Microgrid Solutions

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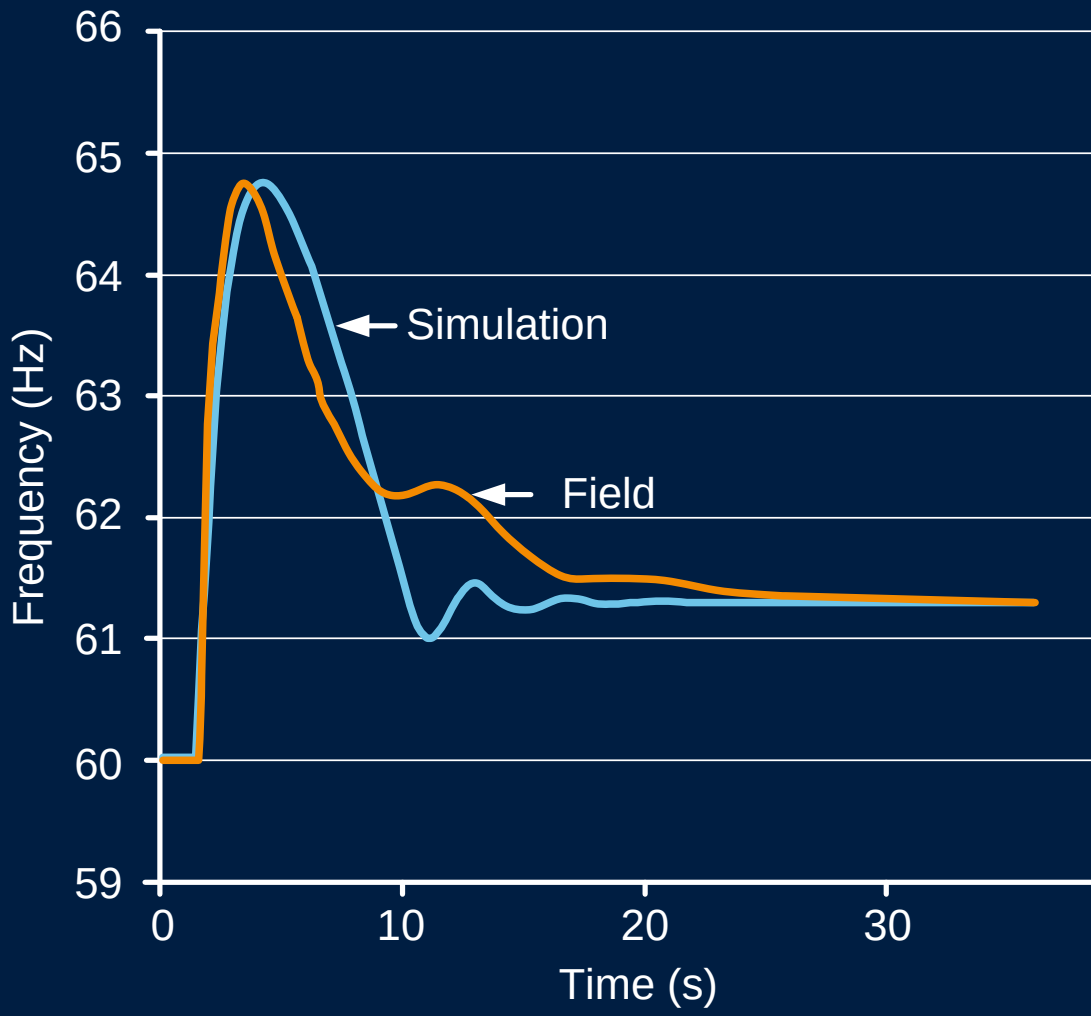
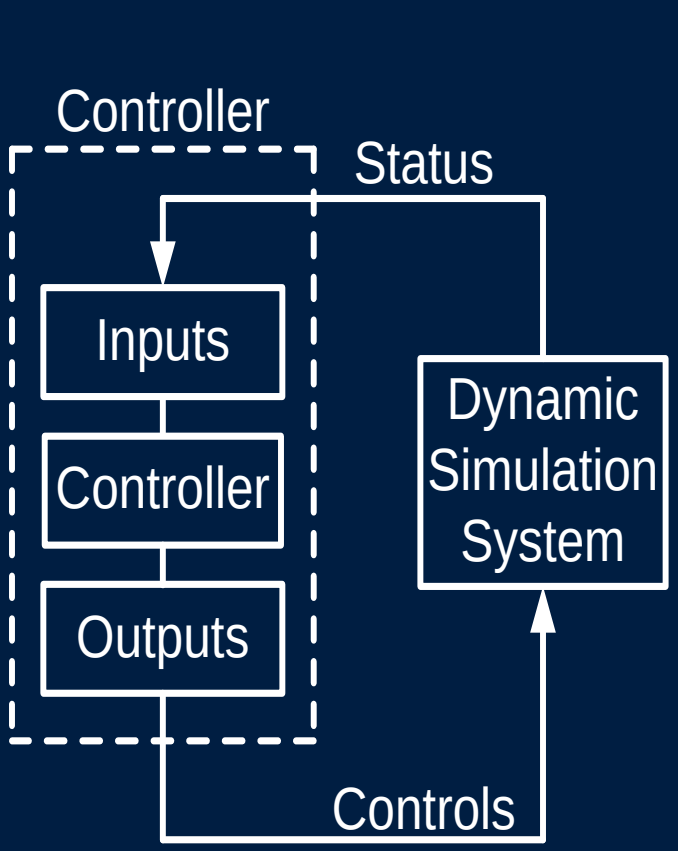
Essential Keys to Successful Microgrid Projects

