SADE PVInvest

RPT-2F72C507
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# Pre-Feasibility Report

## PV + BESS Project

**Prepared by:** Super Admin

**Report date:** 12 June 2026

**Coordinates:** 45.6113N, 5.6322E

**Altitude:** 210 m a.s.l.

**DC Capacity:** 19.825 MWp

**Annual Yield P50:** 26,447 MWh/yr

**Annual Yield P90:** 24,322 MWh/yr

**LCOE:** 3.94 cEUR/kWh

**IRR:** 52.8%

**Site Area:** 27.47 ha (274,684 m2)

**Layout Panels:** 26,791 modules x 19.825 MWp

**Simulation Weather Source:** PVGIS



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# 1. Executive Summary [PV]

| | |
|---|---|
| DC Installed Capacity | 19.825 MWp |
| Number of Modules | 26,791 |
| Annual Energy (P50) | 26,447 MWh/yr |
| Annual Energy (P90) | 24,322 MWh/yr <- lender reference |
| Specific Yield | 1,338 kWh/kWp/yr |
| Performance Ratio | 84.7% |
| Combined Uncertainty 1-sigma | 6.2% |
| CAPEX | EUR 8.92M (EUR 0.450/Wp) |
| NPV (25yr) | EUR 51.88M |
| IRR | 52.8% |
| LCOE | 3.94 cEUR/kWh |
| Simple Payback | 1.9 years |
| CO2 Avoided (annual) | 11,940 t CO2/yr |

P90 represents the annual yield exceeded in 9 out of 10 years based on combined meteorological and model uncertainty (IEC 61724-1:2021 Annex C). It is the standard reference for project debt sizing.

# 2. System Configuration [PV]

## Site Layout

| | |
|---|---|
| Site Area | 27.4700 ha (274,684 m²) |
| Layout Panel Count | 26,791 modules |
| DC Capacity (layout) | 19.825 MWp |
| Total Vertices | 4 |
| BESS Layout Capacity | 59.48 MWh (59,475 kWh) |

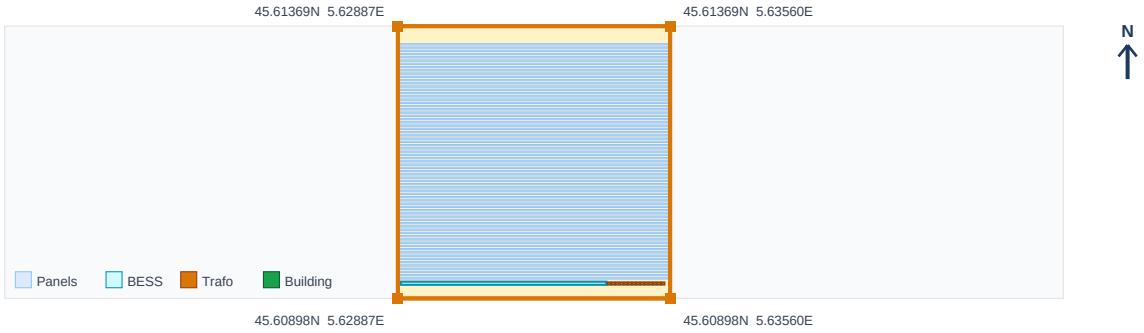



*Figure — Parcel boundary schematic (north up). Blue = panel rows, cyan = BESS, amber = transformers, green = building. Corner labels in WGS84 decimal degrees.*

## Parcel Corner Coordinates (WGS84)

| # | Latitude (°N) | Longitude (°E) |
|---|---|---|
| 1 | 45.608984 | 5.628867 |
| 2 | 45.608984 | 5.635598 |
| 3 | 45.613692 | 5.635598 |
| 4 | 45.613692 | 5.628867 |

## Module

| | |
|---|---|
| Manufacturer / Model | Jinko Solar JKM740N-82HL4-MPS Tiger Neo 740W |
| Cell Technology | N-type TOPCon |
| Rated Power (STC) | 740 Wp |
| Open-Circuit Voltage Voc | 49.30 V |
| Short-Circuit Current Isc | 20.18 A |
| Temp. Coeff. Pmax | -0.300 %/degC |
| Bifaciality Factor | 0.80 |
| Module Area | 3.216 m2 |
| Module Efficiency (STC) | 23.00% |

## Inverter & DC Stringing

| | |
|---|---|
| **Manufacturer / Model** | Huawei SUN2000-125KTL-M0 |
| **AC Rated Power** | 125 kW |
| **MPPT Voltage Range** | 200 - 1500 V |
| **Max. DC Voltage** | 1500 V |
| **Number of Inverters** | 145 |
| **Modules per String** | 27 |
| **Strings per Inverter** | 7 |
| **Total DC Strings** | 1,015 |
| **String Voc (STC-10 degC cold)** | 1454 V |
| **String Vmp (nominal 25 degC)** | 1107 V |
| **DC/AC Ratio** | 1.120 |

