

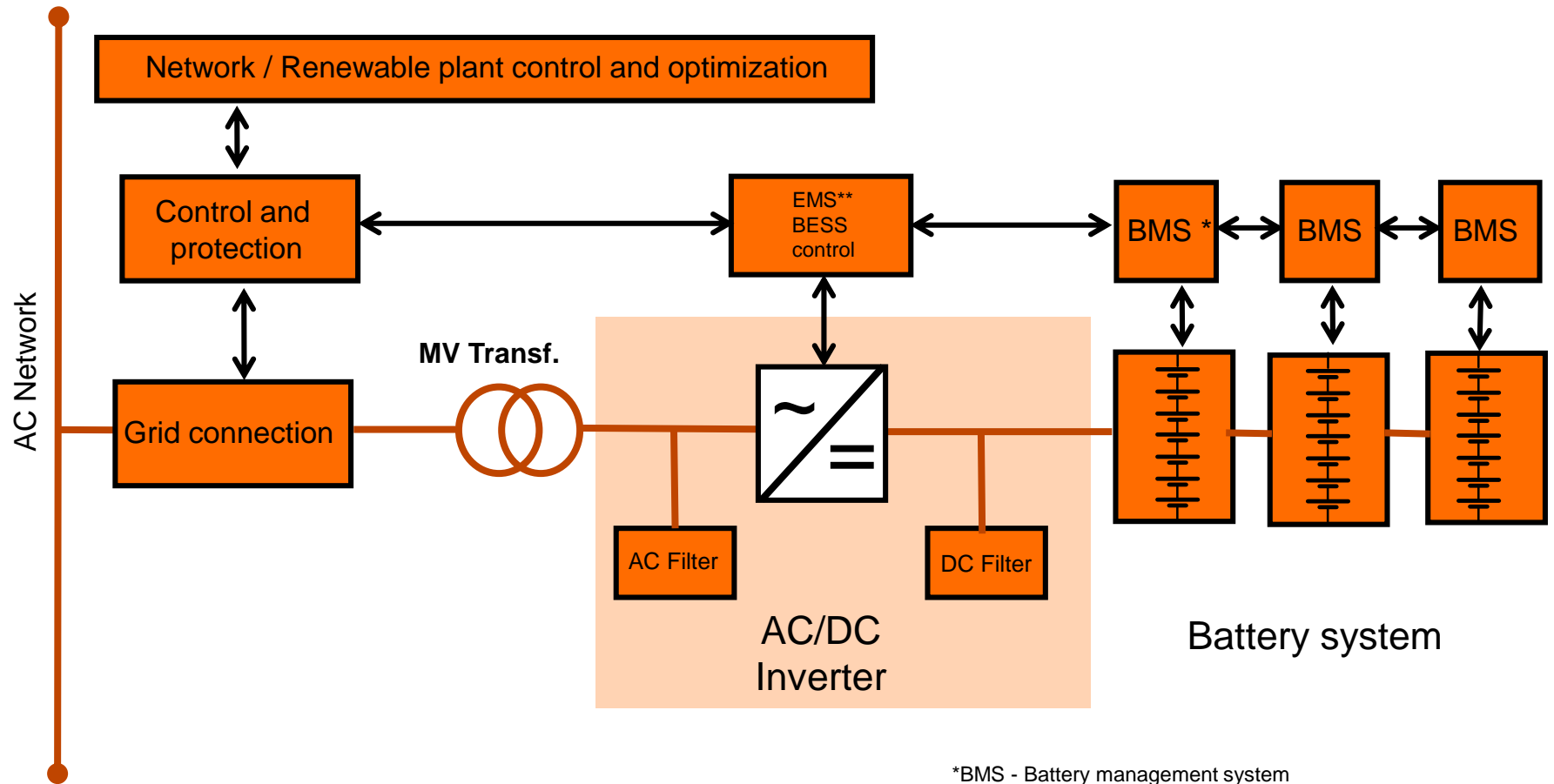


ABB Power Quality Products, June 2016

# Battery energy storage system Energy Storage Inverter (ESI) offering

# Battery energy storage systems

## Functional block diagram



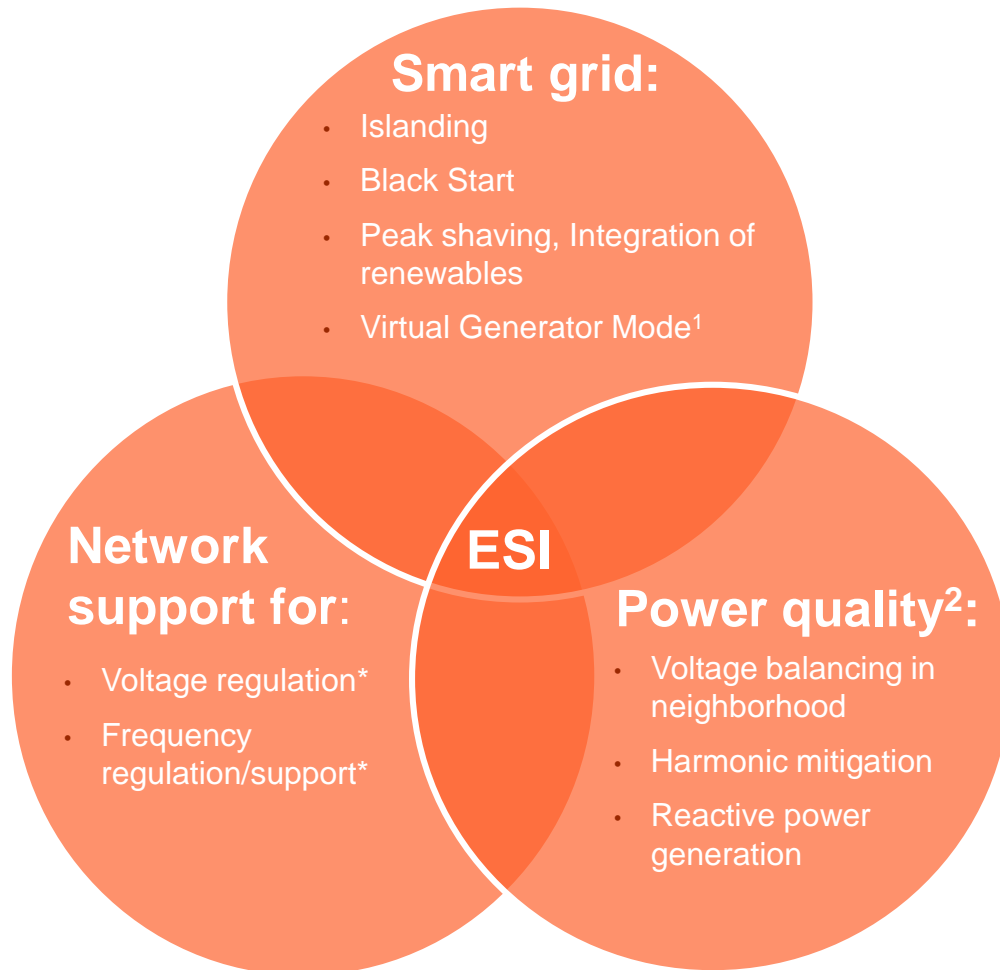
Scope of supply

\*BMS - Battery management system

\*\*EMS – Energy management system/ Master BESS control

# Battery energy storage system

## Energy Storage Inverter (ESI) platform



### Power range:

20kW → 2.5MW

### Multi communication capability:

- CAN
- Modbus TCP/RTU

### Flexible and modular design

\* functionality to be implemented in the EMS

1 : To be implemented by Q4 2016

2: CT's to be provided at the main incomer

# PGHV - energy storage inverters

## From kilowatts to megawatts range

Typical grid connection levels

LV range  
~25 kW – 100kW rating

LV – MV\* range  
~100 kW - 500 kW rating

LV – MV\* range  
~500 kW - 2500 kW rating

\*Through step-up transformer

Optimized ESI converters



Batteries,  
super-capacitors

# Battery energy Storage System Energy Storage Inverter (ESI) range



ESI-I

ESI-M

ESI-S

Losses ~3%

\* Rating per filter (it is possible to have up to 8 inverters in parallel for ESI-I & ESI-M and 4 inverters for ESI-S)

