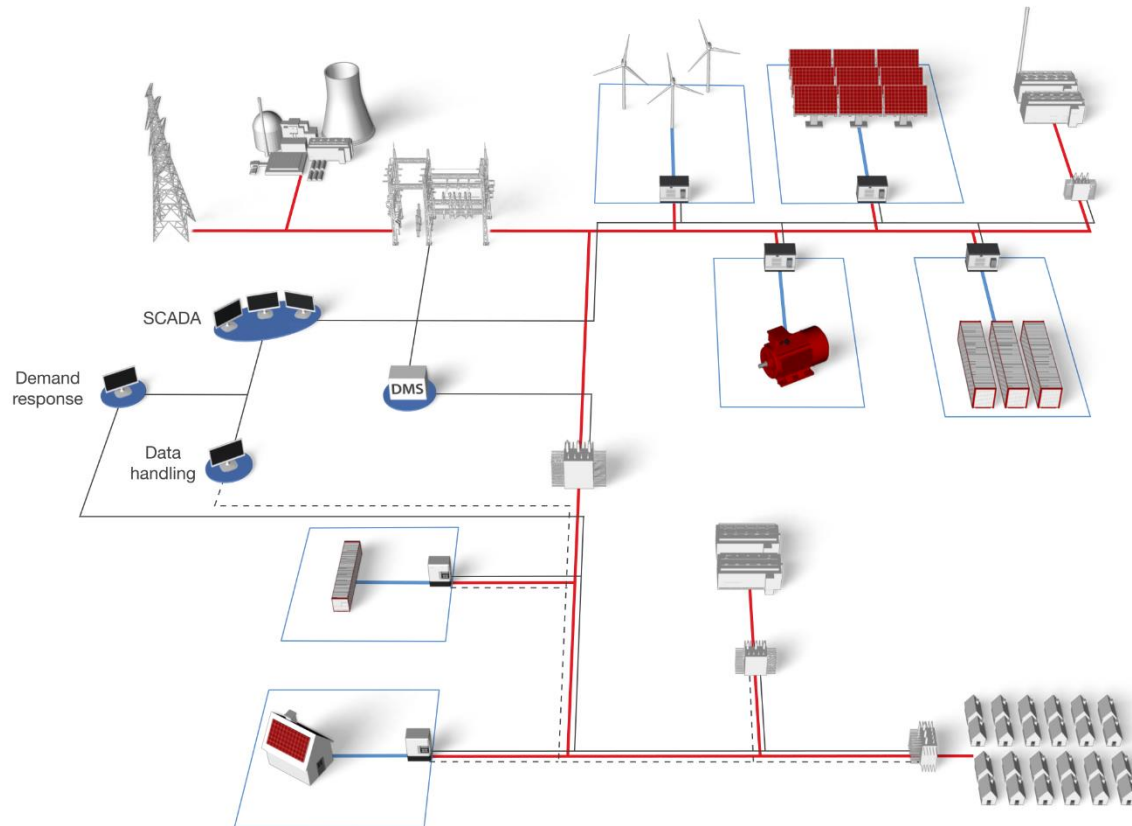


Avoiding Surprise During Microgrid Development using Controller Hardware-in-the-Loop (cHIL) testing

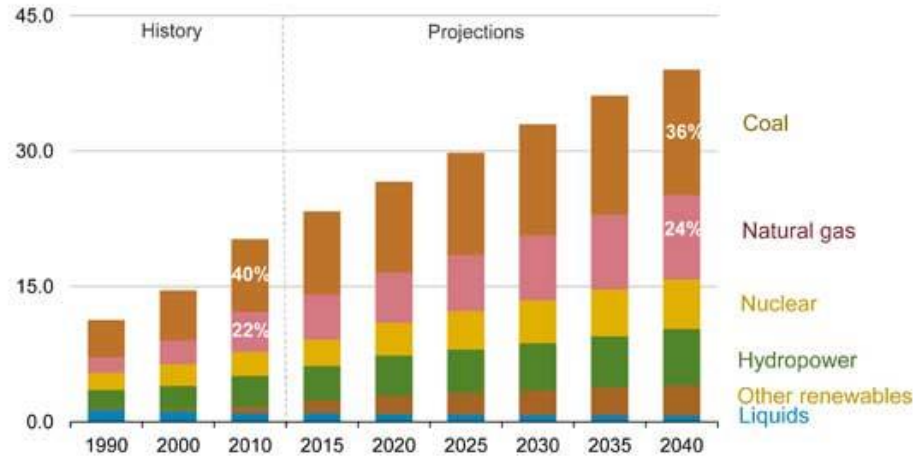
Typhoon HIL, Inc



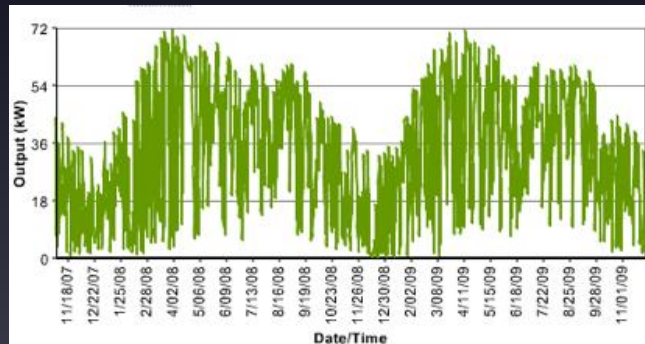
Terrestrial Grid Trend

In electricity generation, renewables and natural gas are the fastest growing sources, but coal still fuels the largest share in 2040

world electricity generation by fuel
billion kilowatt-hours



Source: EIA, International Energy Outlook 2013



Harvard University - Petersham (Petersham, MA) ▶ System details
Power output in kilowatt-hours (kWh) Nov 1, 2007 - Nov 30, 2009

Increasingly
dynamic

30% Renewable Electricity by 2025

30% of electricity consumed by the federal government must come from renewable energy sources by 2025.