# 3. Meteorological Data [PV]

Irradiation and weather data from PVGIS 5.2 (JRC, European Commission). Typical Meteorological Year (TMY) compiled per ISO 15927-4:2005 -- Finkelstein-Schafer statistics, 12 representative months selected from >=15 years of satellite radiation data. Hourly resolution (8 760 records/yr) used for all energy calculations.

| Month | AC Energy (kWh/yr) |
|---|---|
| Jan | 1,248,083 |
| Feb | 1,601,250 |
| Mar | 2,362,958 |
| Apr | 2,168,903 |
| May | 3,426,887 |
| Jun | 2,775,615 |
| Jul | 3,105,244 |
| Aug | 3,181,308 |
| Sep | 2,513,688 |
| Oct | 2,187,424 |
| Nov | 1,191,677 |
| Dec | 771,365 |
| **Annual Total** | **26,534,404** |

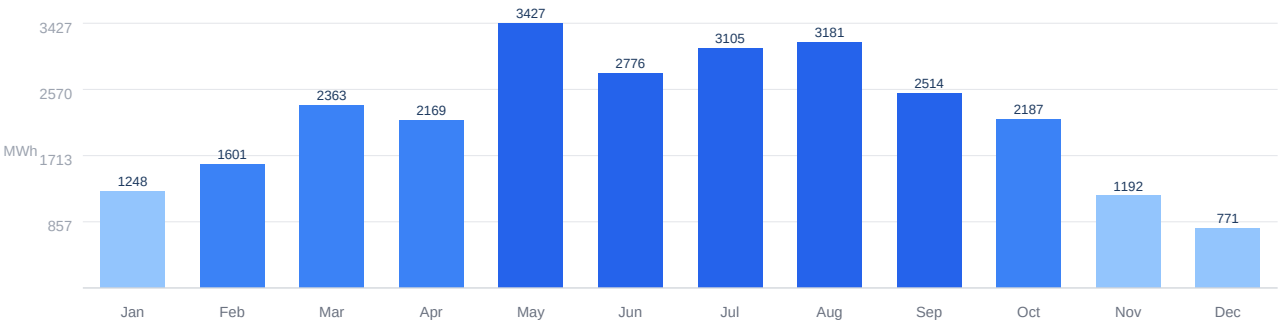



*Figure 1 -- Monthly AC energy production (MWh). Values above bars in MWh.*

## Weather Source Cross-Validation

Annual GHI independently verified against PVGIS 5.2 (JRC European Commission) and NASA POWER (NASA Langley Research Center) per IEC 61724-1:2021 S5.2 cross-validation requirement. Differences <=5% are considered acceptable.

| | |
|---|---|
| **PVGIS 5.2 (JRC) Annual GHI** | 1,501 kWh/m2/yr <- used for simulation |
| **NASA POWER Annual GHI** | 1,367 kWh/m2/yr |
| **Difference (NASA - PVGIS)** | -8.9% -- Exceeds +/-5% -- additional source recommended |
| **Simulation Source** | PVGIS |

*Figure -- Annual GHI comparison: PVGIS 5.2 (blue) vs NASA POWER (green). Arrow (<-) indicates source used for energy simulation.*

WARNING: GHI difference -8.9% between PVGIS 5.2 and NASA POWER exceeds the IEC 61724-1:2021 +/-5% independent-source acceptance criterion. Site-specific measurement data or a third independent dataset is recommended before final investment decision.

## 4. Loss Analysis [PV]

Loss chain follows IEC 61724-1:2021. Each factor is applied sequentially from plane-of-array irradiance to net AC energy at the point of connection.

| Loss Component | Value (%) | Standard Reference |
|---|---|---|
| Cell temperature derating | -0.93 | IEC 61215-2:2021 S8 |
| IAM optical (angle-of-incidence) | -6.14 | IEC 61853-2:2016 |
| Soiling / contamination | -2.00 | IEC 61724-1:2021 |
| LID (light-induced degradation) | -1.50 | IEC 61724-1:2021 |
| Module mismatch | -1.00 | IEC 61724-1:2021 |
| DC wiring ohmic | -1.50 | IEC 61724-1:2021 |
| Inverter conversion | -1.20 | IEC 61683:2021 |
| AC wiring | -0.50 | IEC 60364-7-712:2017 |
| MV transformer | -1.00 | IEC 60076-1:2011 |
| System availability | -1.00 | IEC 61724-1:2021 |

