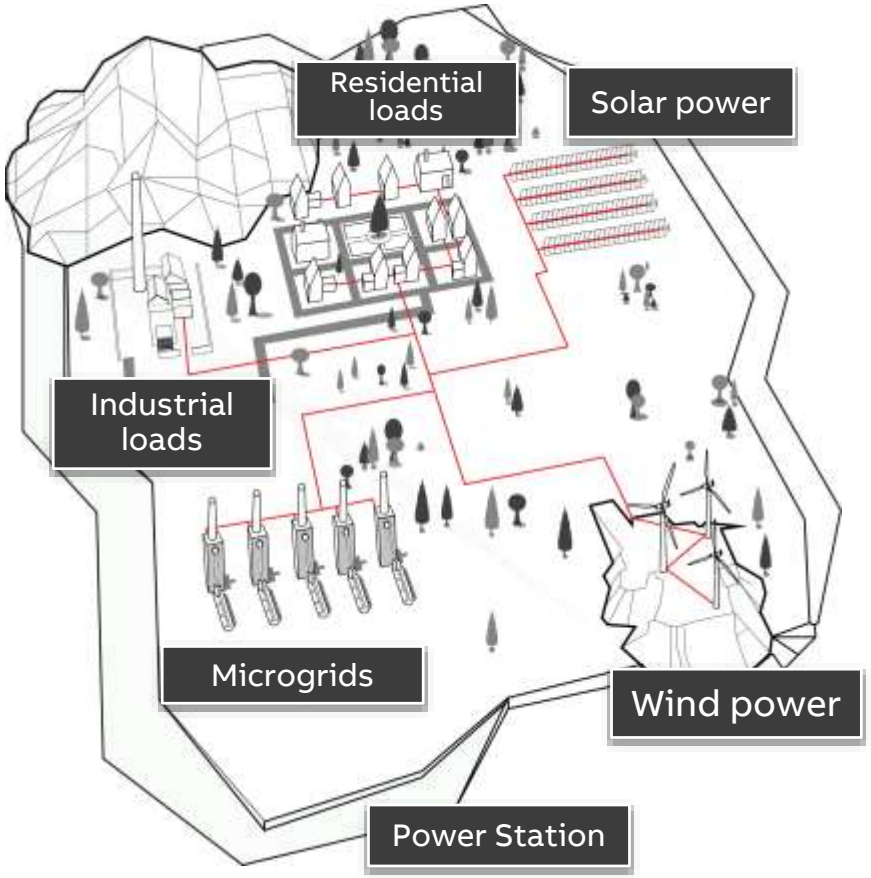
APRIL 20, 2018

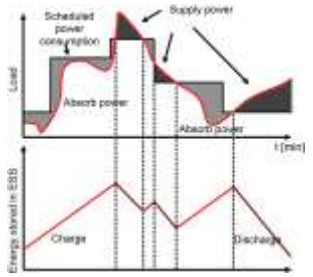
The What's of Electrical Energy Storage

Products and Practices

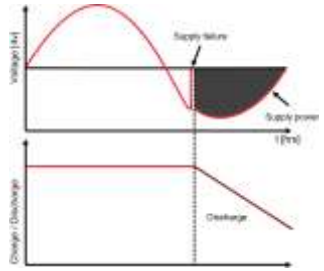
Rob Roys, Western Regional Sales Manager

