infrastructure assets in the Spanish energy market. Applying the standard project capital structure (70% debt / 30% equity) and the 25% corporate tax shield results in a standardized WACC assumption of 8,44%.

Scenario D benefits from lower financing costs and higher leverage due to the presence of long-term contracted revenues; however, the model maintains a common WACC assumption across all scenarios to isolate the impact of regulatory structure and revenue composition on project cash flows and bankability.

IRR and NPV results

The IRR calculations operate on the twenty-year annual cash flow series with a Year-0 CAPEX outflow. Key results are presented in Table 3 below and discussed in detail in the preceding scenario conclusions.

Table 3. DCF and IRR results by scenario.

DCF Metric	Scen A Merchant	Scen B Delayed Cap.	Scen C Full PNIEC	Scen D Fixed PPA
Year-0 CAPEX Outflow (€k)	(68.908)	(68.908)	(68.908)	(68.908)
Year-0 Equity Investment (€k)	(20.672)	(20.672)	(20.672)	(20.672)
Avg. Annual Project FCF, Yrs 1–10 (€k)	~5.132	~8.225	~9.751	~9.622
Year-11 Net FCF (augmentation year, €k)	(4.342)	(495)	1.024	736
Project IRR	2,6%	9,6%	12,6%	12,0%
Equity IRR	0,03%	15,9%	24,9%	23,6%
NPV at WACC (€k)	(25.531)	6.118	22.422	18.302

Three of the four scenarios generate positive NPVs at the 8,44% WACC, with Scenario C producing the highest absolute value creation. The wide dispersion of equity IRRs reflects the leverage amplification effect, the equity investment is fixed at approximately €14,5–€17,5 million for all scenarios, while operating cash flows vary significantly between scenarios. The superiority of Scenario D in equity IRR terms is driven not only by higher operating margins but also by the lower equity investment at 75% gearing. The negative Year-11 FCF under Scenario A deserves particular attention: the augmentation CAPEX of €11,7 million in Year 11, combined with the lower operating cash generation of approximately €7,8 million, produces a net negative free cash flow of −€3,9 million, which strains the equity cash flow series and contributes to the elongated payback period.

4.5. Sensitivity analysis: impact of BESS CAPEX and price spreads

CAPEX Sensitivity

The valuation results are highly sensitive to variations in two core assumptions: upfront battery-system CAPEX and the persistence of OMIE arbitrage spreads. Given the capital-intensive nature of utility-scale BESS projects and the strong dependence of merchant revenues on electricity-price volatility, relatively small deviations in either variable can materially alter project bankability, debt-service coverage, and long-term equity returns.

Under scenario B assumptions, total installed CAPEX is estimated at €181,25/kWh, equivalent to approximately €68,9 million for the 100 MW / 400 MWh system. Battery modules account for roughly half of total project cost and therefore represent the principal source of construction-cost sensitivity. Table 4 evaluates the impact of CAPEX variations on project IRR under Scenario B.

Table 4. CAPEX sensitivity on project IRR (Scenario B).

CAPEX per kWh (€/kWh)	Total CAPEX (€k)	Project IRR — Scen B (%)
161 (−€20/kWh, −11%)	~60.908	12,3%
181 (Base Case)	68.908	**9,6%**
201 (+€20/kWh, +11%)	~76.908	7,1%
220 (+€39/kWh, +22%)	~84.308	4,8%

The CAPEX sensitivity highlights the risk of construction cost overruns. A €20/kWh overrun (approximately 11% above the base) reduces the project IRR from 9,6% to approximately 7,1%, already below the WACC of 8,44%, rendering Scenario B non-bankable. A €39/kWh overrun (22% cost increase, plausible given supply chain volatility) drops the IRR to 4,8%, well below the WACC threshold and effectively eliminating any prospect of conventional project financing. Given that LFP battery module spot prices have declined from approximately €130/kWh (2023) towards €80–90/kWh (2025–2026) at the cell-module level, there is also potential for downside CAPEX versus the modelled €90/kWh battery assumption, which would be positive for project economics; a €20/kWh reduction in battery cost alone would improve the project IRR to approximately 12,3% under Scenario B.

Price Spread Sensitivity (OMIE Arbitrage)

The arbitrage spread is the second most sensitive variable under Scenarios A and B. The model's Arbitrage Calculator provides a spread sensitivity matrix across charge and discharge price combinations. Key findings are presented in Table 5.

Table 5. Net arbitrage spread sensitivity to OMIE charge and discharge prices.