FY 2015 Progress Toward the 30% by 2025 Target

8.3%

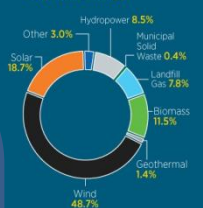
FY 2015 Renewable Electricity Consumption:
4,623,186 MWh

30% by 2025 goal

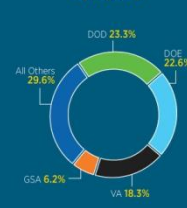
FY 2015 Total Electricity Consumption:
55,720,542 MWh

8.3% Renewable Electricity Consumption:

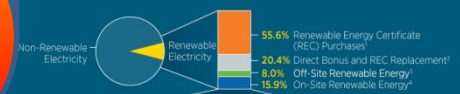
By Technology



By Agency

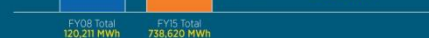


By Procurement Type



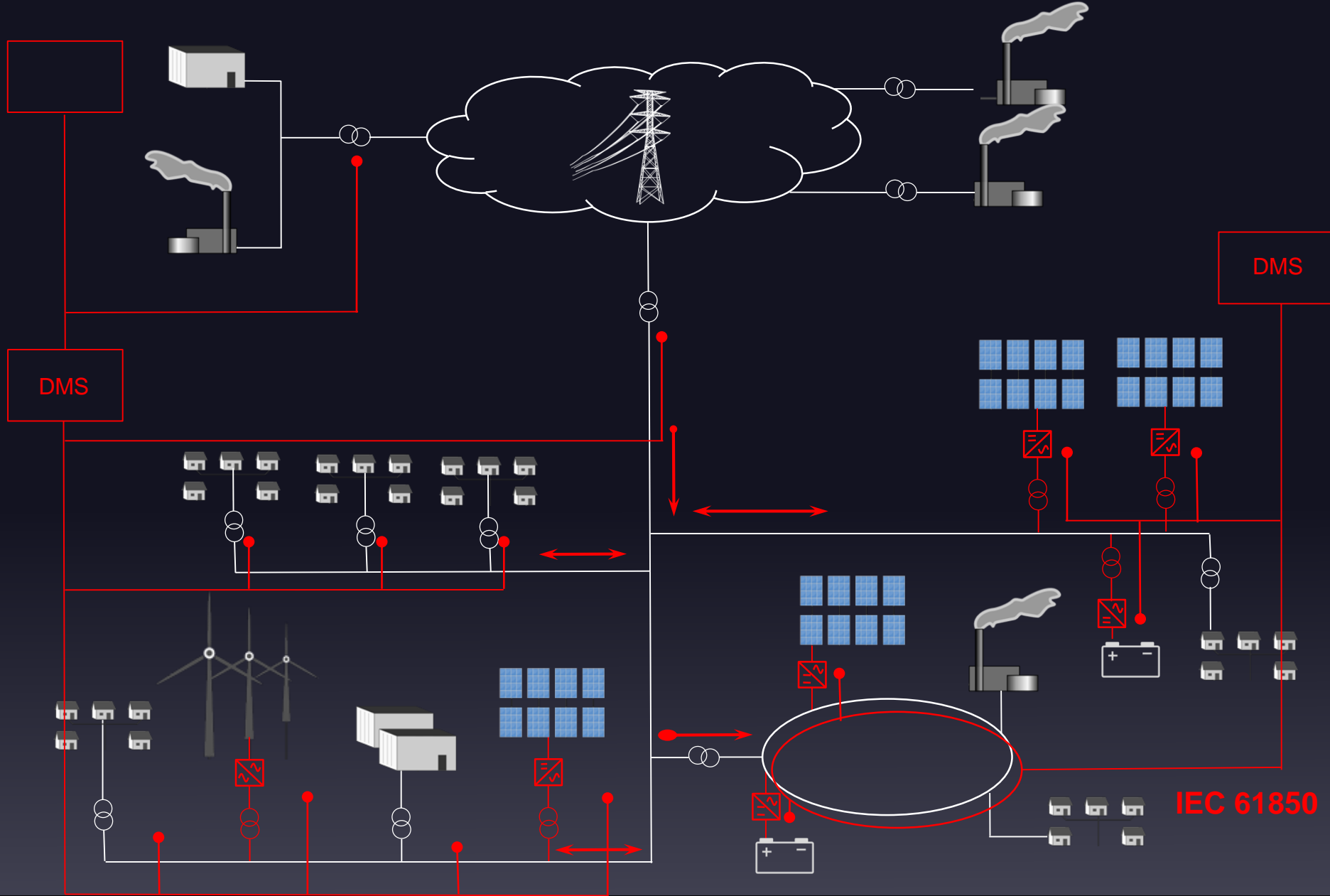
On-Site Renewable Energy Progress

The federal government used more than five times the amount of renewable energy from on-site projects in FY15 than in FY08.

