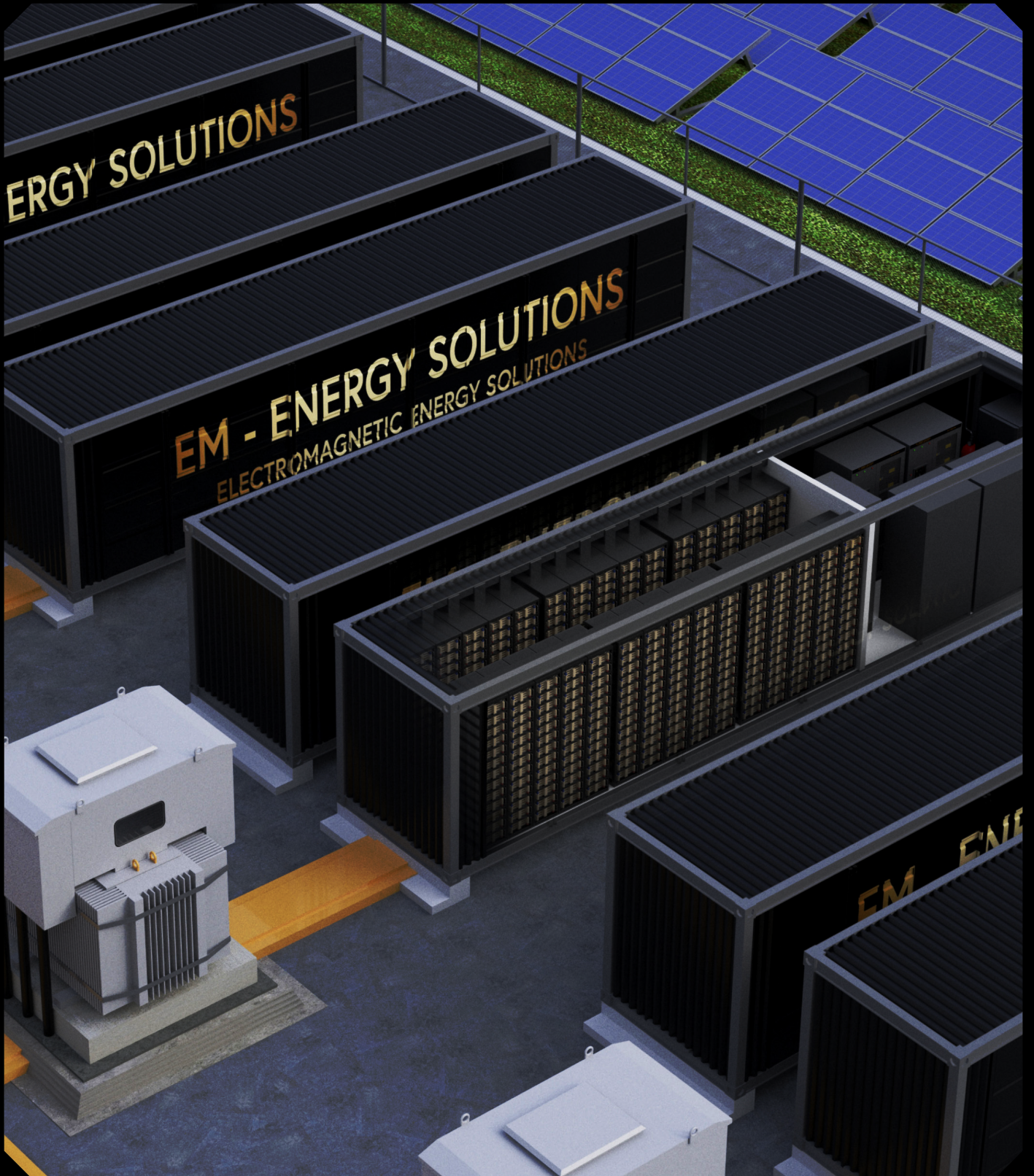


ESS - CPT

Energy Storage System - Clean Power Technology



EM ENERGY SOLUTIONS

EM ENERGY SOLUTIONS

EM (ElectroMagnetic) Energy Solutions is a global company with head office in Trondheim, Norway. EM Energy Solutions designs, manufactures and markets a wide range of world leading power quality and energy optimization solutions, including megawatt scale energy storage systems.

EM Energy Solutions exists to help customers save energy, improve productivity and increase process efficiency, while enabling high penetration of renewable energy through grid code compliance.

EM Energy Solutions is an important player in the fight against climate change and in efforts to improve material and process efficiency.



Power Quality Experts



Innovative



Global Presence



Quality Products and Services

Industry is facing new challenges

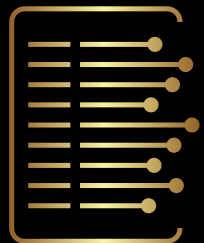
As consumers become active power producers who demand clean, reliable and affordable power, the transforming grid needs innovative technical solutions that can unlock new business models and revenue streams.

This change to energy generation and consumption is being driven by three powerful trends: the arrival of increasingly affordable distributed power technologies, decarbonization of the world's electricity network through the introduction of more renewable energy sources, and the emergence of digital technologies.



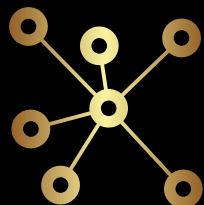
Renewables

The rapid deployment of low-carbon technologies such as wind and solar is making it increasingly difficult to forecast variable generation, creating challenges around grid stability, congestion and market volatility.



Modernization & Digitization

A rise in the number of connected devices and smart sensors enables fast decision-making on dynamic and nodal prices, while intelligent control systems and internet-enabled software optimize power plants and the grid.



Decentralization

The rapid growth of distributed energy resources, including renewables and storage, is creating more small scale producers, greatly increasing distribution grid complexity.

Integrating intermittent renewables into an aging grid requires flexible and resilient technologies, able to ramp quickly and dynamically adjust to real-time grid signals.

Enabling renewable energy integration & market transition

Benefits:

- Energy savings
- Smooth integration of renewable energy
- Reliable energy supply in real-time
- Balanced energy supply and demand
- Improvement of power quality
- Uninterrupted power
- Off-grid capacity

Ability to participate in:

- Frequency response services
- Electricity market



How can energy storage help me?

A battery energy storage solution offers new application flexibility and unlocks new business value across the energy value chain, from conventional power generation, transmission & distribution, and renewable power, to industrial and commercial sectors. Energy storage supports diverse applications including firming renewable production, stabilizing the electrical grid, controlling energy flow, optimizing asset operation and creating new revenue.

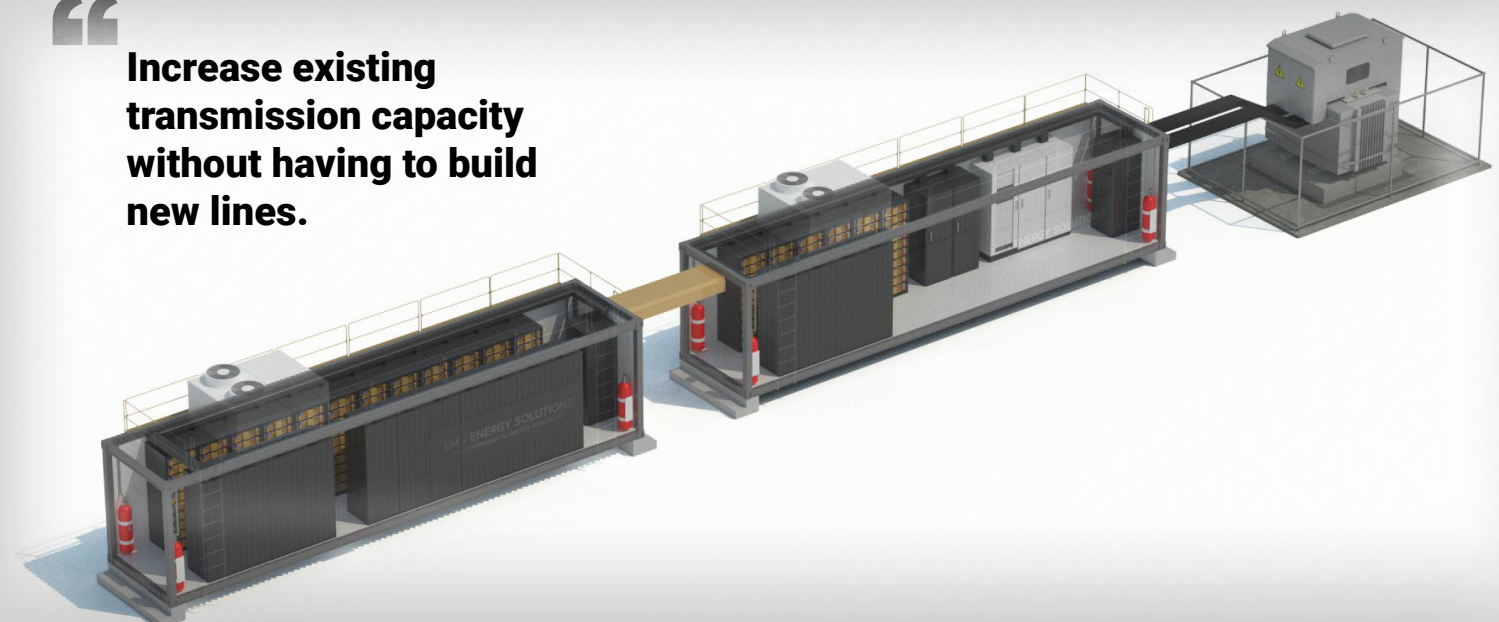
For renewables developers, energy storage offers a faster alternative to a PPA, which may have a lead time of a year or more. For utilities, energy storage offers relevancy with increased distributed generation.

Energy storage can help you increase the dispatchability and predictability of renewables, helping to meet strict code and connection permits.

Transmission and distribution (T&D) architecture buildout and upgrades could, in some cases, be deferred by the use of strategically-located energy storage systems.



