

Tactical Microgrid Systems for the U.S. Military

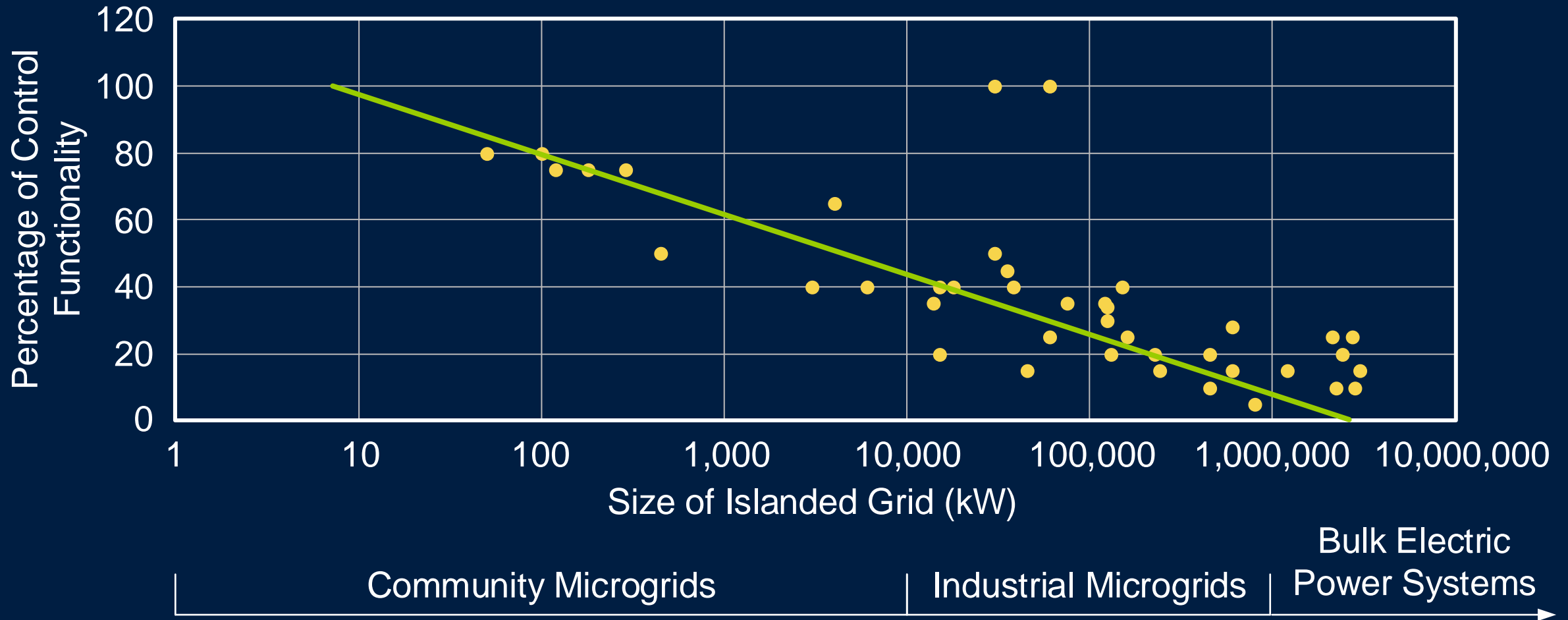
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Project Objectives

