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Eólica y Mercado, Sesión 5 – Hitachi Energy

14 February 2023, Madrid

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Sobre Hitachi Energy

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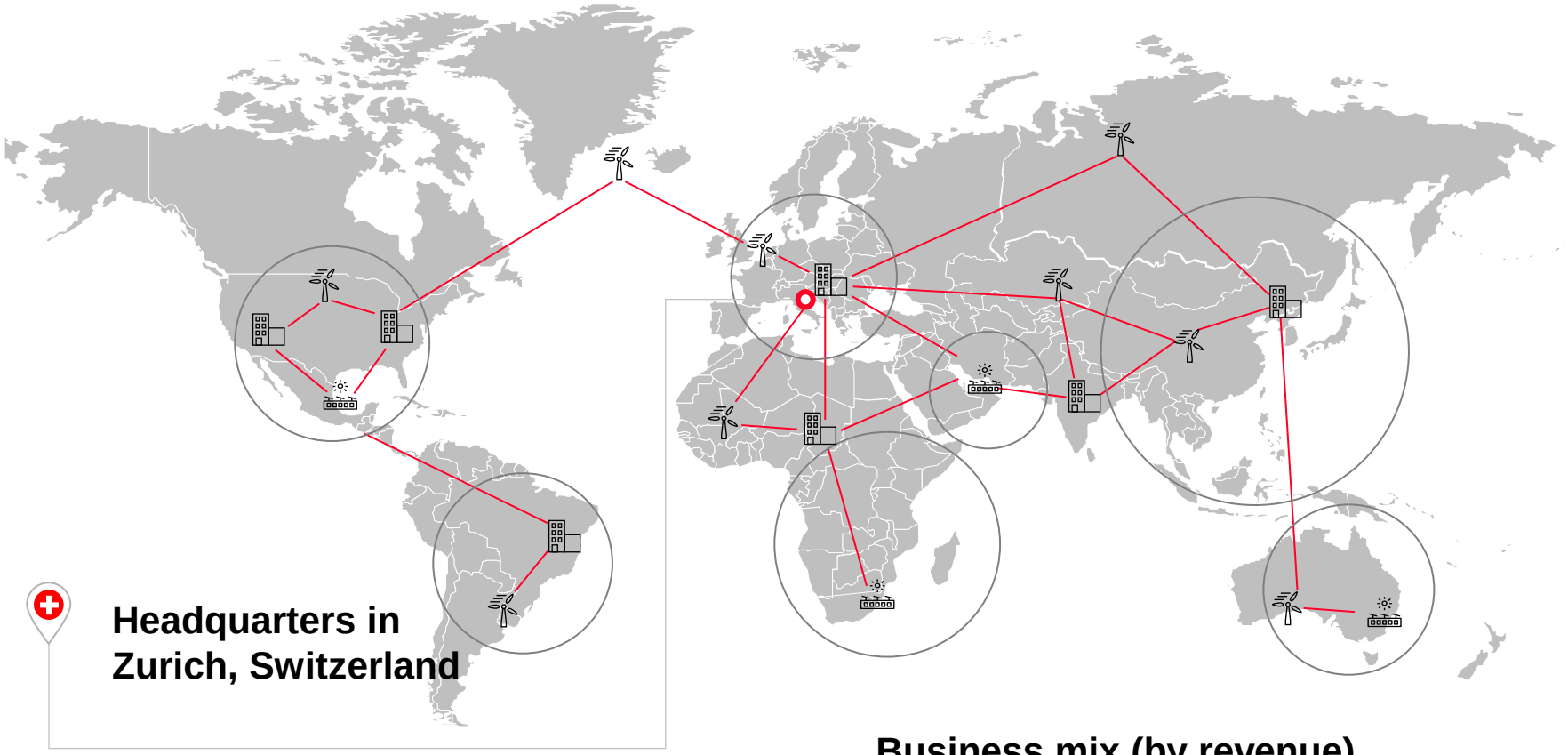

Headquarters in Zurich, Switzerland

40,000 employees

90+ countries with 200 offices

~250 years' heritage combined

5,500 sales employees & field engineers

2,000 engineers & scientists in R&D

Four Business Units

Grid Automation	**High Voltage Products**
Grid Integration	**Transformers**

Business mix (by revenue)

Customers

- Transport & Infrastructure
- Industry
- Utilities

Offering

- Services
- Software & Automation
- Systems
- Products

Geographies

- Asia, Middle East & Africa
- Americas
- Europe

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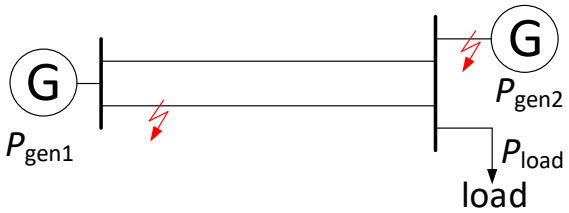
SVC Light® Enhanced Concept

Problems with more renewables?

