



EMT Simulations – Industry Perspective

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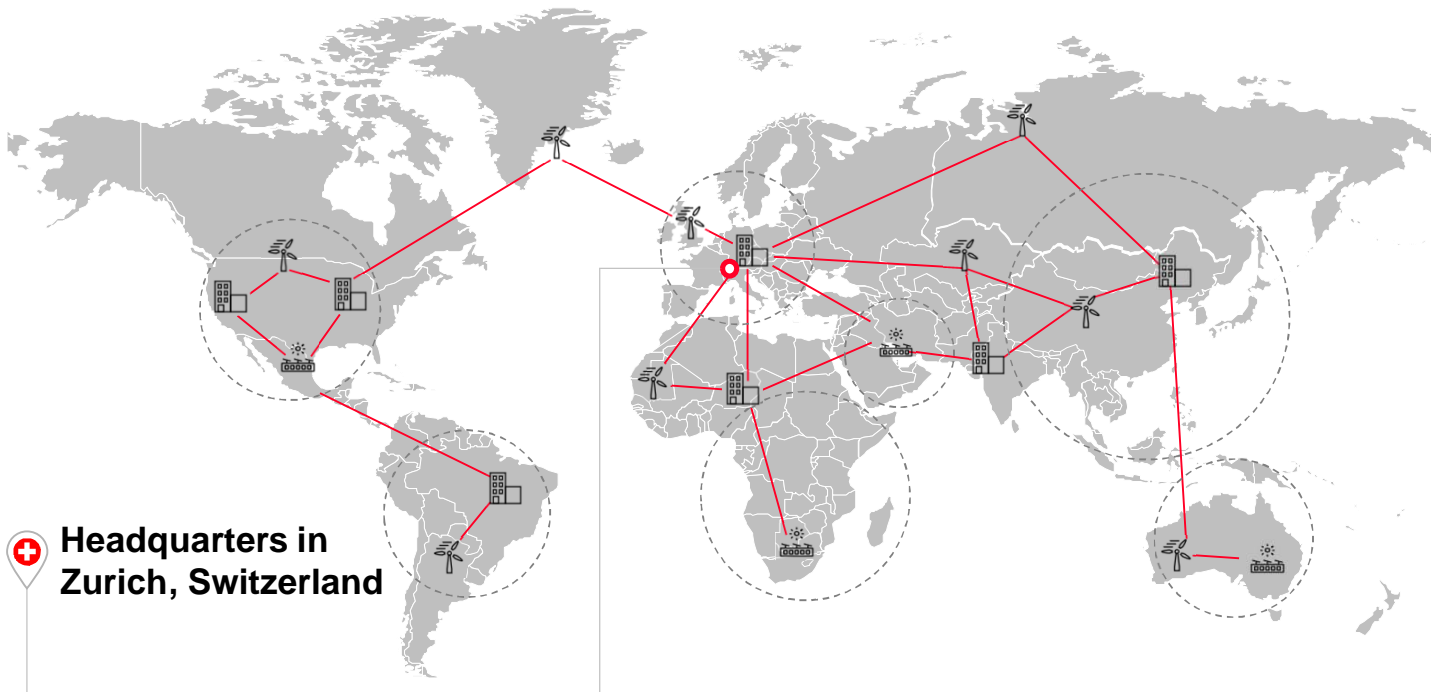
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About Hitachi Energy