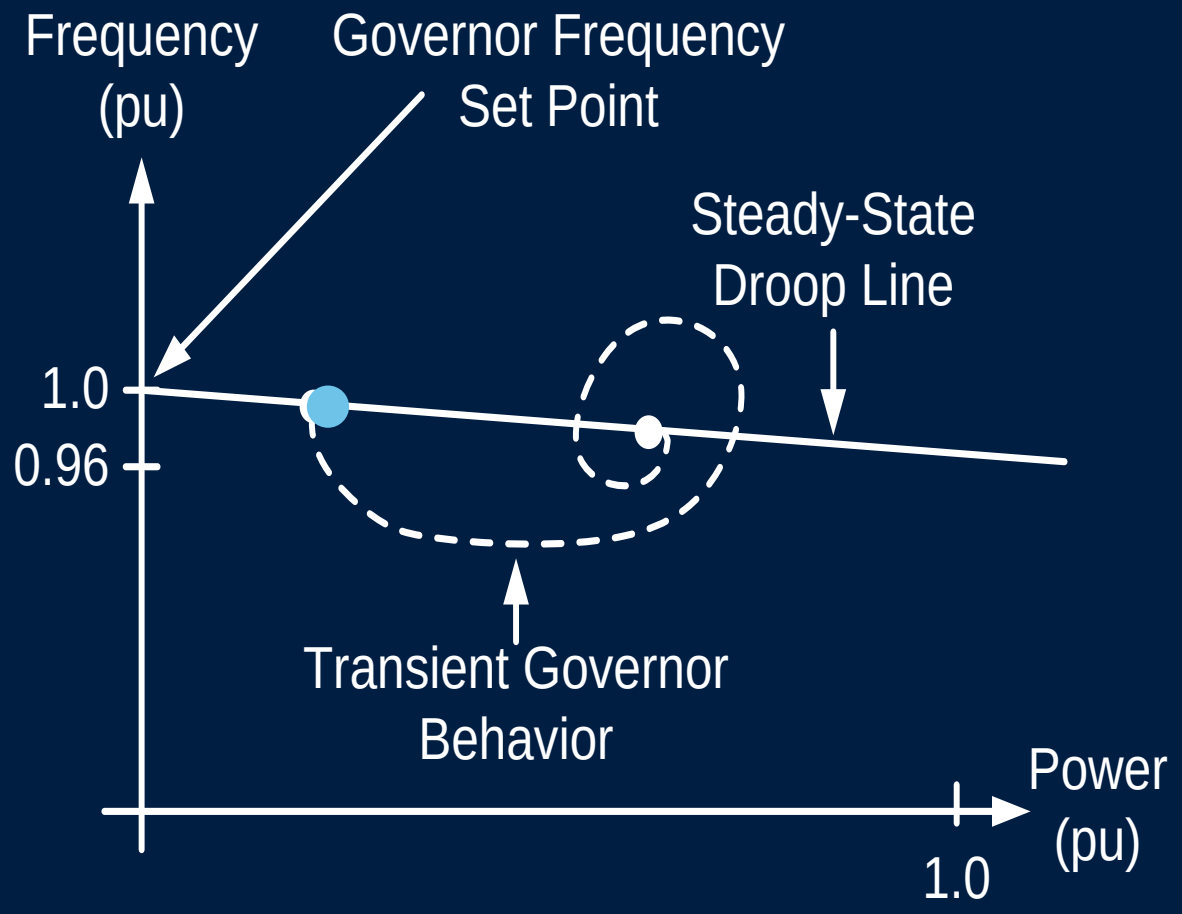
- Comprehensive HIL testing
- Subcycle fast controls
- Adaptive protection
- Practical security
- Fit for function
- Minimal complexity

Hardware-in-the-Loop Testing Improves Factory Acceptance Tests



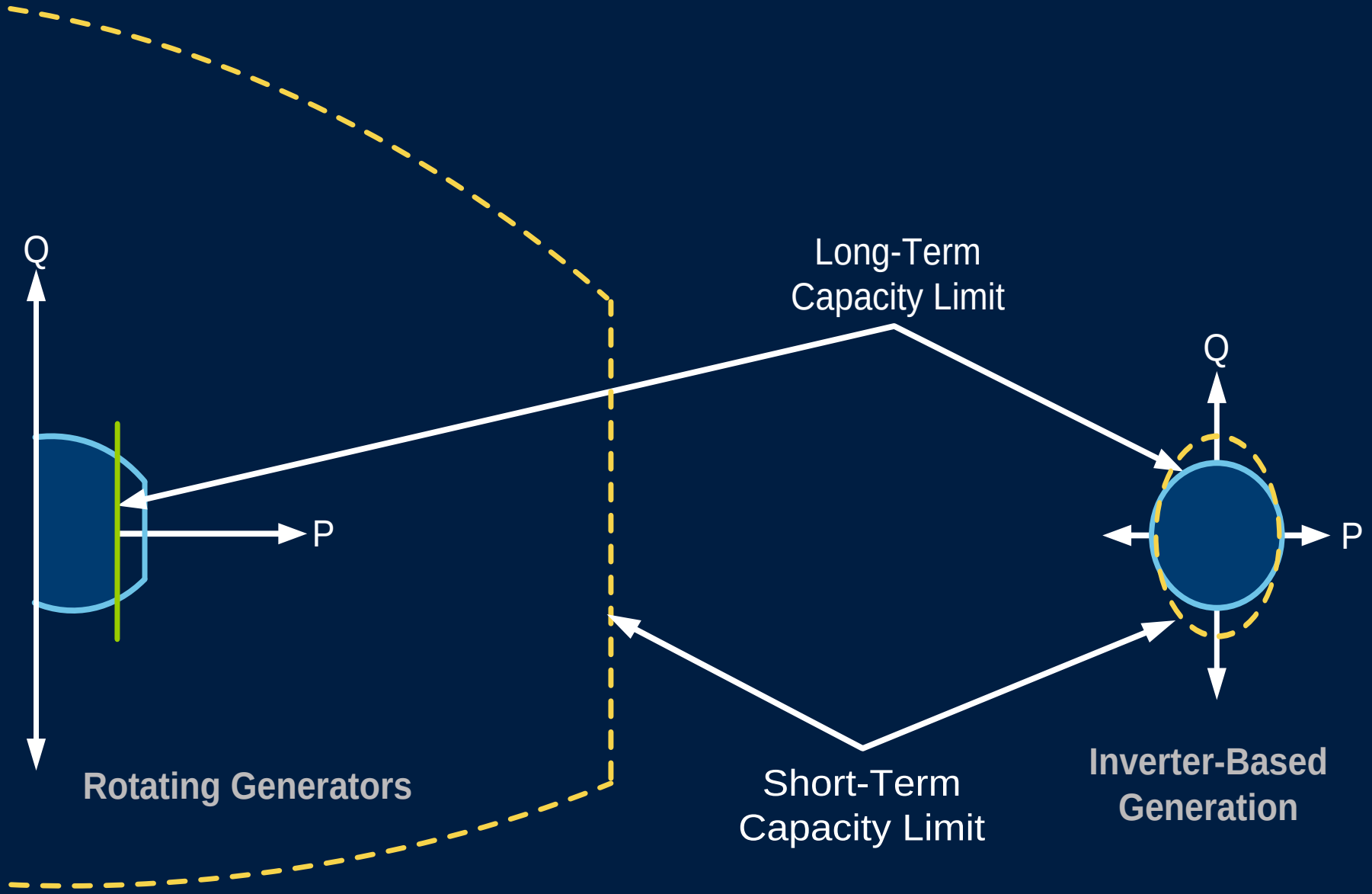
Control Cost, Quality, and Features
Hardware-in-the-Loop Testing