Increase existing transmission capacity without having to build new lines.



ESS - CPT

Energy Storage System - Clean Power Technology

EM Energy Solutions Energy Storage Systems (ESS), built on state-of-the-art technology are modular solutions in terms of output power and energy.

A variety of operation modes and the flexibility to connect to any voltage level make EM Energy Solutions ESS a preferred solution for complete electricity system value chain starting from generation. Particularly suitable for renewable energy integration, from Transmission and Distribution (T&D) down to hybrid, island and micro grids.

Built-in flexible design permits easy scalability to deliver a customized solution from a few hundreds of kWh to several hundred MWh.



Transmission and distribution grids

- ✓ Frequency regulation
- ✓ Power flow optimization
- ✓ Spinning reserve
- ✓ System stability improvement
- ✓ Voltage control

Wind, solar and engine-hybrid power plants

- ✓ Peak shaving
- ✓ Ramp rate management
- ✓ Bridging plant to Frequency response service market
- ✓ Energy shifting
- ✓ Power dispatch management

Industrial grids, micro grids and hybrid systems

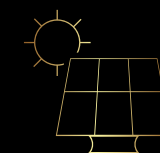
- ✓ Energy management for alternative sources, including solar, wind and fossil fuel plants
- ✓ Black start functionality
- ✓ Peak shaving
- ✓ Power quality compliance
- ✓ Voltage and frequency control
- ✓ Bridging energy sources to Frequency response services market



Battery storage is suitable for many applications, either deployed as a stand-alone system or as part of a hybrid power system integrated with engines, turbines and / or renewables. Flexible power capacity makes EMES ESS easily scalable for different applications. Utilities improve their power quality. Islands and microgrids can increase their renewable penetration, which results in lower levelized electricity costs. Industrial customers can improve their investment and energy costs while ensuring security of power supply.



Reduce Fuel Use
and carbon dioxide emissions with a greater use of clean electricity powered by wind and solar.



Increase Resiliency,
manage the intermittence of renewable energy production and improve overall resiliency when the wind does not blow and when the sun doesn't shine.



Improve Power Quality
and reliability during outages or disturbances in the grid, affecting their operation.



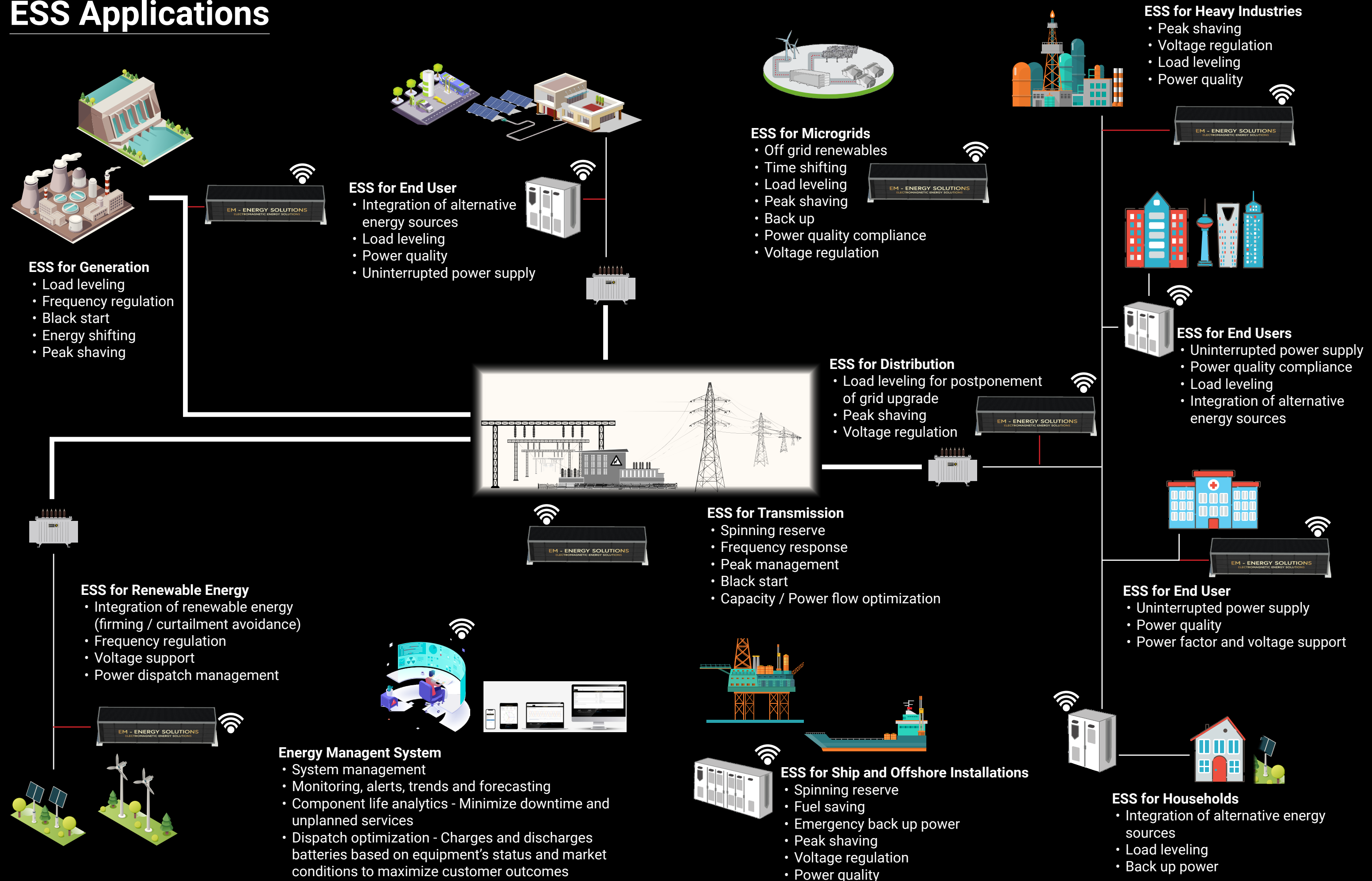
Save Money,
reduce utility bills and generate revenue, avoid costly system upgrades, reduce operating expenses.



Generate Income
balancing electricity supply and demand, frequency response, capacity market, increased asset utilization.



ESS Applications



Modular and Scalable Solution

SYSTEM CONFIGURATIONS

EMES ESS are designed to be highly flexible and modular in regard to power and capacity. The configuration depends on the required application. In an energy configuration, the batteries are used to inject a steady amount of power into the grid for an extended period of time. In a power configuration, the batteries are used to inject a large amount of power into the grid over a short period of time. The configuration of power or energy is determined by the ratio of PCS inverters to batteries.

Thanks to this flexibility, energy storage systems can be used in a wide range of different applications. System operators, utilities, small scale producers as well as industrial and commercial customers can significantly improve the cost-effectiveness, security and sustainability of their energy supply.



20ft ESS - CPT container



40ft ESS - CPT container



MORE ENERGY

Additional batteries are added to achieve desired energy output



MORE POWER

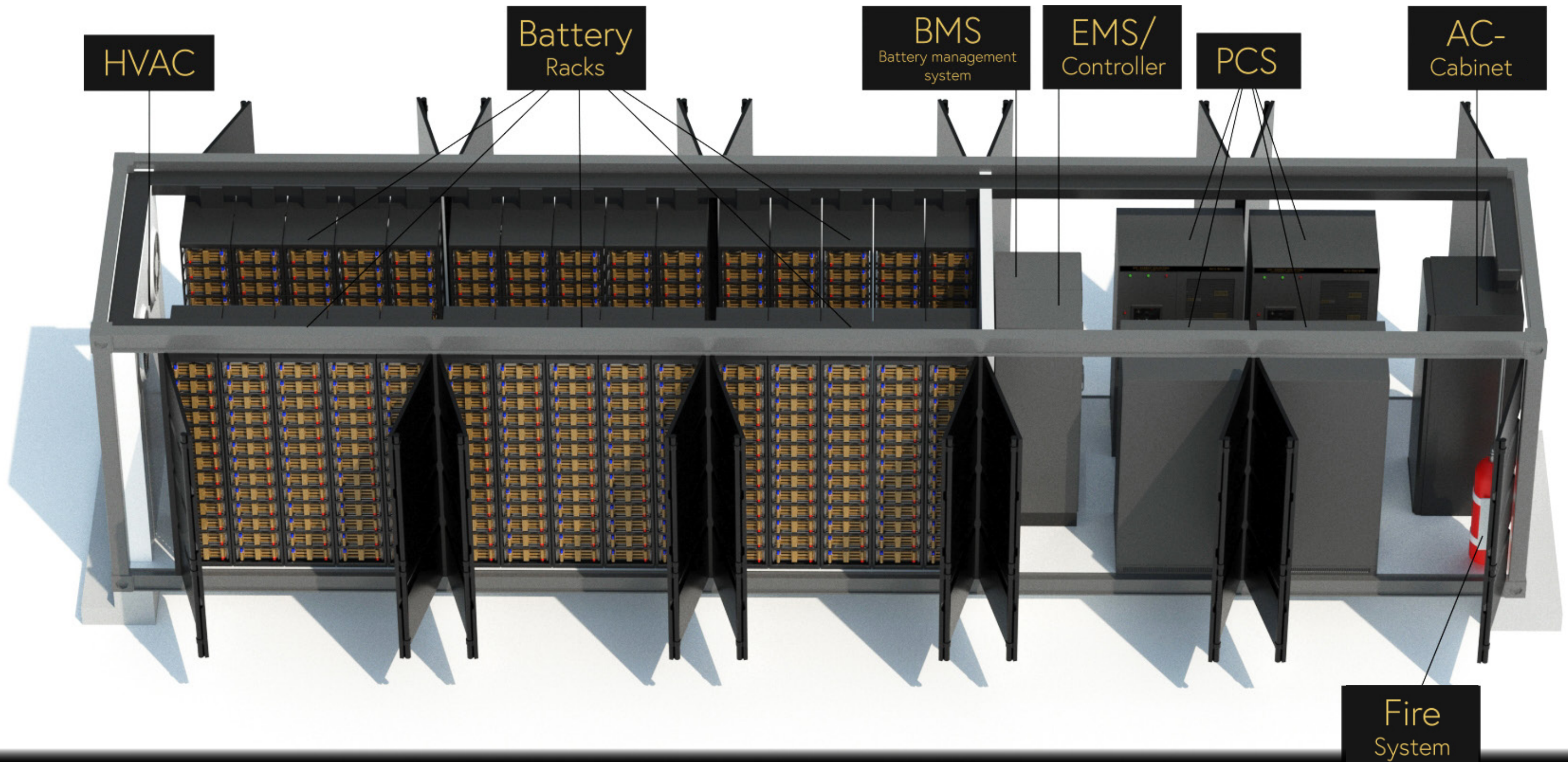
Additional PCS cabinets are added to achieve desired power level

Outdoor power transformers for utility

Additional containers are added to achieve desired power and energy capacity

10/20/40ft containerized Energy Storage Solutions

High energy density, small footprint, short construction period, strong environmental adaptability.
A variety of charge and discharge control strategy, dynamic and static power grid support.