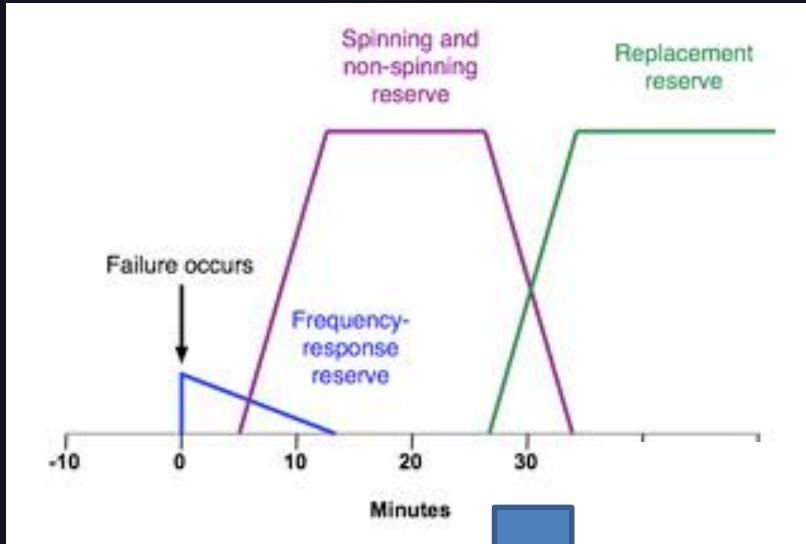


1 Renewable energy certificates (RECs) represent the renewable attributes of generation produced from renewable energy projects and are sold separately from commodity electricity. Agencies can purchase RECs to help achieve their renewable energy goals.
2 Renewable energy that is produced on federal or Indian land and for which the agency owns the renewable attributes, referred to as on-site renewable energy, allows the agency to claim a bonus toward their renewable energy goal. An agency can own the project and REC electricity, or if the buying point is ownership of the REC to another party, it can purchase replacement RECs to replace the bonus.
3 Renewable energy includes both the renewable attributes (RECs) and the source electricity for the renewable attributes.
4 On-site renewable energy is produced from projects on federal or Indian land where the agency owns the renewable energy attributes.

Emerging cyber-physical power grid



Using Dynamics to Achieve Stability



Increasing penetration of “low-inertia” DER

Maintaining grid stability requires accelerating control response

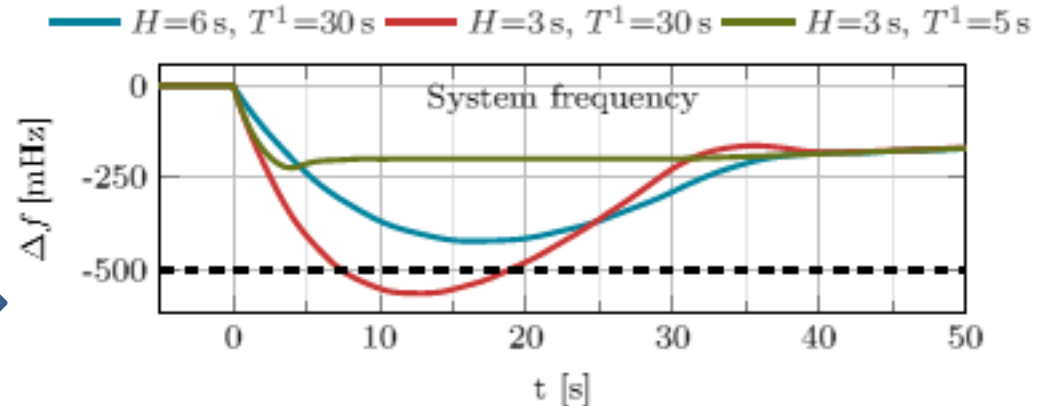


Fig. 5. Dynamic response of the Continental European area power system to faults (8).

Blue: high inertia ($H = 6$ s), i.e. no wind&PV power feed-in share, nominal frequency control reserve.

Red: low inertia ($H = 3$ s), i.e. 50 % wind&PV power feed-in share, nominal frequency control reserve.

Green: low inertia ($H = 3$ s), fast control reserves.

Platform Electrification

Military services and industry are rapidly transforming ground, sea and air platform architectures to replace mechanical, hydraulic, and steam systems with electrically-powered components and controls.

Motivations include:

- *Greater peak power*
- *Increased reliability and maintainability*
- *Expanded flexibility and interoperability*
- *Reduced fuel consumption*

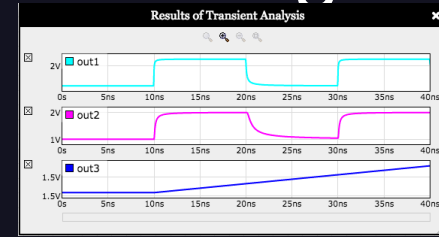
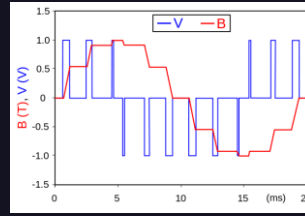
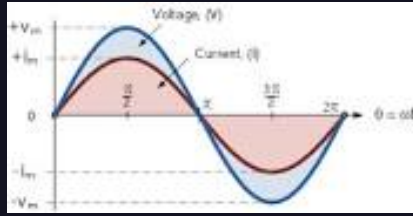


Electrical/electronic components proliferate:

- *Vehicle Power – APUs, batteries, integrated starter/generators*
- *Drive train – motors, regenerative braking, VSD*
- *Electronics – sensors, computing, communications*
- *Auxiliary systems – HVAC, winches, trailers*
- *Power management/networking - onboard, import, export power*

