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ROLE OF REAL TIME SIMULATION IN ENERGY TRANSITION

RESEARCH AND DEVELOPMENT DEPARTMENT

SAUDI ELECTRICITY COMPANY

8th June 2021

Agenda

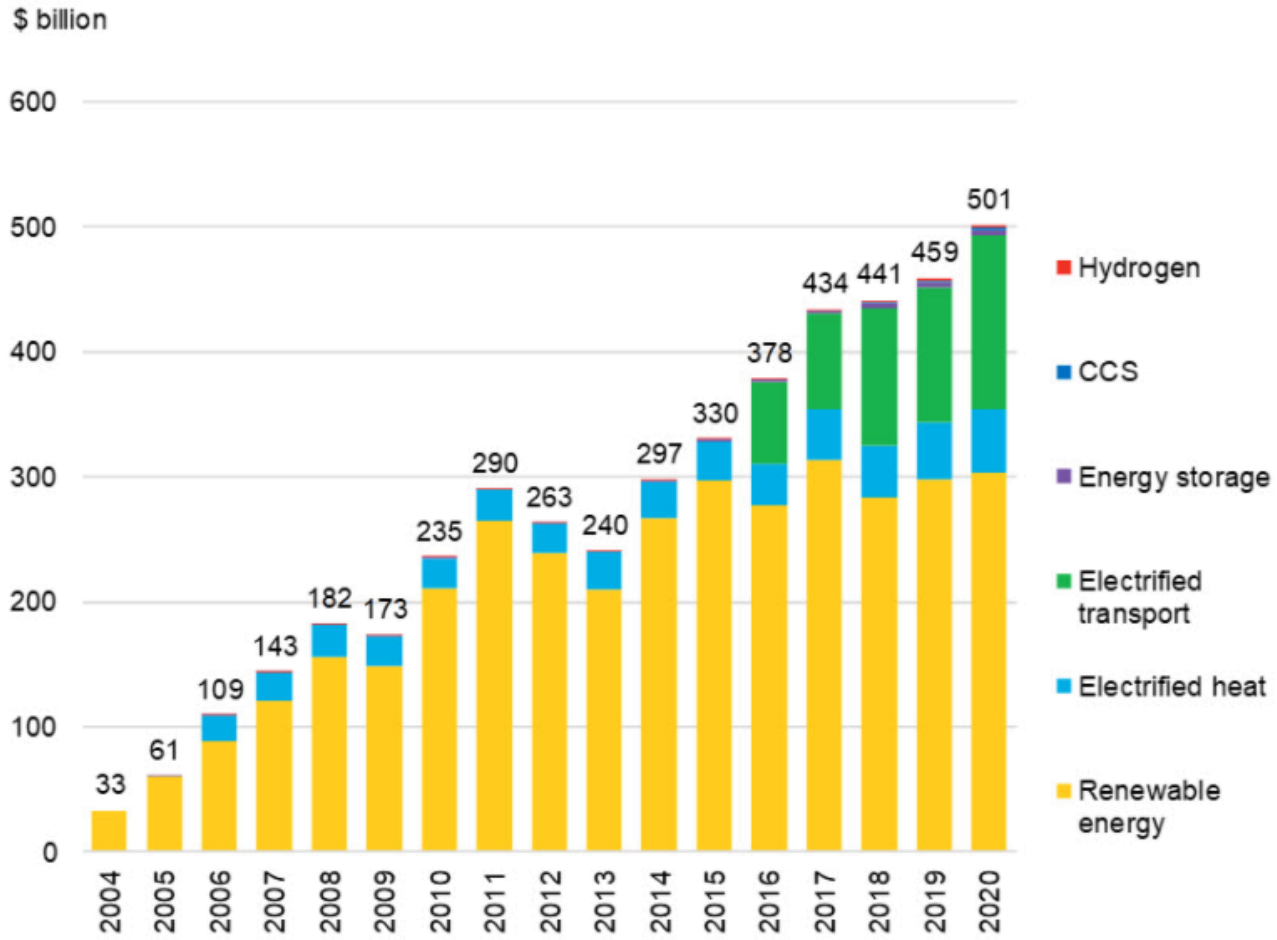
- Energy Transition
- Impact on Electricity Sector
- Need of Modeling and Simulation
- Real Time Simulation
- HIL Testing of Control/Protection
- SEC Real Time Simulation Lab

Energy Transition

Energy transition refers to the global energy sector’s shift from fossil-based systems of energy production to renewables resources.