HITACHI
Inspire the Next



>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 Businesses

**Grid
Automation**

**High Voltage
Products**

Grid Integration

Transformers

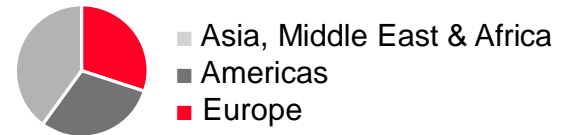
Customers



Offering



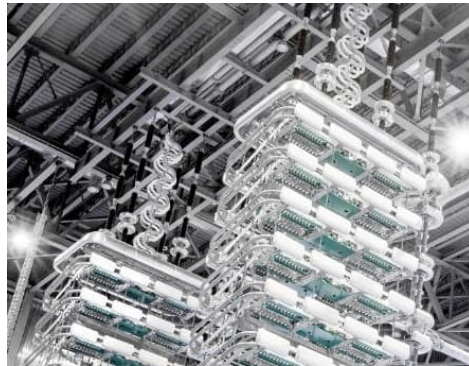
Geographies





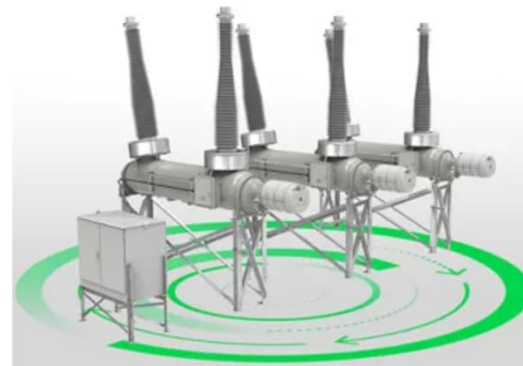
Grid Automation

- Supporting **50% of the top 250** global electric utilities with leading portfolio
- **~US \$4 trillion** mission critical infrastructure assets managed with our software solutions
- **~480 million** electricity consumers



Grid Integration

- **~15,000 systems** operating around the world
- **Leader in FACTS*** and **power quality**
- **Leader in HVDC systems with 130+ GW** installed



High Voltage Products

- Up to **1200 kilovolts AC** and 1100 kilovolts DC, leading portfolio
- **1 in every 4** high-voltage switchgear installed in the world
- Over **100 locations** worldwide provide 24/7 service support



Transformers

- **Complete range** of power, distribution, traction transformers, components, services
- Up to 1200 kV AC and 1100 kV DC, leading portfolio
- **~60 factories** around the world and ~30 service centers

SERVICE

DIGITAL

Capabilities:

 **Electrical Systems**

 **Economics**

 **Financial**

 **Digital**



100s

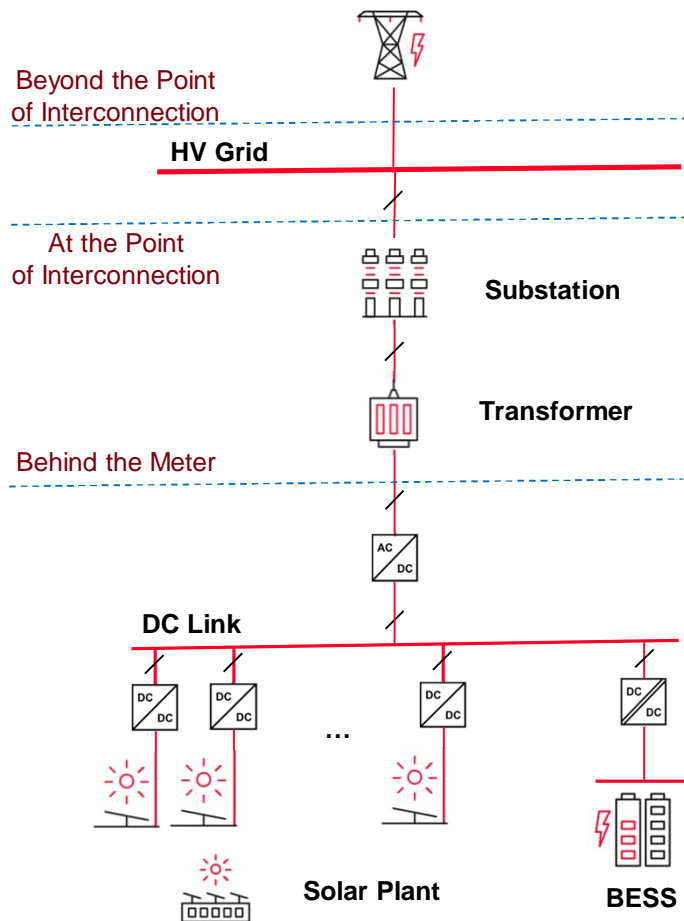
Of Consultants

8

Operations offices



Consultancy Studies Work Scope – Renewables



- **Market Intelligence, Outlooks, and Site Selection**
- **Beyond the Point of Interconnection Studies**
 1. Grid Impact Studies
- **At the point of Interconnection Studies**
 1. Preparation of Required Interconnection Queue Documents
 2. Models Development and validation in PSS/E, DSAT and PSCAD
 3. Security Screening Study
 4. Full Interconnection Study
 5. Steady State Analysis
 6. System Protection/Short Circuit Analysis
 7. Dynamic and transient Stability Analysis
 8. Facility Study
 9. Economic Study
 10. FIS Study
 11. Grid Code (GC) Compliance Study
 12. Sub-Synchronous Resonance (SSR) Study
- **Behind the Meter**
 - “Engineering” studies:
 1. Load flow, short-circuit for equipment rating
 2. Insulation coordination specification
 4. Power Quality
 5. Protection coordination
 6. CT/VT calculations
 7. Earthing design
 8. Black start philosophy if relevant
 - Additional studies:
 1. Integration of energy storage – OPEX/CAPEX analysis
 2. Reliability and availability – FMEA and RCM
 3. LCA management – if CO2 footprint for HV equipment is developers KPI
 4. EMS design and philosophy
 - Electrical Balance of System (EBoS) Design:
 1. Collector systems layout
 2. Electrical panel layout
 3. Step up transformer
 4. Substation
- **Battery Energy Storage System (BESS) Business Case, Sizing, and Investment Outlook**

Power Electronics in Grid

Why the need keep increasing?

Why do we need more grid flexibility?



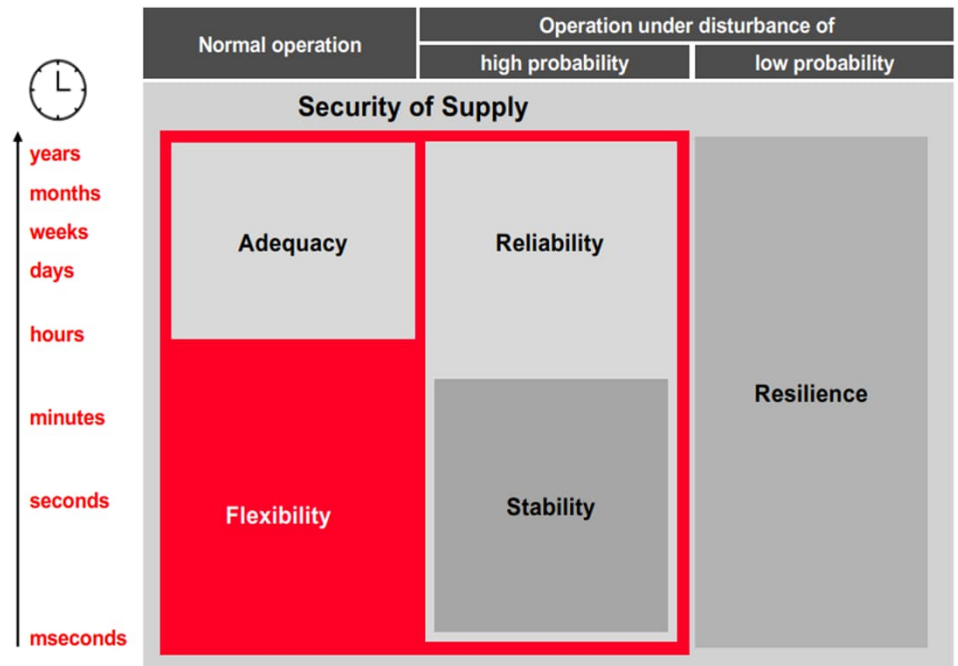
Power systems have always needed **flexibility to balance** varying demand and to deal with unexpected failures