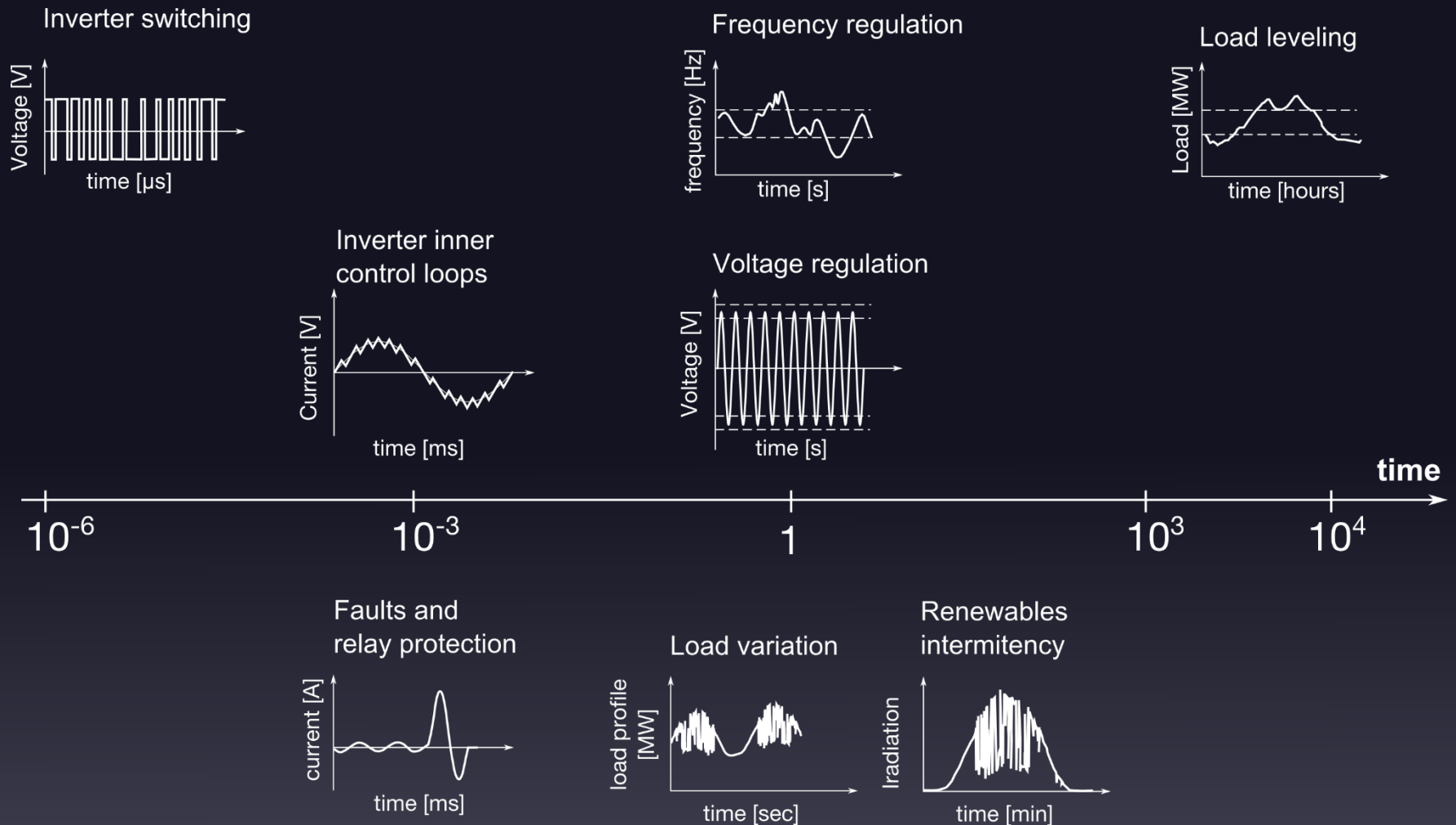


Emerging Capabilities and Challenges



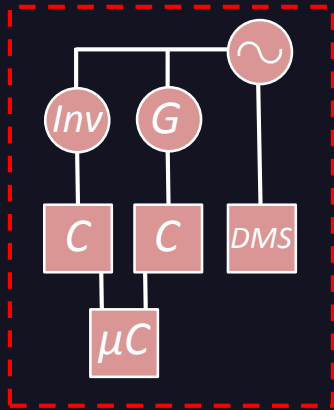
- Power electronics modulate fast switching in hybrid digital-analog devices to approximate analog behaviors
 - Inverting, rectifying, filtering
 - Frequency, voltage, power factor adjustment
- Cyber-physical interactions on microsecond time scales not accurately captured in abstracted models
- Increasing system complexity demands new testing solutions for speed and affordability
- Real-time Controller Hardware-in-the-loop (cHIL) simulation is emerging as the testing solution for power electronics and power systems

How fast are the power system dynamics we need to simulate?

