
FAHD HASHIESH

# Power Quality

# Power Quality – Does it exist?

P Z A S W J S H U E X N D H Z
T F Q K I L J N Q D A X V A G
R S F Q L W B D R O F H J R S
N G X E X A M X E C N S S M U
N R W T L Y V L W D H M O O O
E S H A R L W F O I S N Z N X
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J C I Z K T N N E G U H E C H
E N H T Y S J S V Q K G E S Z
D R C S N B S E I T L A N E P
C W S X A W R B T E P Z J J V
D M J Y X G O F C D N Y E V L
S U R G E S S D A X W T F E L
F P B R W S R J E S W M S G L
R K U W P O W E R F A C T O R

# Is it easy now?


SAGS

SWELLS

HARMONICS

Reactive Power

SURGES

POWER FACTOR

DOWNTIME

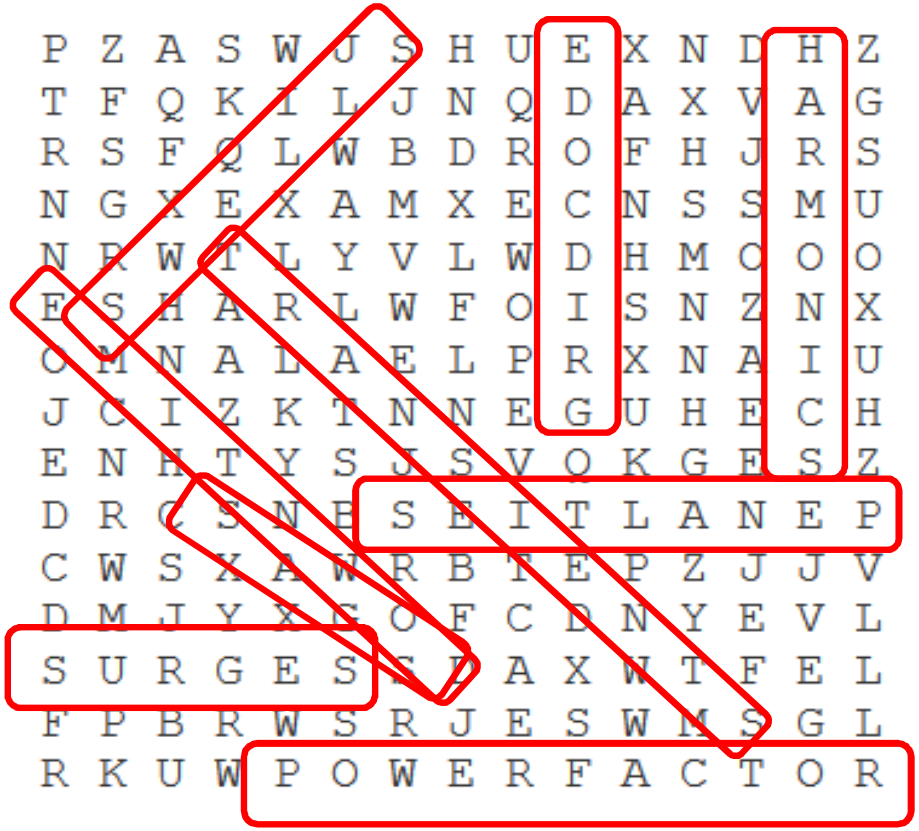
GRID CODE

TRANSIENTS

UNBALANCE

PENALTIES

# Find out Key words?

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# Power Quality

## Consequences of poor power quality

1. Wind power generation

   Not able to connect to the grid in case of overvoltage or undervoltage or if pollution emitted is too high

2. Marine

   Non-compliance, not allowed to connect to grid, increase in running costs, frequent outages and downtime

3. Industry

   Non-compliance to grid codes, not allowed to connect to grid, penalties, lower productivity, potentially higher $CO_2$ emissions

4. Conventional power generation

   Higher stress on generators leading to premature failure/erratic behavior, higher running costs

5. Power distribution

   Not able to connect to the grid – in case of overvoltage or undervoltage or if pollution emitted is too high