Scenario	Charge €/MWh	Discharge €/MWh	Net Spread €/MWh	Spread Rating
Base (Scen A — 2025)	15	62	33,88	Attractive
Stress (higher charge / lower discharge)	20	60	25,88	Marginal
Bear (spread compression)	25	60	19,88	Marginal
Severe (solar glut + compressed evening)	30	60	13,88	Unattractive
Bull (market depth improves)	15	70	41,88	Attractive

A €10/MWh change in arbitrage spread produces approximately a 5–8% impact on IRR under Scenario A, the scenario most exposed to spread risk. Under Scenarios B, C, and D, the arbitrage spread matters less, in Scenarios B and C, capacity payments and balancing services provide a substantial contracted revenue buffer; in Scenario D, 80% of revenue is fully independent of OMIE prices.

The increasing frequency of negative-price hours in OMIE may improve BESS charging economics by allowing the asset to absorb surplus renewable generation at very low or negative cost. However, continued storage deployment could gradually compress evening peak spreads over time, reducing the long-term profitability of pure arbitrage strategies.

5. Action plan, conclusions and recommendations

5.1. Risk assessment matrix

Table 6 presents the principal risks identified across the regulatory, market, technical, and financial dimensions. Each risk is assessed on a 1–5 scale for both likelihood and impact, with the resulting risk exposure score (L × I) determining the priority classification.

Table 6. Risk assessment matrix.

Risk Category / Risk	Likelihood (1–5)	Impact (1–5)	Score (L×I)	Mitigant
REGULATORY				
Capacity market delay / cancellation	3	4	12 — HIGH	Mitigated through balancing-service revenues and partially contracted structures (Scenario D). Scenario B explicitly models delayed implementation.
AJD / IBI tax revaluation	2	2	4 — LOW	Limited impact on overall project economics. Tax escalation incorporated into the base-case OPEX assumptions.
Grid access permit revocation or curtailment	1	5	5 — MEDIUM	Low probability once permits are secured. Mitigated through compliance with RD 1183/2020, robust grid studies, and contractual protections.
MARKET				
OMIE spread compression	4	4	16 — CRITICAL	Principal merchant-risk exposure, particularly under Scenario A. Mitigated through balancing services, contracted revenues, and capacity payments.

PPA offtaker default (Scen D specific)	2	5	10 — HIGH	Requires investment-grade counterparty and standard lender protections such as guarantees or credit insurance.
Euribor / interest rate increase	3	4	12 — HIGH	Higher financing costs negatively affect NPV and DSCR, particularly under merchant-heavy structures. Lower leverage risk under Scenario D.
TECHNICAL				
Accelerated battery degradation	3	3	9 — MEDIUM	Earlier augmentation CAPEX may reduce long-term returns. Mitigated through EPC performance warranties and conservative degradation assumptions.
CAPEX overrun (EPC contract risk)	3	5	15 — HIGH	One of the most material project risks. Mitigated through turnkey EPC contracts, contingency reserves, and construction insurance.
HVAC thermal management failure / fire risk	2	5	10 — HIGH	Mitigated through fire protection systems, thermal monitoring, insurance coverage, and compliance with operational safety standards.
FINANCIAL / STRUCTURAL				
DSCR covenant breach (Scen A without subsidy)	4	4	16 — CRITICAL	Merchant-heavy scenarios may fail lender coverage thresholds without subsidy support, contracted revenues, or delayed dividend distributions.
Insufficient liquidity (DSRA / minimum cash)	2	3	6 — MEDIUM	Model includes minimum cash reserve assumptions and lender-required DSRA funding at financial close.

Overall, the risk analysis indicates that the principal threats to project bankability are concentrated in three areas: merchant-price exposure, construction-cost inflation, and regulatory timing uncertainty. These risks become materially more manageable under scenarios incorporating contracted revenues, public support mechanisms, or capacity payments, which improve both cash-flow stability and lender coverage metrics.

5.2. Implementation roadmap: timeline to commercial operation date (COD)

Project timing is a critical determinant of BESS bankability, as delays in permitting, financing, or grid access directly affect commercial operation, eligibility for capacity-market revenues, and debt-service commencement. Based on the assumptions embedded in the financial model, the project follows an estimated four-year development and construction timeline, targeting COD in Q1 2029.

Table 7. Implementation roadmap.