Type	Nominal power [kW]	Rating [ $A_{rms}$ ]	Nominal network Voltage	DC Voltage Controlled range
ESI-I V1	200	300	400	585 – 830
	315	450		
ESI-I V2	150	180	480	720 – 1200
	270	320		
ESI-M	50	70	400	585 – 830
	70	100		
	90	130		
	100	150		
ESI-S	20	30	400	585 – 830
	30	45		
	40	60		
	50	70		
	55	80		
	60	90		
	70	100		
	85	120		
ESI-S single phase + DC/DC converter	7	30	240	120 – 830
	10	45		
	15	60		
	20	80		
	25	100		
	30	120		

# Battery energy storage system

## How the inverters are specified?



ESI-I

ESI-M

ESI-S

- ESI-S range: ESI-S-**X**yy-IP30  
where:
  - **X**= Master (M) or Slave (S)
  - **yy** = Nominal Power (kW)
  - Example: ESI-S-M30-IP30
- ESI-I&M range: ESI-**A**-**B**-**C**dd-IPxx where:
  - **A** = I or M (type of inverter)
  - **B**= DC voltage range; V1 (585Vdc-830Vdc) or V2 (720Vdc -1200Vdc)
  - **C**= Master (M) or Slave (S)
  - **dd** = Nominal Power (kW)
  - **xx** = IP protection degree
  - Example:            ESI-I-V1-M200-IP21  
                             ESI-M-V1-S100-IP23

# Battery energy storage system Energy Storage Inverter (ESI)



ESI-I

ESI-M

ESI-S

Bi-directional inverter with IGBT  
Standard cabinets (W x D x H):

- ESI-I: 800 x 600 x 2150 mm – IP21  
(Higher IP available)
- ESI-M: 600 x 600 x 2150 mm – IP21  
(Higher IP available)
- ESI-S: 585 x 326 x 795 mm – IP30  
(Wall mounted)

From 20 to 315kW per module

- Modularity (several units can be put in parallel) for high-power applications
- Full redundancy and flexibility (master/master configuration and independent DC busses)



# Battery energy storage system Energy Storage Inverter (ESI)



ESI-I

ESI-M

ESI-S

External communication with EMS (Energy management system) through Modbus TCP/IP/RTU

CAN or Modbus connection to BMS (Battery management system), easy parameterization  
Customizable DC charge and discharge curves to match battery characteristics when communicating with the BMS

Can do much more:

- Harmonic mitigation
- Stepless reactive power compensation
- Load balancing



# Battery energy storage system Energy Storage Inverter (ESI)



ESI-I

ESI-M

ESI-S

## Features

Dynamic power control (P) and reactive power control (Q)

- Individual power control (control per phase)\*, available only for 4-W device

Harmonic mitigation up to 50<sup>th</sup>\*

Load balancing (3-Phases/ 3-Phases + Neutral)\*

Islanding mode

Black start (as an option)

LVRT (Low Voltage Ride Through )

CAN communication

External communication through Modbus (RTU /TCP-IP)