Rapid growth of variable **renewables and electrification** of new loads call for a more flexible power system



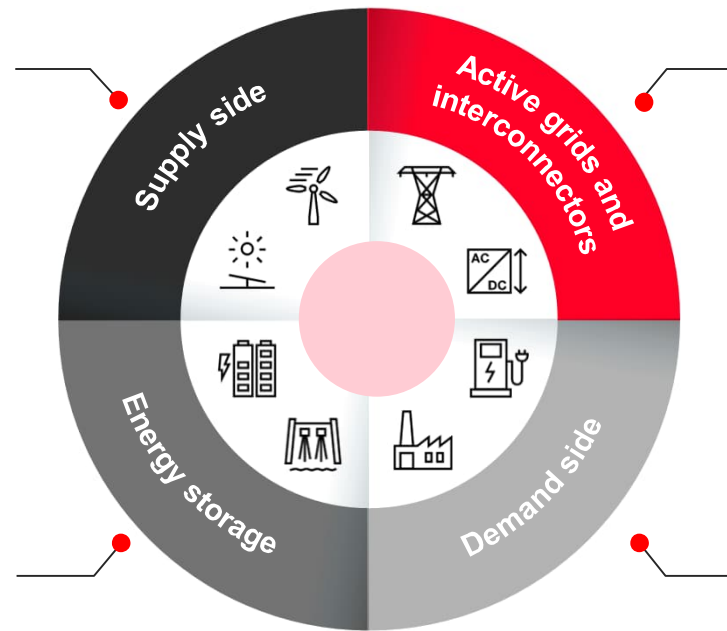
Flexibility is crucial during both normal **power system operation** and during high **probability operational disturbances**



Flexibility plays an important role in supporting power system operations across all time frames from milliseconds to years.