Lower short-circuit power

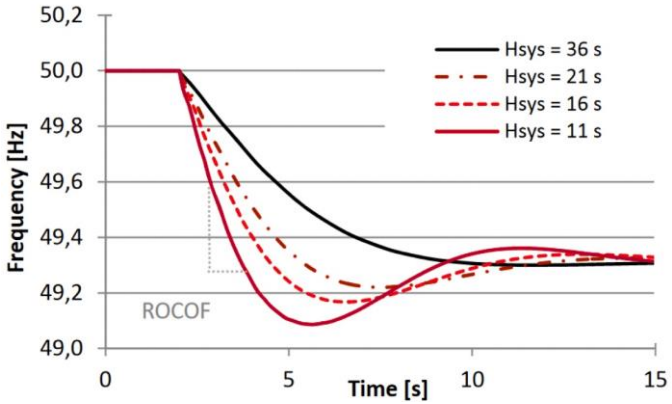
- deeper and widespread voltage dips for grid faults
- Lower power quality (larger voltage variations) Lower inertia
- Grid fault resulting in reduced generated power (power plant or line)



- Power imbalance results in reduced frequency:
  - Frequency change (slope)
  - Frequency deviation
- At too high frequency change and too low frequency, loads and generators are disconnected from power system

Frequency variations

- Lower inertia results in quicker frequency variations



Potential solutions to add inertia to increase stability:

Synchronous Condenser

STATCOM

Enhanced STATCOM:
- STATCOM (SVC Light®)
- Energy storage
- Advanced controller

Comparison

Grid-stabilizing services	Traditional STATCOM	Synchronous condenser	SVC Light® Enhanced
Voltage regulation	● ● ●	● ●	● ● ●
Inertia		● ●	● ● ●
Short-circuit current contribution	●	● ● ●	● ●
Flexibility/ modularity	● ● ●		● ● ●
Controllability	● ●	●	● ● ●

Grid Forming Control – Definition and Objectives

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- The term ”Grid Forming” does not yet have a universally accepted definition.
- All requirements share one objective: **instantaneously react to any change on the grid system and contributing to maintain its stability**.
- Behaving as a voltage source behind an impedance is generally considered a way to achieve the objective.

GC0137 Final Modification Report
National Grid, UK

“*The converter behaves as voltage source behind an impedance in the same way as a synchronous generator. This has two substantial benefits – it i) enables the* ***converter to instantaneously react to any change on the Grid system*** *without any independent control action and ii) power electronic converters with this capability all operate in synchronism with each other in the same way as synchronous generation* ***enabling wider system support during system disturbances***”.

White Paper: Grid Forming Controls
NERC, US

“*Grid Forming Control for BPS-Connected Inverter-Based Resources: controls with the primary objective to maintain an internal voltage phasor that is constant or nearly constant in the sub-transient to transient time frame.* ***This allows the IBR to immediately respond to changes in the external system*** *and maintain IBR control stability during challenging network conditions. The voltage phasor must be controlled to maintain synchronism with other devices in the grid and must also* ***regulate active and reactive power appropriately to support the grid.*** *”*

Draft Standard for Interconnection and Interoperability of (IBR)
IEEE P2800, US

“An.” IBR with grid forming control should not be directly compared with a synchronous generator. The goal is not to attempt to precisely “emulate” the behavior of synchronous machines, although there are elements of this behavior which are desirable, in alignment with existing operation mode of the system
The objective of grid forming IBRs should not be simply to reproduce the behavior of synchronous machines. Instead, ***the focus should be on understanding the needs of the evolving power grid and utilizing the IBRs in the most effective way.***

Connection of HVDC systems to the public network
VDE AR-N 4131, Germany

“In response to a temporary voltage change at the connection point, the HVDC system shall modify the exchanged power without delay. ***The objective*** *of providing this instantaneous reserve* ***is the immediate counteracting to changes*** *in the phasing of the fundamental component of a positive-sequence system* ***thereby contributing to the limitation of the maximum rate of change of frequency****.”*
*“****The objective*** *of dynamic voltage control without any reactive current specification* ***is to counteract a short-term change*** *of the fundamental component amplitude of positive-sequence and negative-sequence systems t****hereby contributing to the limitation of the voltage change****.”*

Grid Forming as a Definition of Performance

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- The objective is to deliver a system with optimized performance under the widest possible range of short circuit power and **instantaneously react to any change on the power system and contributing to maintain its stability**.
- Grid Forming shall not define a specific control strategy, it shall rather define the expected performance in the power system.
- Grid Forming capability is required to improve the grid stability and fulfill Grid Code requirements.

Grid Forming Performance:

Without Energy Storage

- Contribute to grid strength.
- Contribute to short circuit current injection.
- Reduces system unbalance.
- Provide inductive-resistive behavior for harmonics

with Energy Storage

- Provide inertial response.
- Contribute to frequency control.
- Island operation.