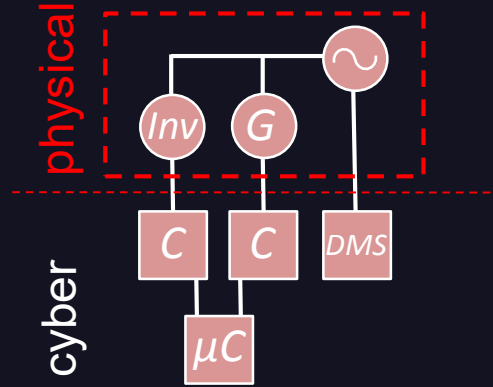


Power System Testing Options

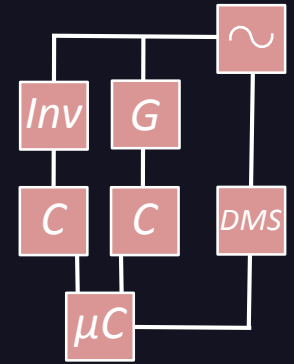
Simulation



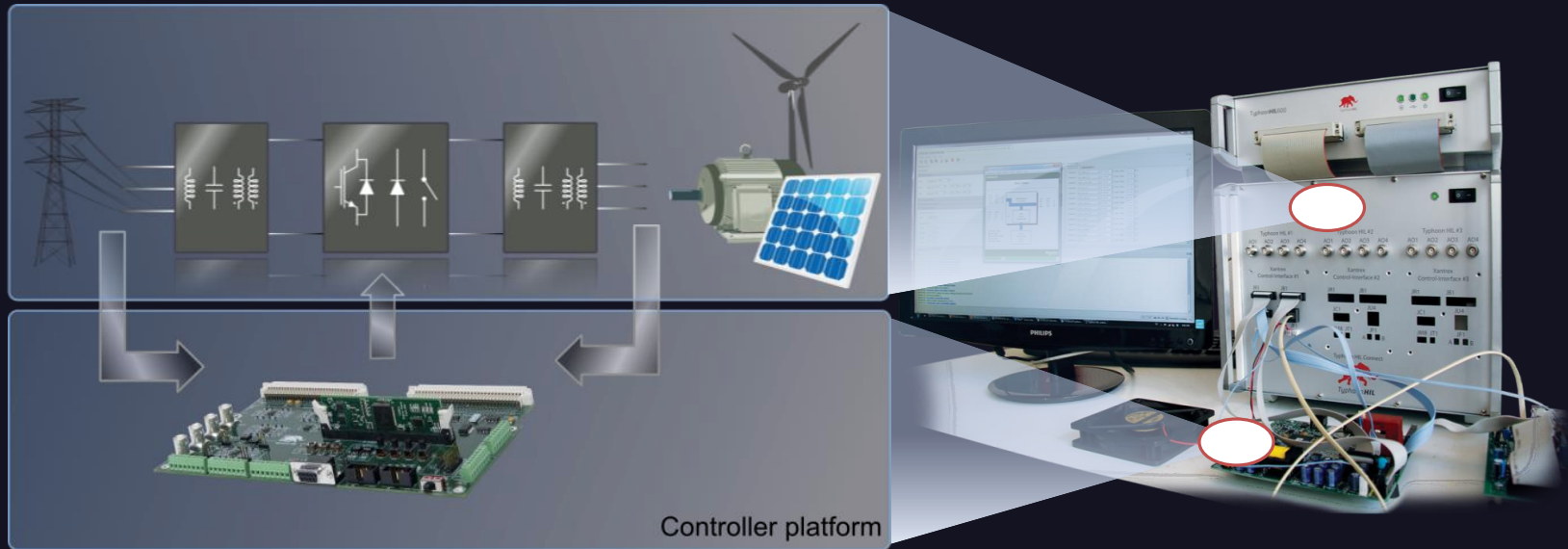
Controller HIL



Complete System



Controller Hardware-in-the-Loop (cHIL): the revolutionary way to develop and test power electronics controllers.



R&D | Development | Converter Testing



Power electronics product lifecycle

Typhoon HIL product offering

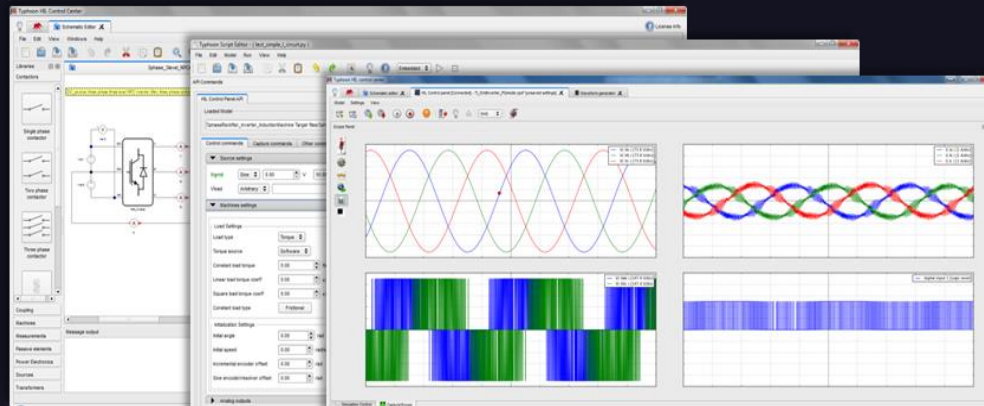
services

Modeling and simulation

HILConnect customization

Continuous build/test/release processes

software



Schematic Editor
Scope and Capture
SCADA
Grid codes toolbox
Power systems
toolbox