Four Flexibility Levers for Power Systems

Dispatchable low-carbon generation
Variable renewable curtailments

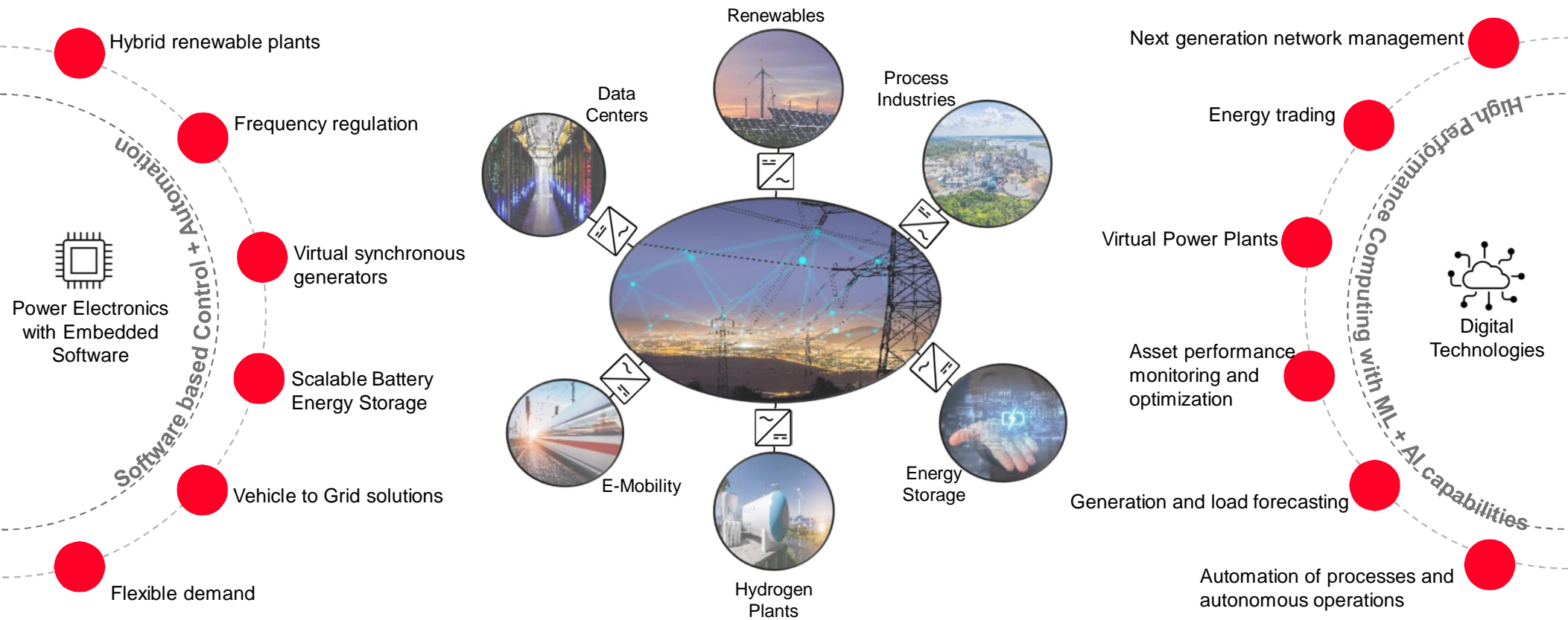


High and medium voltage DC
Flexible AC transmission and distribution systems

Stationary batteries
Long duration storage
Sustainable fuels

Distributed generation
Electric vehicles and heat-pumps

Power electronics and digital technologies are key for grid flexibility



EMT Simulations

For grid interconnection studies

Customer's need

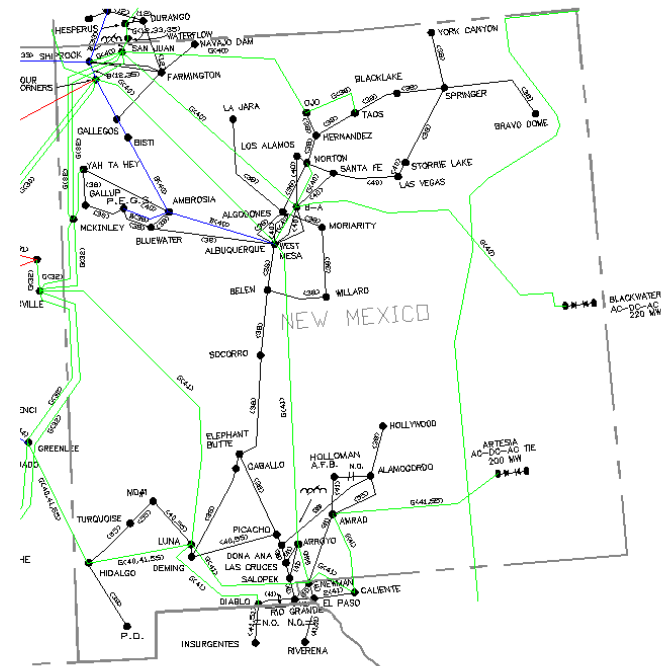
- Integration of wind resources along BA-Blackwater 345 kV line

Challenges

- Radial line, very weak conditions, voltage regulation
- Blackwater 200 MW HVDC (1984) must remain in operation

Consulting Studies

- Powerflow and Stability (PSLF)
- HVDC model development (PSLF)
- Subsynchronous torsional interaction (PSCAD)
- Dynamic Performance Studies (PSCAD)
- Synchronous condenser sizing
- SVC sizing



Today's Challenges & Opportunities

1. Non-uniform requirements across ISOs
2. Model availability – Time and capital needs
3. Generic (Base) vs. Project Specific (Detail) Model at interconnection study stage
4. Interconnection study timeline vs. growing requirements
5. Intellectual property concerns – choice of third-party study partner
6. Ongoing education of the interconnection process for all stakeholders



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