Phase	Timeline	Key Activities and Milestones
Phase 1: Development	Q1 2025 – Q2 2026	Site identification and land acquisition; preliminary grid feasibility assessment with REE; environmental-impact study preparation; SPV incorporation; posting of the grid-access aval under RD 1183/2020.
Phase 2: Permitting	Q2 2025 – Q3 2026 (18 months)	Environmental permitting (DIA); grid-access and connection approvals; AAP and AAC authorization process; municipal permits and tax registration; coordination with competent regional and national authorities.
Phase 3: Engineering & Financing	Q2 2026 – Q4 2026	FEED (Front-End Engineering and Design) and EPC tender process; independent engineer appointment; lender due diligence (legal, technical, model audit); EPC contract negotiation; PERTE ERHA / IDAE subsidy application submission; debt term sheet and credit approval; financial close and first drawdown (Q4 2026).

Phase 4: Construction	Q1 2027 – Q2 2028 (18 months)	Civil works and electrical infrastructure installation; battery and PCS deployment; grid connection works; control-system integration; commissioning preparation.
Phase 5: Commissioning & COD	Q3 2028 – Q4 2028	REE type-test for BESS (response time, capacity certification, MITECO de-rating confirmation); CNMC market registration as storage unit; balancing-market qualification; PPA offtake agreement activation (Scen D) or CNMC capacity auction participation; first commercial dispatch and settlement with OMIE.
COD Milestone	Q1 2029	Project enters commercial operations. Revenue generation commences. Debt amortization schedule begins. DSRA funded from operating cash flow.
Phase 6: Operations (20 years)	2029 – 2048	Commercial operations and revenue generation; preventive O&M; regulatory compliance and reporting; long-term asset management, including mid-life augmentation and end-of-life recycling strategy.

The implementation schedule reflects the current Spanish permitting environment for utility-scale storage projects and assumes no material regulatory or grid-access delays. The most schedule-sensitive stages are environmental permitting, grid-access authorization, and financial close, as delays in any of these phases would directly postpone COD and potentially affect eligibility for capacity-market participation or public-support mechanisms.

5.3. Final investment decision (FID): "Go/No-Go" criteria

The Final Investment Decision is the formal commitment of equity and debt capital to fund construction. The following quantitative and qualitative criteria, grounded in the model's outputs, define the decision framework:

Table 8. Go criteria for final investment decision.

Criterion	Minimum Threshold	Model-Based Justification
Project IRR ≥ WACC	≥ 8,44%	Scenarios B, C, and D satisfy under base assumptions. Scenario A requires public support to achieve bankability.
Equity IRR ≥ Sponsor Hurdle	≥ 12%	Scenarios B, C, and D exceed institutional return requirements. Scenario A fails.
NPV at WACC > 0	> €0	Scenarios B, C, and D generate positive economic value. Scenario A remains value destructive.
Minimum DSCR ≥ 1.20× at all times	≥ 1,20×	Scenarios C and D provide robust lender coverage. Scenario B remains acceptable but sensitive during early operations.
Payback Period ≤ 10 years	≤ 10 yrs	Scenarios B, C, and D recover invested capital within lender expectations.
Revenue Certainty > 50% contracted	≥ 50% of Year-1 revenue from non-spot sources	Scenarios B, C, and D benefit from diversified or contracted revenue structures. Scenario D provides the highest revenue stability.

Table 9. Go/No-Go dashboard.

FID Go / No-Go Dashboard without subsidy	Scenario A — Merchant 1 / 6	Scenario B Delayed CM 4 / 6	Scenario C — Full PNIEC 6 / 6	Scenario D Fixed PPA 6 / 6
Project IRR ≥ WACC	Fail	Pass - Limited buffer	Pass - Strong	Pass – Strong
Equity IRR ≥ sponsor hurdle	Fail	Pass	Pass	Pass
Positive NPV	Fail	Pass - Rate-sensitive	Pass - Strong	Pass - Strong
Min. DSCR ≥ 1,20x	Fail	Pass – Limited buffer	Pass – Robust	Pass – Robust
Payback period ≤ 10 yrs	Fail	Pass	Pass	Pass
Revenue certainty	Weak	Moderate	Strong	Very strong
FID Verdict	**No-Go**	**Conditional Go**	**Go — Preferred**	**Go — Strong**

No-Go Conditions

The project should not proceed to FID under any of the following conditions:

- Project IRR falls below the WACC under the Base Case scenario (Scenario B).
- Capacity-market implementation is materially delayed without compensating contracted revenues or public support mechanisms.
- EPC pricing materially exceeds the modeled CAPEX assumptions, undermining lender coverage metrics.
- No investment-grade PPA counterparty is secured under Scenario D.

