Typhoon HIL

INTEGRATED MICROGRID DEVELOPMENT

USING REAL-TIME CONTROLLER HARDWARE-IN-THE-LOOP CAPABILITY*

*observe the system behavior under multiple network configurations, with load shedding, islanding and reconnection on high time scale range.

MOTIVATION

- Rapid increase of power electronics (PE) penetration shifts the grid dominant physics with substantial kinetic inertia and inductive impedance to digitally manipulated power
- System modeling complexity increases, and dynamic time constants accelerate by three or more orders of magnitude
- A high fidelity, cost-effective tool to test and predict system performance under diverse operating conditions are of utmost importance for microgrid developers.

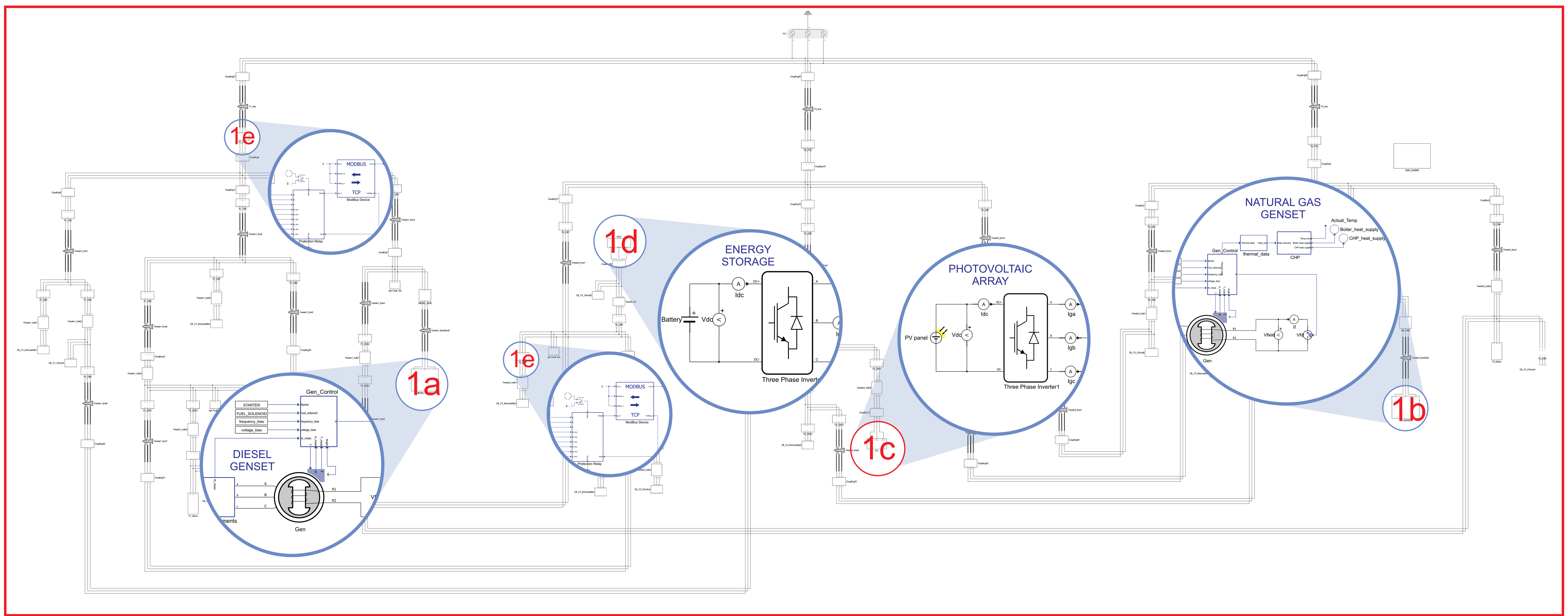
REAL WORLD PROBLEM EXAMPLE

- Hawaii plans to have 100% renewable generation by 2045, transforming its grids into early pilots of Digital Power Systems
- Microsecond phenomena of fast digital controllers and environmental effects complicate the evaluation of system control, stability, and protection

With 12% of PE penetration in 2014, Hawaii responded to recurring grid outages by updating protection settings and connection standards.

SOLUTION

- High fidelity, real time simulator with controller hardware-in-the-loop functionality
- Microgrid implementation with high fidelity models of distributed energy resources, protective devices, complex loads, transmission lines and transformers
- Multi-rate simulation from 0.5 microsecond time step.



Example: Lincoln Lab Banshee microgrid.

1. DERs and protective devices:

a. Diesel generator - Synchronous machine with speed and voltage control loops.

b. Natural Gas genset - Synchronous machine with speed and voltage control loops implemented with combined heat and power approach.

c. Solar inverter - High fidelity switching model of a three-phase inverter. Connected to a detailed model of a photovoltaic panel.

d. Energy storage inverter - High fidelity switching model of a three-phase inverter. Connected to a detailed model of a battery bench.

e. Protection relays - A device for sensing grid currents and voltages and controlling a circuit breaker. Can be fully simulated or integrated via Hardware-in-the-loop.