Energy Storage Applications

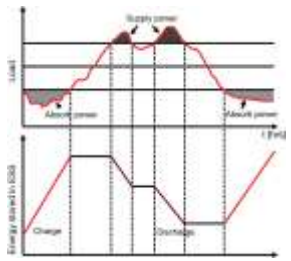




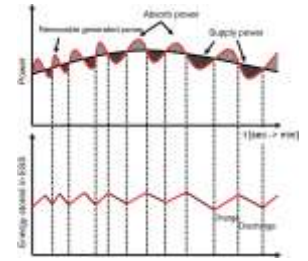
Peak Shaving



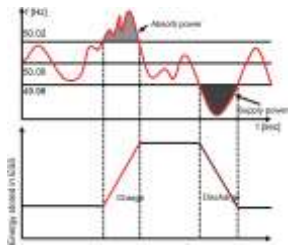
UPS / Islanding



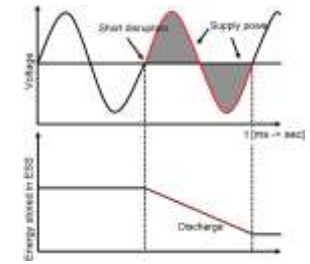
Load Leveling



Capacity firming



Frequency Regulation



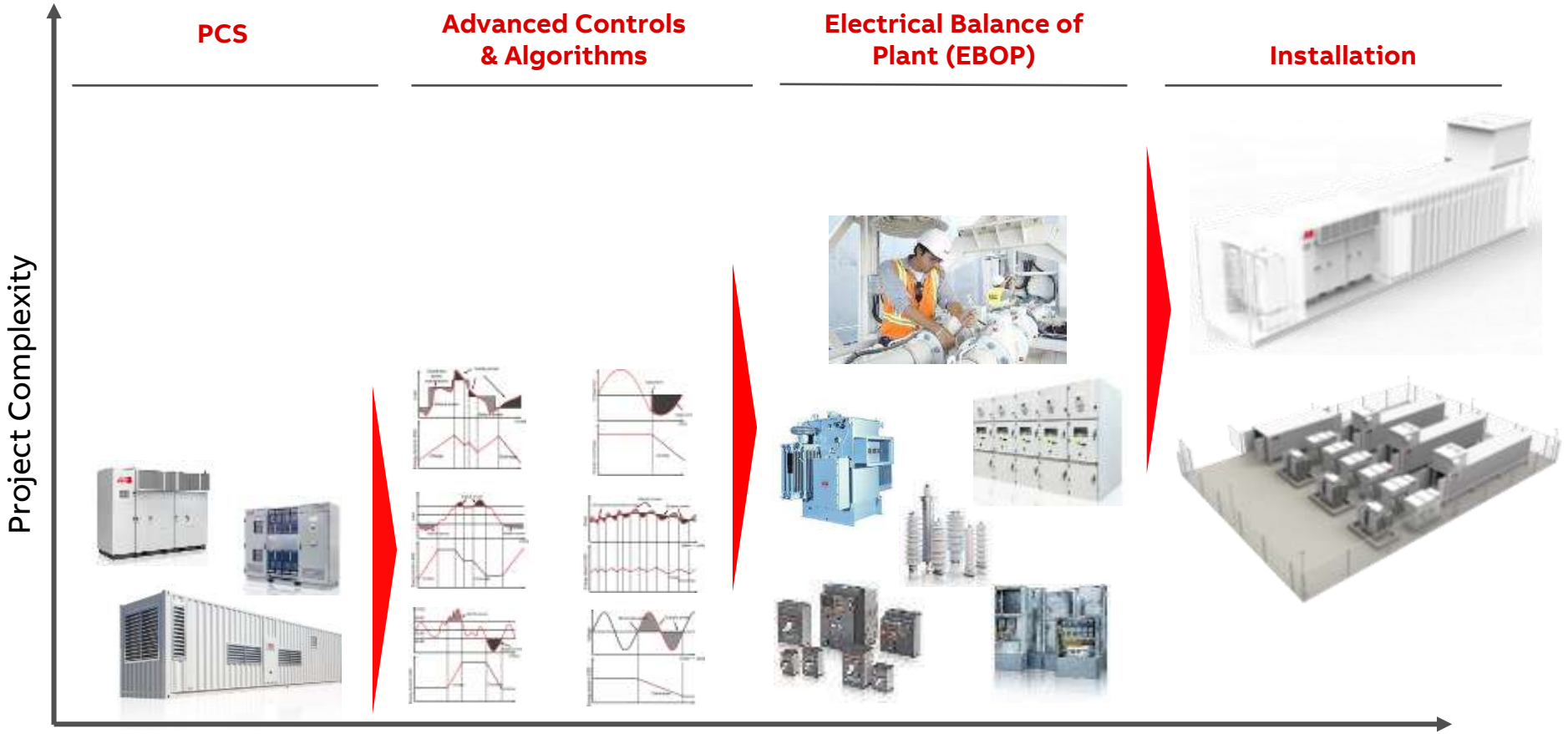
Voltage support

Energy Storage Systems

User implementation

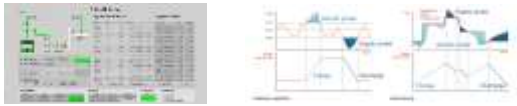
	Users			
Applications	**Industrial, commercial and residential**	**Renewable integrators**	**Transmission and distribution operators**	**Power stations**
Peak shaving	✓		✓	
Load leveling	✓	✓	✓	✓
Frequency regulation		✓	✓	✓
Ramp rate control / Capacity firming		✓		
Power quality	✓	✓	✓	
Spinning reserves			✓	✓

Energy Storage Project Scope



Energy Storage Systems

Overview of system components

System components		
Power Converters		Range of leading-edge power converters to suit a wide range of applications and system sizes
Batteries		Optimal battery technology for every application
Control systems and algorithms		Integrated EssPro EPIC control system enables manual and automatic operation of all system components in various control modes
Protection equipment		State-of-the-art protection systems for AC and DC equipment
Transformers and switchgear		Full range of transformers for local standards LV, MV and HV switchgear ensures safe and reliable grid connection
Modular and scalable		Scalable and flexible systems facilitate easy and safe operation