Picture credit: http://www.ippnw.de/

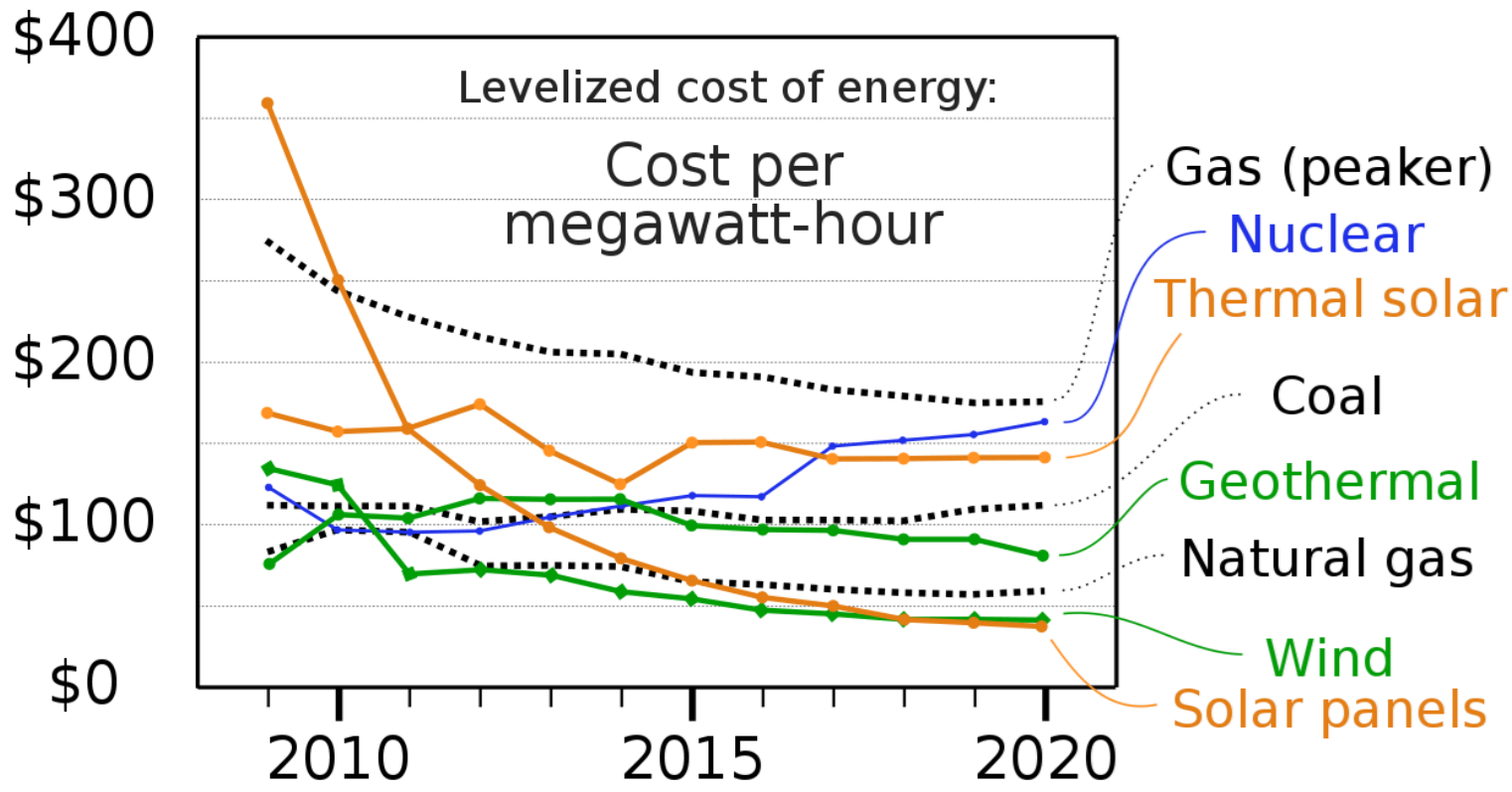
Global Energy Transition Investments 2004-2020



Energy Transition Investment Hit $500 Billion in 2020

Source: BloombergNEF (BNEF)