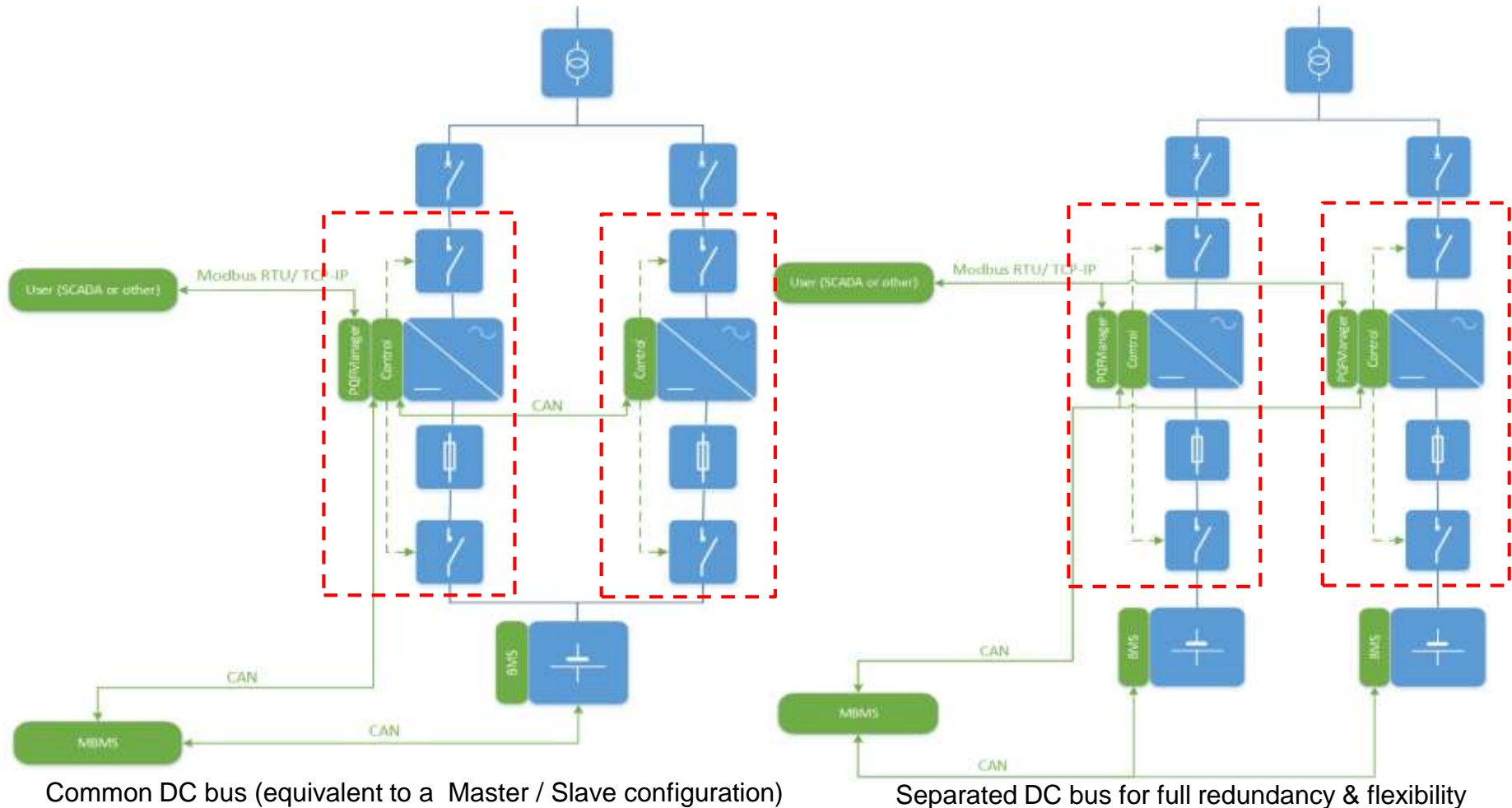
Modularity (several units can be put in parallel) for high-current applications

Full redundancy and flexibility (master/master configuration and independent DC busses)\*

\*UVP (unique value proposition) of the ESI

# Battery energy storage system – block diagram

## ESI - different topologies available



Common DC bus (equivalent to a Master / Slave configuration)

Separated DC bus for full redundancy & flexibility

# Energy Storage Inverter ESI-Manager user interface offering flexible communi- cation tool!



- Flexible communication platform
  - Customer's BESS algorithm can be embedded in our control system
  - Better lifecycle: the software upgrade and the battery replacement can be managed by system integrators
- Standard provided with each Inverter cubicle
- Easy setup of the Inverter
- Three phase network analyzer
  - Numerical data
  - Spectra and time domain waveforms of all important electric parameters
- Inverter status analysis tools
  - Inverter load indication
  - Event log including fault analysis with time stamp
  - Temperature sensor indications
- Connection point for all customer control and monitoring I/O