Energy Storage Systems

Configurations

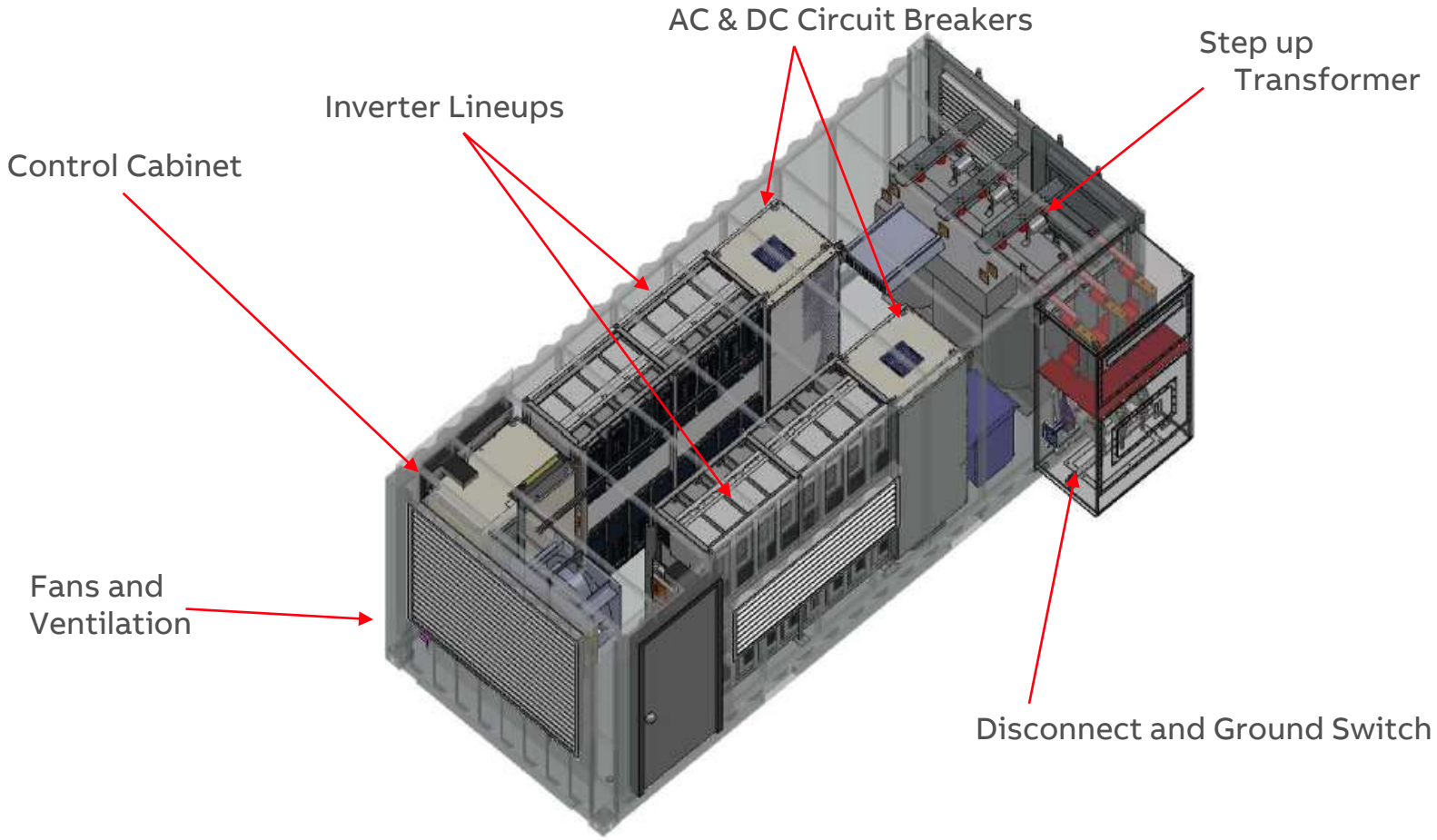
Indoor units

Outdoor enclosures

Outdoor system solutions

Configuration

Example



Energy Storage Systems

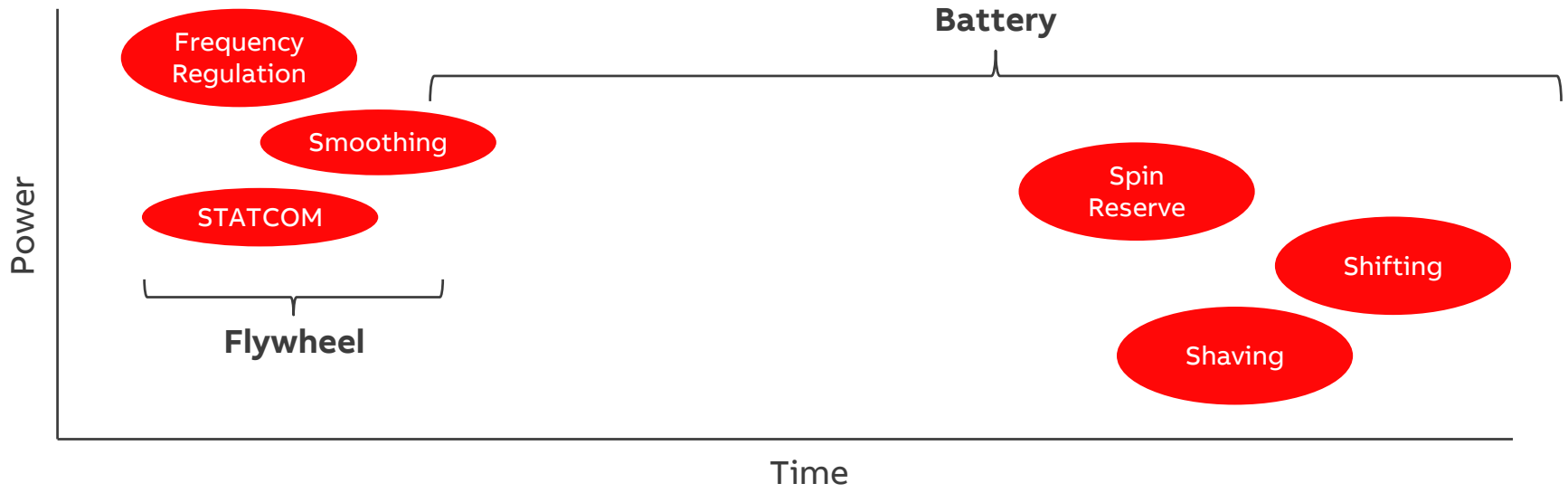
Power vs energy

Power
(AKA: front end, capacity, inverter, PCS)