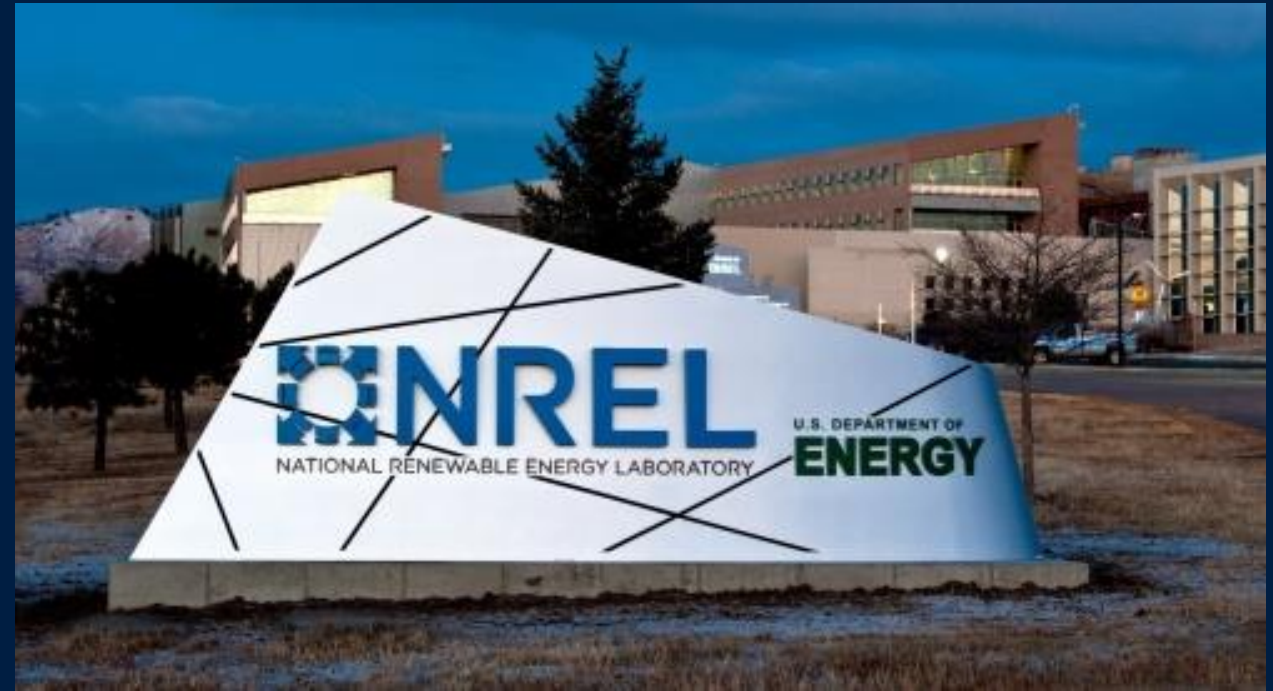
- Provide independent review of TMS-MIL-STD
- Build two TMS-compliant microgrids
- Design user-friendly, plug-and-play configuration
- Scale to any microgrid

Relays Control Small Grids



Same Technology Won Microgrid Shootout

- Work completed simultaneously with TMS-MIL-STD project
- Hardware-in-the-loop (HIL) testing
- Cyber-physical test bed
- Worldwide competition



Relays Are Microgrid Controllers

- Multifunction protection
- Remote I/O
- Metering
- Power quality monitoring
- Programmable logic controller
- IEC 61850
- Sequence of Events recorder
- Embedded and whitelisted
- Mil-spec environmental ratings
- High-speed communication
- Continuous self-diagnostics
- Synchrophasors
- DC battery monitoring
- Human interface displays
- Trip and close controls
- Oscillography recorder
- No operating system
- Hundreds of thousands in operation