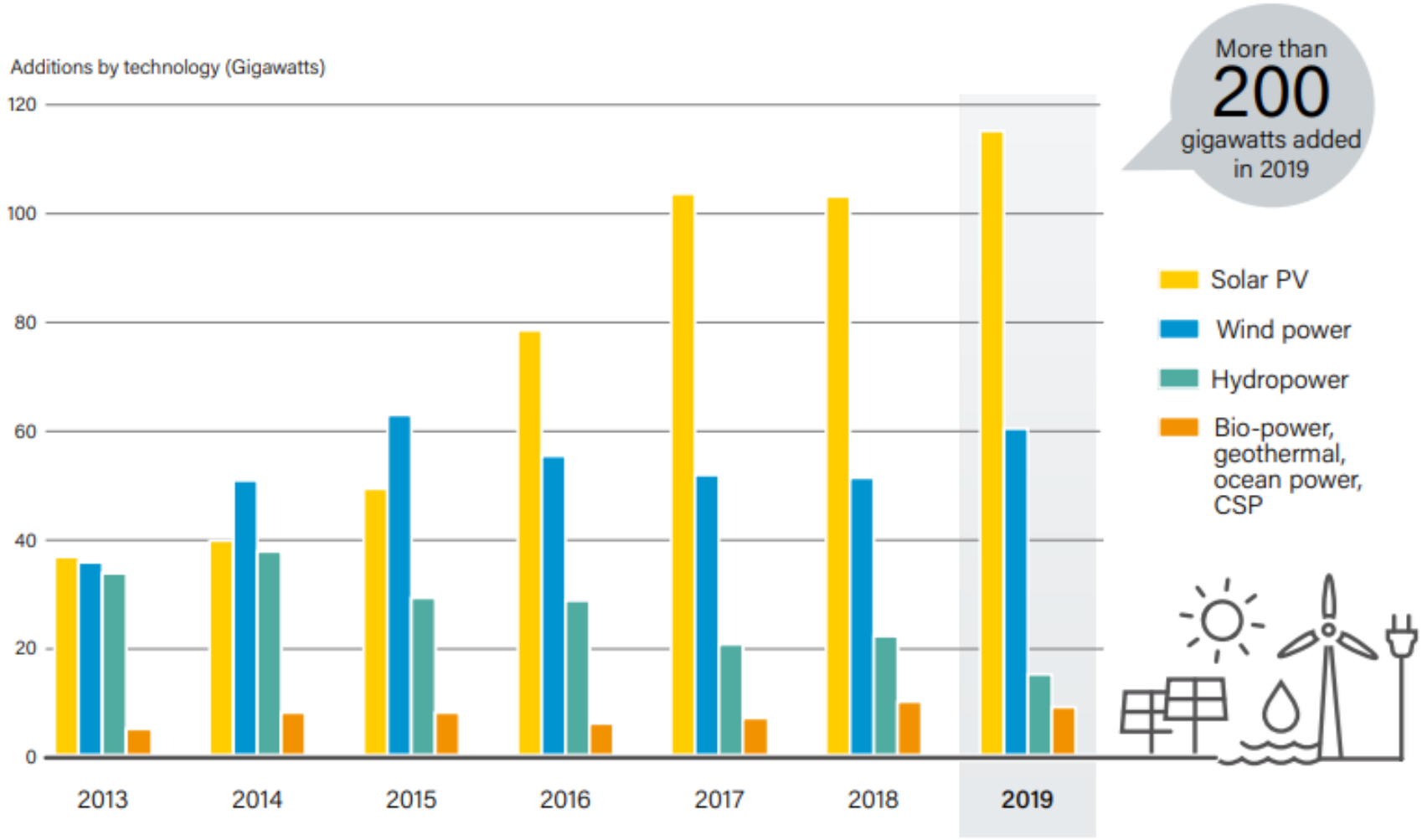
Levelized cost of energy



Levelized cost of renewable energy sources have considerably declined

Source: Ula Chrobak, Popular science

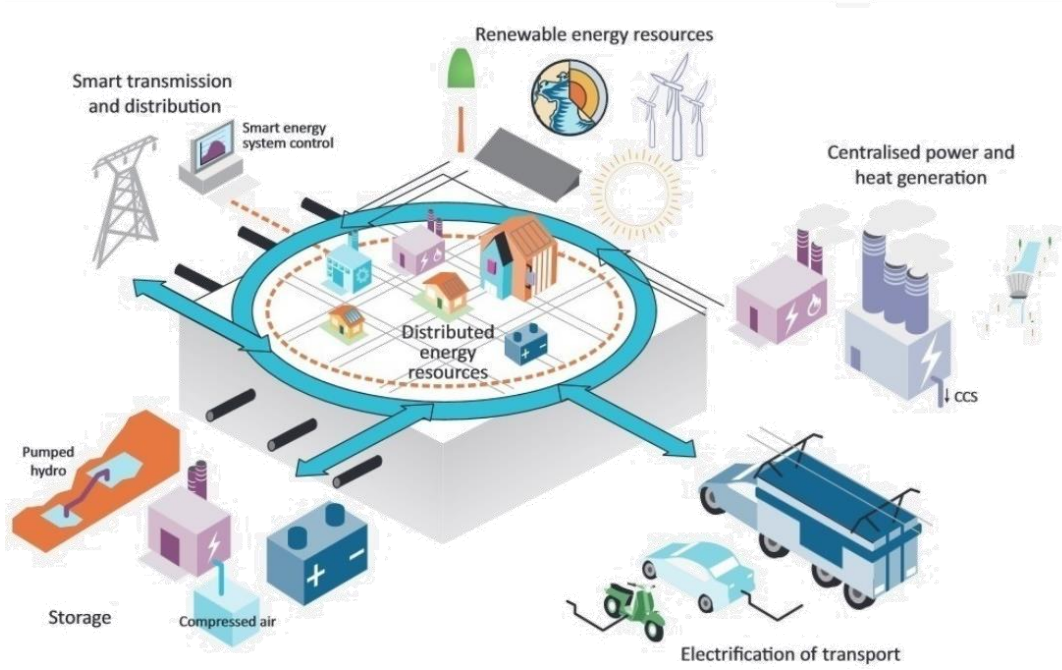
Annual Additions of Renewable Power Capacity 2013-2019



Source: REN21, Renewable 2020 Global Status Report

Impact on Electricity Sector

- Large-scale penetration of renewables in the grid
- Electrification of transportation
- Network developments
  - Co-existence of various types of renewable and non-renewable energy sources
  - Grid enhancements to facilitate decentralized energy systems
  - Transmission network expansion and interconnection to integrate large-scale wind farms and solar parks
  - Smart distribution networks
- Inclusion of large-scale energy storage
- Microgrids grid connected and islanding operation



Need of Modeling and Simulation

The experimental studies are usually economically not feasible. Therefore, simulation becomes a powerful and convenient tool in this research area.