- Measured in kW or kVA
- Represents the instantaneous output limit of the storage system

Energy
(AKA: back end, modules, racks, batteries)

- Measured in kWh or amp-hours
- Represents the total amount of energy in the storage medium



Power Conversion System

Functionality

- Scalability
- Modularity
- Grid stabilizing
- Frequency control
- Voltage control
- Grid forming
- Synthetic inertia
- Fault ride through

Power Conversion System

Inverter operating modes

Current source mode

Able to control power flow by controlling the current from the inverter

Direct current control provides a faster response to a power command

Sinusoidal current regardless of grid voltage distortion

Minimizes DC ripple current

Fast response

Voltage source mode

Able to provide power to the grid in the same manner as a regulator generator

Ability to source negative sequence current to correct grid unbalance

Stabilization of small grids through ‘synthetic’ inertia

Dynamic Power, Voltage Frequency Regulation, Islanding

Can leverage both control modes for maximum performance and output

Energy storage mediums

Various types of methods of storing energy

Mechanical

Gravitation
- Pumped hydro

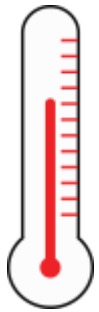
Kinetic
- Flywheel

Thermo-dynamic

Heat
- Thermo-electric

Pressure
- Compressed air (CAES)

Pressure heat
- Adiabatic CAES

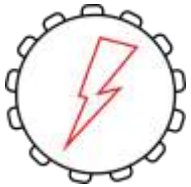


Electromechanical

Batteries
- Lead acid
- NiCd
- NaS
- NaNiCl
- Lithium
- Ni-MH
- Metal Air

Flow Cells
- Vanadium
- ZnBr
- PSBr

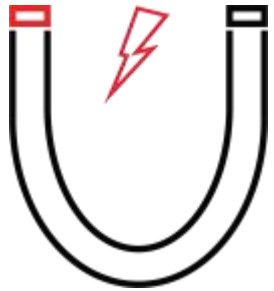
Hydrogen
- Electrolyzer and fuel cell



Electromagnetic

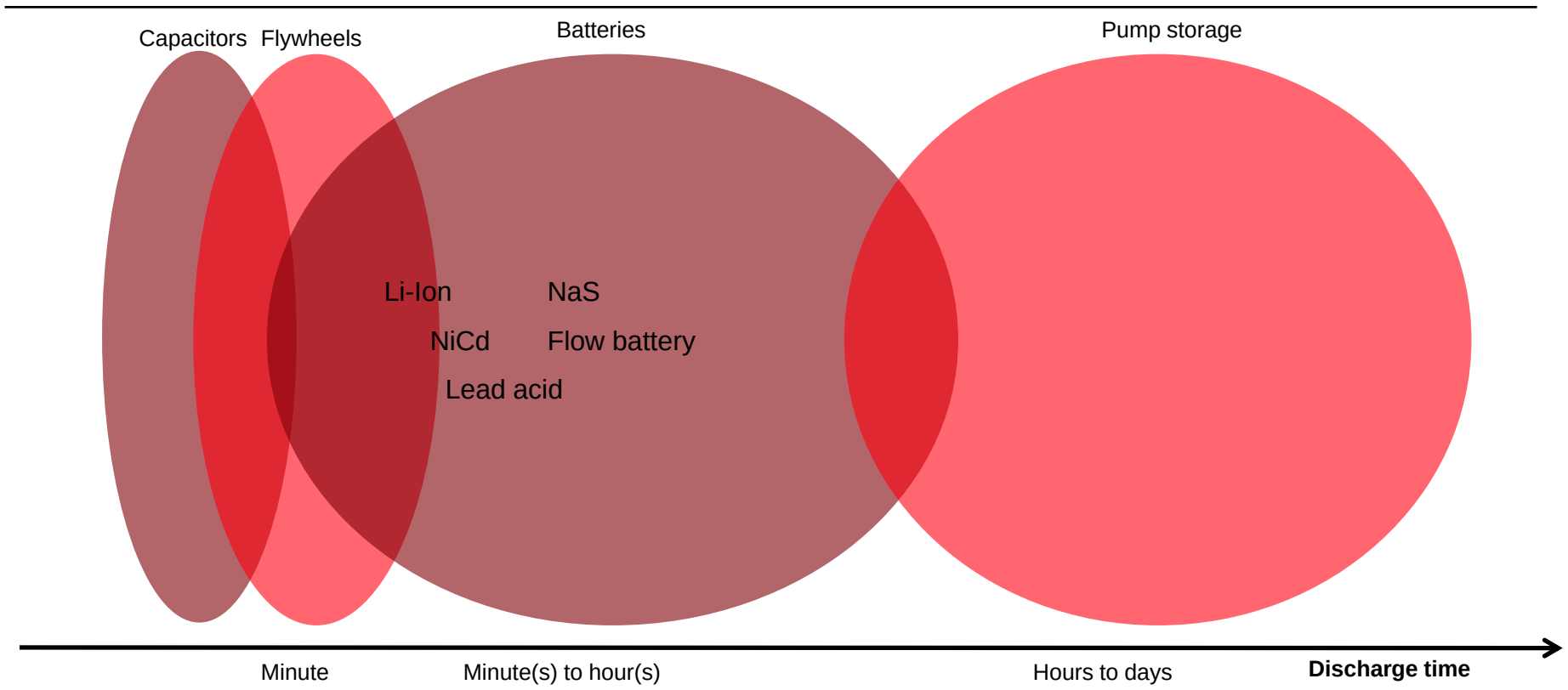
Electric
- Capacitors supercaps

Magnetic
- Super-conducting (SMES)