Tactical Microgrid Standard

The Next Evolution of Operational Power

TQG



Quiet, 1980



TMS



Interoperable, 2018

Demonstration Project

100 kW CAT

60 kW TQG



Loads

Loads

Loads

Loads

30 kW Taylor

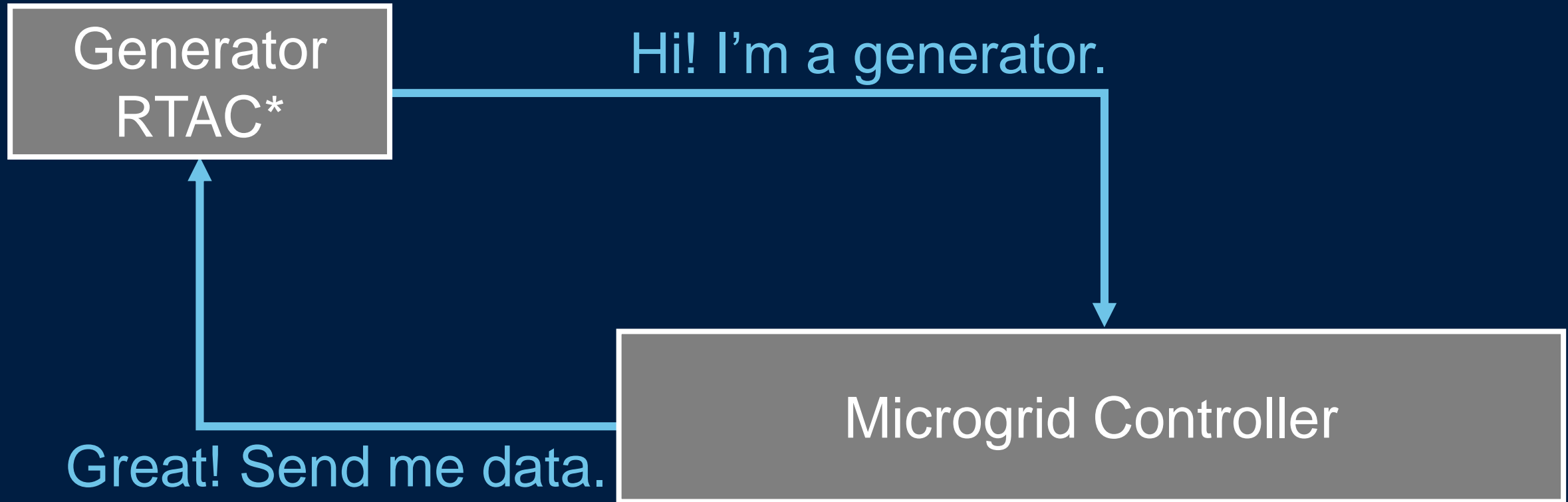