hardware



HIL402



HIL602

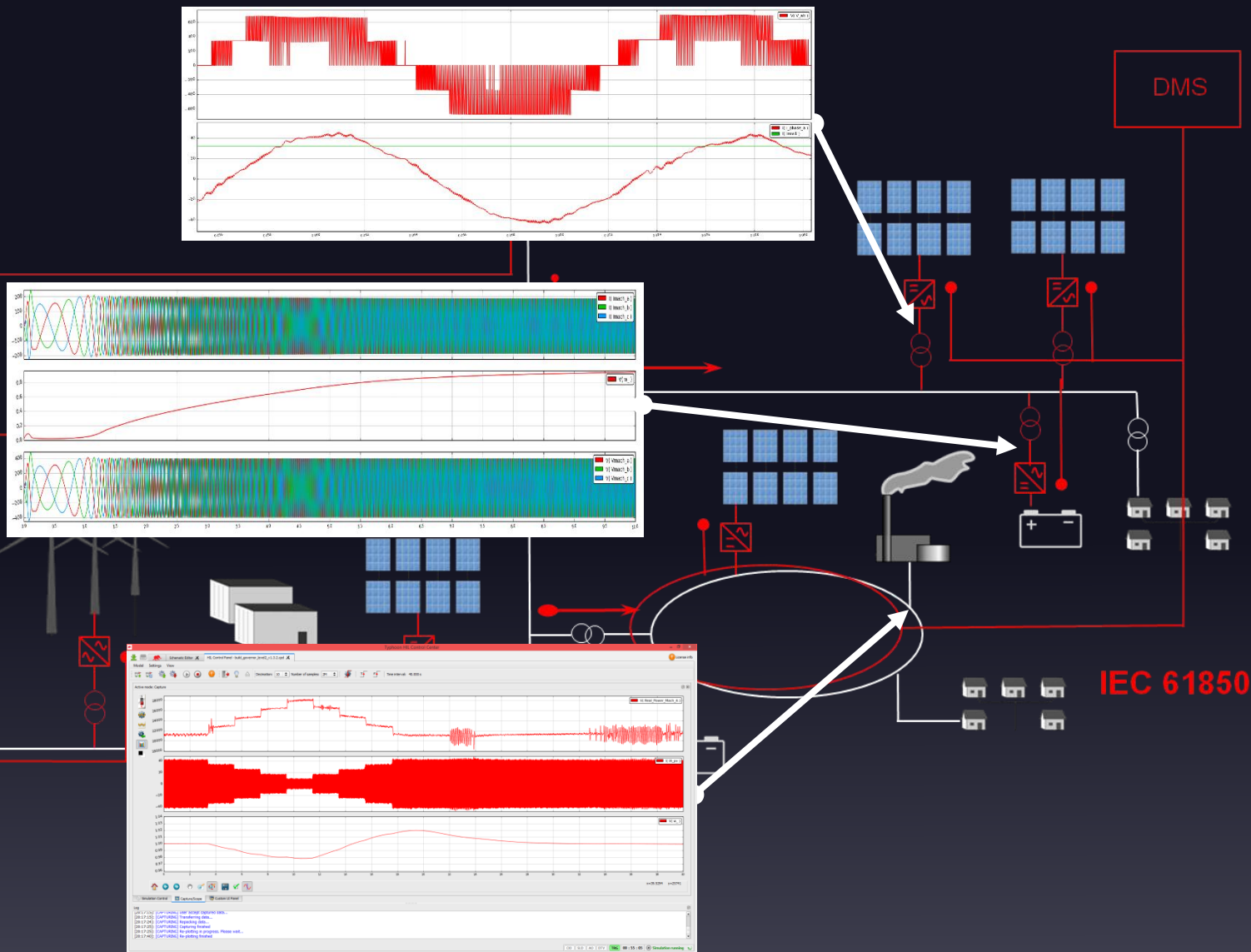


HIL604



HIL Connect

20ns sampling time, and 500ns simulation time step enables real-time simulation from μs to hour domains

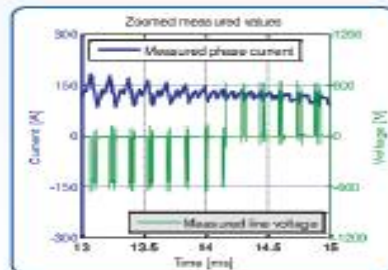
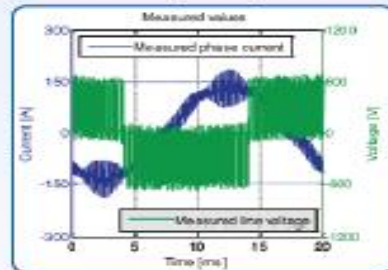


Testing confidence through ultra-high fidelity, 20 ns PWM sampling, 0.5-1 μ s time step

Laboratory setup



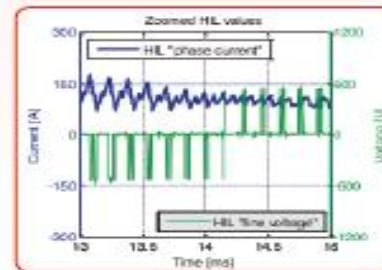
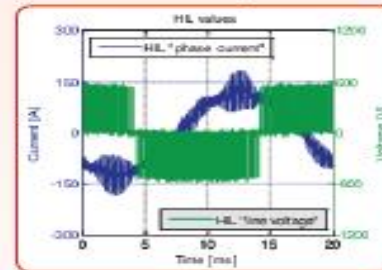
Laboratory setup results