Energy Storage System - From kW to Hundreds of MW

- Modular, flexible and scalable up to hundreds of MW.
- Plug-and-play containerized design, saving time and cost.
- Minimum deployment time
- Fully integrated turn key solution for smart energy management.
- Compatible with different battery technologies.



Modular Design



Excellent Performance



Easily Fundable



Easy to Install

ESS frequency regulation application example

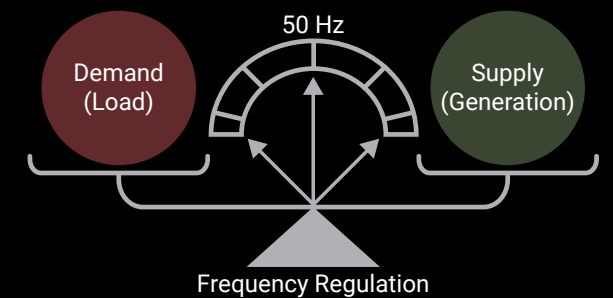
Plant Control Building

- Intelligent control and Scada systems
- Diagnosis of operational features and immediate notifications
- Facilitate maintenance and reduce operation costs

40 ft Containerized Energy Storage System

- Power conversion
- Intelligent Energy Management System
- Long life high capacity Li-ion batteries
- Smart system with a wide range of operation modes

Outdoor Power Transformer for Utility



Indoor ESS Installations

Energy Management System, PCS, Batteries & Switchgear

Battery Storage & Management System

- Long life Li-ion battery
- BMS - Battery Management System
- Local controller and EMS

PCS - Power Conversion System

- AC-coupled, DC-coupled or Hybrid systems
- 4 quadrant operation
- High efficiency
- Wide range of smart operation modes
- Up to 500 KW in a single cabinet

Intelligent EMS & Scada

Switchgear

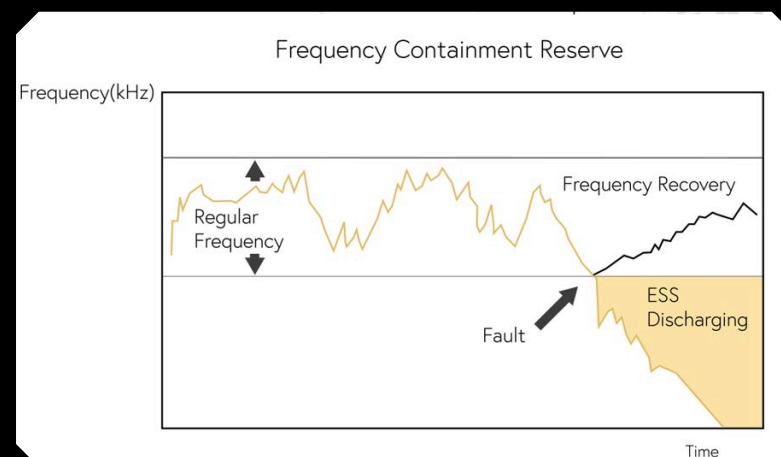
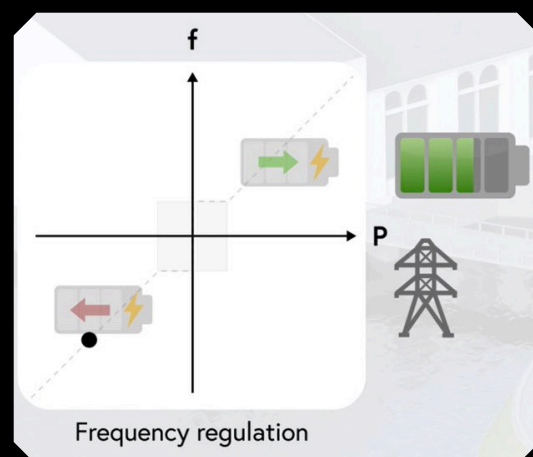
ESS - Operation modes

Frequency Control

Keeping the grid frequency and voltage within strict limits is essential for maintaining the stability of the grid. This requires access to very fast response assets. EM Energy Solutions ESS can start to store or deliver energy within a few microseconds.

EM Energy Solutions ESS is capable of both charging and discharging, at the power level or levels, within the installed capacity or according to the preset operation mode combinations.

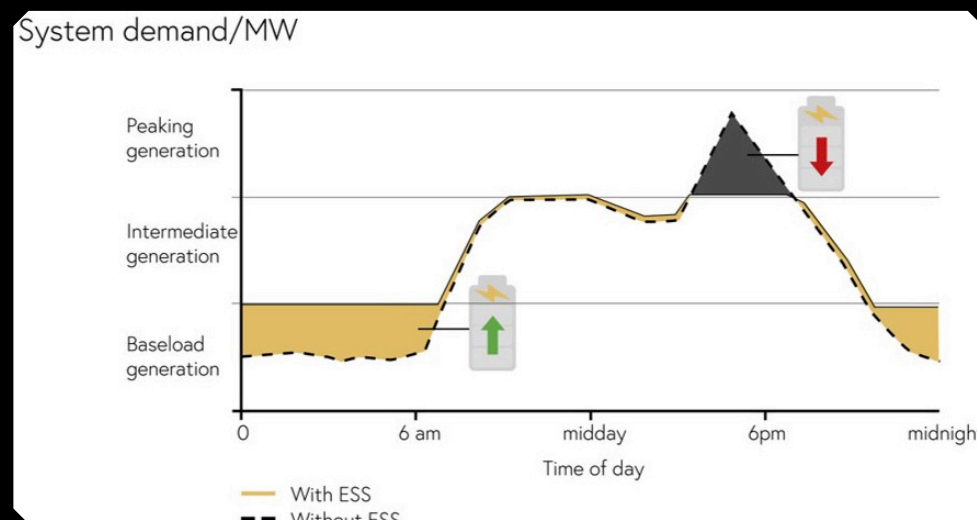
Energy storage can provide frequency response for system reliability much more efficiently than today's system, at lower cost, and with substantially reduced emissions than thermal generation.



Peak Shaving

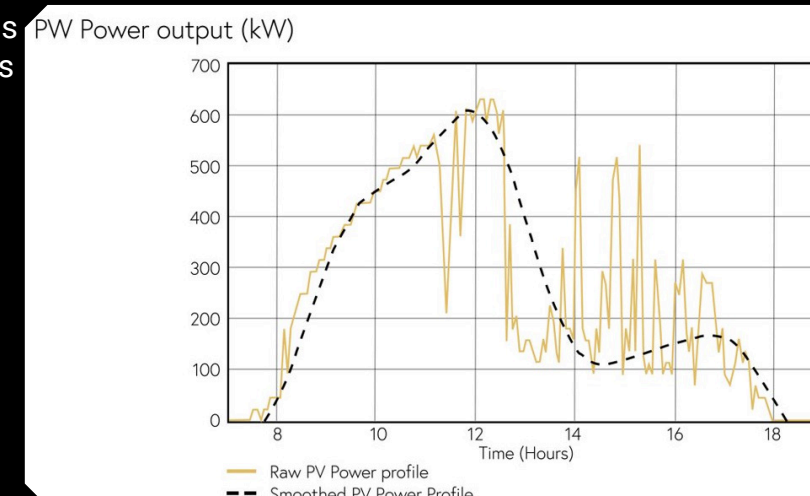
The distribution network is increasingly taxed by new sources of load, such as electric vehicles, and distributed generation. Energy storage can absorb intermittent local generation and insulate the grid from sudden spikes in local load, easing the strain on distribution infrastructure. The ESS acts as a network load

relief and automatically injects power to support grid stability during contingency events. This enables operators to increase the operational capacity of existing transmission lines, without having to build another tower or line.



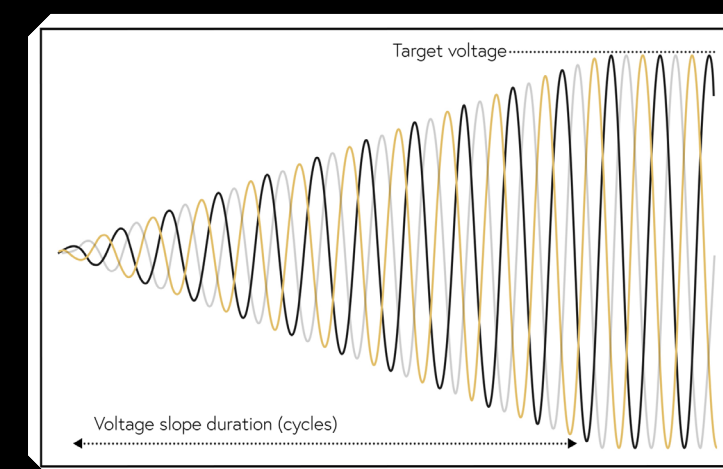
Ramp rate control / Capacity firming

EM Energy Solutions Energy Storage Systems is capable of stabilizing renewable power sources by alternately charging and discharging. This is especially important with renewable energy sources such as wind and solar farms. In these applications, the ESS will fill the gaps that occur when output dips due to a major reduction in wind energy or when clouds move over a solar farm.