30 kW Gillette



Loads

Loads

Data Distribution Service (DDS) Brings Plug-and-Play Communications



* Real-time automation controller

Soldier-Friendly RTAC Configuration



Increased Reliability With Reduced Part Count



TQG
before
refurbishing

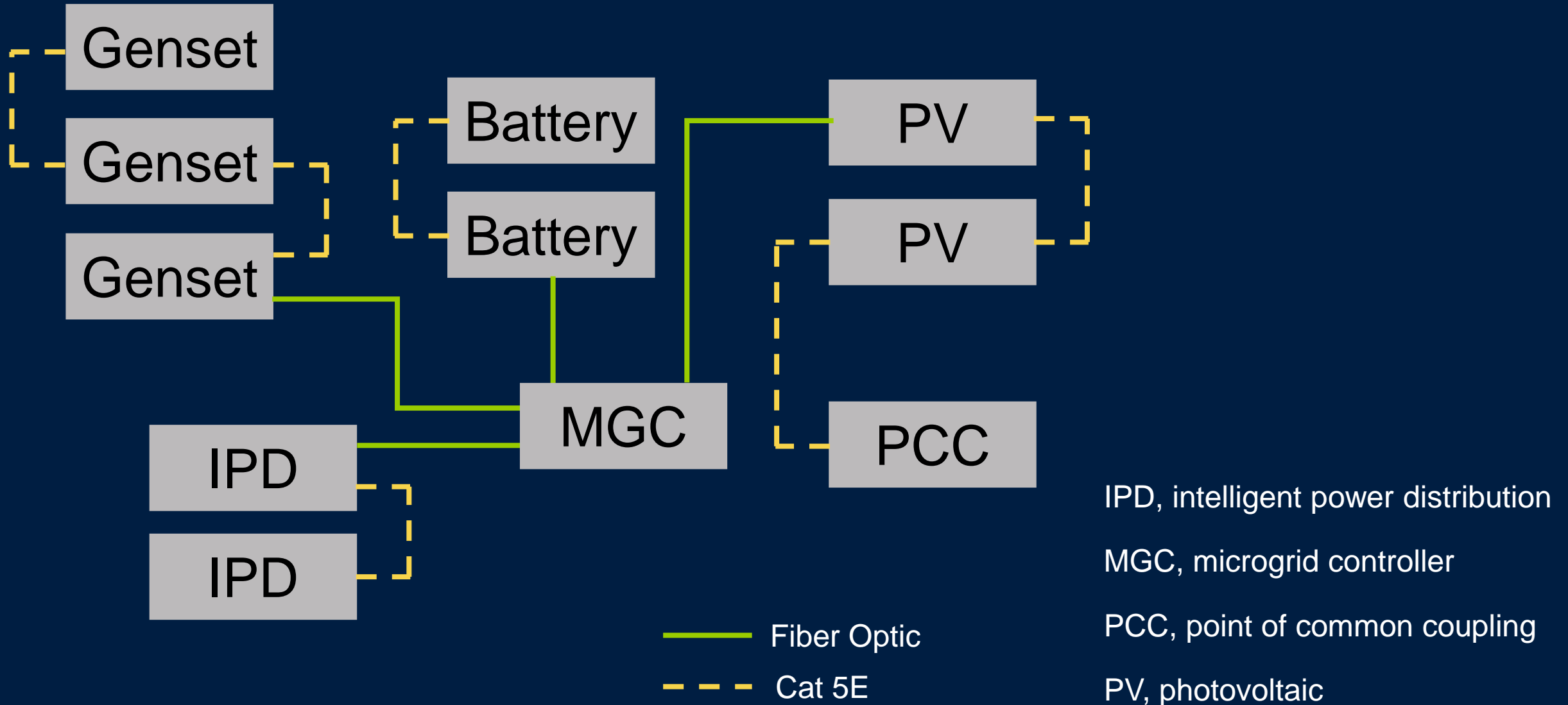


Custom-built
electronics removed
from TQG

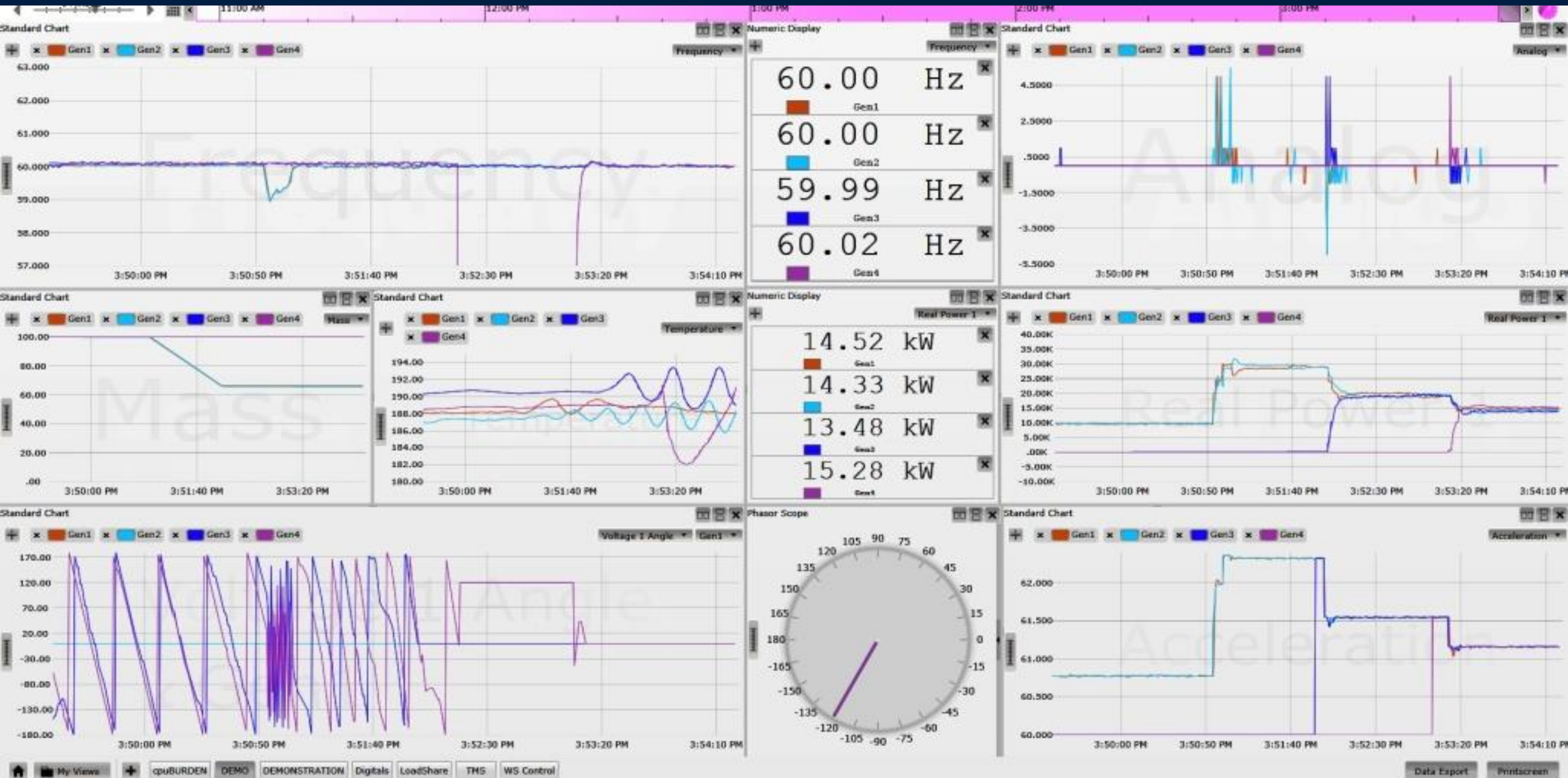


Replaced with fewer,
lighter commercial
off-the-shelf parts