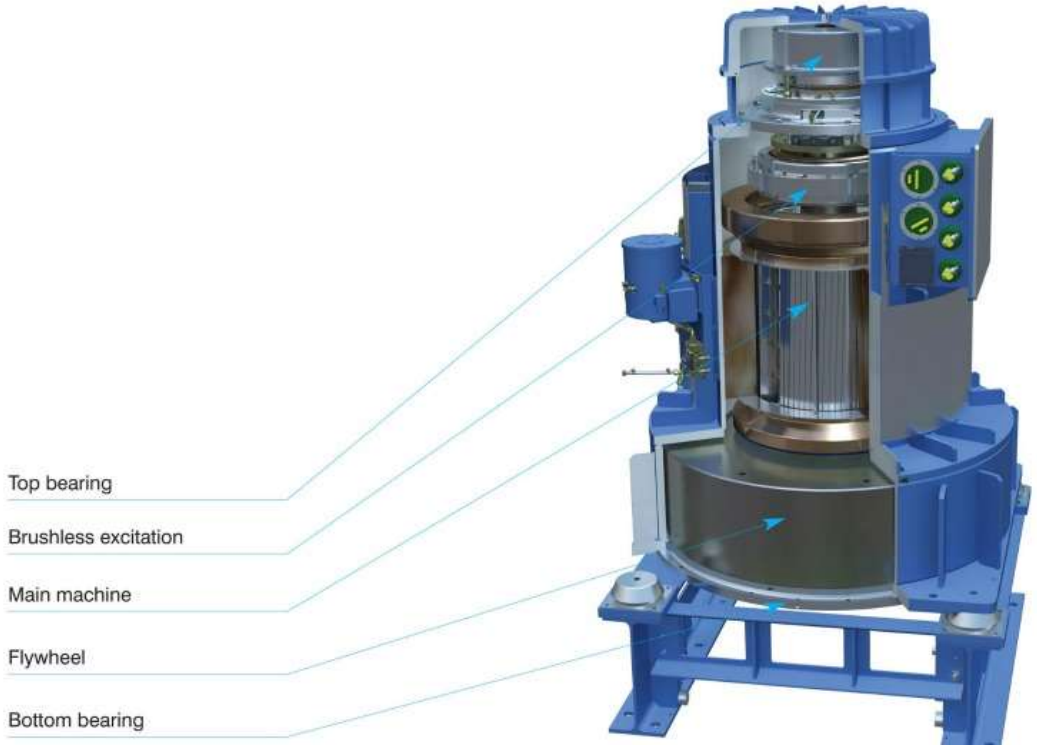
Energy Storage

Choice of technology



Energy Storage

Flywheels



Performance Data:

Net. energy content	16.5 MWs
Max Input/output power	1650 kW
Speed range	1800 to 3400 rpm
Total weight	6000 kg
Rotor weight	2900 kg
Idling losses	~12 kW
Greasing frequency	5 years
Bearing service life	8 years

Features:

- Helium filled
- Magnetic support
- Redundant bearings

Energy storage applications

Battery characteristics

Capacity [kWh]

Output power [kW] and C-rating of batteries

Number of cycles per time period

Expected lifetime [years], [cycles]

Discharge depth [%]

Self discharge [% per month]