Black Start / Soft Start

ESS allows a power plant to bootstrap itself after a blackout, grid connection loss and/or loss of generation capacity with its associated ancillary systems until it is synchronized to the grid. EM Energy Solutions ESS can provide the balance of plant power needed for a restart. Transformer inrush is due to the magnetizing current of the transformer core. With EM Energy Solutions Black Start - function, the inverter ramps the voltage and frequency to manage the inrush currents. These ramps are settable to ensure operation can be optimized to the characteristics of each site.

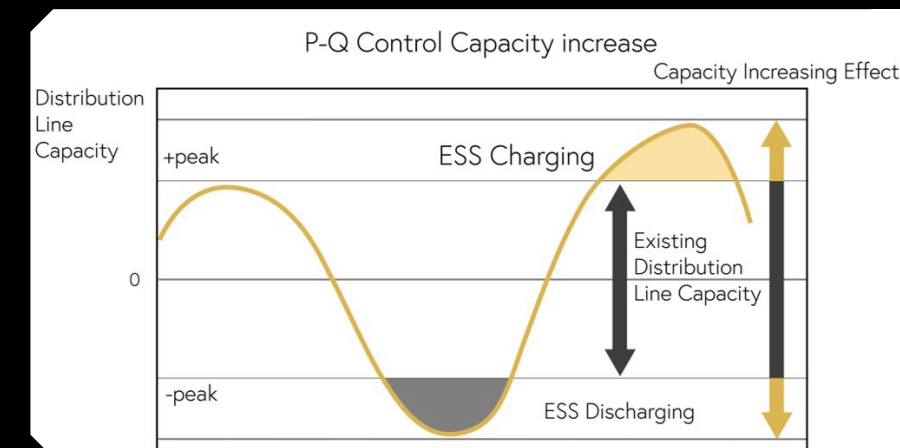


PQ Control for Distribution Network

As renewable energy is being widely adopted, the existing distribution network will reach its full capacity, requiring investment for capacity expansion.

Installing ESS for P/Q control can have the same effect of increasing capacity without new capacity installation.

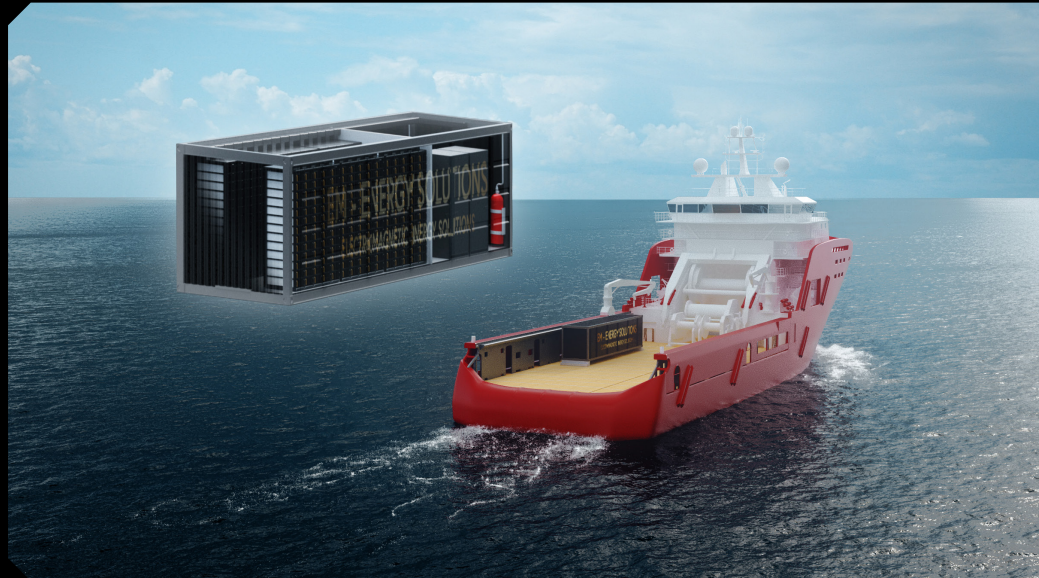
P= Active Power (W)
Q= Reactive power(VAr)



Spinning Reserve

Reserve capacity helps maintain output during generator failure or unexpected transmission loss, which could require power reductions to customers. Keeping generator capacity online but unloaded wastes fuel and causes unwanted air emissions. ESS can take the place of conventional spinning reserve generation and improve efficiency.

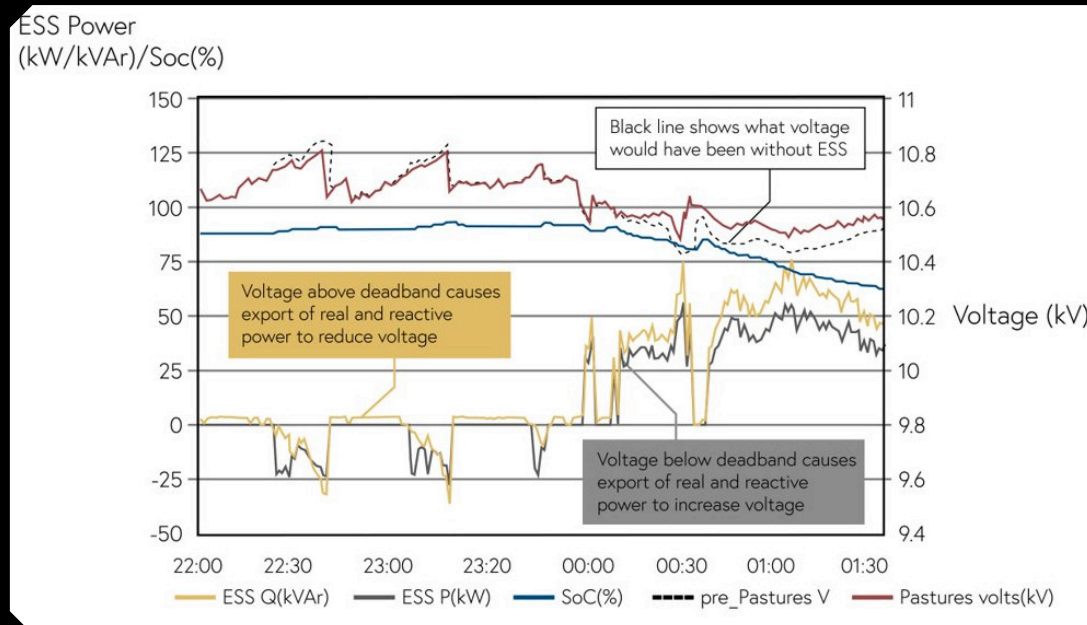
As an example a DP (dynamic positioning) operation for ships, the need for energy often comes in peaks. Having to start and shut down diesel engines to handle these peaks leads to more use of diesel, increased emissions and the need for service and maintenance. Experience also shows that diesel engines operate more efficiently under stable load conditions. EM Energy Solutions ESS is an ideal solution for such operations. The response time for increased thrust power when using ESS compared to starting up a diesel engine is much shorter, it reduces the wear and tear of the engines, and balances the energy consumption.



Voltage Support / Volt - VAr Control

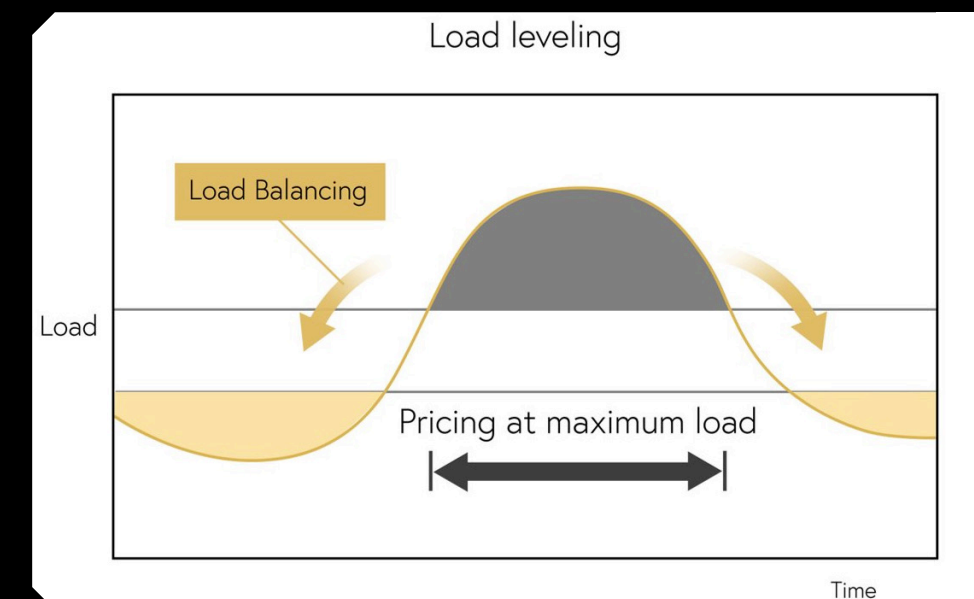
In voltage support mode the ESS will inject power into the electrical distribution grid to maintain voltages within the acceptable range at every stage between each end of all power lines. Unlike system frequency, which is consistent across the network, voltages experienced at points across the system depend on the real and reactive power characteristics of the load and a low power factor results in low voltages at the load points.

Using EM Energy Solutions ESS to inject reactive power (VAr) near to the loads enables the system voltage to be maintained by avoiding transmission losses and the consequent voltage drops across the network due to the flow of reactive power. This is particularly important for minimizing the effects of rapidly varying, high consumption load.