*Net Performance Ratio: 84.7% (IEC 61724-1: AC energy / (GHI x module area x STC efficiency))*

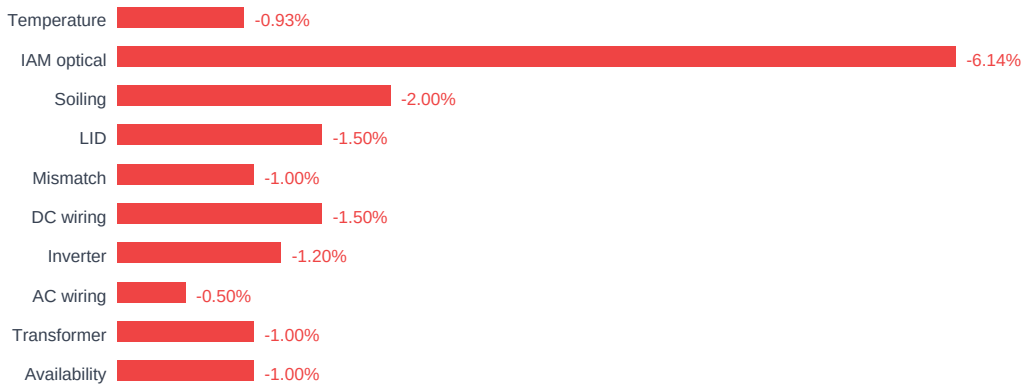



*Figure 2 -- Loss cascade components. Green = gain.*

# 5. Yield Uncertainty & Exceedance Probability [PV]

Uncertainty evaluated per IEC 61724-1:2021 Annex C -- RSS combination of independent uncertainty sources. Monte Carlo with 2 000 samples from a lognormal distribution.

## Uncertainty Budget

| Uncertainty Source | 1-sigma Value (%) |
|---|---|
| Ghi Interannual | 4.0 |
| Ghi Model | 3.0 |
| Transposition | 2.0 |
| Module Power | 2.0 |
| Temperature Model | 1.5 |
| Soiling | 1.0 |
| Mismatch Wiring | 1.0 |
| Inverter | 0.5 |
| Availability | 1.0 |
| **Combined RSS -- 1-sigma** | **6.2** |

## Annual Yield Exceedance Probabilities

| Level | MWh/yr | Definition | Primary Use Case |
|---|---|---|---|
| P50 | 26,447 | 50% of years exceed this | Energy contracts |
| P70 | 25,585 | 70% of years exceed this | Conservative planning |
| P90 | 24,322 | 90% of years exceed this | Debt sizing reference |
| P99 | 22,830 | 99% of years exceed this | Worst-case / insurance |


*Figure 3 -- Annual yield at exceedance probabilities. P90 (amber) is the lender reference.*

*P90 = 10th percentile of simulated distribution. In lender convention, P90 = energy exceeded in 90% of years.*

# 6. Financial Analysis [PV]

| | |
|---|---|
| CAPEX | EUR 8.92M (EUR 0.450/Wp) |
| OPEX (annual) | EUR 198,253/yr |
| Electricity Tariff | 18.00 cEUR/kWh |
| Discount Rate (WACC) | 7.0% |
| Project Lifetime | 25 years |
| NPV (25yr) | EUR 51.88M |
| IRR | 52.8% |
| LCOE | 3.94 cEUR/kWh (IEC TR 62936:2020) |
| Simple Payback | 1.9 years |
| CO2 Avoided (annual) | 11,940 t CO2/yr |
| CO2 Avoided (25yr) | 298,512 t CO2 |

## Cumulative Cash Flow Milestones

| Year | Cumulative CF (EUR M) | Cumulative CF / CAPEX |
|---|---|---|
| 1 | EUR -4.34M | -48.7% |
| 5 | EUR 14.65M | 164.2% |
| 10 | EUR 40.00M | 448.4% |
| 15 | EUR 67.27M | 754.1% |
| 20 | EUR 96.60M | 1082.8% |
| 25 | EUR 128.13M | 1436.3% |