6. Solar power generation

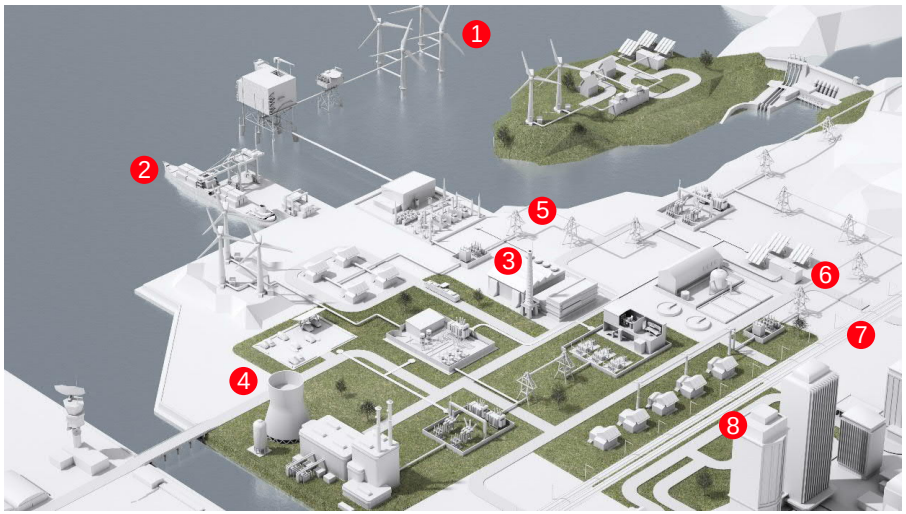
   Not able to connect to the grid in case of overvoltage or undervoltage or if pollution emitted is too high

7. Railway

   Non-compliance, penalties, frequent outages and downtime, reduced operational efficiency

8. Infrastructure

   Penalties, frequent outages and downtime, reduced equipment life, potentially higher $CO_2$ emissions



# Power quality actual drivers & challenges

## Power quality is under pressure from …

### Changes in the generation mix

Increase level of renewables
- Lower system stability / reliability/inertia
- Increased harmonics
- Voltage stability issues

From centralized to distributed
- More complex system controls
- Microgrid deployments
- Reverse flow issues

Energy storage deployment
- Increased level of harmonics
- More complex system controls
- Energy support duration uncertainty

### Traditional industries/ demand

Heavy industries
Arc furnaces causing:
- Large reactive power demand
- Non compliance /penalties
- Harmonic distortion

Other industries
Mills, variable speed drives, heavy motors causing:
- Poor power factor
- Harmonics

Railway systems
AC and DC railways causing:
- Harmonics
- Poor power factor
- Poor load balance

### Digitalization and new load demands

E-mobility
- Spread location of chargers
- Restrict feeder hosting capacity
- 3-ph supply imbalance
- Voltage sag during charging

Expansion of data centres
- Increased harmonics
- Grid reinforcement required
- High reliability & dependability need

Smart grids/cities
Higher loads, harmonics and data flows from:
- Internet of things/smart homes
- Smart cities/highways

### Changes in the regulation

New grid code requirements
More stringent provisions for:
- Dynamic voltage control
- Harmonics
- Reactive power support

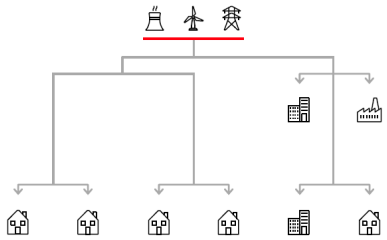
TSO / DSO developments
System operators develop new responsibilities / interfaces

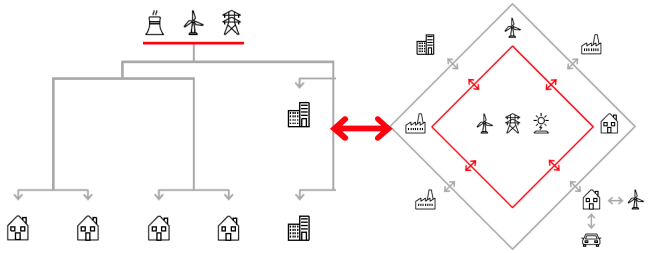
Share of market regulation costs
- Energy trading
- Power factor correction
- Harmonics mitigation

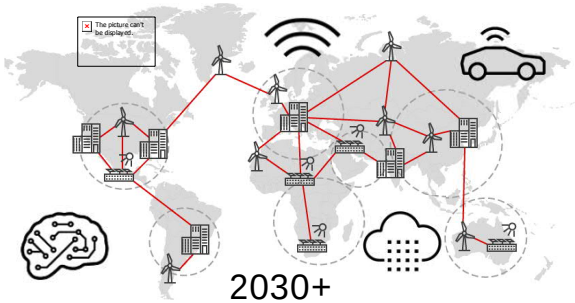
# Power systems and markets of the future

## Renewables, grid edge technologies and digitalization drive the evolution of future power systems

| Yesterday | Today | Tomorrow |
|---|---|---|







2000 — 2020 — 2030+

Factors:
- Global warming – ecological threats
- Stimulated, regional introduction of renewables
- Reduction of photovoltaics & battery storage costs
- Consumer to Prosumer development
- Digitalization trend
- Interconnection technology development