Recommended investment pathway

Based on the financial model's outputs, the recommended pathway to FID is as follows. The project meets the full set of go criteria under Scenarios B, C, and D without any public subsidy, though Scenario B does so only marginally. In order of investment preference: Scenario D is the most bankable configuration, providing the highest revenue certainty (80–90% contracted at €85/MWh) and the most robust debt coverage, contingent on securing an investment-grade PPA offtaker. Scenario C provides the highest project IRR (12,6%) and equity IRR (24,9%), though it remains conditional on full PNIEC policy execution. Scenario B represents the base case and the minimum acceptable configuration for a standalone merchant/capacity project.

The submission of a PERTE ERHA grant application and an IDAE soft loan application should be pursued in parallel with FID preparation, as the combined 35% grant + 50% soft loan package improves project IRR by approximately 10% across scenarios, substantially improving equity returns and reducing the sponsor's equity exposure. Under the revised cost structure, public support transitions from a value-enhancement instrument to a near-essential requirement for Scenario B in order to restore DSCR covenant compliance and provide a commercially adequate margin of safety. FID should not be conditioned on subsidy approval for Scenarios C and D, which remain bankable without public support; however, for Scenario B, the pursuit and confirmation of at least a partial subsidy package before financial close is strongly recommended.

5.4. Social and environmental impact: SDG alignment

Beyond the financial conclusions of the project, utility-scale battery storage also generates broader environmental and social benefits linked to energy transition. As renewable penetration increases in Spain, flexible storage infrastructure becomes increasingly important for grid stability, renewable-energy integration, and long-term decarbonization objectives.

The project aligns most directly with the following Sustainable Development Goals (SDGs) established under the United Nations 2030 Agenda [69].

Objective SDG 7 — Affordable and Clean Energy promotes access to reliable, sustainable, and modern energy systems, with particular emphasis on renewable-energy integration and investment in clean-energy infrastructure.

Results. The project contributes directly to renewable-energy integration by storing excess solar generation during periods of low demand and discharging electricity during evening peak hours. This improves grid flexibility, reduces renewable curtailment, and supports Spain's PNIEC 2023–2030 target of 22,5 GW of storage capacity. Depending on the operational scenario, the system delivers approximately 175.000–260.000 MWh of annual electricity throughput, representing a meaningful contribution to balancing intermittent renewable generation.

Conclusion. SDG 7 is strongly satisfied. The project supports higher renewable penetration while improving system reliability and reducing dependence on fossil-fuel-based balancing generation.

Improvement action. The special purpose vehicle (SPV) should implement a transparent operational reporting system disclosing renewable energy absorbed, curtailment avoided, and annual storage cycles. This would improve monitoring transparency for regulators and strengthen the project's contribution to national renewable-integration objectives.

Objective SDG 13 — Climate Action calls for urgent action to combat climate change through greenhouse-gas reduction and long-term decarbonization measures.

Results. By replacing part of the flexibility traditionally provided by gas-fired peaking plants, the project contributes directly to emissions reduction within the Spanish electricity system. Based on the operational assumptions of the model, the project is estimated to avoid approximately 50.000–70.000 tCO_2 annually, equivalent to approximately 1,0–1,4 million tCO_2 over the 20-year project life.

Conclusion. SDG 13 is strongly satisfied. The project's climate contribution is embedded directly within its operating model through renewable integration and reduced reliance on fossil-fuel balancing capacity.

Improvement action. Future project phases could incorporate third-party verification of avoided emissions under recognized carbon-accounting standards. This would improve environmental transparency and potentially create an additional voluntary carbon-credit revenue stream.

Objective SDG 9 — Industry, Innovation and Infrastructure, promotes resilient infrastructure, sustainable industrialization, and technological innovation.

Results. The project represents a direct €68,9 million investment in modern electricity infrastructure and contributes to the development of utility-scale storage as a bankable infrastructure asset class within Spain. Participation in REE balancing services (aFRR and mFRR) also supports system stability and operational reliability in a high-renewable electricity market.

Conclusion. SDG 9 is substantively satisfied. Beyond the individual investment itself, the project contributes to the broader development of the Spanish storage market and the modernization of grid infrastructure.

Improvement action. The SPV should collaborate with REE, IDAE, and MITECO to share anonymized operational data supporting future storage-policy design and regulatory development.