Load leveling

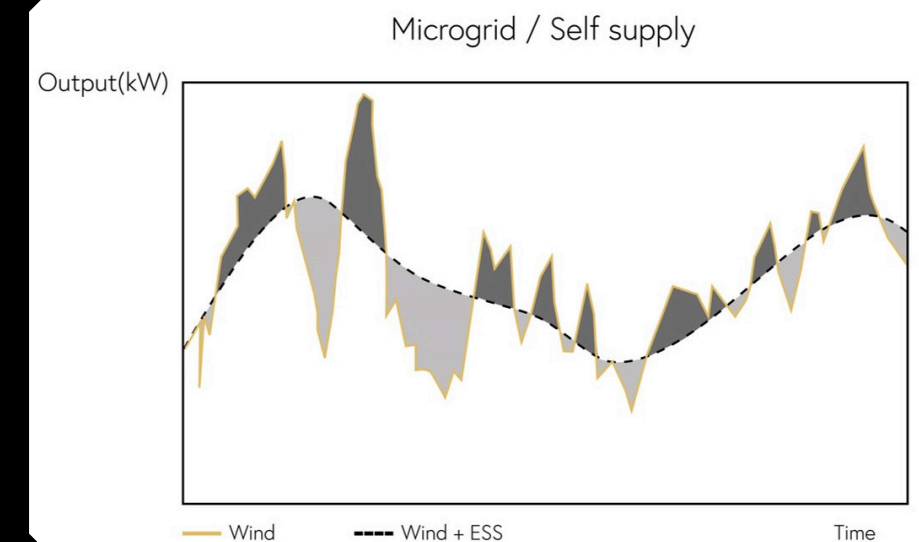
Demand charges can represent a significant portion of commercial and industrial users' electricity bills. Energy storage can deliver power during times of peak usage to lower your consumption of grid power and dramatically reduce monthly demand charges. In addition, if you pay variable energy rates, energy storage can shift consumption away from expensive time-of-use periods and lower your electricity rates.



Microgrid

A microgrid is a discrete energy system consisting of diesel power generation, renewable energy, ESS, etc. and loads capable of operating in parallel with, or independently from, the main power grid.

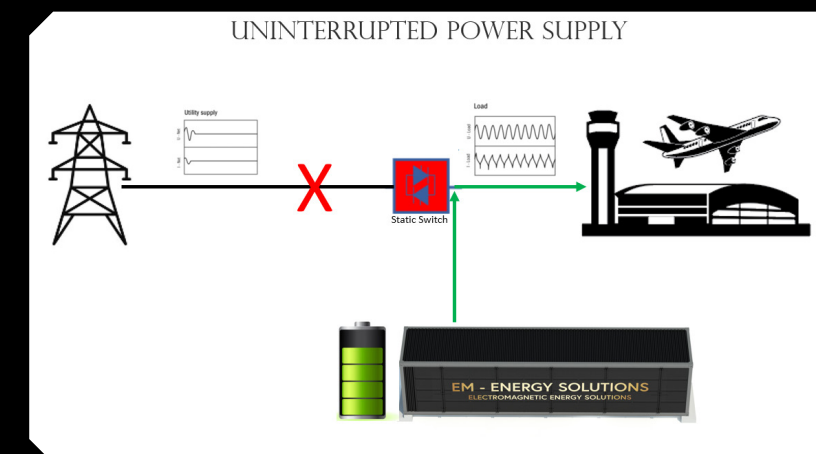
EM Energy Solutions ESS helps stabilize the grid system through power smoothing control as well as voltage and frequency regulation.



Backup Power

For many large-scale commercial and industrial energy consumers, any outage is disastrous for operations. Companies operate highly sensitive equipment, such as robotics, variable speed drives, and critical manufacturing lines that are vulnerable to even the smallest imperfection in power quality. Any problems with power supply can have significant, and in some cases disastrous, impacts on production, equipment, and revenue.

Energy storage onsite gives you the protection you need to ensure you stay up, even if the grid goes down. Furthermore, energy storage can improve power quality and effectively filter out any imperfections in grid power.



Bi-directional Power Conversion System (PCS)



Modular design
- High Redundancy & Flexibility.



Power electronic device based on IGBT's three level NPC topology. Low-noise, accurate performance and high efficiency.



Up to 500 KW in a single cabinet.



Wide range of smart operation modes.



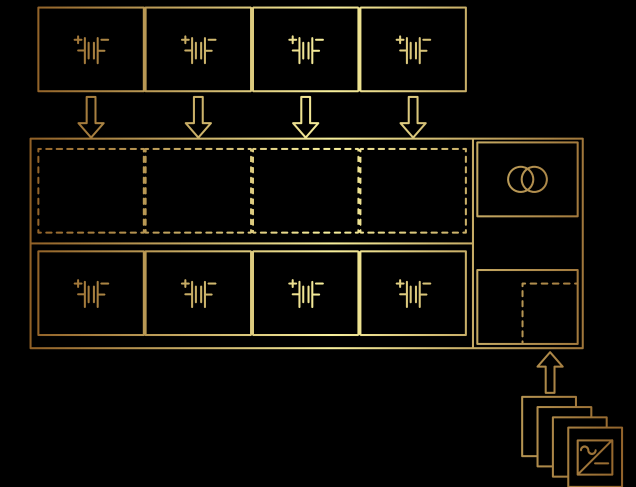
Automatic synchronization to diesel generators and inverters without the need for communication.



Multiple Battery String Technology

Energy storage solutions have never been so conveniently extensible. With EM Energy Solutions multi-string tech, the battery banks in different strings are de-coupled.

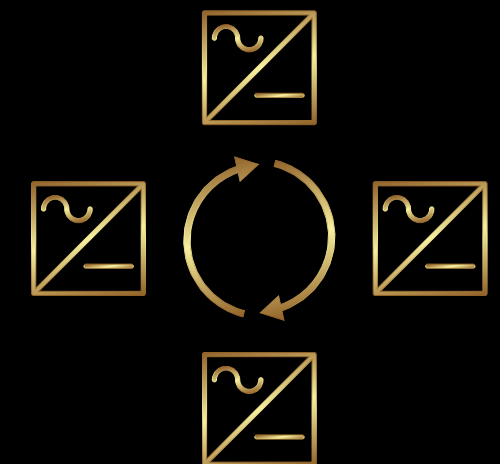
A small system could be installed initially and then expand to larger one later just adding up with new battery and inverter modules, without concern about the wiring and mixing up of new and pre-installed battery banks.



Virtual Synchronous Generator (VSG) tech for Off-grid Parallel Operation

The parallel operation of inverters in islanding mode has been an issue in the past due to the synchronization of sinusoidal voltage.

Most inverter manufacturers will implement a master-slave pattern (master: grid forming, slave: grid-interactive), or introduce a synchronizing communication cable. With the VSG tech, EM energy Solutions - Energy Storage Inverters can operate all in grid-forming mode in parallel without synchronizing cables. The virtual inertia made by VSG tech also enables the Energy Storage Inverter to synchronize with and stabilize the utility grid or diesel generator.

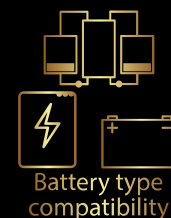


Pre Engineered Containerized ESS Solutions

10/20/40ft containerized energy storage solution for wide range of applications including Demand Charge Management, FCR, Back-up, PV, Self Supply, Microgrid and more.

EMES Container solutions include:

- Energy Storage inverter (PCS – Power Conversion System)
- Battery Management System (BMS)
- Energy Management System / Master Controller / Scada Sytem
- Transformer (optional)
- Battery bank(s)
- HVAC system
- Firefighting system
- Auxiliary distribution



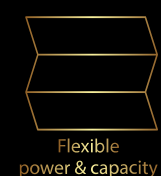
Battery type compatibility



Easy to configure



Non-walk-in maintained



Flexible power & capacity

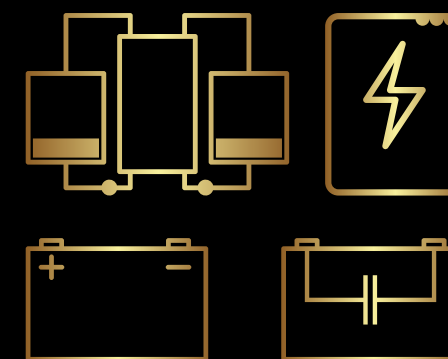


Multiple battery string tech



Outdoor Capable

Battery Chemistry Compatibility



EMES storage inverters have optimized the mathematical model of different kinds of batteries in the DC algorithm, supporting a wide range of various battery types that are based on various chemistries, from Lead-acid, LFP, NMC, flow batteries, to super-capacitors. The battery cabinet/rack is designed for standard 19in battery system.

Energy Management System

EMES offers a fully integrated EMS system tailored to customer needs. The system combines comprehensive controls, asset management, and system visibility across sites or entire fleets.

Commercial / Industrial

Power Management System

Integrated monitoring and control system of ESS provides optimal solutions for commercial and industrial end-users. The Operation Center allows convenient and effective operation of ESS.