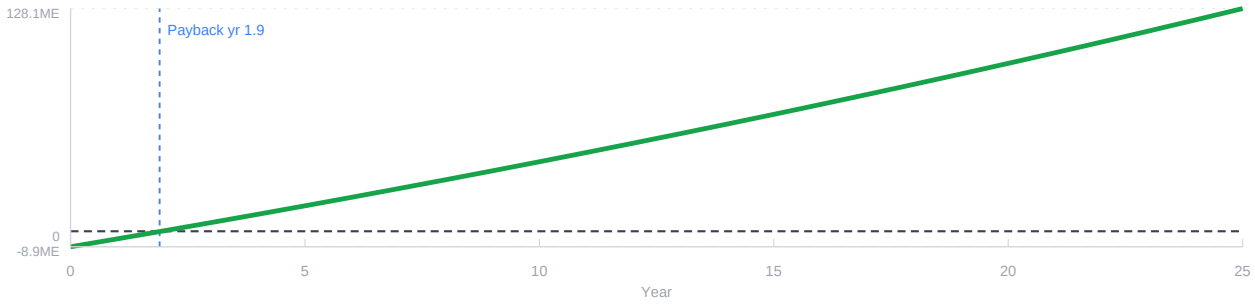



*Figure 4 -- Cumulative cashflow over 25-year project lifetime (MEUR). Blue dashed line = simple payback year.*

*LCOE per IEC TR 62936:2020. CO2 grid factor: 0.5 kg CO2/kWh (IEC TS 62257-9-8 basis).*

# 7. Bill of Quantities [PV]

Indicative Bill of Quantities derived from simulation inputs per IEC 62548:2016. Quantities follow standard industry sizing rules (string combiners at 12 strings, cable runs estimated from GCR and panel count). Actual prices depend on project scale, region, and market conditions.

## PV Modules

| Item | Specification | Qty | Unit |
|---|---|---|---|
| Jinko Solar JKM740N-82HL4-MPS Tiger Neo 740W | 740Wp N-type TOPCon — 3.22m² — η23.0% | 26,791 | pc |

## Inverters

| Item | Specification | Qty | Unit |
|---|---|---|---|
| Huawei SUN2000-125KTL-M0 | 125kW AC, 200–1500V MPPT | 145 | pc |

## Mounting Structures

| Item | Specification | Qty | Unit |
|---|---|---|---|
| Ground-mount fixed-tilt frame (hot-dip galvanised) | Dual-portrait, 2 modules/frame, wind class II per EN 1991-1-4 | 13,396 | frame |
| Driven steel pile Ø76mm × 1.5m | Hot-dip galvanised S355, 4 piles/frame | 53,584 | pc |

## DC Wiring & Protection

| Item | Specification | Qty | Unit |
|---|---|---|---|
| DC string cable 6mm² (H1Z2Z2-K) | 1.5kV DC rated, halogen-free, UV resistant | 56,840 | m |
| DC main cable 16mm² (H1Z2Z2-K) | 1.5kV DC, SCB to inverter DC inputs | 4,250 | m |
| DC string combiner box (12-input, IP65) | 12-input, fused, monitoring connector, stainless hardware | 85 | pc |
| DC string fuse 10A gPV (10×38mm) | 1000V DC, 10A, aR/gPV | 1,015 | pc |
| DC surge protector Type II (1000V DC) | Imax 40kA 8/20us, pluggable varistor module | 85 | pc |
| DC load-break isolator 1000V / 32A | 2-pole, 1000V DC, 32A, lockable | 1,160 | pc |

## AC Wiring & Protection

| Item | Specification | Qty | Unit |
|---|---|---|---|
| AC output cable 35mm² (YKY / FG16OR16) | 0.6/1kV, XLPE insulated, 4-conductor | 21,750 | m |
| AC main circuit breaker | 4-pole, rated to inverter output, Icu >=10kA | 145 | pc |
| AC surge protector Type II (275V AC) | Imax 40kA, 3P+N, pluggable module | 145 | pc |

## Medium Voltage

| Item | Specification | Qty | Unit |
|---|---|---|---|
| Dry-type MV transformer 953kVA | 953kVA, 0.4/10(20)kV, AN cooling, IP23 enclosure | 19 | pc |
| MV ring main unit (RMU) 24kV | SF6 insulated, 2x cable + 1x transformer bay | 19 | pc |

## Monitoring & Control

| Item | Specification | Qty | Unit |
|---|---|---|---|
| Plant data logger / SCADA gateway | RS-485 Modbus + Ethernet + 4G, cloud telemetry | 1 | lot |
| On-site weather station | Class-A pyranometer, ambient + module temp, anemometer | 1 | set |

| | | | |
|---|---|---|---|
| Revenue-grade smart meter (MID Class 0.5S) | Class 0.5S active energy, MID 2014/32/EU certified | 1 | pc |