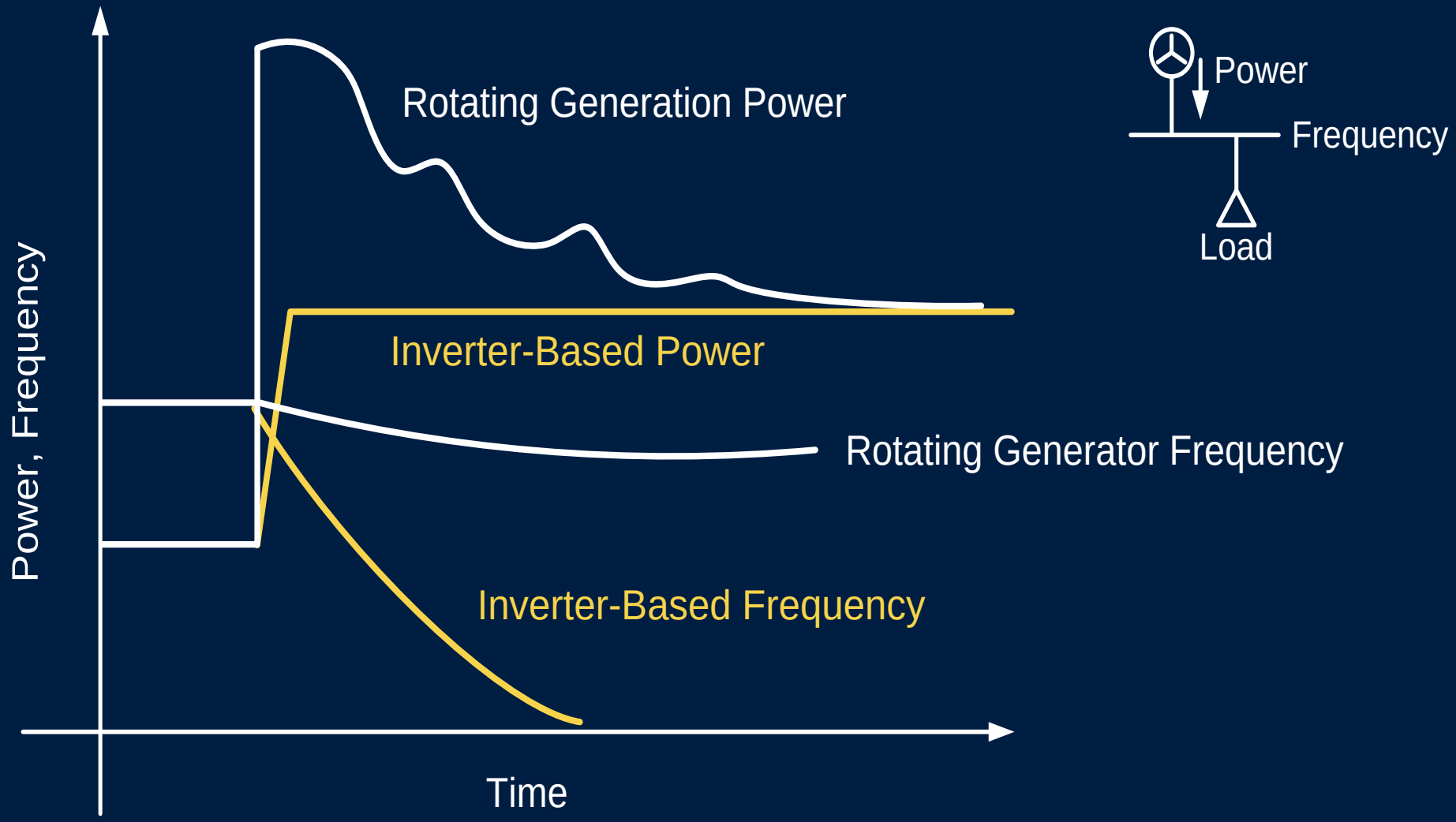


Both Mechanical and Electrical Systems Must Be Modeled Accurately

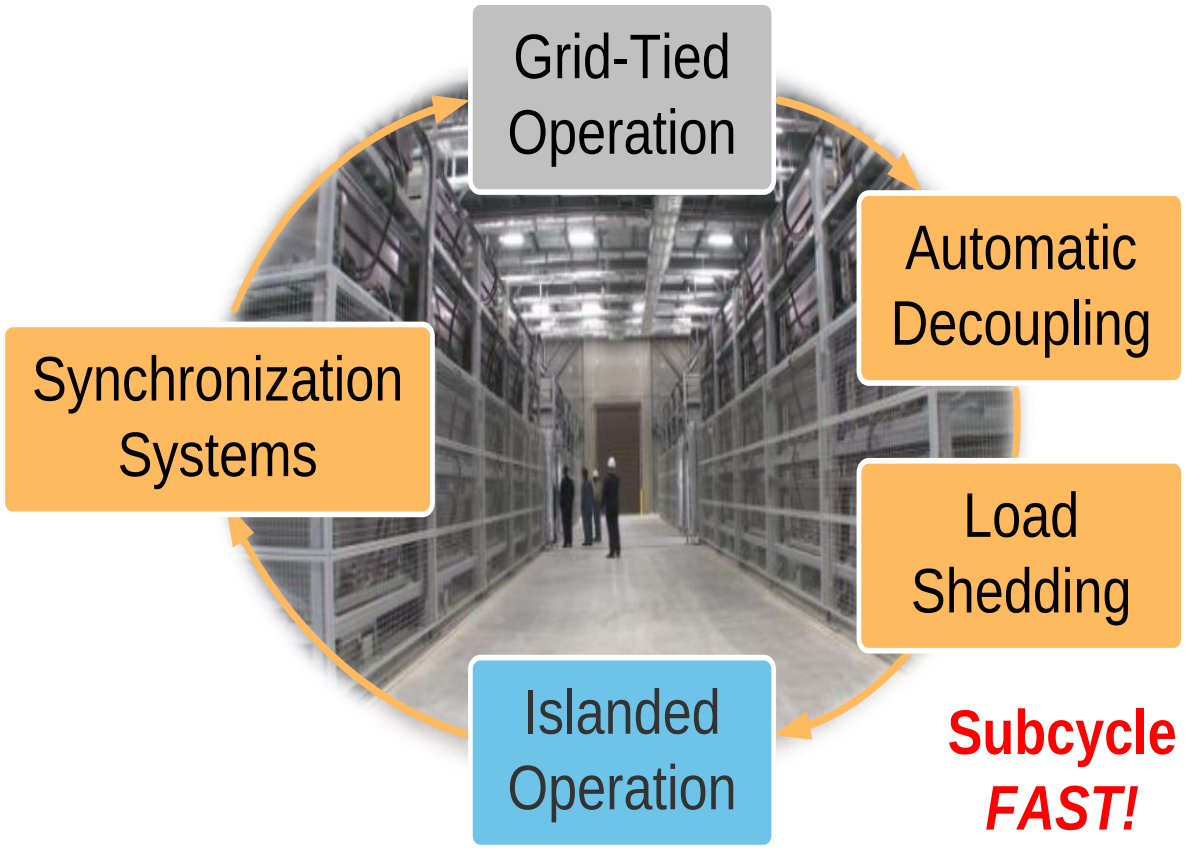
Inverter-Based Generation Has Limited Overload Capacity