Operation and maintenance costs

Dimension of the battery installation

Safety - electrical, mechanical and operator

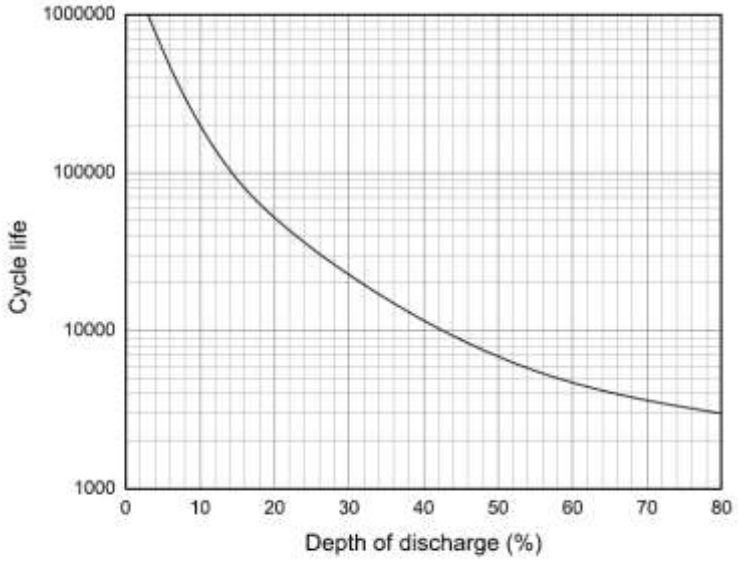
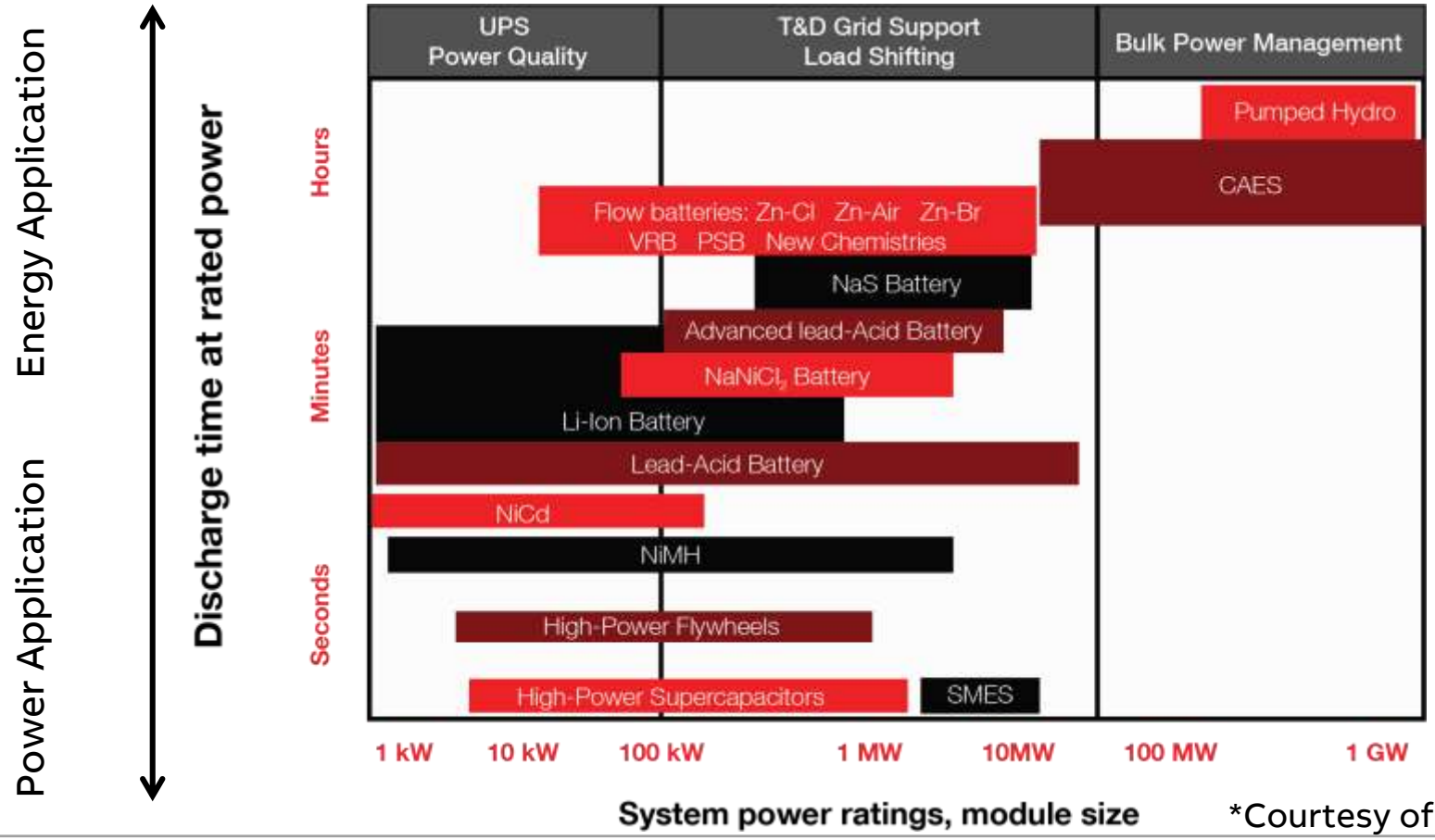