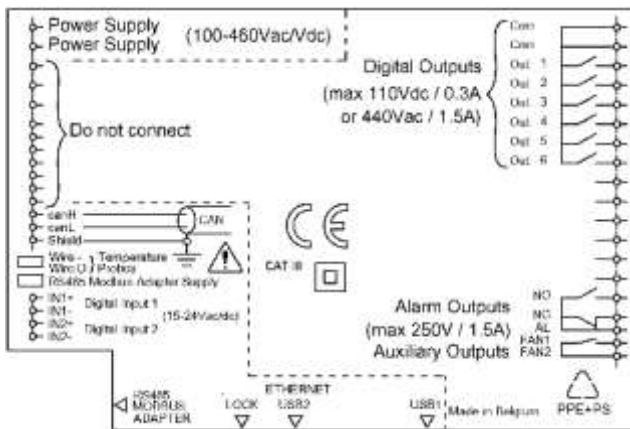
# Energy Storage Inverter ESI-Manager as an excellent user interface offering extensive network analysis tools!



- Touch sensitive multicolored display
- Supports six languages:

- English
- French\*
- German\*
- Spanish\*
- Chinese\*
- Korean\*

(\* To be implemented soon)



- More connectivity for communication purposes : Modbus RTU (RS485), Modbus TCP (Ethernet), Open CAN, ESI-Link (RS232)
- Up to 8 temperature probes
- Access to the parameter of various units from the master
- Enhanced on screen help



# Energy Storage Inverter ESI-Link software - Option



- Direct control and monitoring of the ESI from local or remote computer
- Windows based software to:
  - Consult and program the Inverter
  - Monitor parameters
- Multicolored display of
  - Voltages
  - Currents
  - Other parameters

# Battery energy storage system

## Falbygdens Energi – Falköping – Sweden - 2011



- ESI-I and batteries
- ESI-I 250A three phase
- Year of commissioning - 2011
- Goal of project:
  - Study of integration of renewable: wind turbine
  - Study of the ESI in a real application grid
- Battery: Li-ion from LG
- Power and energy rating:
  - 75kW
  - 135kWh
- Features:
  - Harmonic mitigation
  - Power factor correction
  - Load shifting
  - Peak shaving

# Battery energy storage system

## EKZ, Dietikon, Switzerland – 2012

Customer:  
Elektrizitätswerke des  
Kantons Zürich (EKZ)

Year of  
commissioning: 2012



### Customer need

- Battery energy storage facility connected to the distribution grid, with integrated solar panels and e-mobility charging stations

### ABB response

- Turnkey BESS providing 1 MW for 15 minutes including system studies and specification
- Containerized Li-ion-battery based solution including converter, transformer, switchgear, control and protection systems
- Standard and advanced control algorithms

### Customer benefits

- Possibility to evaluate grid-linked BESS for peak shaving, frequency regulation and integration of renewables
- Forecasting to enhance operational efficiency
- State-of-the-art technologies enabling to address future demands on the grid



# Battery energy storage system

## OAK Ridge – USA - 2012



- ESI-S 100A single phase
- Year of commissioning - 2012
- Goal of project:
  - Study of integration of renewable: solar panel
  - Study of algorithms which optimise the network management
- Battery: Li-ion from GM (Volt car battery)
- Power and energy rating:
  - 25 kW
  - 25 kWh
- Features:
  - Islanding
  - Harmonic mitigation
  - Power factor correction
  - Remote communication: Modbus RTU

# Battery energy storage system ESI-S



ESI-S

- Wall-mounted and compact design (W x D x H: 588 x 326 x 795 mm)
- 3-Wire and 4-Wire connectivity with same unit
- Ratings: 50/60 Hz

Type	Nominal power [kW] @ 400 Vac	Nominal current (Arms)	DC Voltage Controlled range
ESI-S Three-Phase	20	30	585 – 830
	30	45	
	40	60	
	50	70	
	55	80	
	60	90	
	70	100	
	85	120	
Type	Nominal power [kW] @ 240 Vac	Nominal current (Arms)	DC Voltage Controlled range
ESI-S single phase + DC/DC converter	7	30	240 - 830
	10	45	
	15	60	
	20	80	
	25	100	
	30	120	

- Up to four units of equal power rating in parallel

# Battery energy storage system ESI-S



ESI-S

- Bottom cable entry (AC/DC cables)
- Enclosure protection degree: IP30
- Touch screen user interface (ESI-Manager)
- CE & C-Tick versions available
- AC protection
  - AC breaker – loose part
- DC protection
  - DC contactor + fuses – loose parts
- AC/DC protections to be installed outside the ESI-S cubicle

