Energy Storage
Supporting better utilization of Renewable Energy

Totally Integrated Power – SIESTORAGE
Growth of power demand is driving investment in transmission and distribution

Renewables and distributed power generation grow above average

Main driver for the Energy Management market

Global power generation capacity in TW

+2.8% p.a.

Installed 2013: 6.3
Deinstallations: 2.1
New installations: 5.9
Installed 2030: 10.1

Gas

SCPP*  CCPP**

Simple cycle power plants  Combined cycle power plant

Source: Siemens Energy 2020 Project 2014 - Base Case Scenario
Growing share of renewables and distributed generation calls for end-to-end energy management

- Further development of electrification levels in emerging economies
- Grid modernization required in many regions
- Increasing level of renewable and distributed generation
- Grid stability challenges
Outlook Thailand
Energy policy laying the foundations for energy storage

- Thailand relies heavily on natural gas for power generation with IPPs followed by the State (EGAT) dominating ownership.

- Trying to reduce the reliance on diminishing gas resources, The Alternative Energy Development Plan AEDP 2015-2036 encourages investments in regional transmission expansion, clean coal and renewable energy.

- The AEDP sets RE Targets at 25% and approx 20GW by 2035 shifting from biomass to solar as the main focus (6GW). (IEA)

- In 2015 Solar power investments exceeded $2bn and 1,200 MW capacity were added, outperforming the market and 6x more than in 2014 (forbes)

- Providing power to rural areas remains a challenge and both Panasonic and Delta electronics have introduced containerised PV + lead acid battery storage solutions in Thailand. Whilst Thailand’s PTT (State O&G) company is one of the 3 investors in 24M; a spin-off from A123 Systems who produce Lithium ion battery technology.

- Thailand plans to: reduce energy consumption 3.2%, save over 16 thousand million Baht in energy imports and reduce co2 by 2.0 million tonnes. (dede thailand)

- EGAT is undertaking a national micro-grid pilot project in Mae Hong Son Province to improve system reliability. The region has high potential for RE incl. solar, hydro, biomass, and biogases. To compensate variability smart grid technologies such as energy storage and demand response are to be applied. (CIGRE Thailand)
Blackouts: Increasing Risk

Blackouts - in Future
- Will happen more often
- Will occur all over the globe
- Will affect millions of people
- Will be more difficult to handle
- Will last much longer
- Will result in big social crises
- Will result in fatal economic losses
- Will be initiated as new terror acts

What are our options?
Improve Grid Stability with tools such as balancing services and in the event of a crisis have the ability to ISLAND parts of the network and provide fast black-start facilities in order to maintain sections of the grid and restore operations faster.

This list is just a summary! Global blackout events are not completely listed.
Storage utilization for very different purposes

- **Application Segmentation (use-cases):**
  - **Reserves**
    - Response to emergencies
  - **Firming**
    - Variable generation (PV, Wind)
      - Avoid curtailment
      - Rules for grid integration
      - Energy arbitrage (time shifting)
  - **Time shifting**
    - Conventional power plants
      - Increase flexibility/load optimization
  - **System stability**
    - Consumer / Prosumer
      - Residential/commercial self supply
      - Industrial peak shaving
    - Decentralized generation
      - On-Grid + grid upgrade deferral
      - Remote areas/off-grid
    - Distribution grid
      - Ensure stability
      - Load optimization
    - Transmission grid
      - Ensure power system stability

- **Power:**
  - 1 kW
  - 100 kW
  - 1 MW
  - 10 MW
  - 20 MW

- **Units:**
  - Minutes
  - Seconds
  - Hours
  - Days
  - Weeks
  - Months
  - Years

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Identification of the most attractive business cases

Investment viability depends on application, technology and geography
Siemens Storage References
What we did so far...