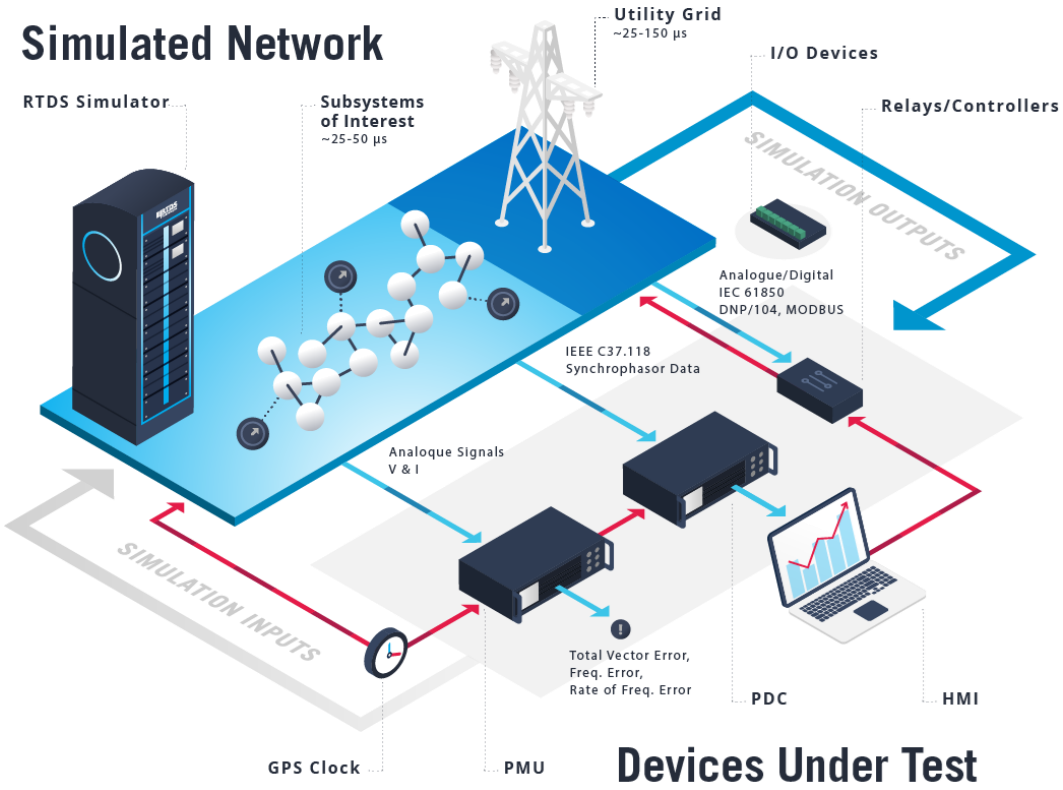
Type of Simulation	Load Flow	Transient Stability Analysis (TSA)	Electromagnetic Transient (EMT)
Typical timestep	Single solution	~ 8 ms	~ 2 - 50 µs
Output	Magnitude and angle	Magnitude and angle	Instantaneous values
Frequency range	Nominal frequency	Nominal and off-nominal frequency	0 - 3 kHz (<15 kHz)

Non-real-time simulations will simulate events faster or slower than real time depending on case complexity.

Physical devices can not be integrated and tested with non-real time simulators

Real Time Simulations

- Provide a “real world” modeling, testing, and validation environment
- Hardware in the loop (HIL) testing of control and protection
- Large-scale renewable generation integration
  - Test concepts, controls, and integration-supporting technologies
  - Integrate renewable controllers and energy storage systems onto the test grid
  - Study control interaction of different devices in the network