# Battery energy storage system ESI-S modules examples



ESI-S

Requested power (kW)	Inverter combinations ESI-S (3-Phase)	Dimensions (W x D x H mm)
100	2 x ESI-S-M50	2x (588 x 326 x 795)
120	2 x ESI-S-M60	2x (588 x 326 x 795)
140	2 x ESI-S-M70	2x (588 x 326 x 795)
170	2 x ESI-S-M85	2x (588 x 326 x 795)
200	3 x ESI-S-M70	3x (588 x 326 x 795)

Note: Different combinations of inverters for any given power are possible. Each system must have at least one master inverter. A combination of master-master or master-slave is acceptable, however, multiple master combination provides higher degree of redundancy.

# Battery energy storage system ESI-M



ESI-M

- 3-Wire hardware
- Ratings: 50/60 Hz

Type	Nominal power [kW] @ 400 Vac	Nominal current (Arms)	DC Voltage Controlled range
ESI-M	50	70	585 – 830
	70	100	
	90	130	
	100	150	

- Up to eight units of equal or non-equal power rating in parallel
- Top and bottom AC/DC cable entry
- cable entry cubicle available as an option
- Available in cubicle (IP21/IP23/IP41) and in plate version (IP00)
  - Cubicle dimensions: 600\*600\*2150 mm
  - Plate dimensions: 498\*400\*1696 mm

# Battery energy storage system

## ESI-M



ESI-M

- Touch screen user interface (ESI-Manager)
- CE and C-Tick versions available
- AC protection included in the ESI-M cubicle
  - AC contactor + fuses
  - AC breaker as an option
- DC protection included in the ESI-M cubicle
  - DC contactor + fuses
- DC filter can be included (option) in the ESI-M cubicle
- Cable entry cubicle (**as an option**)
  - DC protection, DC filter and main AC connection to the grid

# Battery energy storage system ESI-M modules examples



ESI-M

Requested power (kW)	Inverter combinations ESI-M	Cable entry cubicle	Dimensions (W x D x H mm) Without any entry cubicle
140	2 x ESI-M-M70	1	1200 x 600 x 2250
160	1 x ESI-M-M90 + 1 x ESI-S-M70	1	1200 x 600 x 2250
180	2 x ESI-M-M90	1	1200 x 600 x 2250
200	2 x ESI-M-M100	1	1800 x 600 x 2250
250	1 x ESI-M-M90 + 1 x ESI-S-M90 + 1 x ESI-M-M70	1	1800 x 600 x 2250

Note: Different combinations of inverters for any given power are possible. Each system must have at least one master inverter. A combination of master-master or master-slave is acceptable, however, multiple master combination provides higher degree of redundancy.



# Battery energy storage system ESI-I



ESI-I

- Ratings: 50/60 Hz

Type	Nominal power [kW] @ 400 Vac	Nominal current (Arms)	DC Voltage Controlled range
ESI-I V1	200 315	300 450	585 – 830
Type	Nominal power [kW] @ 480 Vac	Nominal current (Arms)	DC Voltage Controlled range
ESI-I V2	150 270	180 320	720 – 1200

- Up to eight units of equal or non-equal power rating in the same voltage range in parallel
- Bottom cable entry standard (without cable entry cubicle)
- Available in cubicle (IP21 / IP23 / IP41)
- Cubicle dimensions: 800\*600\*2150 mm
- Cable entry cubicle: 600\*600\*2150 mm

# Battery energy storage system ESI-I



ESI-I

- Touch screen user interface (ESI-Manager)
- CE and C-Tick versions available
- AC protection included in the ESI-I cubicle
  - AC breaker
- DC protection included in the cable entry cubicle
  - DC contactor + fuses
- DC filter (optional) can be included in the cable entry cubicle
- Base frame included

Note: One cable entry cubicle can house DC protection and cabling for up to two inverter modules