2. Controller Hardware-in-the-loop microgrid testbed

a. Four Typhoon HIL high fidelity real time simulators connected in parallel.

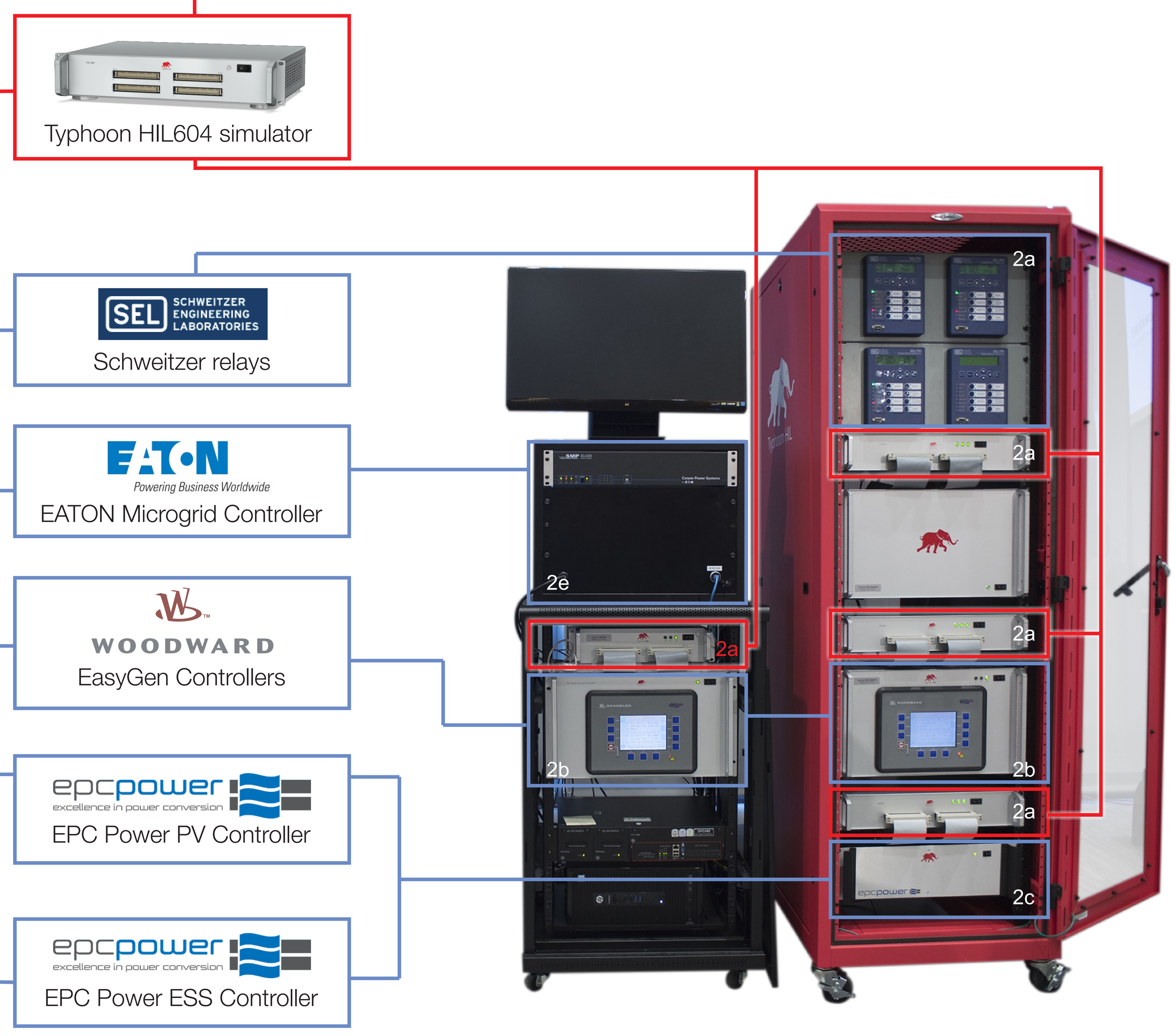
b. Two Woodward Easygen controllers for diesel and natural gas gensets.

c. Two EPC controllers for energy storage and solar inverters.

d. Three Schweitzer relay for point of common coupling circuit breakers.

e. Eaton microgrid controller - Communicates with simulated devices and real controllers though standard protocols such as Modbus and IEC61850. Operates with a time scale in the range of minutes, hours and days.

3. Real time measurement and data logging.



CONCLUSION

The controller hardware-in-the-loop (C-HIL) approach combines high fidelity models for different components with wide range of time scales. C-HIL provides a cost-effective, reliable testbed through which to examine any range of configurations and operating conditions event before investing in hardware.

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