Factors:
- Full scale deployment of renewables across all regions
- Increased share of energy by wire
- Massive introduction of grid connected Electrical Vehicles
- Utilities re-inventing themselves with new business models
- «Internet of Energy»
- Autopilot features using artificial intelligence


 Sources: ABB

# Power quality future drivers & challenges

## Further renewable integration process

Larger Renewable integration
- Technology cost reduction
- Meet 2030 targets
- Further increase of related current issues

Substantial increase of DG and shut down of traditional plants
- Further reductions in system inertia/stability

Energy storage full deployment
- Improve renewables dispatching
- Ancillary Services market
- Power systems control interactions

## Decarbonization process

Integration of RES at industrial
- Reduce CO2 emissions
- Impact on the industrial process – variability/ power factor / harmonics

E-mobility deployment
- Mass transportation electrification (trucks)
- Reverse flow issues with V2G

Railway systems
- SFC integration
- Energy storage deployment

## Digitalization and new load demand

Demand side management
- Electrical equipment can be affected by power quality issues

Further Expansion of data centres
- Large power demand
- Remote locations with lower
- Green data centres

Further development of Smart grids/cities
- Demand increase
- Behind the meter generation

## New regulation and developments

New grid code requirements
More stringent provisions for:
- New generation
- New load type
- Behind the meter regulation

TSO / DSO developments
- HV and MVDC grids
- New interconnections
- New principles for planning/operation

Affordability of power
- Further pressure to lower consumer prices
- Use of system (UoS) charging mechanisms

# Fundamentally new challenges for power systems

## Coping with the increasing installation of wind energy

### Volatile generation profile

- Maximum output varies depending on wind and sunlight
- No perfect forecast available for wind and sunlight
- Most of the renewable energies have little to none base load capability

### Inertial response capability

- Wind and solar installations are non-synchronous generation technologies that connect to grid via power electronics and have little or no inertial response capability

### Location constrained

- Areas with the best resources are often situated in remote locations. Tapping into these resources will require efficient ways to transport a large amount of power over long distances

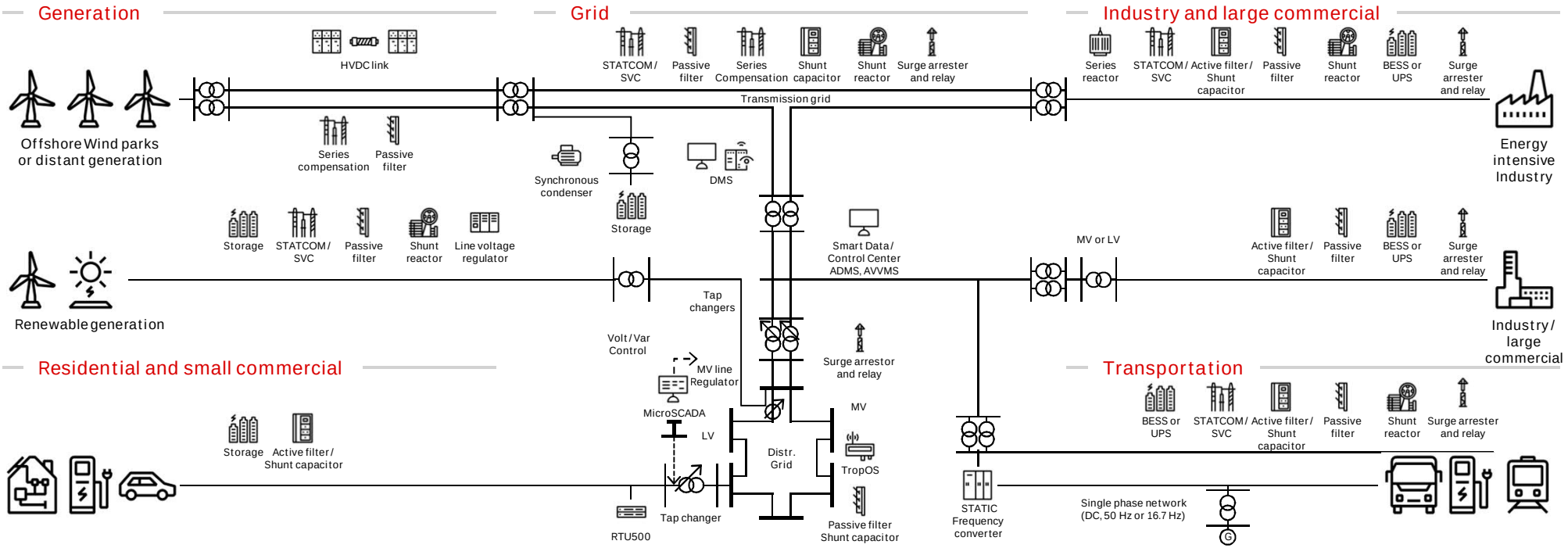
### Modularity and distributed

- More production entities dispersed along the power system
- Increasing levels of distributed generation will require new approaches to regulate and manage the energy production and the power system