Figure C.1—Cycle-life curve for a sample battery system

Power vs Energy

Various types of methods of storing energy



*Courtesy of Sandia

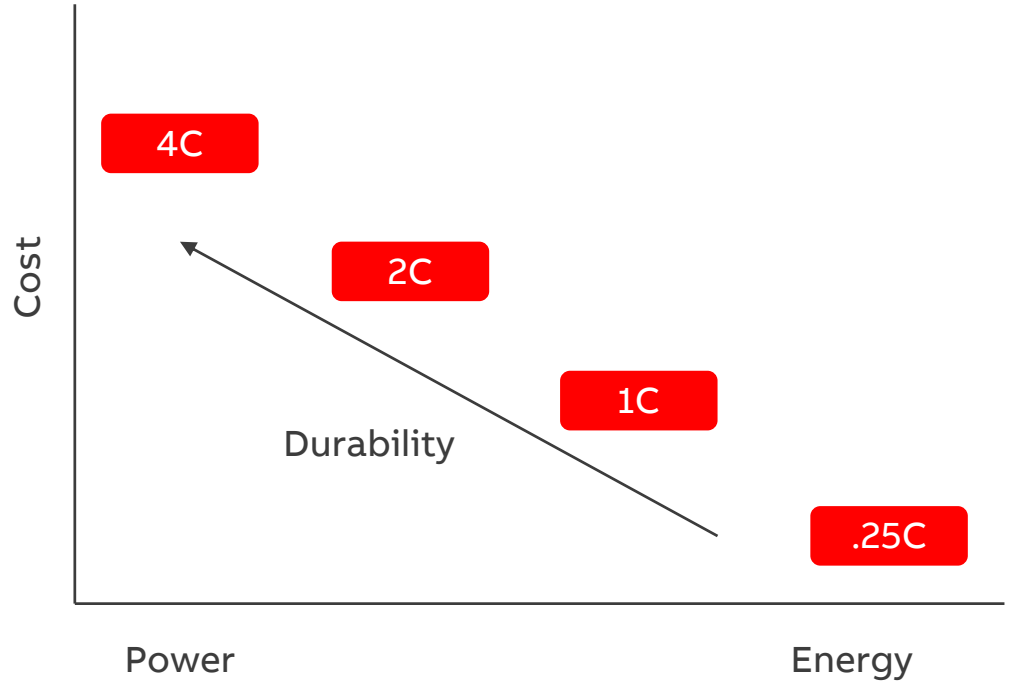
Energy Storage

Battery C Rate

C Rate

$$\frac{\text{Storage Power}}{\text{Storage Energy}}$$

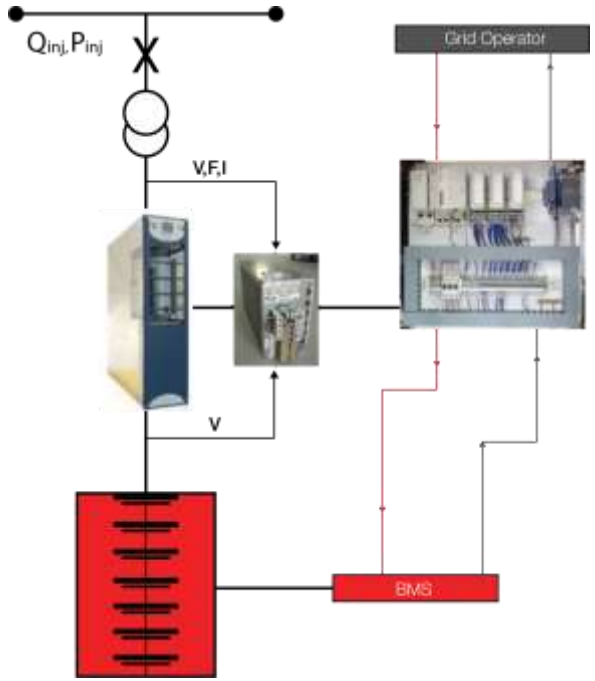
*1MW/250kWh = **4 C***



Integration & Control

ESS simple or smart control capabilities

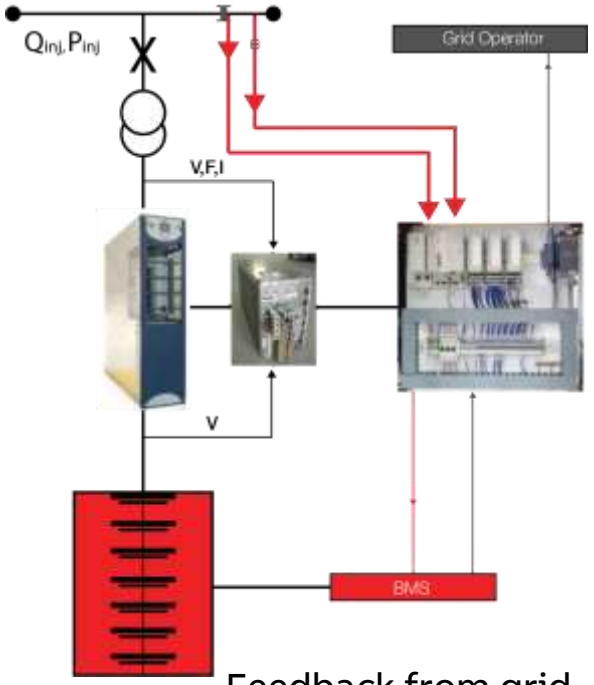
Open Loop Control



Start/stop P&Q setpoints manually inserted

Can implement both control forms to adapt to customer business model

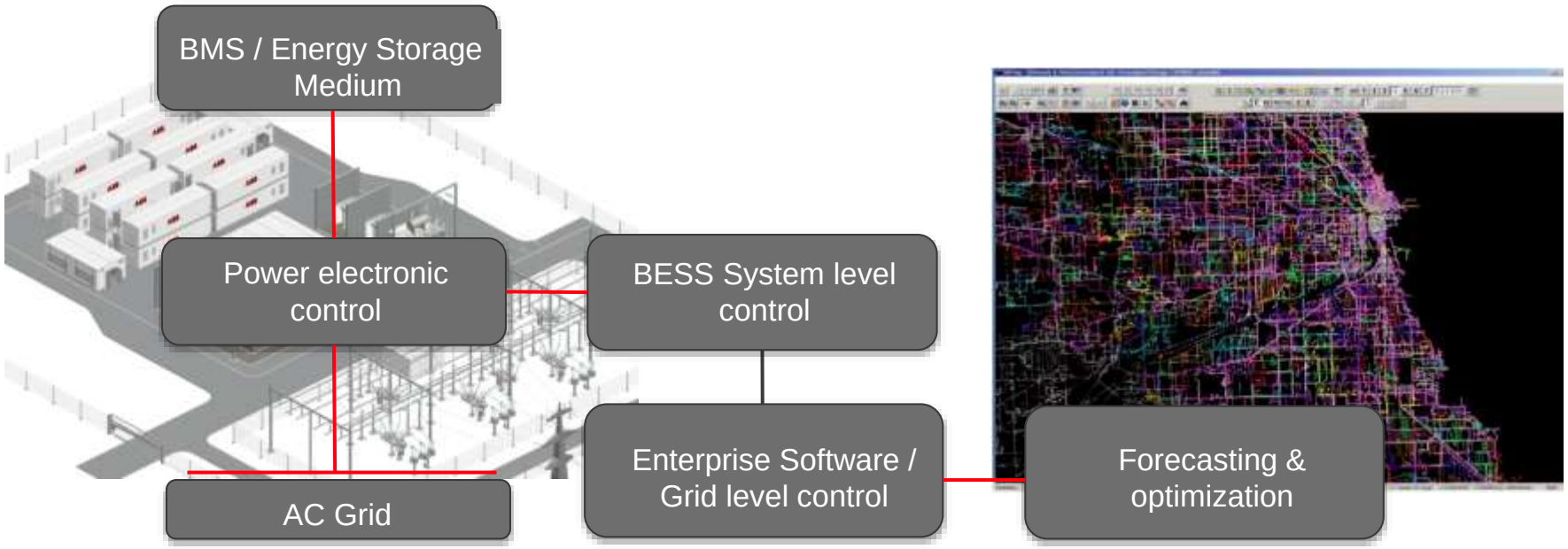
Autonomous Control



Feedback from grid
(P,Q,V,I, Freq)
Used to calculate next P&Q setpoint

Integration & Controls