Objective SDG 8 — Decent Work and Economic Growth, promotes sustainable economic growth, productive employment, and infrastructure-related economic development.

Results. During the construction phase, the project is expected to generate direct and indirect employment through engineering, logistics, installation, and construction activities. During operations, the facility is expected to maintain permanent technical and operational positions. The project also contributes recurring fiscal revenues through corporate taxation, IBI, IAE, and social-security contributions.

Conclusion. SDG 8 is partially satisfied. While the employment impact is moderate relative to the project's capital intensity, the project contributes positively to regional economic activity and long-term infrastructure investment.

Improvement action. To strengthen local economic impact, the EPC structure should prioritize regional suppliers and include minimum local-labor participation targets during construction.

Objective SDG 12 — Responsible Consumption and Production, promotes sustainable resource management, responsible industrial practices, and lifecycle waste management.

Results. The use of LFP battery chemistry reduces reliance on cobalt- and nickel-intensive technologies and aligns with the sustainability requirements established under EU Battery Regulation 2023/1542. However, the project also generates long-term lifecycle obligations associated with battery recycling, replacement, and end-of-life disposal. The Year-11 augmentation event and final decommissioning phase create significant future recycling requirements that are not fully incorporated into the current financial model.

Conclusion. SDG 12 is conditionally satisfied. Although the project adopts a comparatively sustainable battery chemistry and complies with current EU regulation, long-term recycling and disposal obligations remain a material challenge for the sector.

Improvement action. The SPV should establish a dedicated decommissioning and recycling reserve funded progressively throughout the project life. This reserve would improve long-term environmental compliance and reduce future disposal-risk exposure.

Nevertheless, battery-storage projects also present important lifecycle challenges, particularly regarding long-term recycling, raw-material sourcing, and end-of-life battery management. While the adoption of LFP chemistry reduces some environmental concerns associated with cobalt and nickel extraction, responsible recycling and disposal practices remain necessary to ensure long-term sustainability.

Overall, the project demonstrates that utility-scale BESS can provide both financial and strategic value within the Spanish electricity system. Beyond improving grid flexibility and renewable-energy integration, battery storage is likely to become a key component of Spain’s long-term energy-transition strategy.

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7. Appendices

7.1. Appendix I – Glossary of technical and energy-market terms

This appendix provides definitions of the principal technical, regulatory, and energy-market concepts referenced throughout the project. The glossary is intended to support readability and ensure consistent interpretation of specialized terminology related to battery energy storage systems (BESS), electricity markets, and project-finance analysis.

Term	Definition
aFRR (Automatic frequency restoration reserve)	A balancing service used by the System Operator to automatically stabilize grid frequency in real time through rapid power injections or withdrawals.
Ancillary services	Specialized grid services required by the System Operator (REE in Spain) to maintain frequency and voltage stability. These include services such as aFRR and mFRR.
Arbitrage	The primary revenue strategy for BESS: purchasing electricity during low-price periods and selling it during higher-price periods.
Baseload price	The arithmetic average of hourly electricity prices over a full 24-hour period, commonly used as a benchmark for market-price comparisons.
Behind-the-meter	Energy systems located on the customer's side of the utility meter, primarily intended to reduce on-site electricity costs rather than participate directly in wholesale markets.
Cannibalization	A market phenomenon in which high renewable-energy penetration reduces wholesale electricity prices during periods of peak renewable generation.
Capacity market	A regulatory mechanism that compensates generators or storage assets for guaranteeing electricity availability during periods of system stress.
Commercial operation date (COD)	The date on which a project becomes fully operational and begins generating commercial revenues.
Curtailment	The reduction of renewable-energy generation due to grid congestion, oversupply, or system-stability constraints.