**Renewable energies are the key drivers in the evolution of the power system**

# Power Quality technologies

## Increased penetration of power electronics based generation and consumption influences the traditional power quality business



# ABB and Power Quality

## Unmatched knowledge, portfolio and experience

Site assessment

- Site audits
- Feasibility and system impact studies
- Assessment of assets and their contribution to power quality

Consulting

- Technical and economic analysis
- Business case and model definition
- Definition of functional requirements
- Project planning

Solution design

- Analysis of upgrade vs replacement strategies
- Asset life cycle evaluation
- Solution definition and selection of products

Solution delivery

- Project management and planning
- Products delivery and insourcing
- System engineering
- Deployment
- Commissioning and running acceptance tests

Software

- Monitoring, protection and control equipment
- Cyber security analysis
- Gateways and SCADA system
- Voltage control applications
- Asset health center

Services

- Remote technical support
- Advanced technical experts
- Asset lifetime management
- Spare parts and replacements
- Training

ABB offers a broad portfolio of products, systems and services along the project execution

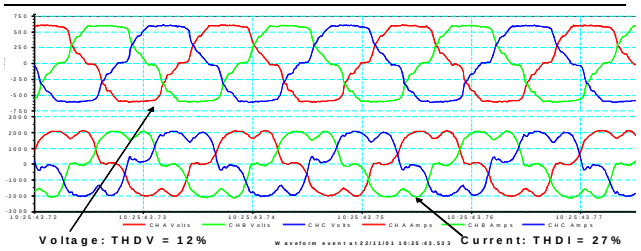
# ABB offerings to enhance utility networks efficiency

## Offering what the customers need

### Measurement

AND / OR

### Analysis




### Solution

### Products

### Service

### Training

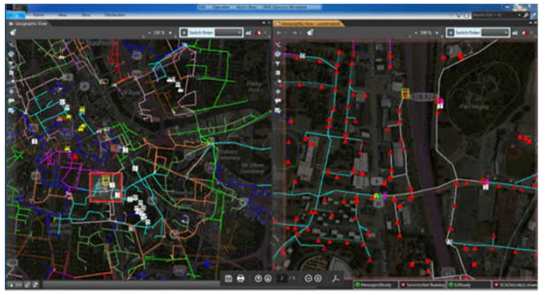
# ABB offerings to enhance utility networks efficiency

## Product portfolio overview

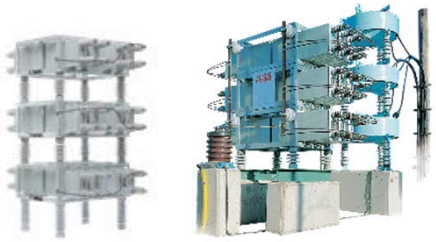
### HVDC and FACTS

### Switched capacitor banks

### Volt-var management software



### Fixed capacitor banks and filters



### Variable shunt reactors

### Capacitor accessories

# Power Quality

## Technologies Highlights

# ABB offering for Power Quality

## FACTS

Solution benefit

### Fixed Series Compensation

Cost effective solution to increase power transfer capability in transmission corridors instead of building new transmission lines

- Improved voltage and transient stability
- Improved voltage profile along the lines

### Thyristor Controlled Series Compensation (TCSC)

- Provides damping torque on inter-area electromechanical oscillations (POD)
- Inherent immunity against sub synchronous resonance (SSR)
- Enhances capabilities for dynamic power flow control
- Often the TCSC is combined with fixed series compensation to increase transient stability in the most cost effective way

### SVC Classic

- Improved voltage stability, facilitated integration of renewables
- Load balancing
- Flicker mitigation and power quality enhancement
- Increased productivity by power factor improvement

### STATCOM (Hybrids)

- Similar benefits as for SVC Classic
- More robust integration in weak grids
- High performance flicker mitigation
- Reduced footprint thanks to fewer passive elements