Grid Forming as a definition of performances rather than definition of control strategy

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SVC Light® Enhanced – an all-in-one solution

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Providing both active and reactive power

Grid-forming capability provides stable operation and a robust control

MACH™ Control System

Control Algorithms & System Expertise

Reactive power is dynamically generated and exchanged with the network to control the voltage and respond to emergency conditions

SVC Light®

Reactive Power

Active power is introduced to provide additional grid services.

Supercapacitors

Active Power

Active Power

Reactive Power

Power System

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Power Consulting
Reference case

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Project description: Concept Validation of a 330 MW Offshore Wind Farm

Customer: Equinor, Norway

Customer needs

- Consulting services for FEED electrical studies
- Consulting services to support the development of an overall plant controller for grid compliance at PCC

Power Consulting's response

- Support in design of electrical power system including MV collection system, HV interconnection and sizing of equipment
- Definition and implementation of power plant controller in DigSilent Power Factory
- Definition of Philosophy to minimize losses and optimize reactive power compensation

Customer benefits

- Overall optimized electrical system solution
- Definition of control philosophy of Power Park controller according to TSO demands
- Optimized coordinated action to control WTGs, tap changer and SVCs

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Offshore Wind power integration: Power Quality

Case Study - Reference

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Customer: Örsted (Denmark), Hornsea II

Customer needs:

- Hornsea Two is a 1,800 megawatt (MW) project, about 100 kilometer off the Yorkshire coast in the North Sea
- Completion estimates in 2020

Our response:

- THREE 240 MVA STATCOM SVC Light to Hornsea Two windfarm.
- Hitachi Energy contract also includes the installation and commissioning of 66-kilovolt (kV), 220 kV and 400 kV gas-insulated switchgear (GIS) and 400/220 kV onshore and 220/66 kV offshore transformers and reactors
- Hitachi Energy will also be responsible for the project management, engineering, manufacturing, supply and c
- Commissioning of the IEC 61850 based substation automation, control and protection systems for the onshore substation and the two offshore platform substations

Customer benefits:

- Studies and technical recommendation to apply reactive power compensation
- Full compliance with Grid Code requirements
- True partnership during design, tendering and project execution to ensure full FACTS potential at the customer site

Amprion STATCOMs

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Customer
Amprion, Germany

Customer needs
- Replace reactive power deficit left as a result of massive changes in the country's grid on journey to 80% renewable energy by 2050

Our response
- Two SVC Light® STATCOM systems, one rated at 300 Mvar and one at 600 Mvar

Customer benefits
- Flexible and efficient delivery of reactive power
- Low losses and high reliability

Year
2023

SVC Light®

MACH ® Control System

Enable retirement of fossil fuel generation

World's most powerful STATCOMS using SVC Light ® technology

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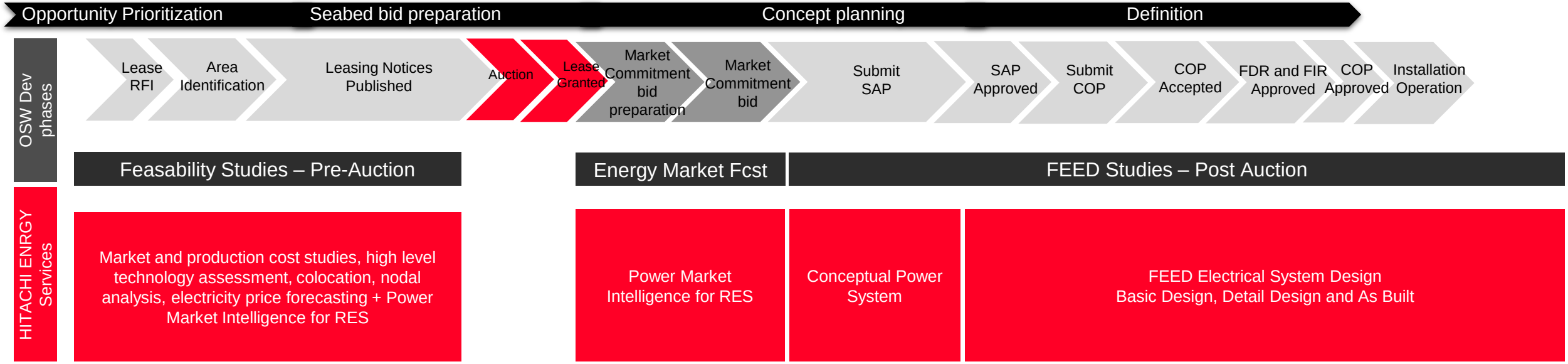
Energy Market, Feasability and FEED studies



SAP: Site Assessment Plan
COP: Construction and Operations Plan
FDR: Facility Design Report
FIR: Fabrication and Installation Report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