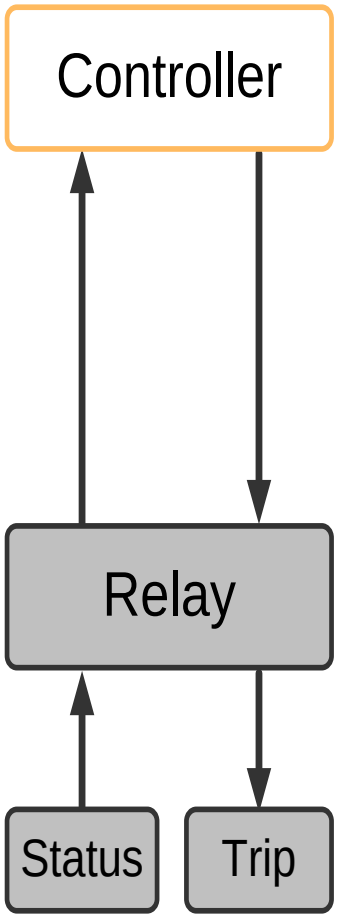
Load Balancing Must Happen *FASTER* With Inverter-Based Generation



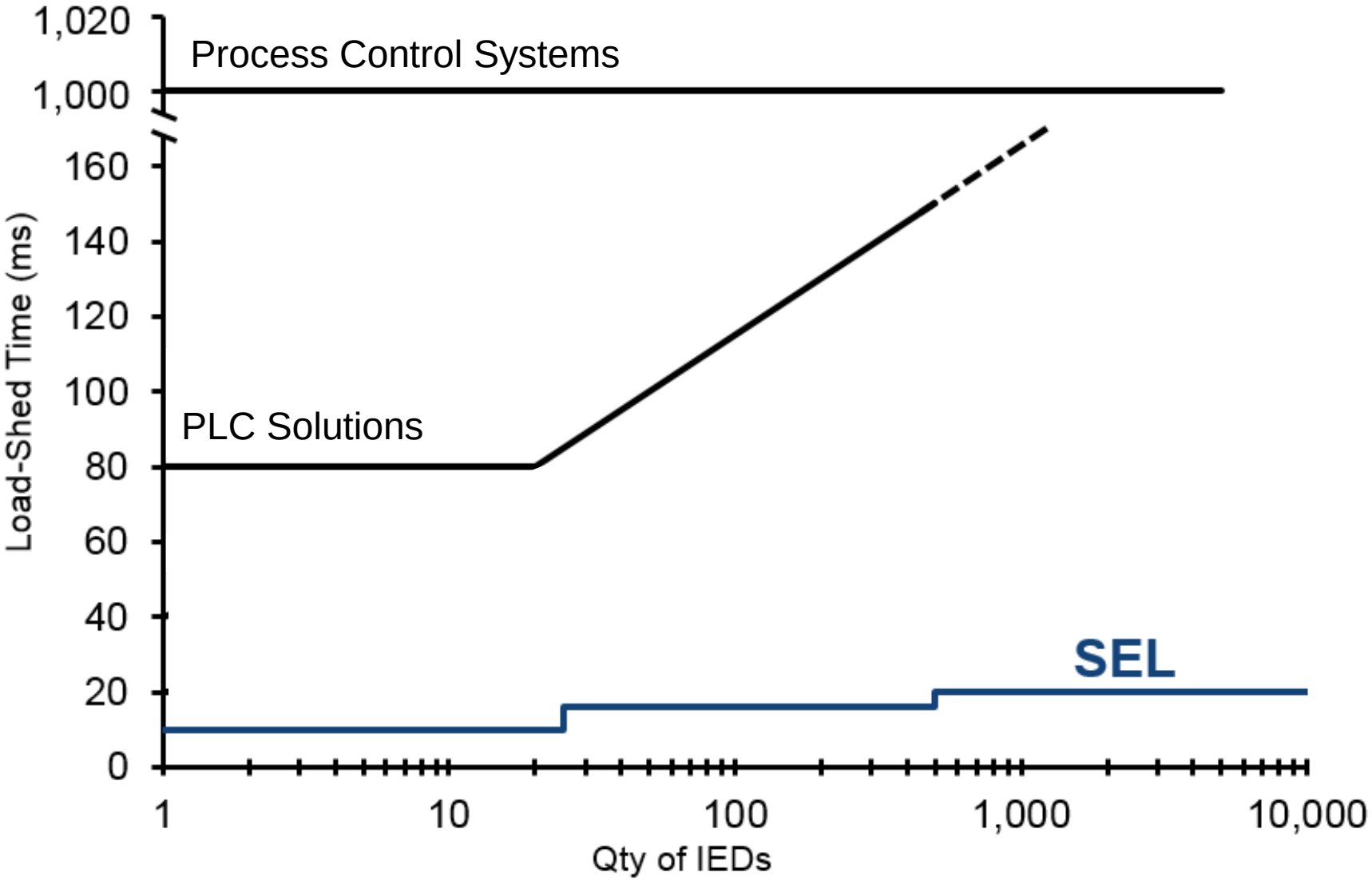
FAST Load Shedding Prevents Blackouts



Subcycle *FAST!*



Controllers Must Take Action *FASTER*



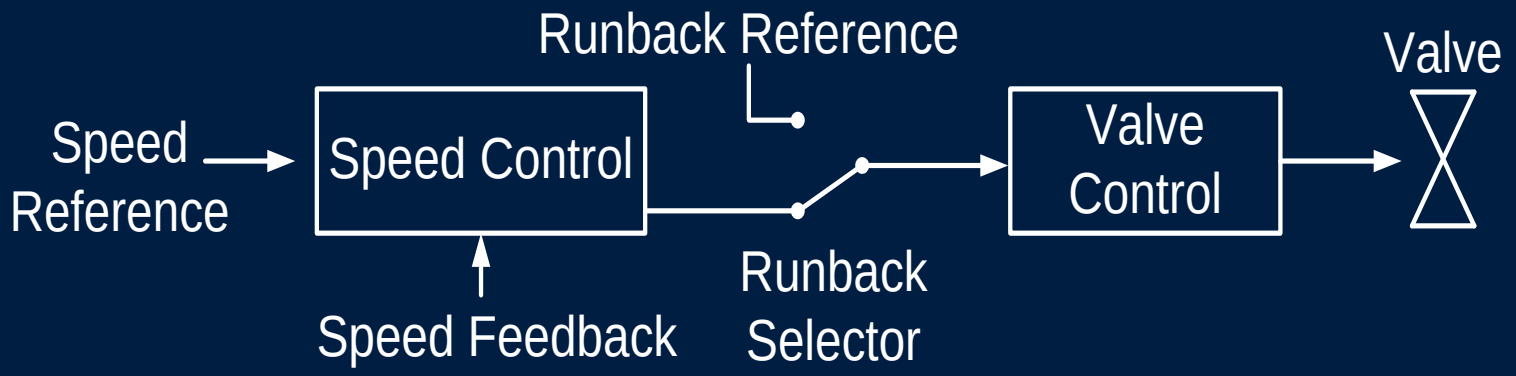
Solutions Must Be Scaled!

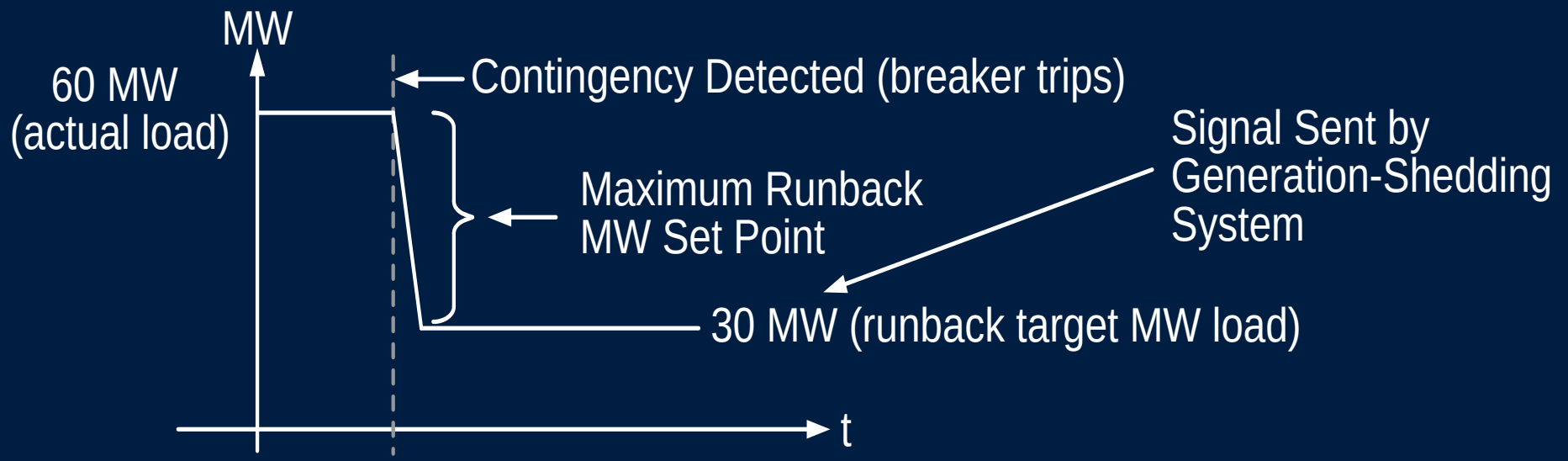
Feature	Relays Only	Relays + RTAC	POWERMAX Utilities & Industries