HIL400 based setup



HIL400 setup results

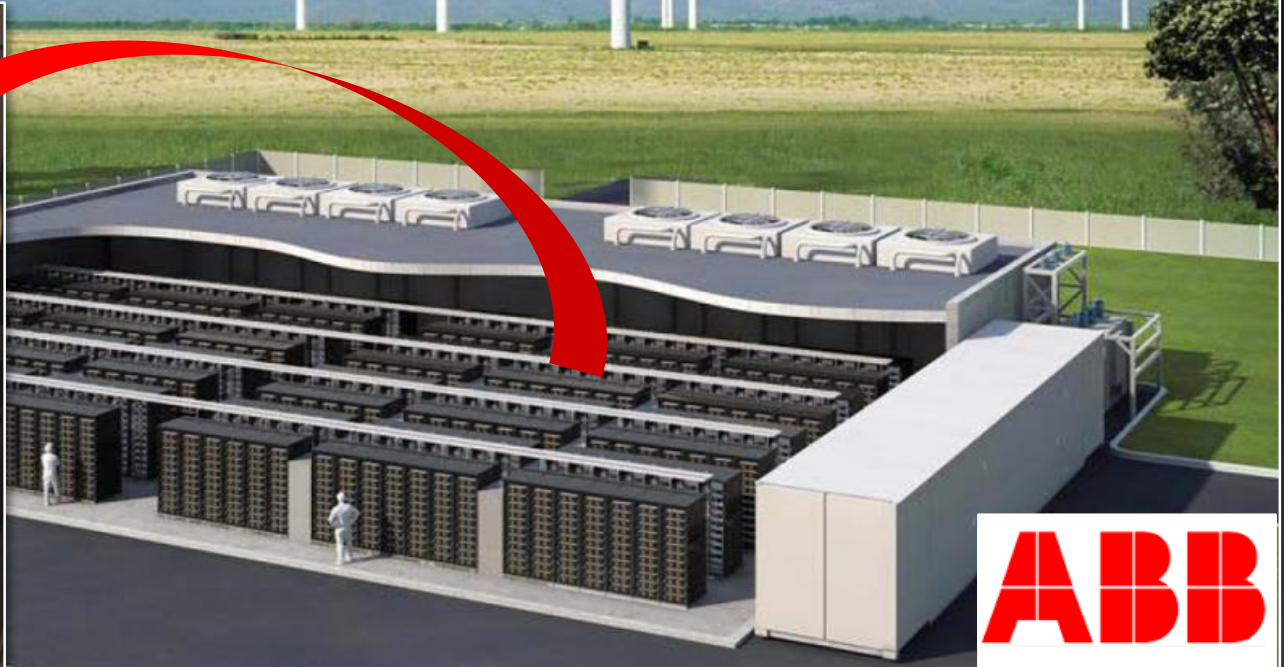
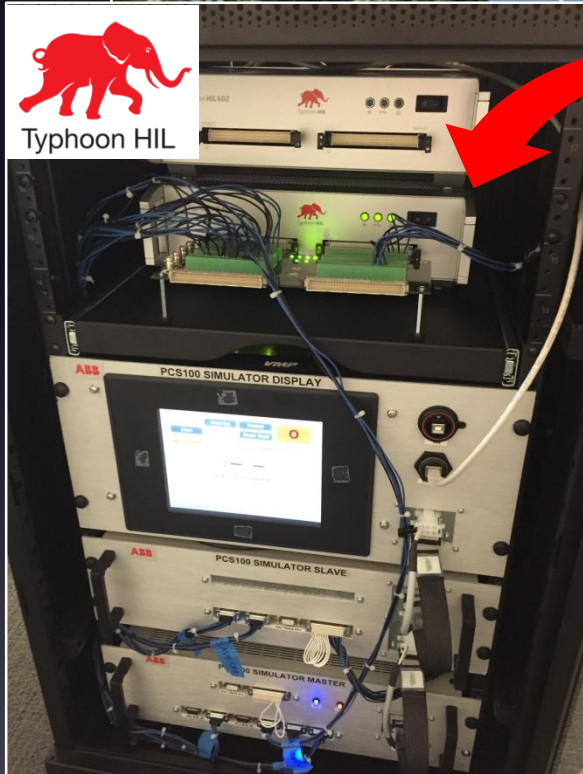


Ease of use is critical

The image displays several overlapping screenshots of the Typhoon HL software interface, illustrating its ease of use and comprehensive simulation capabilities. The main window shows a schematic editor with a detailed circuit diagram of a grid-tie inverter, including a transformer, diodes, and a filter. A 'Preview of PV curve for $\rho = 100.0$ [W/m²] $T_c = 0.0$ [°C]' is shown, plotting current (A) against voltage (V). A 'TI Control Panel - PQ control of grid-tie converter' window provides real-time monitoring of key parameters: DC bus voltage (394.98 V), Grid line voltage (391.14 V), Inverter line voltage (391.14 V), Grid line current (0.95 A), Active power (-565.32 W), and Reactive power (302.30 VAr). A 'Commands settings' panel allows configuration of decoupling, grid connector, and reference settings. A 'Parameters settings' panel lists parameters like Pref, Gref, and PRef. A 'Model Control' section includes buttons for 'Connected/Disconnected' and 'Start/Stop'. A 'Console' window shows a log of system events, such as 'Successfully disconnected from COM port' and 'Control number of cycles started'. A 'Typhoon HL Test Suite' window displays a table of test cases, including 'Frequency drop' and 'Frequency drop 1', with a 'Test configuration wizard' for parameter selection. A 'Test specific parameters' dialog shows a graph of Power reduction (ΔP) versus frequency (f) with a red arrow indicating the power reduction region. A 'Script editor' window shows a Lua script for controlling the inverter. A 'Scope Plot' window displays three-phase voltage and current waveforms. A 'Simulation Control' window shows the simulation status and time. A 'Message output' window displays system messages, such as 'Flare generator successfully updated'.

Typhoon HIL 8 MVA Grid battery real-time simulation

[Tehachapi Energy Storage Project](#)



Use Case: 8 MVA Grid battery integration

[Tehachapi Energy Storage Project](#)