> 20 MW Storage (15 Projects)

Variety of customers:
- Grid operators,
- Utilities,
- Industries

Variety of applications:
- Islands / Microgrids
- Diesel offset
- Renewable integration
- Black-start
- Frequency and Voltage Regulation
SIESTORAGE solution for a remote micro grid
Example: Ventotene island, Italy

**Challenge**

- Energy supplied by a diesel generator plus consumer owned PV.
- Storage and micro grid project to ensure and improve the power supply of Ventotene

**Solution**

- Modular energy storage system of 500 kW and 600 kWh
- Integration into the island grid by use of a Siemens control system
- Main applications: diesel offset, frequency and voltage regulation

**Benefits**

- Minimization of costs of energy generation
- Stability of the entire energy supply system of the island
- Helps Island to be more self sufficient by responding to load to optimise generation performance.
- Expected cost and environmental benefits due to less reliance on diesel generation.
The solution: The energy storage system SIESTORAGE

Establishing a balance between the generation and consumption of energy

Meeting the challenge of power grids

Providing much faster response time compared to a conventional generator

Running independent micro-grids
Applications
To better Utilise Renewable Energy
1. Black Start
To start a machine or build a grid

Example in an industrial application: Where a gas-fired power plant is used to provide back-up power, SIESTORAGE provides ignition to the starting motor of the gas turbine in the place of diesel generation, ensuring rapid start up.

Challenges
- Grids can experience partial or total system failure known as brownouts or blackouts
- Conventional generators require an external auxiliary power supply to start or re-start and have to be synchronized before re-connecting to the grid
- Black start capability is often mandated for fast response generators or can be provided as an ancillary service

Solution with SIESTORAGE
- Faster response time than conventional generator to provide black start, allowing grids to be re-energized faster and reducing production downtimes
- Reducing losses related to production downtimes
- Providing the power quality parameters required by the generator to be synchronized and reconnected to the grid
2. RE Integration
Controlling how RE behaves in the Grid

EMS predicts one day ahead the production curve (t1, t2, Preferred schedule) based on weather forecast.

Challenges
• Providing clean sustainable energy that is variable and intermittent
• Greater challenge for grid operators to balance supply and demand due to variability of renewable energy
• Grid codes for connection to the grid, e.g. ramp rate, reactive power and power factor requirements
• Penalties for scheduling deviations

Solution with SIESTORAGE
• Compensating the variability and intermittency of renewables by quickly charging and discharging to smooth output
• Limiting ramp rates to comply with grid codes and connection agreements
• Frequency and voltage regulation to improve power quality
• Better forecasting, scheduling and dispatch accuracy through controlled output
• Improved supply and demand matching due to time shifting
• Faster cost recovery through energy arbitrage
4. RE Integration

Energy arbitrage / Time shifting: Making RE available when needed

Challenges

- Wind power is most intense during the night and solar power at midday. Demand normally peaks during the morning or evening, creating a mismatch
- In some instances renewable plants are required to curtail production as local demand cannot absorb capacity
- Market prices reflect demand requirements and can become negative for oversupply and high when demand peaks

Solution with SIESTORAGE

- Providing a means to better utilize renewable energy capacity by storing it and making it available when the load requires
- Cost can be recovered faster or revenue increased by storing renewable energy and selling it into the market when prices are higher/demand is higher
3. Grid Balancing Services
E.g. Frequency Regulation

Quick response (seconds to minutes) to frequency fluctuations is required to maintain grid stability.
Continuous ramping of generators reduces efficiency and asset lifetime.
Requirements for frequency regulation are increasing with the integration of renewables due to their unpredictable nature and large fluctuations.
End users with increasingly higher levels of technology demand better power quality.

Challenges

Solution with SIESTORAGE

- Faster and more precise response time than any other primary control systems (<10 s)
- Higher payments for ancillary services (pay for performance) due to the faster response time and increased accuracy (compared to a conventional generator)
- Higher cost efficiency in grid management due to improved response accuracy
- Greater flexibility in regulation services portfolio
- More competition in regulation markets
5. Diesel Replacement/Offset
Where Grid Power is not available or intermittent

Challenges
- Diesel generators are the only solution to provide power in remote locations without connection to the main grid
- Large diesel generators pollute the local environment (high fuel consumption and millions of tons of emissions per year) and provide significant hazards related to transport and storage
- Ramping of diesel generators is inefficient and requires more fuel
- Diesel fuel is increasing in price (year on year) while the cost of renewable energy is falling