## Civil & Site Works

| Item | Specification | Qty | Unit |
|---|---|---|---|
| Security perimeter fence (2m height) | Galvanised chain-link, concrete posts, anti-climb top rail | 2,134 | m |
| Internal gravel access road (4m width) | 200mm compacted gravel, geotextile base, drainage gradient | 232 | m |
| Cable trenching (300x700mm) | 300mm wide, 700mm deep, sand bedding, warning tape, reinstatement | 21,402 | m |
| Earthing / grounding system | Copper mesh 50mm², driven earth rods, surge arresters, R < 5 Ohm | 1 | lot |

*Quantities are indicative for preliminary budgeting. Cable runs and civil works require a detailed site survey. Excludes grid connection, planning permits, insurance, EPC margin, and land acquisition.*

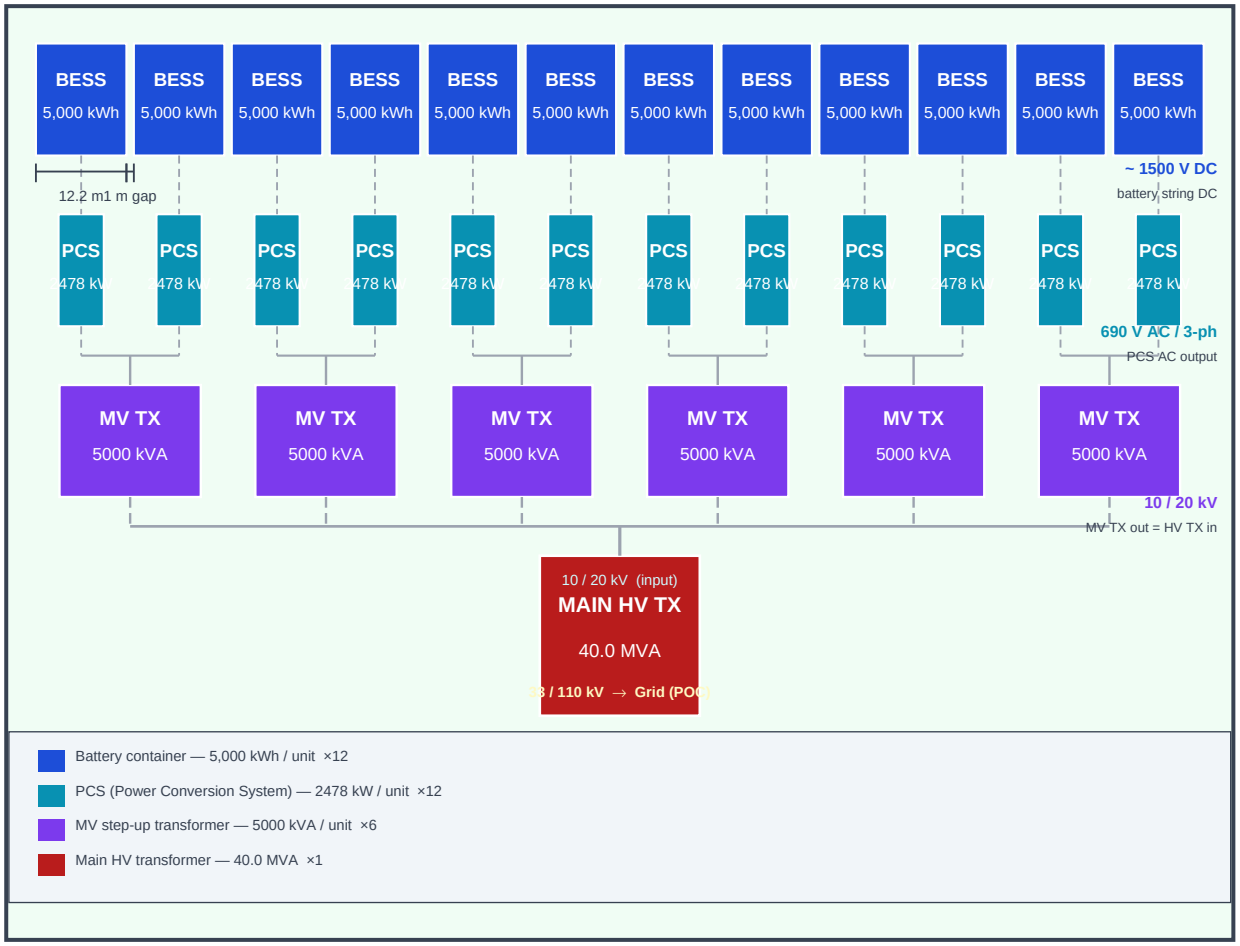
**Contact info@sade.systems for a detailed quotation**