Operation mode

- Schedule-based load leveling main functions
- Demand-based peak shaving
- Independent operating substituting
- Diesel generator
- Back-Up / UPS
- Continuous Power Quality

Main Functions

- Monitoring and control of PCS, battery and other equipment
- Analysis of operational effectiveness such as cost saving
- Maximize Renewables generation utilizing ESS

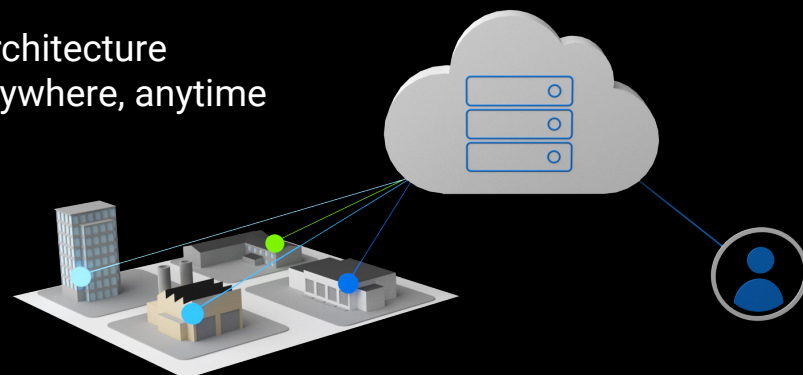
ESS for Distribution

Features for generation, transmission & distribution

- Voltage Regulation
- Frequency Support
- Capacity market
- Real-time alarms
- VPN-based remote site access
- Power Factor Regulation
- EMS-grouped battery protection
- Control actions Scheduler
- Primary Fast Frequency Response
- Dynamic VAR Support
- Peak Shaving
- Frequency Response services
- Auto charge/discharge services
- SOC Management
- Automatic Resource Control
- Renewable Firming
- Weekly vulnerability scanning
- Non-Spinning Reserve

Visualize and explore the relative power and energy performance of all your assets

- Scalable & highly available IT architecture
- Web-based, accessible from anywhere, anytime
- Real-time monitoring
- Analytics & reporting
- Cyber security and safety

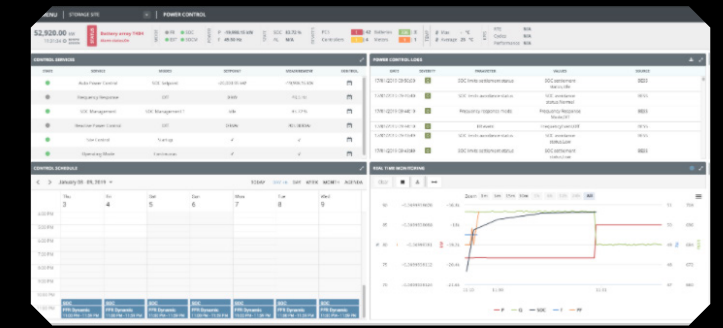


EMES Energy Storage System (EMS) is a modular solution which complies with any grid code requirements and is scalable for use by plants of from a few hundreds of KW up to hundreds of MW. It integrates with any battery technology, battery management, ensuring the result will be compliant with the grid code requirements and plant-specific needs.

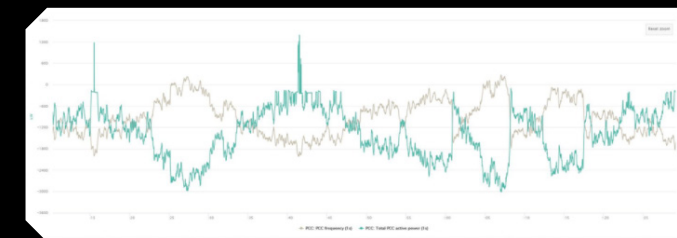
Comprehensive data collection at every level of the storage system provides real-time insights and enables 24/7 remote monitoring and support.



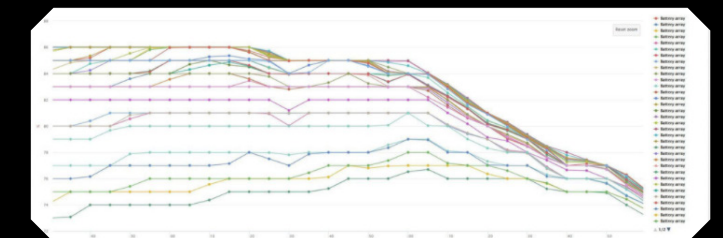
Battery Control Interface



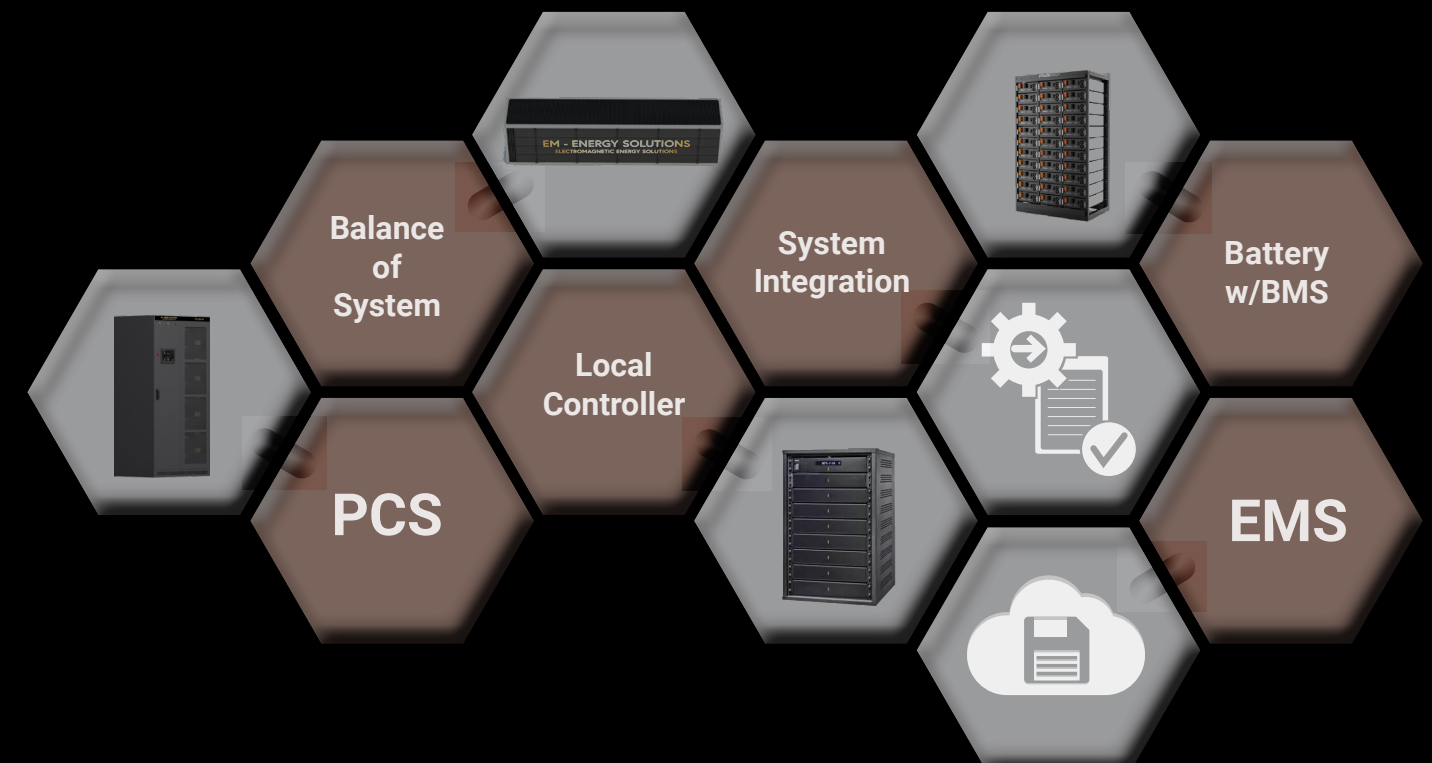
Real Time Monitoring



Frequency Response Services



SOC Management



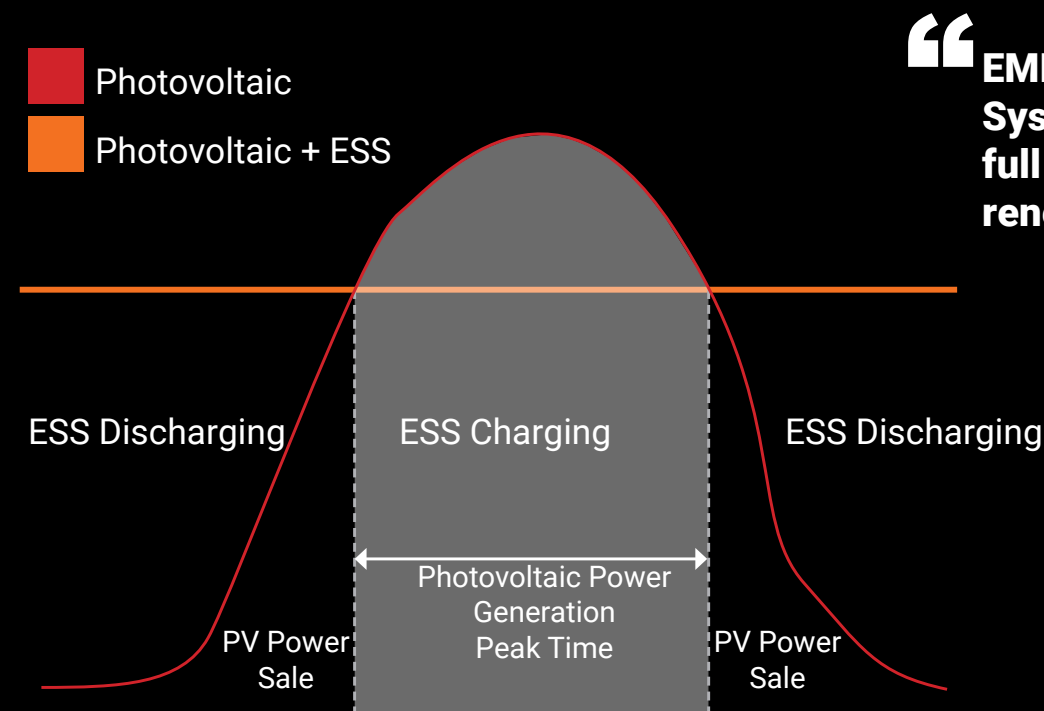
Intermittent Energy Sources

The coincidence of peak energy production by renewable resources with power demand is one of today's big challenges when integrating more renewable energy in the energy mix. Renewable energy sources are very intermittent and the energy may be available when it is not needed and may not be available when it is needed. Solar and wind energy especially are less predictable – wind may blow twenty four hours per day, but its intensity is highly variable. Wind turbines generate no electrical power at very low wind speeds and must be stopped to avoid damage when the wind speed is very high so that they could be idle for three days or more waiting for suitable wind conditions.