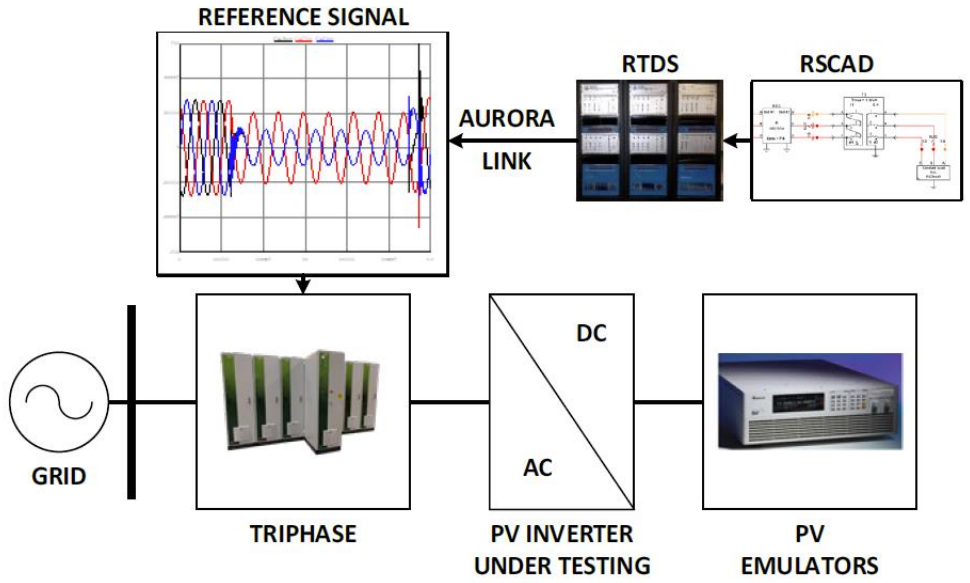
Source: RTDS Technologies

Simulation time of an event = Real time it takes for an event to occur

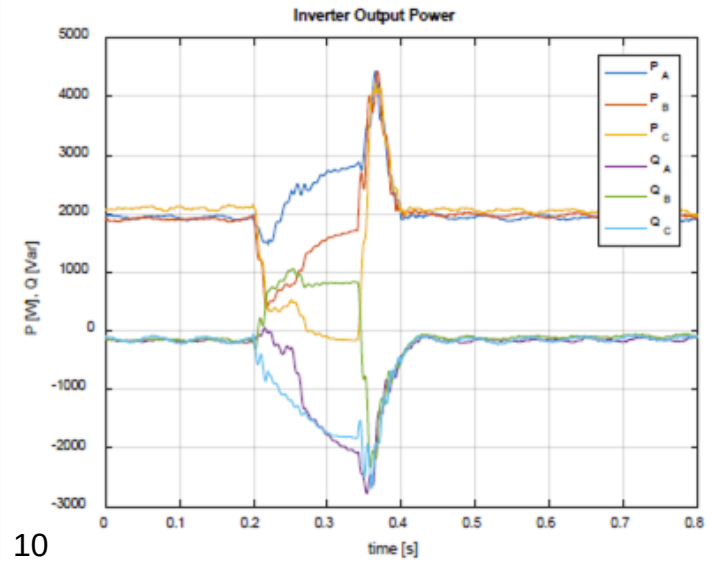
HIL Testing of a PV Inverter

Inverter testing at the Power Networks Demonstration Centre, UK

- Studying inverter response to transmission level faults
- Will ultimately feed into UK distribution code recommendations, standard inverter test procedures

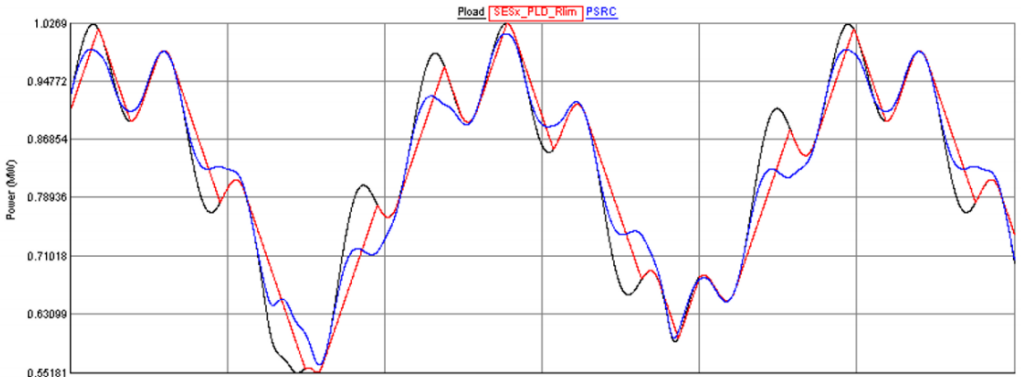


20kW inverter output power during a solid A-B-G fault applied to the 132kV circuit