# 8. Battery Storage (BESS) Investment Analysis [BESS]

## System Summary

| | |
|---|---|
| Storage Capacity | 59,475 kWh (59.48 MWh) |
| PCS Power | 29,738 kW (C-rate 0.5) |
| Container Size | 5,000 kWh per container |
| Number of Containers | 12 |
| Annual Cycles | 365 cycles/yr |
| Annual Charged | 19,537,538 kWh/yr (19537.5 MWh/yr) |
| Annual Discharged | 17,583,784 kWh/yr (17583.8 MWh/yr) |
| Round-Trip Losses | 1,953,754 kWh/yr |
| Tariff Spread | 8.00 c-EUR/kWh (peak - off-peak) |

## Indicative Site Layout




*Schematic site arrangement (indicative, not to scale). 12 × 5000 kWh containers, 6 × 5000 kVA MV step-up TX, 40.0 MVA main HV TX.*

## Financial Summary

| | |
|---|---|
| Total CAPEX | EUR 18,883,312 (318 EUR/kWh all-in) |
| OPEX / Year | EUR 283,250/yr |

| | |
|---|---|
| Year-1 Net Cashflow | EUR 3,294,291 |
| Year-1 Revenue (total) | EUR 3,577,540 |
| IRR | 15.9% (20-year DCF) |
| NPV | EUR 14,045,433 |
| Simple Payback | 5.8 years |
| LCOE | 14.32 c-EUR/kWh (discounted energy cost) |

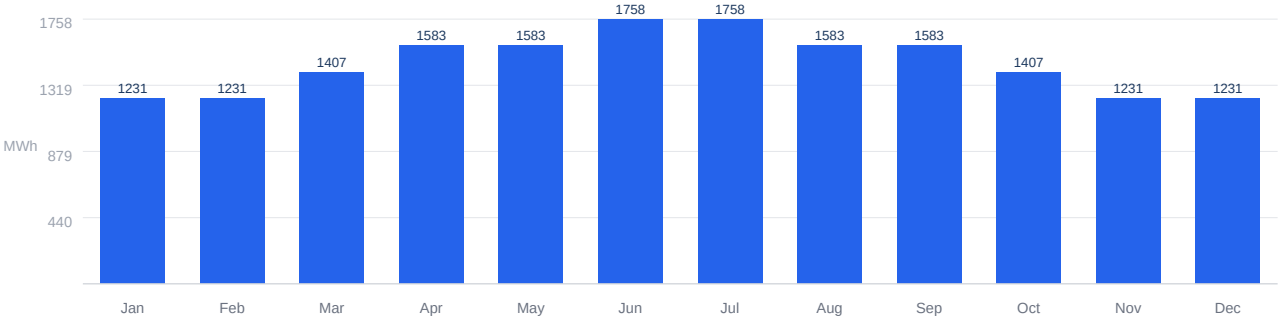
## Year-1 Revenue Breakdown

| | |
|---|---|
| Arbitrage (price spread) | EUR 1,406,703 (39%) |
| FCR (Frequency Containment Reserve) | EUR 892,125 (25%) |
| aFRR (auto Frequency Restoration Reserve) | EUR 446,062 (12%) |
| mFRR (manual Frequency Restoration Reserve) | EUR 237,900 (7%) |
| Capacity Market | EUR 594,750 (17%) |

## 20-Year Cumulative Cashflow


*Cumulative cashflow over 20-year project lifetime (EUR)*

## Monthly Discharge Profile (Year 1)




*Estimated monthly discharge kWh, Year 1 (before degradation). Seasonal weights based on typical grid price variability.*

## Bill of Quantities (BOQ)

| Component | Qty | Unit | Note |
|---|---|---|---|
| LFP battery container (5 MWh / 20-ft) | 12 | pcs | 59.5 MWh total, incl. BMS |
| Spare battery modules (2%) | 1 | pcs | O&M; stock |

| | | | |
|---|---|---|---|
| Bidirectional PCS (~2480 kW) | 12 | pcs | 29.7 MW total, 4Q inverter |
| 5000 kVA LV/MV step-up transformer | 6 | pcs | 0.4/10(20) kV, ~2 container(s)/unit |
| MV switchgear / ring main unit | 1 | set | IEC 62271-202 |
| LV AC cable 240 mm2 (3-phase) | 1440 | m | container to transformer |
| MV cable 95 mm2 (3-phase) | 2700 | m | to grid point of connection |
| HVAC / thermal management | 12 | set | container climate control |
| Fire detection & suppression | 12 | set | NFPA 855 / FM Approved |
| Container foundation / plinth | 12 | pcs | concrete pad |
| Earthing & lightning protection | 1 | set | IEC 62305 |
| EMS / SCADA + market interface | 1 | lot | IEC 62933-5-1 |
| Revenue-grade metering | 6 | pcs | MID-certified |
| Civil works (fencing + access) | 504 | m2 | 42 m2/container incl. clearances |

*Rule-of-thumb quantities for preliminary design and budgeting. Excludes grid connection, permits, EPC margin and land. Detailed engineering required per NFPA 855 / IEC 62933.*

# 9. PV + Storage Dispatch & Combined Economics [PV+BESS]

In a co-located PV + storage plant the battery is charged primarily by on-site solar generation; surplus PV is exported directly to the grid, and the stored energy is shifted to higher-value peak and ancillary-service windows. The flows below quantify this operating strategy.