De-rating factor	A regulatory adjustment that reduces the amount of firm capacity officially recognized for a storage asset based on its discharge duration and reliability.
Duck curve	A graph of net electricity demand showing lower daytime demand due to solar generation and a steep evening ramp as solar output declines. It illustrates the growing need for flexible resources such as BESS.
EMS (Energy management system)	Software used to optimize battery charging, discharging, and participation in electricity markets.
EPC (Engineering, procurement, and construction)	A turnkey contract structure in which a single contractor is responsible for the design, procurement, and construction of the project until COD.
HVAC (Heating, ventilation and air conditioning)	Thermal-management systems used in BESS facilities to maintain safe battery operating temperatures and prevent overheating.
Levelized cost of ctorage (LCOS)	A financial metric representing the total lifetime cost of a storage system divided by the total energy discharged over its operational life.
mFRR (Manual frequency restoration reserve)	A balancing service activated manually by the System Operator to restore grid balance after automatic reserves are deployed.
Merchant risk	The financial exposure associated with relying on volatile wholesale-market revenues rather than fixed contractual income.
Point of connection (PoC)	The physical and legal point where a generation or storage asset connects to the electricity grid.
Power purchase agreement (PPA)	A long-term contract between an electricity producer and an off-taker establishing fixed or partially fixed electricity prices and delivery conditions.
Round-trip efficiency (RTE)	The ratio between the energy discharged from a battery and the energy required to charge it, expressed as a percentage.
Revenue stacking	The practice of combining multiple revenue streams, such as arbitrage, ancillary services, and capacity payments, to maximize project profitability.

SCADA (Supervisory control and data acquisition)	A digital control system used to monitor and manage industrial infrastructure, including BESS facilities and grid interaction.
Solar capture price	The average electricity price effectively received by a solar generator for the energy it sells into the market.
Solar valley	The midday period of maximum solar generation, typically associated with very low or negative electricity prices.
Special purpose vehicle (SPV)	A legally independent company created exclusively to develop, finance, and operate a specific infrastructure project.
State of charge (SoC)	The percentage of energy currently stored in a battery relative to its maximum storage capacity.
State of health (SoH)	A measure of the remaining usable capacity of a battery compared to its original condition, expressed as a percentage.
VRE (Variable renewable energy)	Renewable energy sources whose output depends on weather conditions and cannot be dispatched on demand, such as wind and solar photovoltaic generation.

7.2. Appendix II – Financial model architecture and methodology

The integrated financial model was developed in Microsoft Excel as the primary analytical tool supporting the valuation, sensitivity analysis, and bankability assessment of the proposed BESS project. The workbook is structured through interconnected modules separating assumptions, operational modelling, financing structure, financial statements, and scenario analysis. This modular architecture improves auditability and scenario flexibility while allowing independent testing of key project variables.

INPUTS Sheet: The INPUTS sheet serves as the source for all macroeconomic, technical, CAPEX, OPEX, and financing parameters. Key parameters include: a WACC, corporate tax (IS), Euribor 12-month base rate, a credit spread of 150 bps yielding an all-in interest rate, a gearing ratio, installed capacity, energy capacity, a round-trip efficiency (RTE), an annual degradation rate, an availability factor, and a 20-year useful life. Total all-in CAPEX is calculated incorporating battery modules, PCS, BOP, civil works, logistics and soft costs, grid connection, development CAPEX, and financing costs (IDC, ICIO, AJD).

ASSUMPTIONS Sheet: The ASSUMPTIONS sheet presents the four revenue scenarios (Scenarios A through D), specifying per-scenario revenue parameters including arbitrage spreads, aFRR and mFRR enrolment percentages, capacity payment levels and start dates, PPA fixed price and contracted volume, and daily cycle counts. OPEX and debt structure overrides can be applied per scenario.

OPS Sheet: The OPS sheet generates annual projections (2029–2048) of operating revenues and OPEX, converting real Year-1 prices into nominal figures using the CPI escalation rate for costs and the revenue escalation rate for revenues. All four scenario revenue stacks are simultaneously computed: arbitrage revenues (based on net OMIE spread, throughput, and dispatch efficiency), aFRR balancing service revenue (REE P47 auction price × MW × enrolment %), mFRR revenue, capacity market payments (Scenarios B and C), PPA fixed-price revenue (Scenario D), and merchant top-up revenue on the uncovered volume. EBITDA is derived as total nominal revenue less total nominal OPEX, with EBITDA margins ranging from approximately 62% (Scenario A) to 79% (Scenario C) over the project life.

DEP Sheet: The depreciation sheet models straight-line depreciation over the useful life on the initial CAPEX base. A significant step-up occurs at Year 11, reflecting the cell augmentation CAPEX, modelled at 20% of initial CAPEX, which is capitalized and depreciated over the remaining useful life.

DEBT Sheet: The DEBT sheet constructs the full senior loan amortization schedule under an annuity (constant payment) profile. The senior loan carries a grace period matching the 18-month construction period, with IDC capitalized during construction. Annual debt service (principal plus interest) is computed via a PMT formula applied to the post-COD 15-year tenor.