Solution with SIESTORAGE
- Co-installation with diesel generators to reduce fuel consumption by allowing the generator to operate at a fixed output and avoid ramping up and down
- Co-installation with renewable plants and diesel generators to optimize renewable integration and micro-grid operation
- Opportunity for off-grid and grid applications for CO₂ abatement and climate protection
Technology
Modular SieStorage System
The battery energy storage system SIESTORAGE
Consistency for a reliable power supply

Comprehensive SIESTORAGE advanced technology

Energy automation and grid integration
Medium-voltage switchgear
Transformer
Power electronics

Li-ion battery modules

Solution and implementation expertise

Experience with network operators
E-house manufacturing
System integration expertise
One of the leaders in smart systems
SIESTORAGE modular concept
Four components into an innovative solution

- **Grid connection cabinet**
  - (400 x 600 x 2,200 mm)
  - Cable tap for grid connection
  - Busbar system

- **Inverter cabinet**
  - (600 x 600 x 2,200 mm)
  - 2 inverter modules and related control equipment
  - **Each module:**
    - V nominal: 400 V
    - I nominal: 170 A
    - S nominal: 139 kVA
    - P nominal: depending on the battery type

- **Control cabinet**
  - (800 x 600 x 2,200 mm)
  - HMI (Human Machine Interface)
  - System Control unit (SCU)
  - Ethernet switch
  - 24V DC power distribution
  - Aux. Power transformer (optional)

- **Battery cabinet**
  - (600 x 650 x 2,200 mm)
  - **Content example***:
    - 14 modules
    - 1 BMS (Battery Management System)
    - Power: 90 kW
    - Energy: 45 kWh
    - *Depending on supplier

- New battery ranges with different C-rates available e.g. C4 for high power, low energy.
- Several New converter ranges
- Containerised and non-containerised solutions available

*System Control Unit

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SIESTORAGE modular concept
Design flexibility

Flexibility to address all needs of storage power and capacity

4 Power Stacks – Content
- 2 inverter cabinets with 2 inverter modules
- 1 control cabinet
- 1 grid connection cabinet (optional)
- X battery cabinets (max. 5 connected to one inverter module)
- Rated power: 554 kVA
- Rated capacity: 180 kWh (scalable)

12 Power Stacks – Content
- 6 inverter cabinets with 2 inverter modules
- 1 control cabinet
- 1 grid connection cabinet (optional)
- X battery cabinets (max. 5 connected to one inverter module)
- Rated power: 1662 kVA
- Rated capacity: 540 kWh (scalable)

2x12 PS: Example of installation in standardized container

The system can be packaged in standardized containers or installed in either pre-existing or custom-built buildings to fit the available space. It allows installation almost everywhere and provides safety and reliability.
- Rated power: 3324 kVA
- Rated capacity: 1,080 kWh (scalable)
Fully integrated Microgrid Management System

Features

- Distributed generator control also for renewable generation
- Network synchronisation
- Load Control
- Storage control
- Online control via HMI
- Grid monitoring and control
- Generation forecast
- Load forecast
- Schedule optimization
- Enhanced SCADA functionality
- Dynamic grid constraint consideration using state estimator function
Siemens End to End Turnkey Solution
To better Utilise Renewable Energy
Totally Integrated Power: Everything for a future-proof power supply

Automation
- Process/Industrial automation
- Operation & Monitoring
- Load management
- Hydro curves
- Forecast
- Maintenance
- Status reporting/failure management
- Protocols
- Power Quality
- Cost center
- Building automation

Electrification
- Renewables
- Storage technologies
- Medium-voltage switchgear and protection technology
- Transformer
- Low-voltage switchboard with protection and measuring technology
- Low-voltage distribution

Products, systems and solutions
- Consulting, planning
- Engineering
- Ordering, delivery
- Installation, commissioning
- Operation
- Service, modernization
SIESTORAGE offers more

From planning and system integration through to commissioning and services

Comprehensive storage, LV and MV equipment and integration expertise

Storage system combining cutting-edge power electronics and Li-ion batteries

Consistency

Advanced technology

Flexibility

Cost-efficiency

Safety

Reliability

One-stop shop

Power supply in milliseconds and high redundancy for outstanding availability

Optimization and savings potential for a wide range of applications

Fully security-tested and certified system

Covering all needs of storage power and capacity thanks to modular system