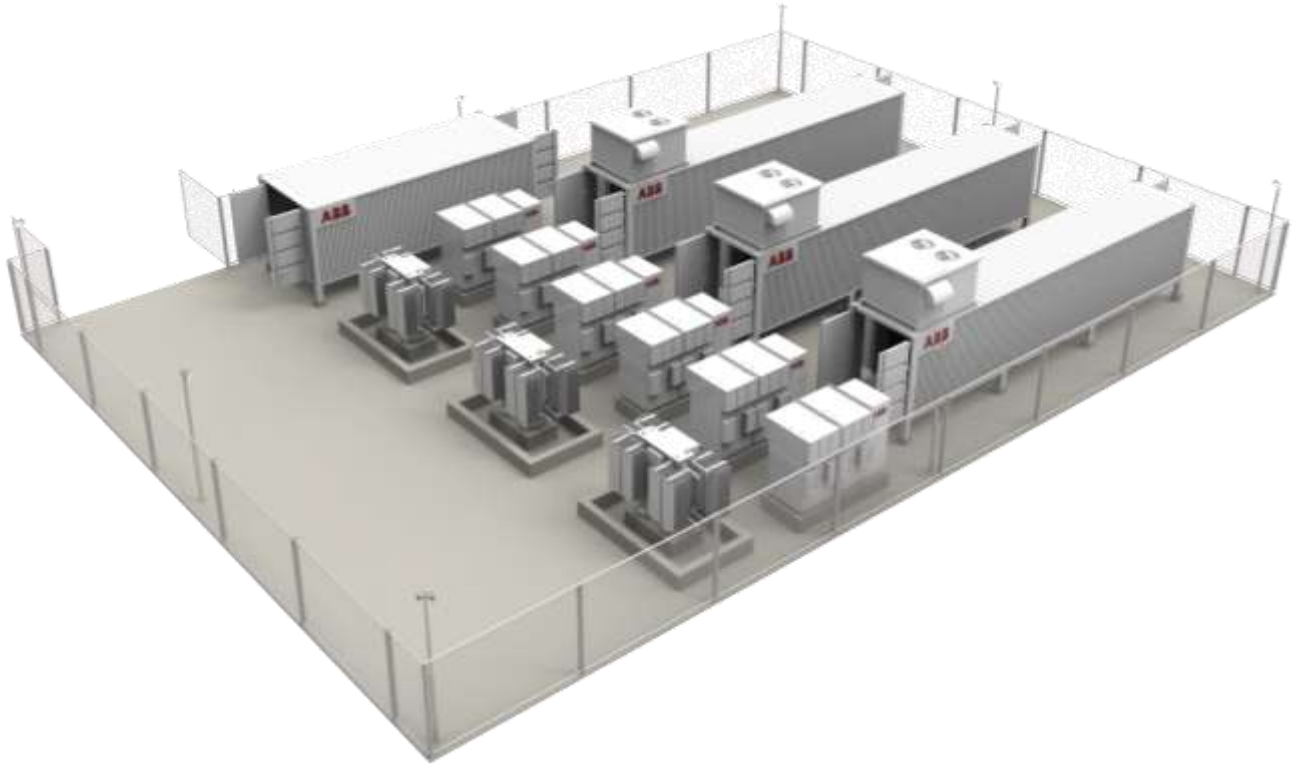
BESS Control Architecture



Power technology **Control** **‘Smartness’**

Why Energy Storage?

Common denominators



High and unpredictable operating costs

- ✓ Fuel – cost and availability
- ✓ Demand Charges
- ✓ TOU rates
- ✓ Weather-related outages

Variable power

- ✓ Renewable energy – wind and solar
- ✓ Complex distributed generation
- ✓ Highly cyclic and demanding loads
- ✓ Power quality issues
- ✓ Unreliable power

Constrained Systems

- ✓ Transmission or distribution constraints
- ✓ Growth capped by system
- ✓ Renewable penetration limited
- ✓ Zero Net Energy policy

Q & A

Do not hesitate to contact me…

Contact Info

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