Relays	✓	✓	✓
SEL controllers	–	**SEL-3530-4**	**SEL-3555**
SEL POWERMAX libraries	–	**Partial**	**Complete**
Generators	Limited size	Distributed	Centralized
Security	**Comprehensive**		

Security for Critical Infrastructure

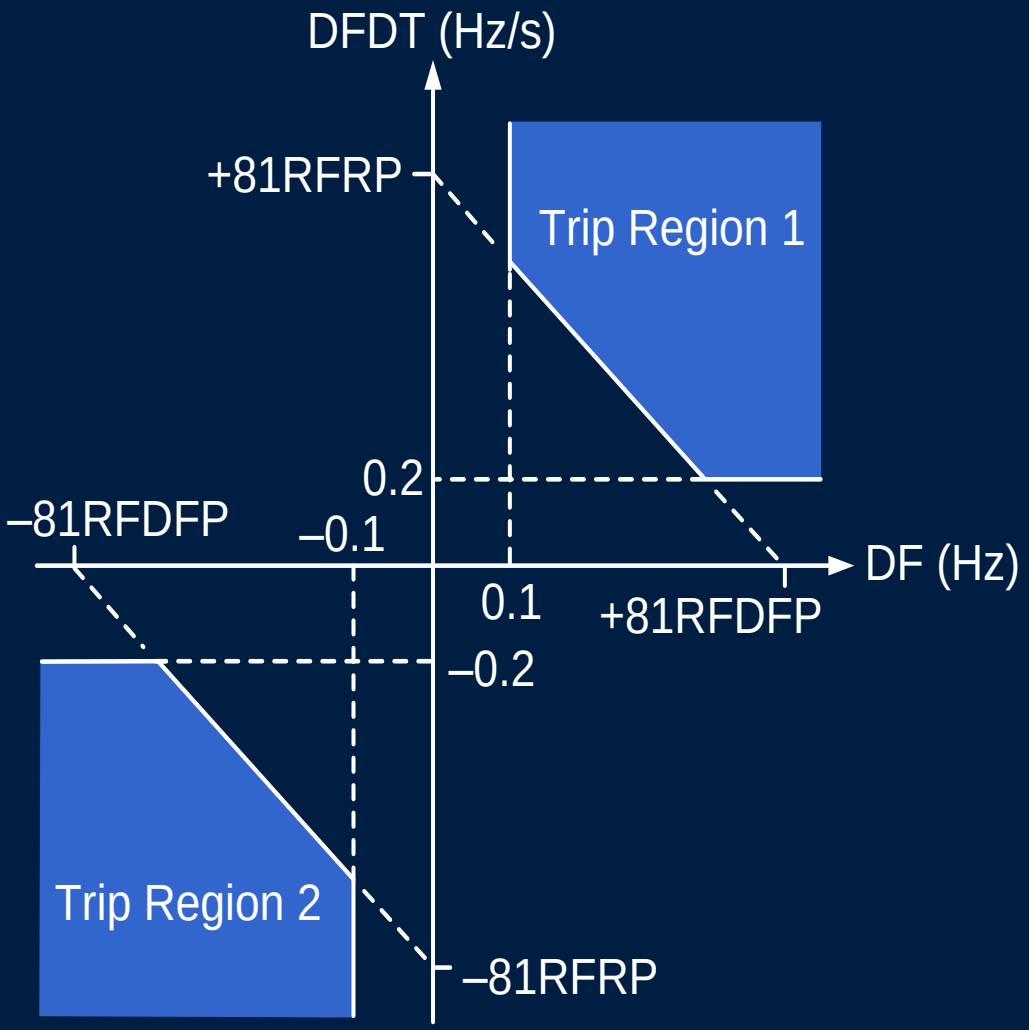
- Avoid OS and software
- Made in the USA
- Mature processes
- Vertical integration
- Cybersecurity