### Rail Static Frequency Converters (SFC)

Active power in-feeding 3 phases-1 phase to 16,7/25 Hz, 50/60 Hz

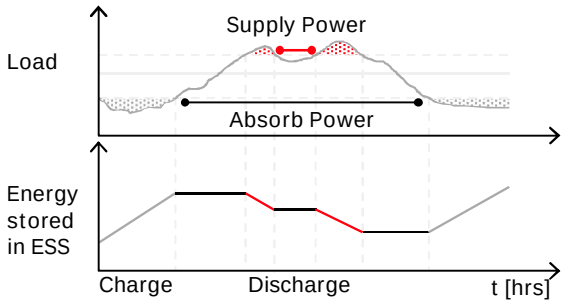
- Full decoupling of grids
- Independent, fast control of frequency
- Voltage, active and reactive power on both sides
- Connection to weak grids

Series Compensation | Shunt Compensation | SFC

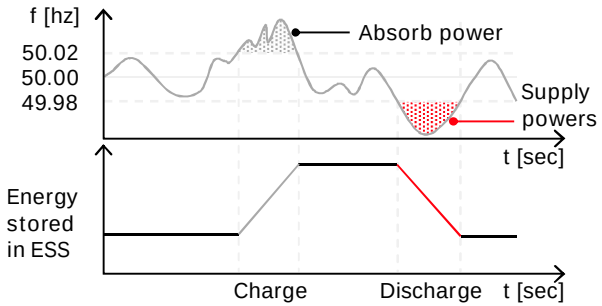
# ABB offering for Power Quality

## Advanced control algorithms enable applicability of BESS in every market segment

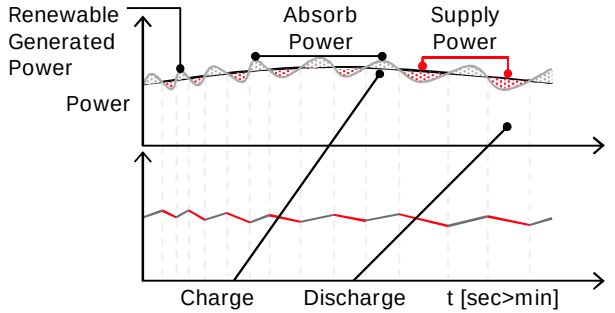
System adequacy



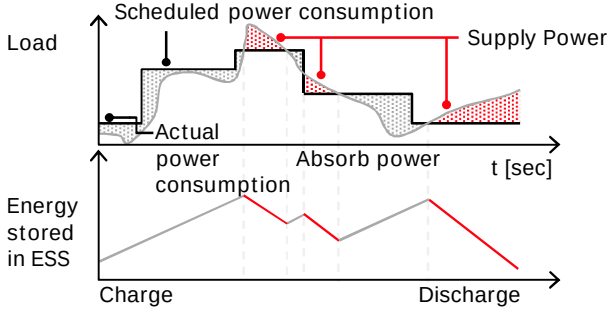

Ancilliary services



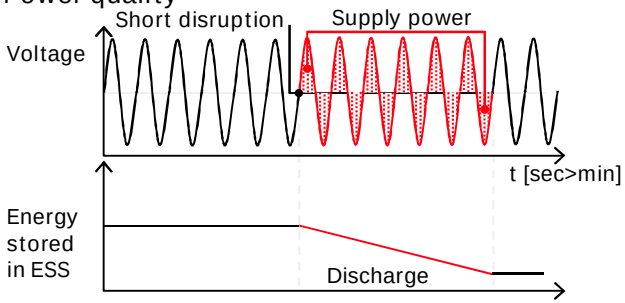

Integration of renewable resources



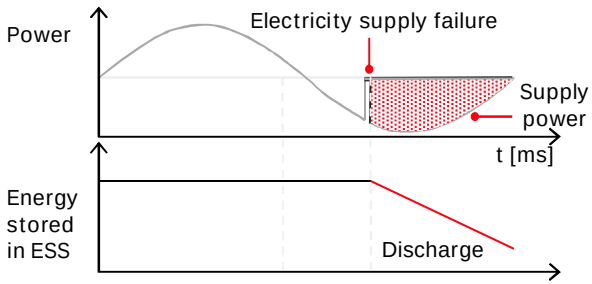

Energy resiliency




Power quality




Energy storage systems



# QPole Pole mounted capacitor bank

## Features and benefits

Features:

- Can be mounted on pole or ground (pad mounting)
- Frame sizes available for 3, 6 and 9 capacitors
- Highly reliable vacuum switching
- Controller suitable for local as well as remote operations

Benefits:

- Capacitor connection and disconnection as per requirement
- Improved voltage profile along the network
- Feeder level compensation of reactive power
- Reduced losses, increased system capability