Renewable energy has a very low marginal cost. When the amount of renewable energy currently being generated exceeds the current energy demand, systems operators must either curtail the supply thus wasting this green available low cost resource or find a home for the surplus. EMES Energy storage systems enables this surplus to be harvested when it is available for use when the demand for energy increases.

ESS for Photovoltaic Power Generation

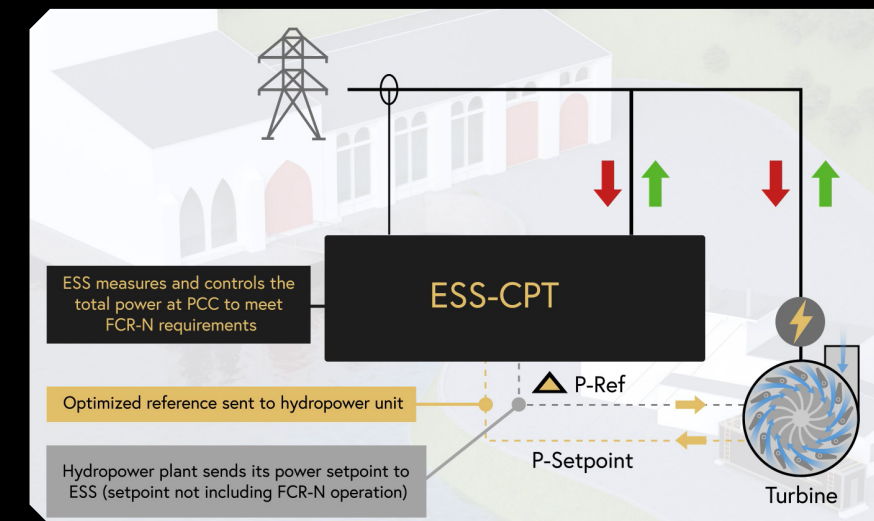
ESS is installed in photovoltaic power plants and is charged with power generated during a set period of time (10AM to 4PM). Power is discharged at other times of the day with higher energy demand to generate revenue.



“EMES Energy Storage System unlocks the full potential of your renewables.”

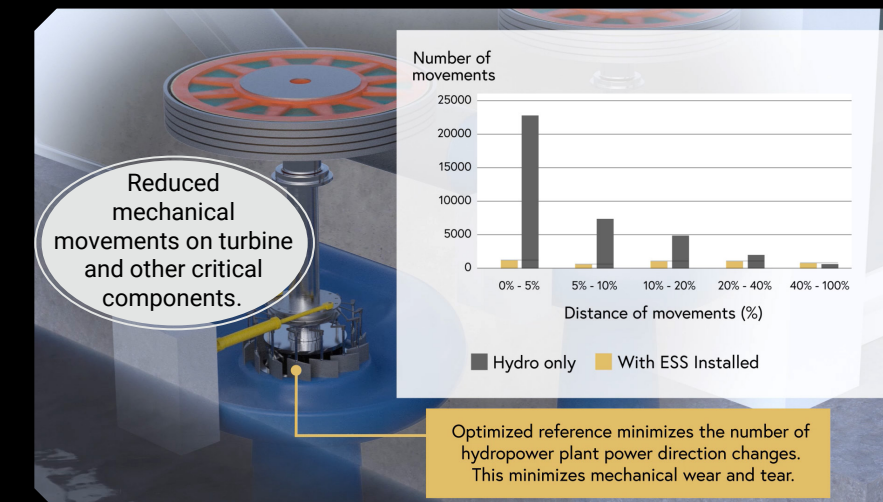
Frequency Containment Reserve Market

Frequency regulation provides regulation of grid frequency to balance supply and demand based on signals sent by the grid operator.



Combined Hydropower + Energy Storage System

System specs: Case 2 Hydro + 2x ESS	
Hydro capacity	20 MW
Hydro control range	+/-3 MW
ESS Capacity	3 MW, 1,5 MWh
Total FCR-N Capacity	6 MW

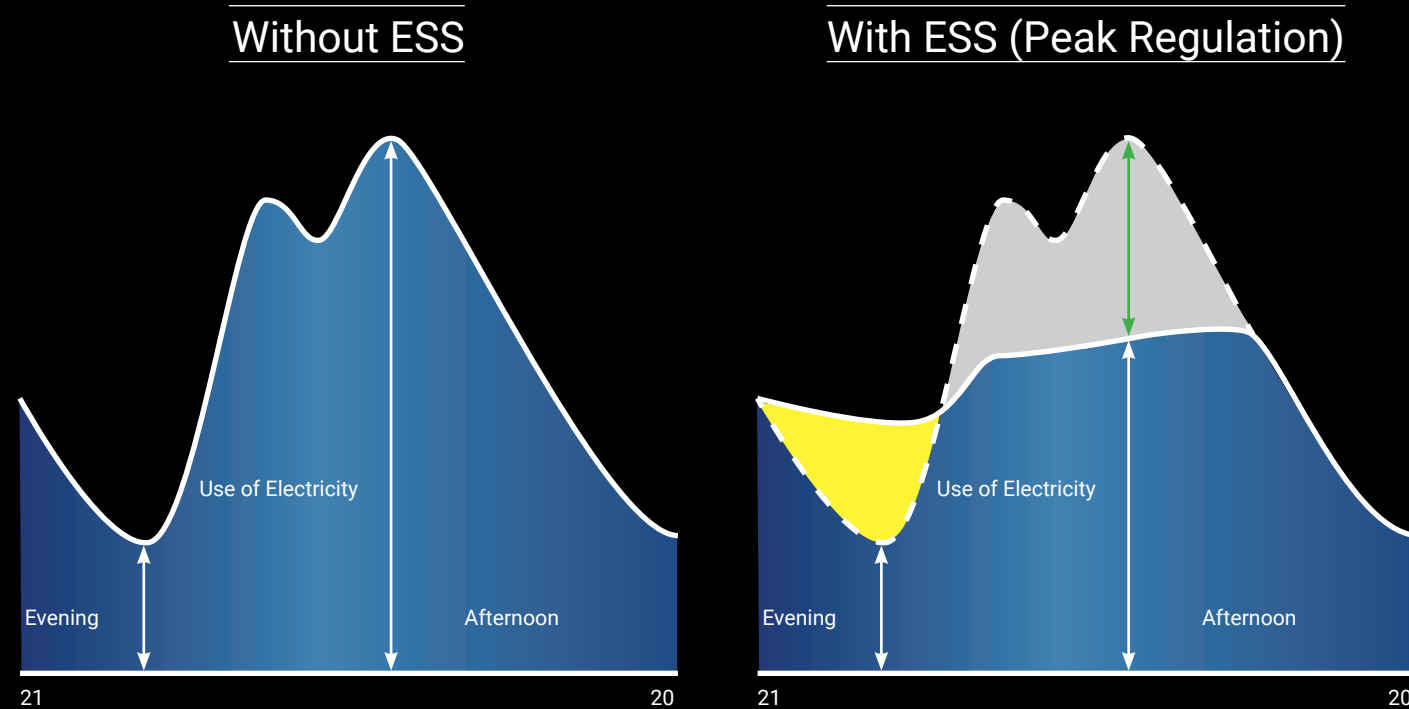


- 100 % availability on FCR-N market in year 2020 with a market price of 13.20 €/MW (2020) = **694.000 €** yearly income.
- Hydropower plant service lifetime not affected by combining ESS + Hydro FCR-N operation.
- Turbine and other critical components last for their design lifetime.
- +- Annual saving on increased lifetime of turbine and other components = 20 M €/40 years = 500.000 € annual.

	Hydro only	Hydro + 2x ESS
Mechanical control movements	40.000 pcs/month	4500 pcs/month
Number of movements in 40 years	19 M	2 M
Expected lifetime (*40 years design lifetime)	20 years	40 years

Load Leveling - Reduce Demand Charges

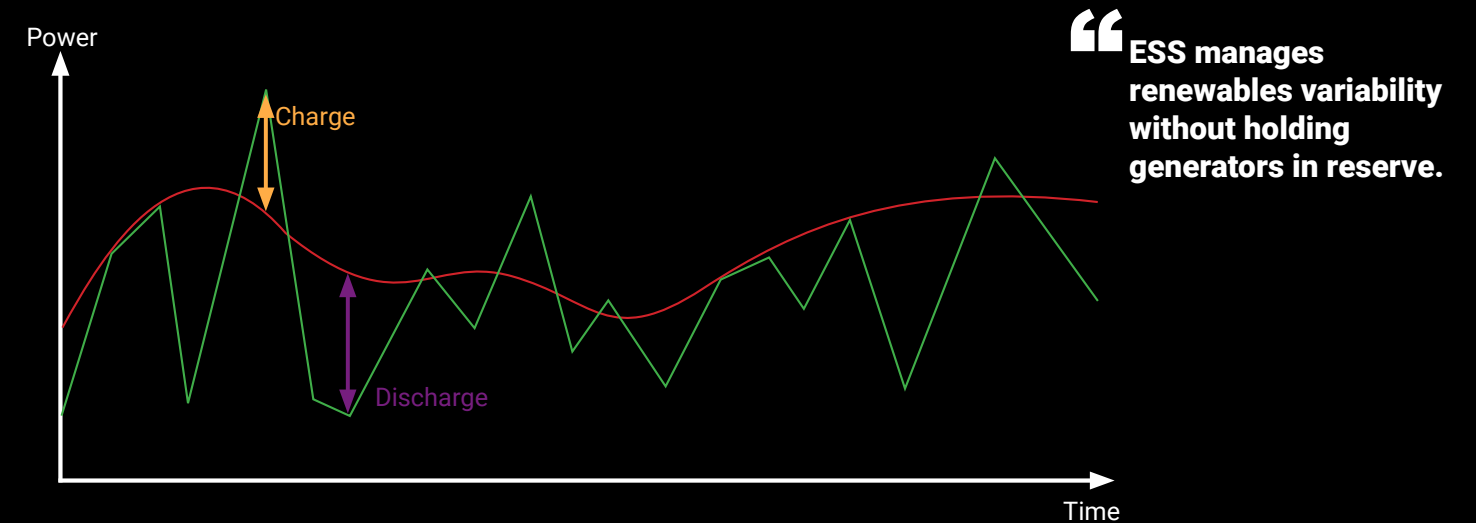
Load Leveling(Shifting / Shaving) - ESS charges during low demand and discharges during peaks to supply power to the grid to reduce the maximum peak, consequently reducing electricity charges.