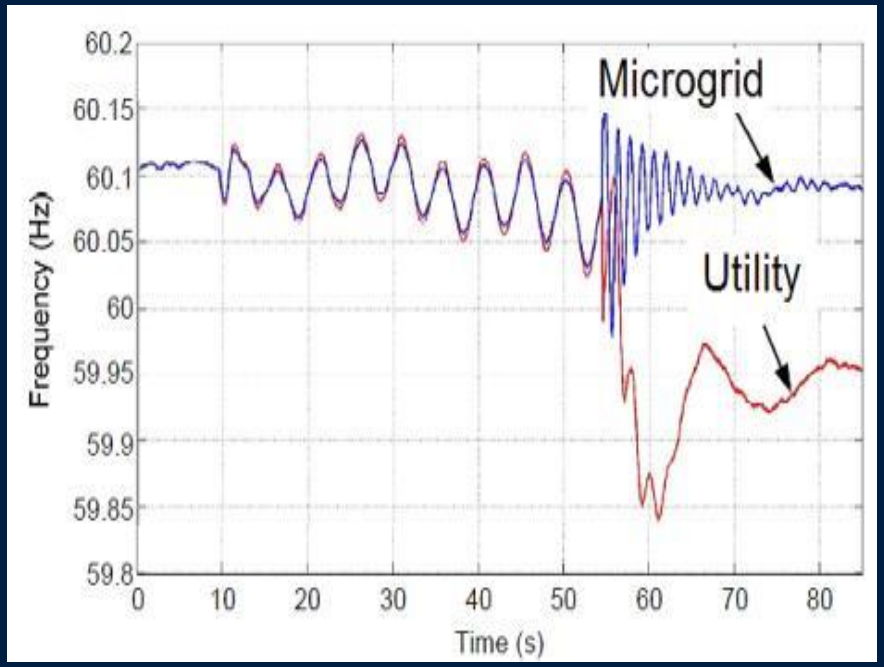
Generation Runback Philosophy



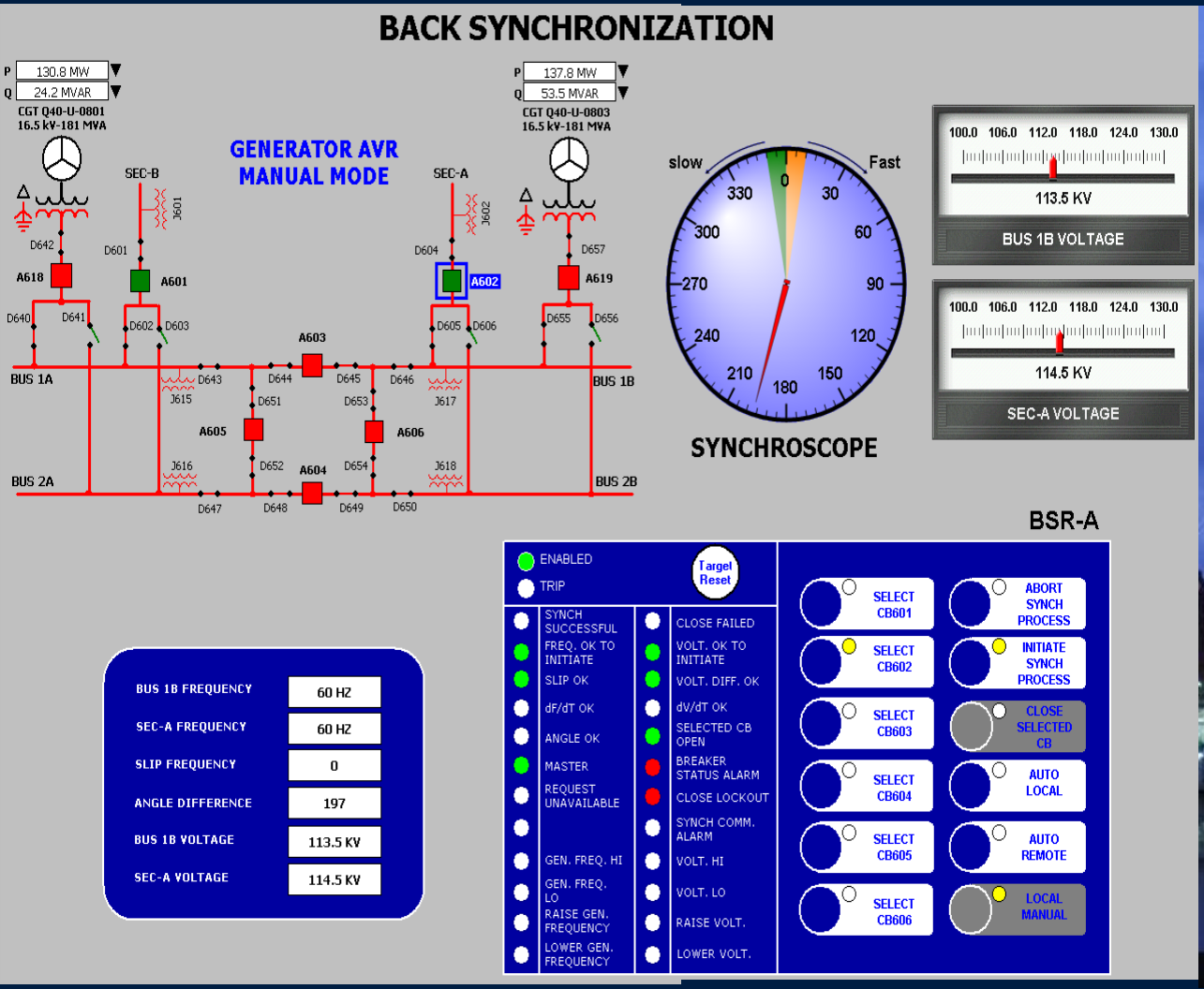


Seamless Islanding and Decoupling Systems



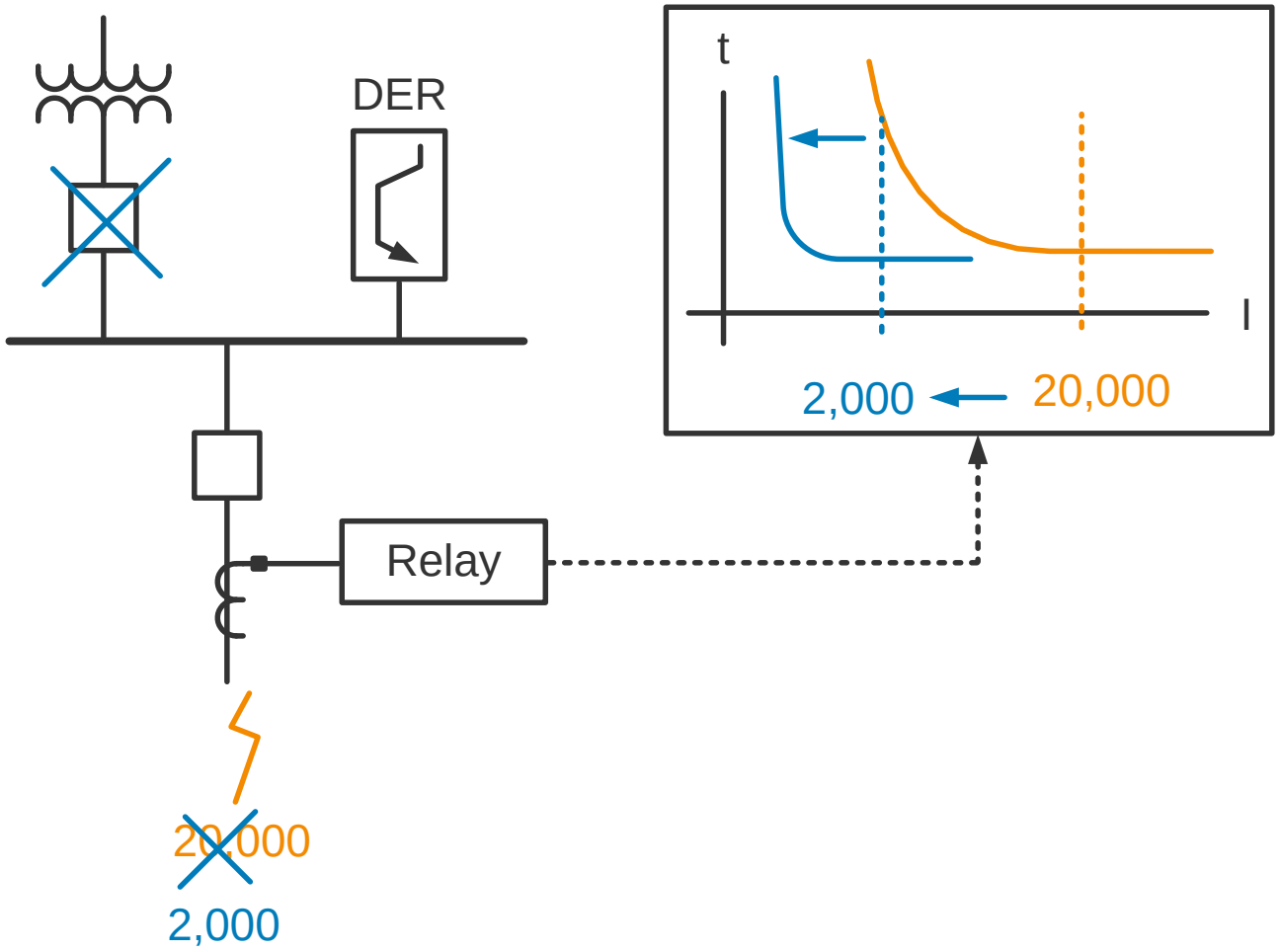


System Synchronization
Safely Reconnecting Islanded Grids

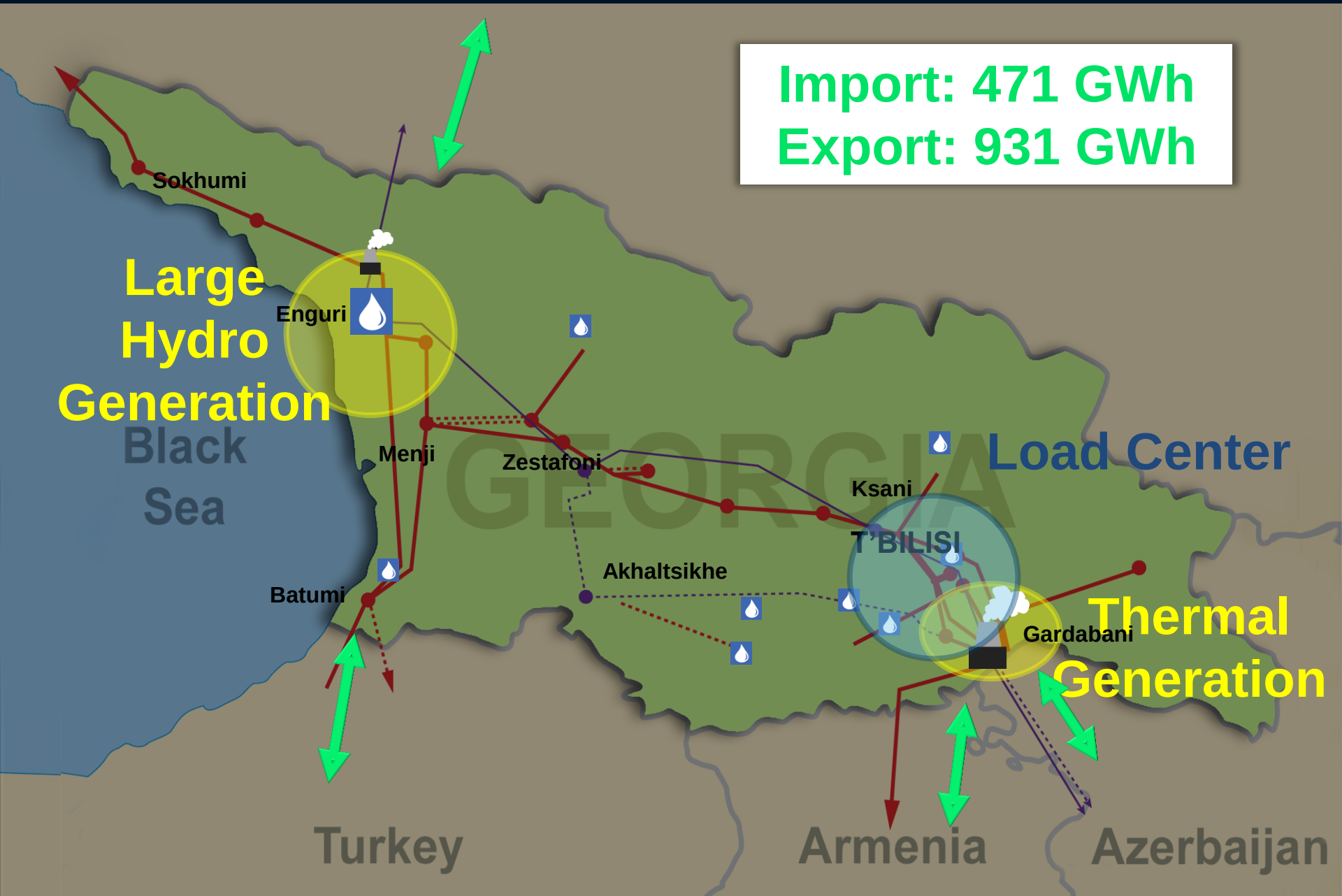


Protection Must *ADAPT* To Changing Fault Conditions