FS Sheet: The Financial Statements sheet integrates all upstream sheets into a complete set of projected income statements, balance sheets, and cash flow statements. The income statement runs from EBITDA to net profit via depreciation, EBIT, net interest expense, earnings before tax (EBT), corporate income tax (with BIN/fiscal-loss carry-forward logic per Article 26 LIS), and net profit. The cash flow statement produces annual free cash flow available for debt service (CFADS) and the equity cash flow series used for levered IRR computation.

SUBSIDIES Sheet: The SUBSIDIES sheet operates as a standalone analytical module that quantifies the financial impact of public support instruments. It models two subsidy types, non-repayable CAPEX grants and IDAE/EIB soft loans. The eligible CAPEX base for grant purposes reflects only the battery modules, PCS, BOP, and eligible civil works under GBER Article 41 and the PERTE ERHA regulatory framework. The sheet outputs adjusted project IRR, adjusted equity IRR, and adjusted DSCR, and derive the minimum grant percentage required to achieve bankability for each scenario.

SUMMARY Sheet: The SUMMARY sheet consolidates the key financial returns, IRR/NPV series, CAPEX structure, revenue composition by scenario, and risk commentary into a single investor-facing dashboard. It presents four scenario columns against defined lender thresholds. The IRR/NPV cash-flow series for all eight streams (project FCF and equity CF per scenario) are embedded directly in this sheet for auditability.

RATIOS Sheet: The RATIOS sheet presents DSCR (CFADS / annual debt service), LLCR (NPV of CFADS to loan maturity / outstanding debt), Interest Coverage Ratio (EBIT / interest), Debt/EBITDA, Net Debt/EBITDA, Equity Ratio, leverage, ROE, ROA, EBITDA margin, EBIT margin, net profit margin, revenue per MWh, OPEX per MWh, and net book value per MW.

Arbitrage Calculator: This ancillary sheet provides a step-by-step derivation of the net OMIE arbitrage spread for each scenario, based on OMIE 2025 average prices, RTE (85%), regulatory exemptions from peajes (Circular 3/2020 CNMC) and cargos (RD 148/2021), imbalance cost, and a dispatch efficiency factor.

7.3. Appendix III – Spanish regulatory, fiscal, and accounting framework

This appendix summarizes the principal Spanish regulatory, fiscal, and accounting provisions relevant to the development and operation of a utility-scale battery energy storage system (BESS) structured through a special purpose vehicle (SPV). The objective is to provide additional technical detail supporting the financial assumptions, tax treatment, and accounting methodology applied throughout the valuation model and scenario analysis.

IBI — Impuesto sobre Bienes Inmuebles (Property Tax)

The Impuesto sobre Bienes Inmuebles (IBI) is a municipal tax levied annually on the cadastral value of real property, including industrial installations, under the Ley Reguladora de las Haciendas Locales (RDL 2/2004). For utility-scale energy storage systems, the tax base is the cadastral value of the fixed infrastructure, principally the battery enclosures, civil works, and grid connection assets, registered in the Catastro Inmobiliario. Applicable rates vary by municipality between 0,4% and 1,1% of cadastral value; the model applies a rate of 0,70% on the total asset value.

In the model, IBI is projected as a fixed percentage of the gross asset base, escalated nominally at the CPI rate (2,0%/yr). The IBI expense is modelled as a fully deductible OPEX item under Article 14 LIS.

Legal Reserve — Ley de Sociedades de Capital (LSC)

Under Article 274 of the Ley de Sociedades de Capital (LSC), Spanish private limited companies (S.L.) and public limited companies (S.A.) are required to appropriate 10% of annual net profit to a legal reserve until it reaches 20% of share capital. This reserve is non-distributable except to offset losses when no other reserves are available. In the context of a BESS SPV, the legal reserve obligation represents a constraint on shareholder distributions in the early operational years, since the SPV's share, capital is sized to satisfy lender equity requirements.

The model implicitly accounts for legal reserve constraints in the equity cash flow series: distributable equity cash flows represent post-dividend amounts after considering the legal reserve appropriation. In the first profitable years, the SPV will be required to set aside a portion of net profit before any distribution to the sponsor.

Corporate Income Tax (IS) — Impuesto sobre Sociedades

The applicable corporate income tax rate is 25% (Article 29 LIS — Ley 27/2014, de 27 de noviembre). The model applies this rate consistently to all scenarios across the full 20-year project life, computed on earnings before tax (EBT) after deducting interest expense and the depreciation shield, per standard Spanish accounting under Plan General Contable (PGC).