Renewable Integration – Smoothing of Wind Power

ESS - CPT integration will improve power quality and stabilize renewable output by providing smart operation modes such as constant power control, smoothing control and energy shifting. These functions give the grid operators the benefits of reducing link cost of renewable and improving power quality and compliance grid code.

ESS will improve wind-energy dispatch by reducing forecast errors and improving the utilization of transmission capacity. The ESS can also be used by the system operator for providing ancillary services to mitigate the variability and uncertainty of wind power on the grid side.



Demand Charge Energy Charge **After ESS Installation** Demand Charge Energy Charge Additional Benefits

Reductional Electricity Charge

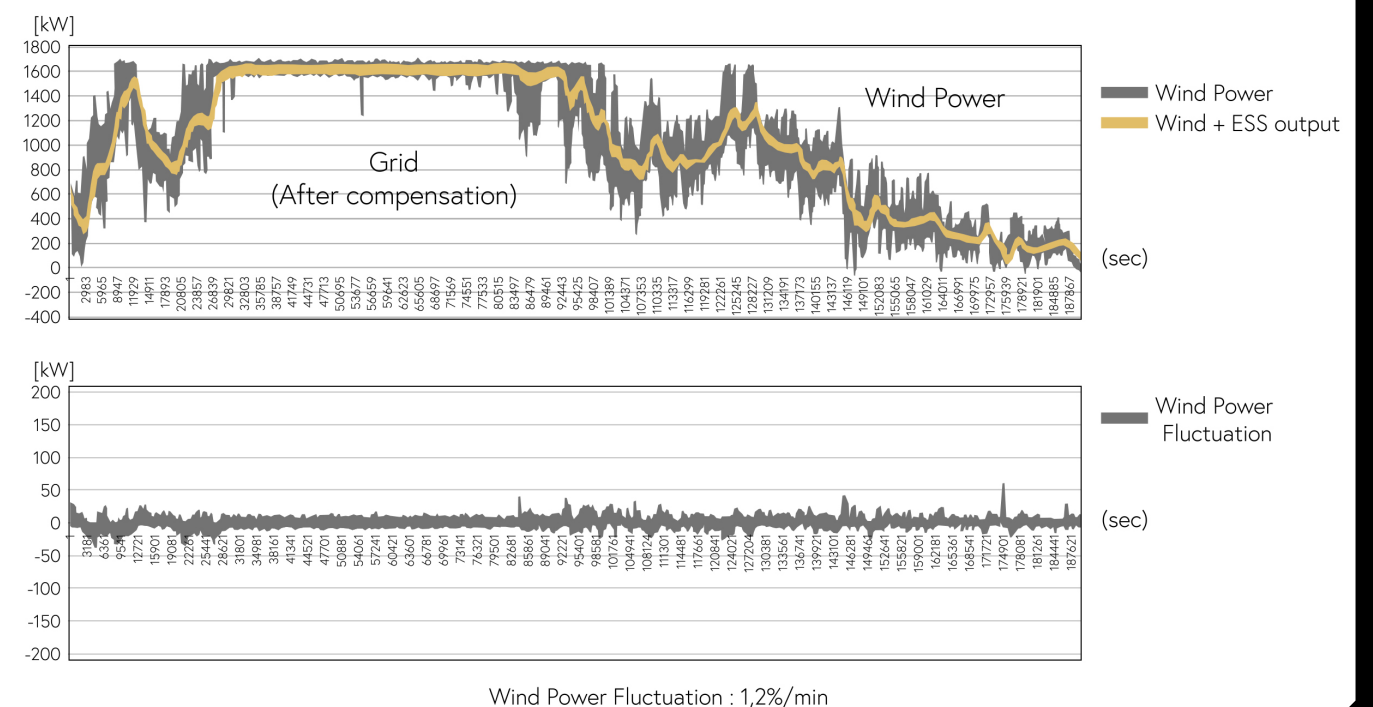
Maximum energy cost saving as the battery is charged at night, when grid tariffs are lower, and supplies power during daytime at peak hours

- Reduction of standing charge through peak shaving.
- Reduces the use of electricity beyond the contracted amount, thus reducing overuse charges.
- Complies with carbon dioxide (CO₂) reduction regulations.

Energy Storage System in capacity firming modus for smoothing of wind energy

Capacity firming prevents undesirable short-duration effects from rapid fluctuations in wind and solar generation due to intermittency and weather conditions.

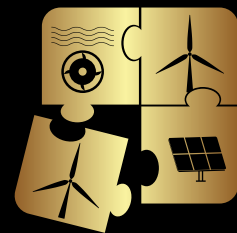
After ESS compensation wind power fluctuation is reduced to less than 1.2%



UNLOCKING NEW BUSINESS POSSIBILITIES WITH EMES ENERGY STORAGE SOLUTION



Improve Financial Performance
Enable monetization of assets through new income streams, increased utilization, improved yield, and reduced cost of operation.



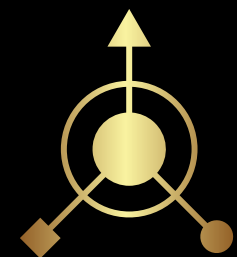
Renewables Integration Increased
Benefit from improved integration and maximized usage of renewable energy from photovoltaics and wind turbines.



Electrical Grid Optimised
Not only defer upgrades, frequency regulation, relieve congestion, control voltage, provide reserves and ancillary services, but also improve reliability with backup power and black start functionality.



Decreased Energy Costs
Industrial and commercial end users are able to mitigate demand charges, optimize differential (Time of Day) energy prices, while also benefitting from additional onsite photovoltaic generation.



Create Microgrids
A new and more flexible grid can be created by locally integrating renewable energy generation and smart devices with energy storage and real-time communication.



EM Energy Solutions APPROACH

EMES broad portfolio of Reservoir Solutions can be tailored to your operational needs, enabling efficient, cost-effective storage distribution and utilization of energy where and when it's needed most. Our expert systems and applications teams utilize specialized techno-economic tools to help optimize the lifetime economics of a project. Our approach results in an investment grade business case that provides the basis of project planning and financing.

1	2	3	4	5
Consulting Services	Business Case	Project Planning & Financing	Turnkey Service Project	Service Agreement
Customized solutions based on needs analysis	Cost-Benefit Analysis	Value Engineering, Plan & Budgets, Financing	Implementation & Production roll out	Training, Operations, Long Term Services

System Design Process & Optimization
Once the project scope, business objectives and services are established, EMES technical experts will define the energy sources, equipment and services required. Using advanced system planning and optimization tools, EMES will deliver a tailored solution to meet the desired objectives.



EM Energy Solution Operational Services

Proper energy storage system maintenance is complex. Maximizing the lifetime value of your asset requires technicians with a comprehensive skill set across multiple technologies to ensure optimal performance and reduce the risk of system downtime, all while upholding thorough health and safety standards. EMES offers a complete lifecycle service package based on the customers’ requirements and can lower operating costs and mitigate operational and financial risks. EMES services include:

Routine Maintenance

Routinely service equipment and keep the energy storage system online and optimizing the performance.

Unplanned Maintenance

EMES provide 24/7 support, monitoring and troubleshooting. Minimizing risk, boosting uptime and lifecycle production.

Service Team

EMES engineers and service personnel are on standby to give the best technical advice and onsite support. Our projects department is comprised of highly skilled experts.

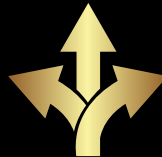
EMES Operations Center

Provides continuous monitoring and diagnostics services 24 hours a day, 365 days a year. Advanced ESS control and SCADA system enables continuous tracking of key operating parameters and detects abnormal conditions. EMES technicians can then troubleshoot or reset the equipment remotely, in real-time.



Reliable

- EMES Energy Storage Systems comes with performance guarantee
- Universal & certified PCS and container/ cabinet system



Flexible

- Modular ACDC/ DCDC bi-directional PCS
- Modular container/ cabinet energy storage system
- Indoor/outdoor installation



Compatible

- Grid support and grid forming
- Battery agnostic
- Global grid certified

Guarantees

Performance Guarantee

The specific performance criteria and duration of the performance guarantee will vary depending on your application, economic incentives, and requirements. Performance guarantees are only available to customers who maintain a contractual services agreement with EMES and include:

Availability Guarantee

This guarantees that the battery energy storage solution will be available to charge or discharge electric energy at the nameplate power output and at the agreed-upon percentage of time.

Capacity Guarantee

The amount of energy that the battery is able to extract from and discharge to the grid can be guaranteed.



EM ENERGY SOLUTIONS

FUTURING
SMART
ENERGY



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Unlock new business value with flexible, modular ESS solutions

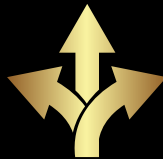
EM Energy Solutions ESS - CPT

The electricity industry is facing new challenges that have not been seen in 100 years. As consumers become active power producers who demand clean, reliable, and affordable power, the transforming grid needs innovative technical solutions that can unlock new business models and revenue streams.



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For more information about EM Energy Solutions Energy Storage System visit:
www.emenergysolutions.com