# Battery energy storage system

## ESI-I modules examples



ESI-I

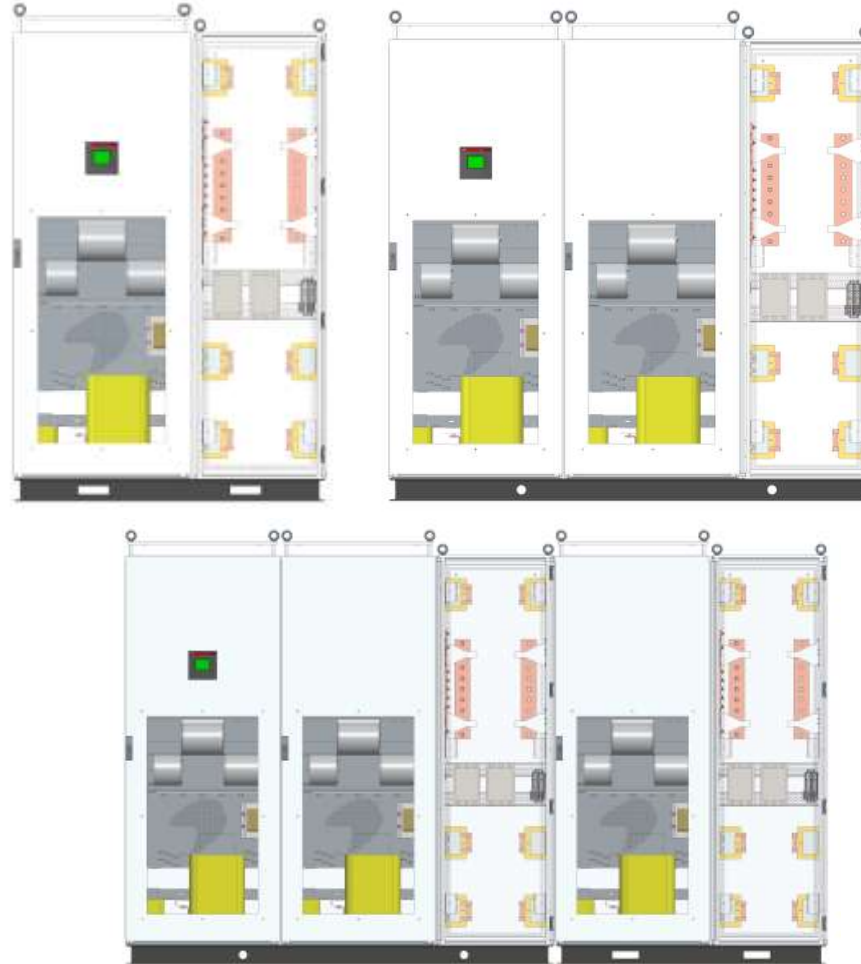
Requested power (kW)	Inverter combinations ESI-I V1	Number of Cable entry cubicles	Dimensions (W x D x H mm) Including cable entry cubicle
200	1 x ESI-I-M200	1	1400 x 600 x 2250
250	1 x ESI-I-M315	1	1400 x 600 x 2250
300	1 x ESI-I-M315	1	2200 x 600 x 2250
500	1 x ESI-I-M315 + 1 x ESI-I-M200	1	2200 x 600 x 2250
600	2 x ESI-I-M315	1	2200 x 600 x 2250
700	1x ESI-I-M315 + 2 x ESI-I-S200	2	3600 x 600 x 2250
800	2x ESI-I-M315 + 1 x ESI-I-S200	2	3600 x 600 x 2250
1500	5 x ESI-I-M315	3	5800 x 600 x 2250

# Battery energy storage system

## ESI-I modules examples of physical layout



ESI-I



# Energy storage inverter

## Functionalities overview

- Active/Reactive power control (kW AC or DC target/kvar AC)
- Individual power control per phase ( $P_i$  and  $Q_i$ ,  $i=1\dots3$ )
  - Available in the ESI-S version only (4 W )
- Low Voltage Ride Through
- Islanding
- Black start
- Communication protocols: Modbus (RTU/TCP-IP), CAN (on request)
- Reactive power generation (static, target  $\cos(\phi)$ )
- Load balancing
- Harmonics cancellation (from 2<sup>nd</sup> to 50<sup>th</sup>, order selectable, level adjustable)

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