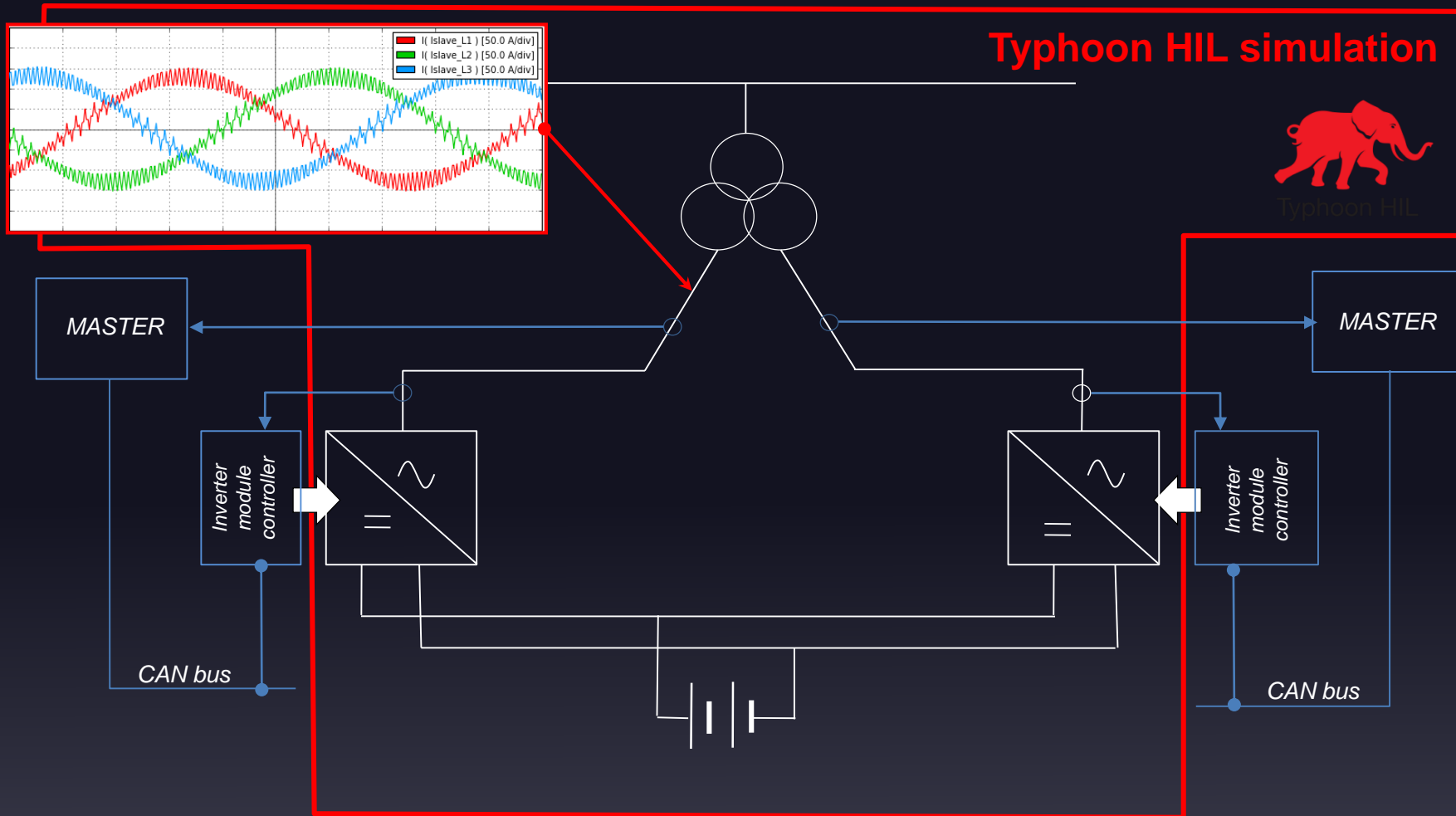
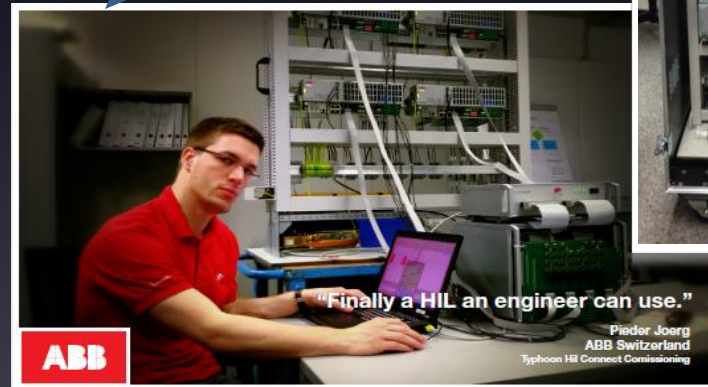
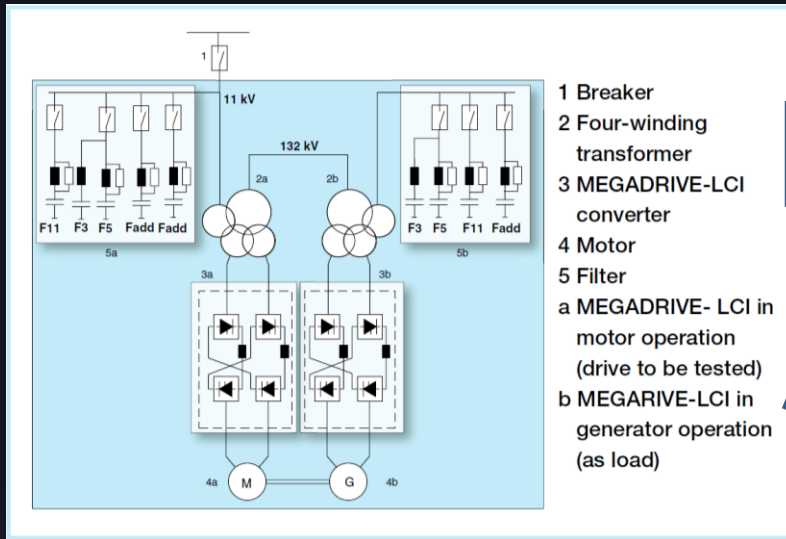


ABB-Statoil: 48MW compressor drive integration options

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c-HIL Project Risk Reduction

- ❑ Streamline design-development-testing-commissioning
- ❑ Facilitate investigation of design alternatives
- ❑ Accelerate and expand testing opportunities
- ❑ Overcome interoperability issues easily & early
- ❑ Potential post-installation value
 - troubleshooting
 - cyber-physical security
 - future modification



Test relentlessly.

www.typhoon-hil.com