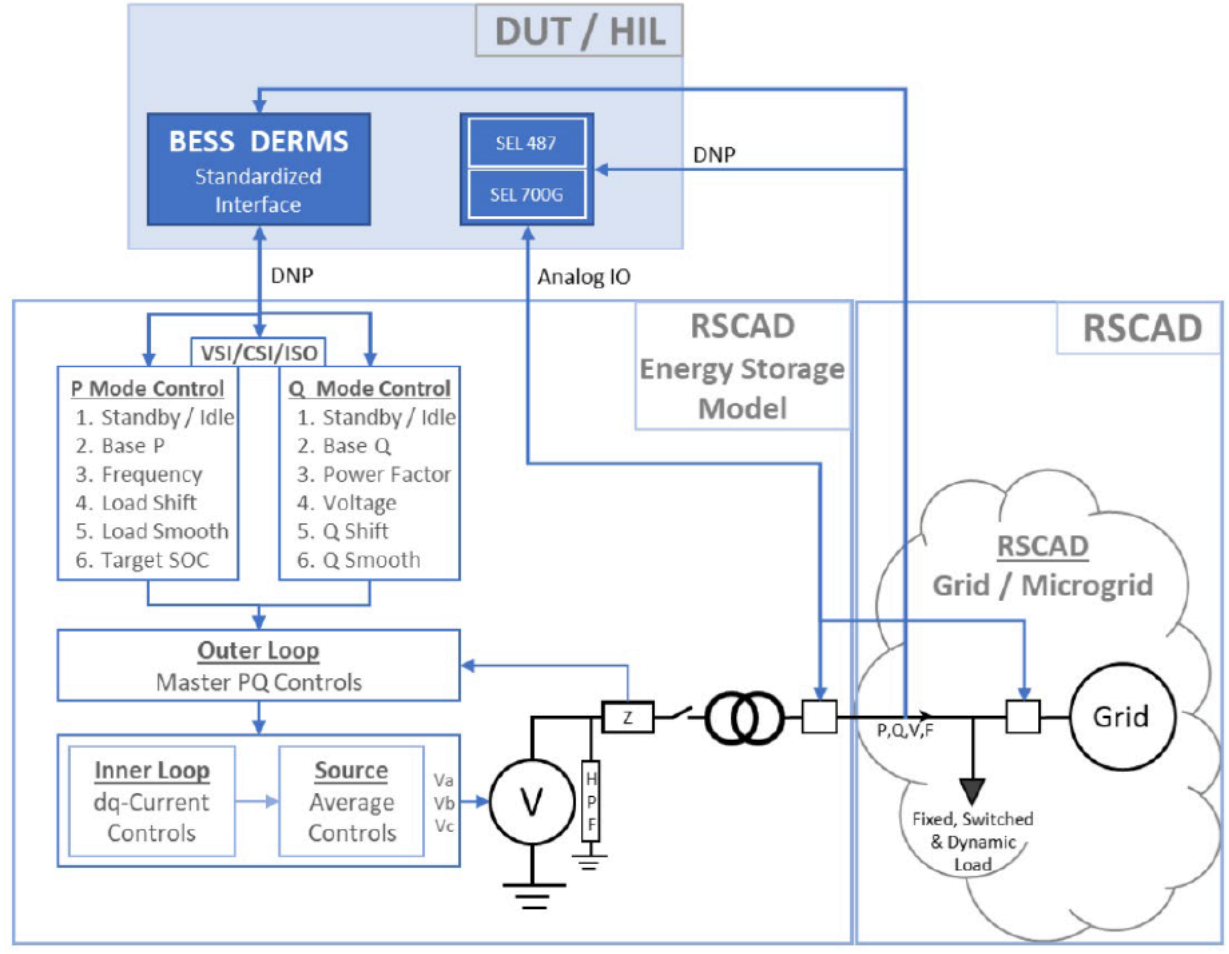


HIL Testing of Battery Energy Storage System

- Testbed for Battery Energy Storage System (BESS) integration
- Validate functional behavior, coordination and effect on local protection



In the event of sudden changes in demand, the battery is charged/discharged for a gradual change in grid power.