Tax Losses and BIN (Bases Imponibles Negativas).

Article 26 LIS governs the treatment of tax losses. Under Spanish law, accumulated negative tax bases (BINs) arising from losses may be carried forward indefinitely. However, for entities with a turnover exceeding €20 million, the annual offset of prior-year BINs is limited to 70% of the positive tax base in the offset year (the '70% cap'), with the remaining 30% minimum tax imposed. The model incorporates the 70% BIN offset limit (parameter in INPUTS), though given the positive EBT trajectory of Scenarios B, C, and D from Year 1, no BINs are accumulated in practice. Scenario A accumulates no BINs because EBT remains marginally positive throughout, though the margin is insufficient to satisfy the WACC hurdle.

Aval (Grid Access Guarantee) - RD 1183/2020

Royal Decree 1183/2020, of 29 December 2020, regulates access and connection to electricity transmission and distribution networks in Spain. Under Article 9 and Annex III of RD 1183/2020, applicants for a new grid access permit are required to post a financial guarantee (aval) with the competent authority (REE or distribution company, as applicable) as a condition of receiving the access and connection permit. For utility-scale projects, the aval is fixed at €40.000 per MW of requested capacity.

The aval represents a refundable deposit for the following reason: upon completion of construction and successful commissioning of the project to its permitted capacity, RD 1183/2020 mandates the restitution of the guarantee to the project developer. The aval is therefore a recoverable financial asset at the point of financial close, constituting a guarantee receivable (fianza constituida) that must be recorded on the balance sheet as a non-current financial asset, not as an intangible or tangible fixed asset. Under the PGC (NRV 9.ª — Instrumentos Financieros), financial guarantees given are initially recognized at fair value and subsequently at the higher of the best estimate of the obligation or the amount recognized at inception.

Because the aval is a recoverable financial instrument and not a productive asset consumed over the project life, it is not subject to depreciation. Classifying the aval as depreciable CAPEX would be a material accounting error under PGC: it would overstate the depreciation charge, understate taxable income in the early years, and misrepresent the asset base. In the model, the aval component within Development CAPEX is therefore excluded from the depreciation base and recorded as a non-depreciable item consistent with its classification as a financial guarantee deposit.

Additional Spanish Fiscal and Regulatory Provisions

AJD — Actos Jurídicos Documentados.

The tax on documented legal acts (AJD) applies to the formalization of the project finance mortgage over the project assets. AJD is calculated on the value of the mortgage deed, which is set at the total senior debt plus interest (typically 125% to 150% of principal). In the model, the AJD rate is applied to the senior debt principal as a simplification. AJD is a one-time capital expenditure capitalized as part of financing costs and depreciated as part of the total CAPEX base. AJD rates vary significantly by autonomous community, from 0% (País Vasco) to 1,5% (Andalucía, Cataluña, Murcia), and the model's INPUTS sheet incorporates a dynamic AJD rate look-up table enabling the user to select the project's autonomous community.

ICIO — Impuesto sobre Construcciones, Instalaciones y Obras.

The tax on construction works (ICIO) is levied by the municipality on the cost of works requiring a municipal building permit (licencia urbanística). The standard rate ranges from 2% to 4% of the construction budget.

IAE — Impuesto sobre Actividades Económicas.

The business activity tax (IAE) is a municipal tax levied on entities carrying out economic activities. For grid-connected electricity generation and storage operations, IAE is calculated on installed capacity in kW at a rate of approximately €0,72/kW/yr. IAE is modelled as a recurring OPEX item, escalated at CPI (2,0%/yr), and is fully deductible against IS.

VAT (IVA).

The standard VAT rate of 21% applies to most CAPEX components. For SPV-structured projects registered for VAT, input VAT on construction costs is fully recoverable from the Spanish Tax Authority (AEAT) through the standard refund mechanism (Modelo 303/308). The model notes an estimated recovery lag of 6–12 months for the construction-phase IVA. This IVA refund delay constitutes a working capital funding requirement during construction that must be incorporated into the financial close equity/bridge financing structure.

RD 148/2021 and Circular 3/2020 CNMC — Storage Exemptions.

Two critical regulatory provisions directly enhance the arbitrage economics of grid-connected BESS: (1) RD 148/2021 explicitly exempts energy storage facilities from system charges (cargos del sistema) on electricity consumed for charging, and (2) CNMC Circular 3/2020 exempts BESS connected to the transmission or distribution network from access tolls (peajes de acceso) on energy charged.