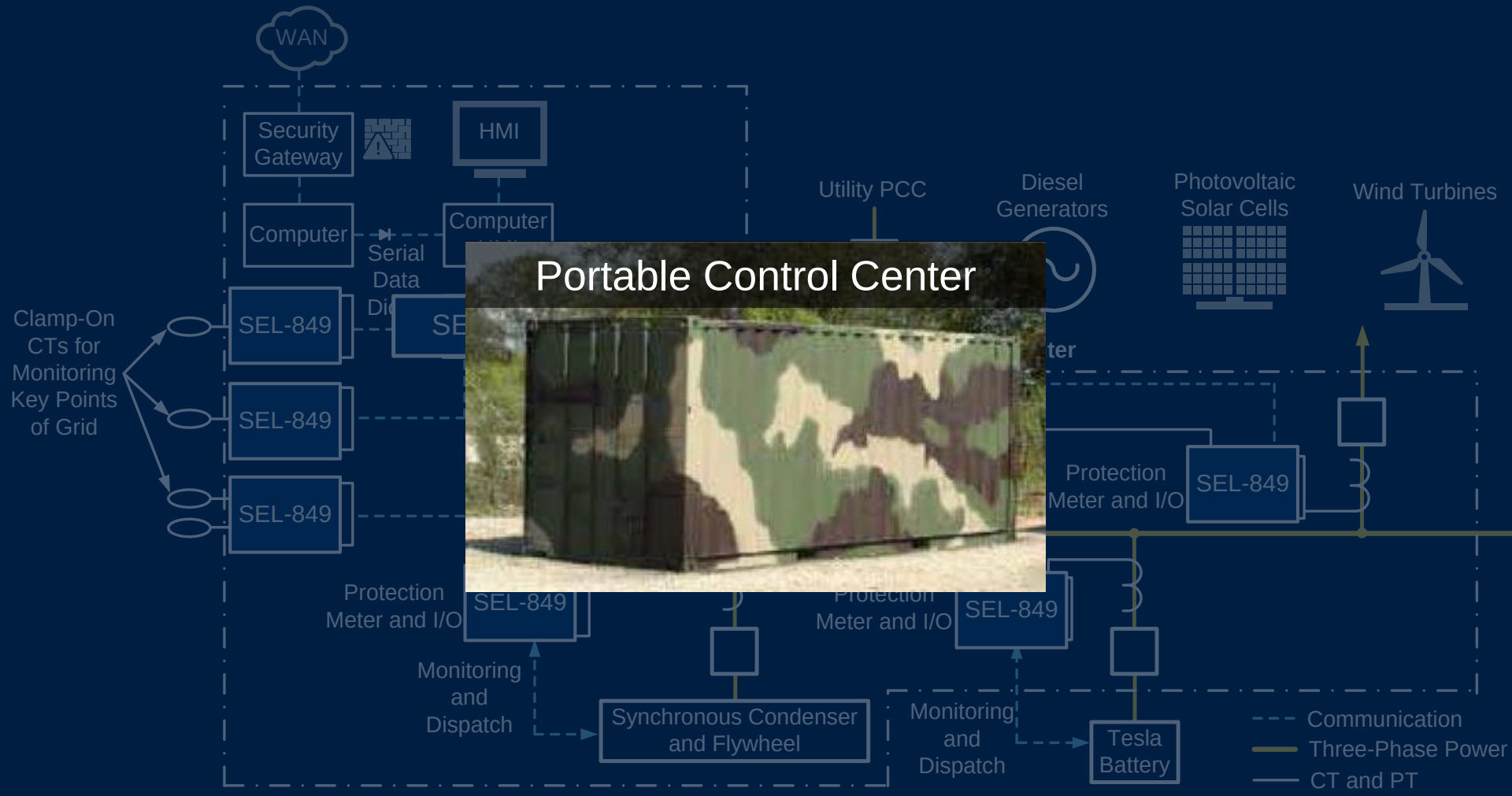
- Fault levels
- Grounding
- Directions
- Impedances



Physics Are the Same – Big or Small



Navy Seabees, U.S. Navy
Portable Microgrid Controls, Protection, and Security



Rugged and Economical for Restricted Budgets

- Load shedding
- Voltage / VAR optimization
- Frequency / power dispatch
- Autosynchronization
- Decoupling
- Comprehensive HIL testing

DGs, wind turbines, synchronous condenser, flywheel, and loads

Conclusions on Lessons Learned

- **Testing** reduces installation and maintenance costs
- **Fast control systems** prevent outages
- **Reliable load balancing** maintains stability
- **Adaptive protection** saves lives
- **Security in depth** is mandatory

Questions?