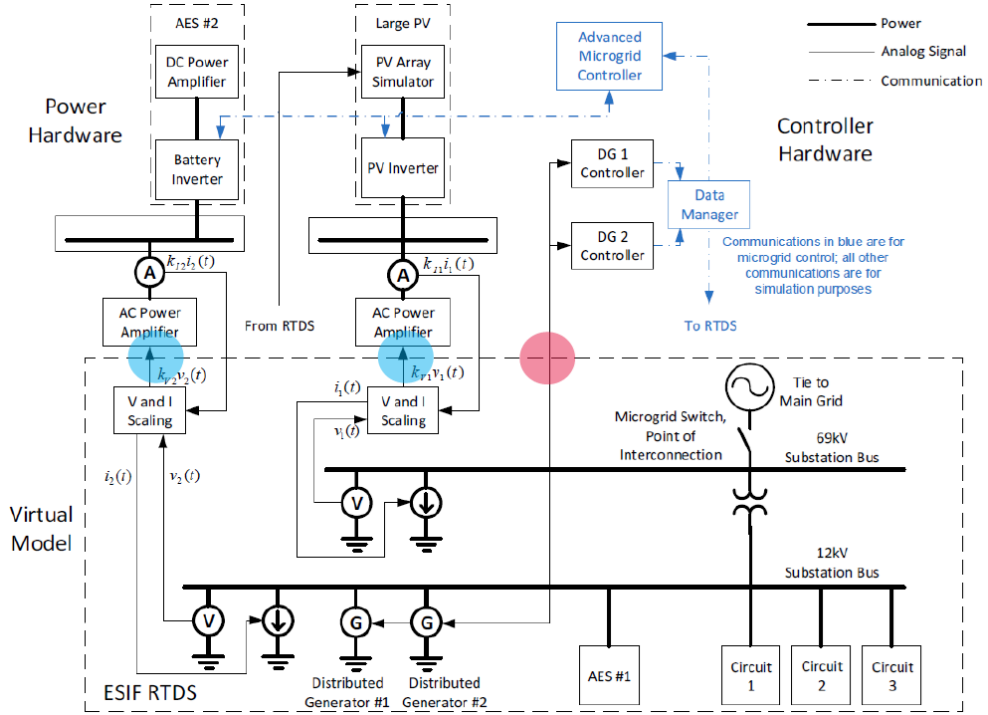


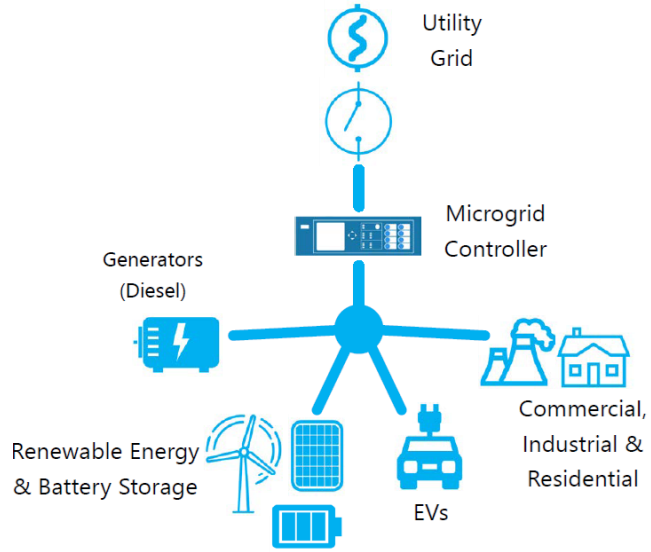
Reference: Nayak Corporation

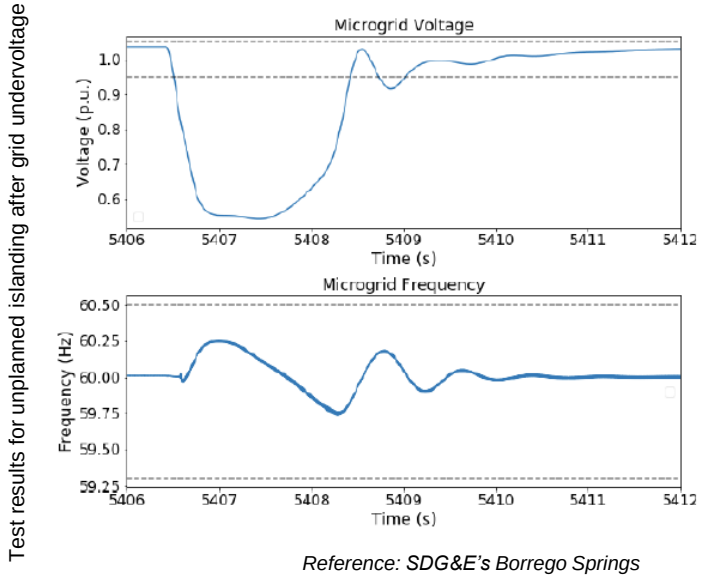
HIL Testing of Microgrid

Challenges:

- Coordination of multiple generation sources
- Intermittent nature of renewable sources
- Managing multiple loads with varying priority
- Each individual asset has its own controller
- Coordination issues between local control, secondary level controls and protection







Reference: SDG&E's Borrego Springs

Real Time Simulation Lab in Saudi Electricity Company

Real Time Simulation Center in SEC

The Real Time Digital Simulation (RTDS) laboratory in the center consist of 40 racks of digital micro processors which can compute & process data in real time by 2 to 50 micro seconds to verify the actual behavior of the electricity grid.