## Annual Energy Flows

| | |
|---|---|
| PV generation (AC) | 26,534,404 kWh/yr (26534.4 MWh) |
| PV -> battery (charging) | 19,537,538 kWh/yr (19537.5 MWh) |
| PV -> grid (direct export) | 6,996,866 kWh/yr (6996.9 MWh) |
| Grid -> battery (top-up) | 0 kWh/yr |
| Battery discharge | 17,583,784 kWh/yr (17583.8 MWh) |
| Battery charging covered by PV | 100% |
| PV cycled through battery | 73.6% (rest exported directly) |
| PV exported directly | 26.4% |

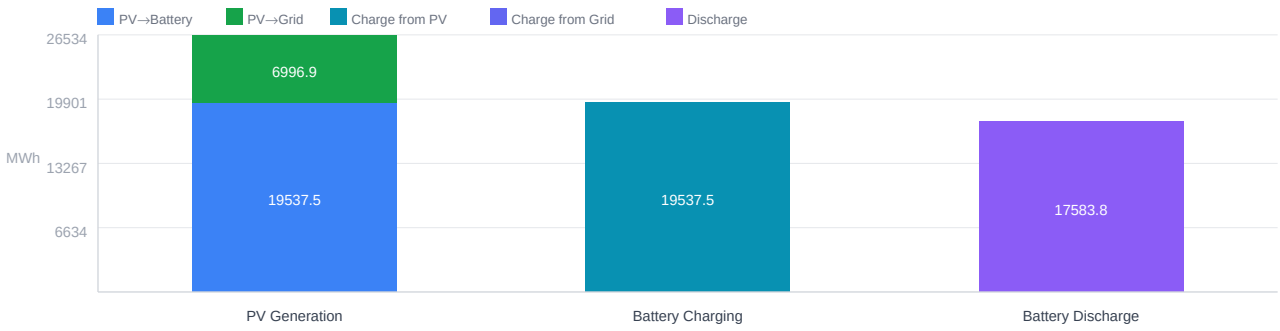



*Figure — Annual energy dispatch flows (MWh). PV generation is split between direct battery charging and direct grid export. Battery column shows charge sources (from PV vs. grid top-up). Discharge column shows energy delivered to the grid.*

## PV Self-Supply Benefit (indicative)

| | |
|---|---|
| On-site PV charging cost | 3.94 c-EUR/kWh (PV LCOE) |
| Avoided grid off-peak cost | 7.00 c-EUR/kWh |
| Energy charged from PV | 19,537,538 kWh/yr |
| Annual self-supply benefit | EUR 597,849/yr |

*Indicative upside from charging the battery with on-site PV (at its LCOE) instead of purchasing grid power at the off-peak tariff. Shown separately; the combined NPV/IRR below treats the PV and BESS revenue streams independently (conservative).*

## Combined Project Economics

| | |
|---|---|
| Total CAPEX (PV + BESS) | EUR 27,804,715 (27.80 M-EUR) |
| Combined IRR | 28.8% |
| Combined NPV | EUR 65,923,552 (65.92 M-EUR) |
| Combined Payback | 3.5 years |

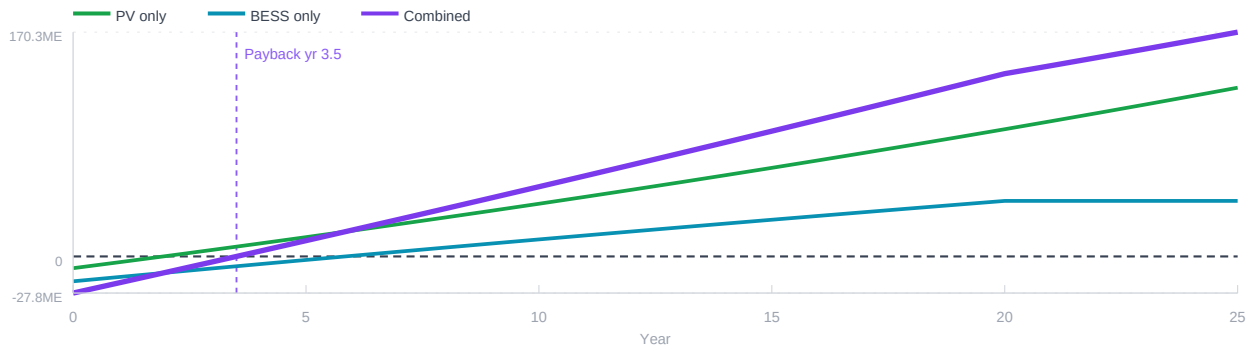



*Figure — Cumulative cashflow over project lifetime. Green = PV standalone, Cyan = BESS standalone, Violet = combined portfolio. The combined curve reaches breakeven at the marked payback year.*

*Combined figures aggregate the PV plant and the battery system. PV export revenue and BESS arbitrage / ancillary revenue are modelled independently; the dispatch flows above describe the physical integration of the two assets.*

# 10. Methodology & Standards Reference

## Solar PV

| Component | Method / Model | Reference |
|---|---|---|
| Solar geometry | Sun position -- zenith, azimuth, hour angle | ISO 52010-1:2017 |
| Irradiance transposition | GHI -> POA sky diffuse + ground-reflected | IEC 61853-3:2018 Annex B |
| Cell temperature | Thermal derating above 25 degC STC (U0 + U1 x wind speed) | IEC 61215-2:2021 S8 |
| IAM correction | Fresnel + Beer-Lambert physical model | IEC 61853-2:2016 |
| Energy loss cascade | 10-step sequential loss chain | IEC 61724-1:2021 S6.2 |
| Bifacial rear irradiance | Infinite-sheds, rear-side albedo-weighted | IEEE 1907.1-2020 |
| DC string sizing | Voltage at temperature extremes | IEC 62548:2016 S4.6 |
| Uncertainty analysis | Monte Carlo 2 000 samples, lognormal RSS | IEC 61724-1:2021 Annex C |
| Financial DCF | 25-yr NPV / IRR / LCOE / CO2 | IEC TR 62936:2020 |
| Weather data source | TMY per Finkelstein-Schafer statistics | ISO 15927-4:2005; PVGIS 5.2 (JRC) |
| Weather cross-validation | Independent PVGIS 5.2 vs NASA POWER GHI check | IEC 61724-1:2021 S5.2 |

## Battery Storage

| Component | Method / Model | Reference |
|---|---|---|
| BESS sizing | Capacity -> container count; PCS at C-rate 0.5 | IEC 62933-2-1:2018 |
| Round-trip efficiency | AC-AC efficiency incl. PCS + auxiliary draw | IEC 62933-2-1:2018 S6 |
| Capacity degradation | Calendar + cycle ageing, linear fade per year | IEC 62933-5-2:2020 |
| Energy arbitrage | Off-peak charge / peak discharge dispatch | Tariff spread model |
| Ancillary services | FCR / aFRR / mFRR capacity revenue stacking | EU 2017/1485 (SO GL) |
| Capacity market | De-rated capacity availability payment | EU 2019/943 Art. 21-27 |
| Financial DCF | 20-yr NPV / IRR / LCOS / payback | IEC 62933-1; IRENA ESVT |
| Safety & fire | Container fire detection + suppression | NFPA 855:2023; IEC 62933-5-2 |
| Grid connection | MV step-up + protection coordination | IEEE 1547-2018; IEC 62271-202 |

*PVGIS 5.2 data: (c) European Union 2001-2024 (Joint Research Centre, European Commission). NASA POWER data: NASA Langley Research Center (LaRC) POWER Project. Standards: IEC (International Electrotechnical Commission), ISO (International Organization for Standardization), IEEE (Institute of Electrical and Electronics Engineers). Battery standards: IEC 62933 (electrical energy storage systems), NFPA 855:2023 (stationary energy storage installations), EU 2017/1485 & EU 2019/943 (European electricity market & balancing). Revenue assumptions reflect 2024-25 European ancillary-service averages and should be confirmed against the local TSO/DSO market rules.*

## 11. Disclaimer

This pre-feasibility report has been prepared by SADE PVInvest solely for informational purposes. energy yield and financial projections are based on computer simulation using PVGIS 5.2 TMY data for the PV plant and battery dispatch / market-revenue assumptions for the storage. Actual performance may differ materially due to: inter-annual meteorological variability, market price volatility, ancillary-service rule changes, equipment degradation, soiling, grid curtailment, actual costs, and regulatory changes.

This report is not an independent technical energy assessment. Users should commission an independent technical due diligence study before project development or financing.

*PVGIS data: (c) European Union 2001-2024 (JRC). Generated by SADE PVInvest on 12 June 2026.*