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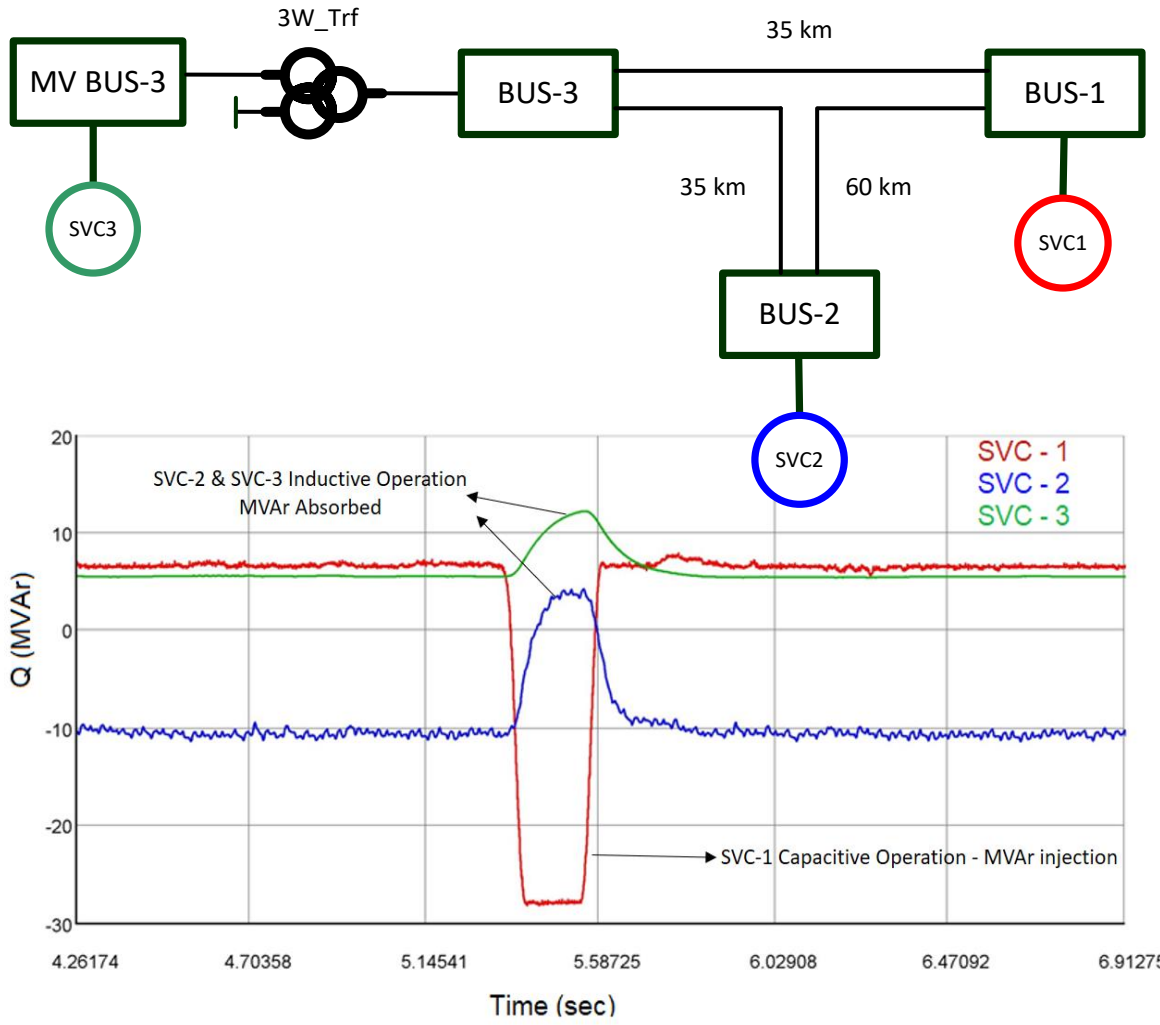
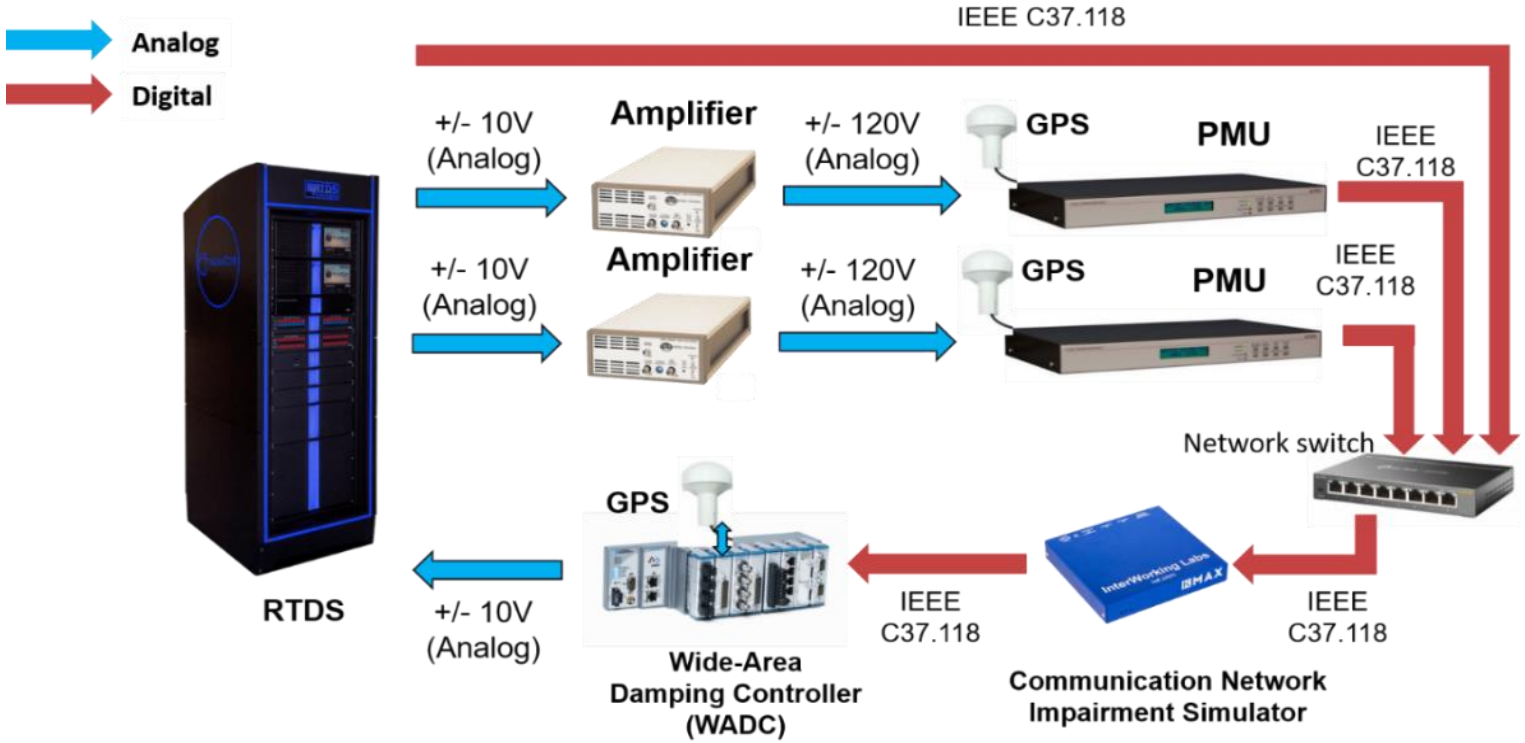
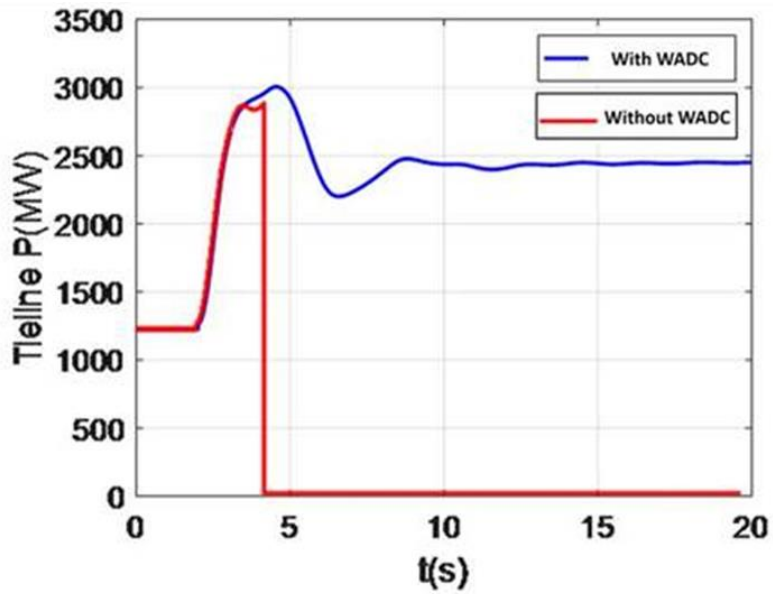
HIL Testing of FACTS Controller Interaction



HIL Testing of WADC





Thank You