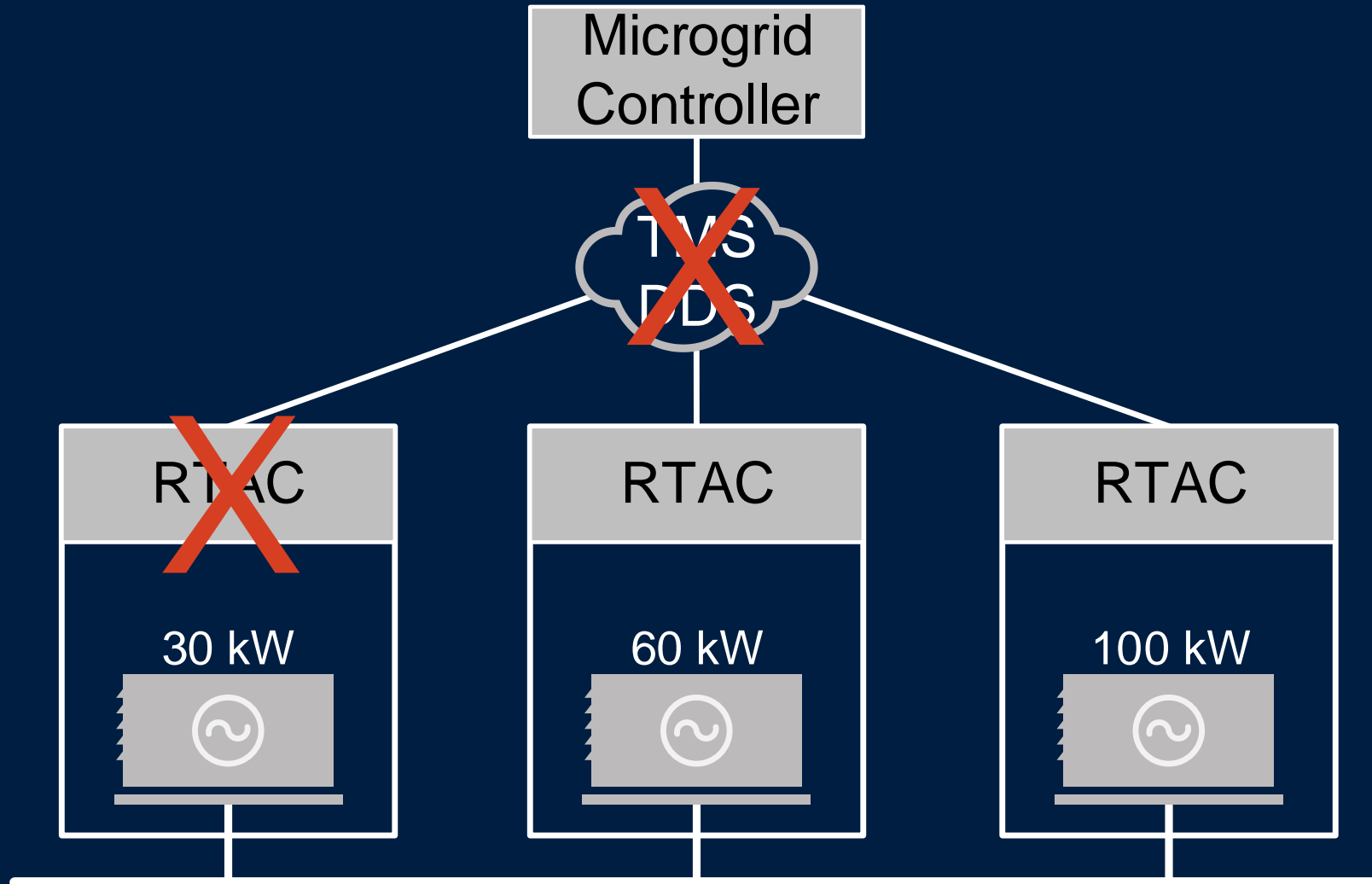
Secure Networks Support Any Size Camp



Time-Synchronized Condition Monitoring

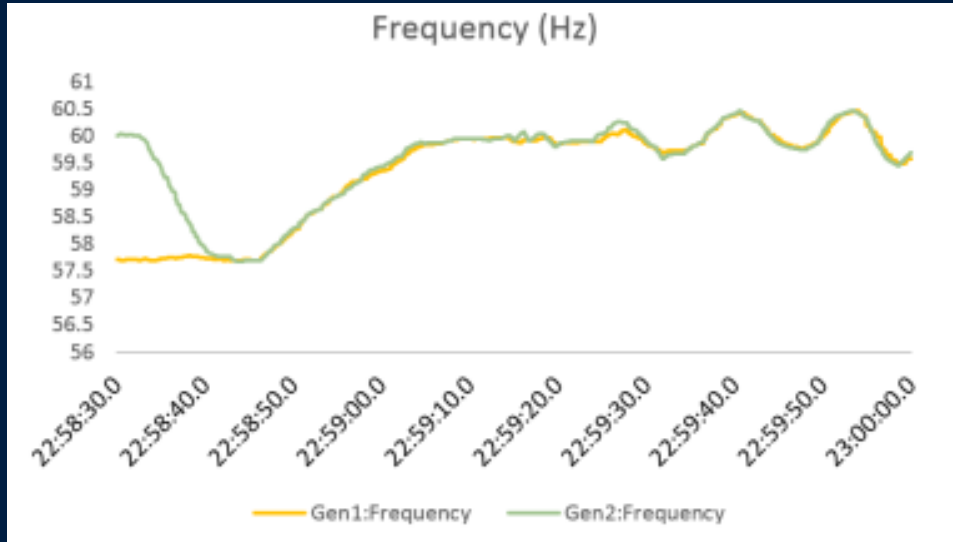


No Single Point of Failure

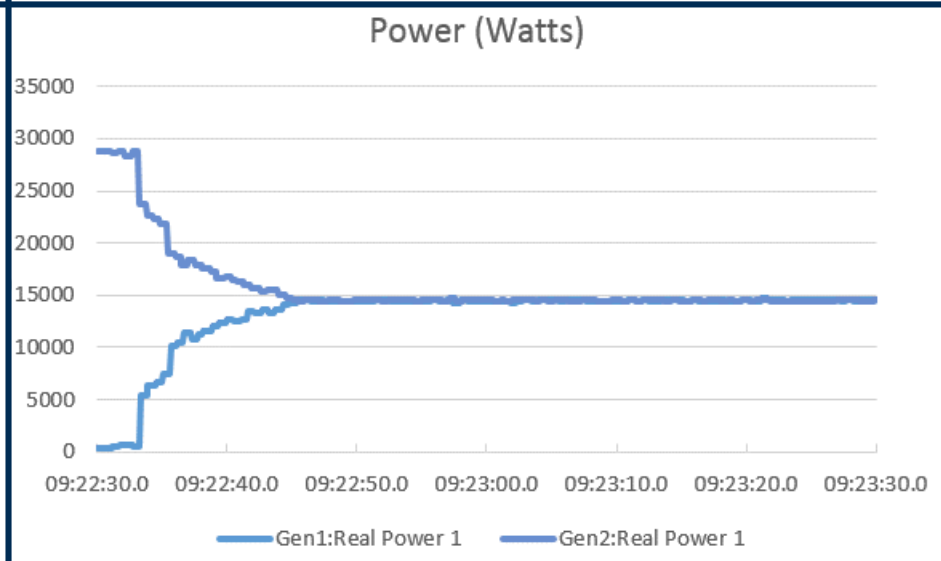
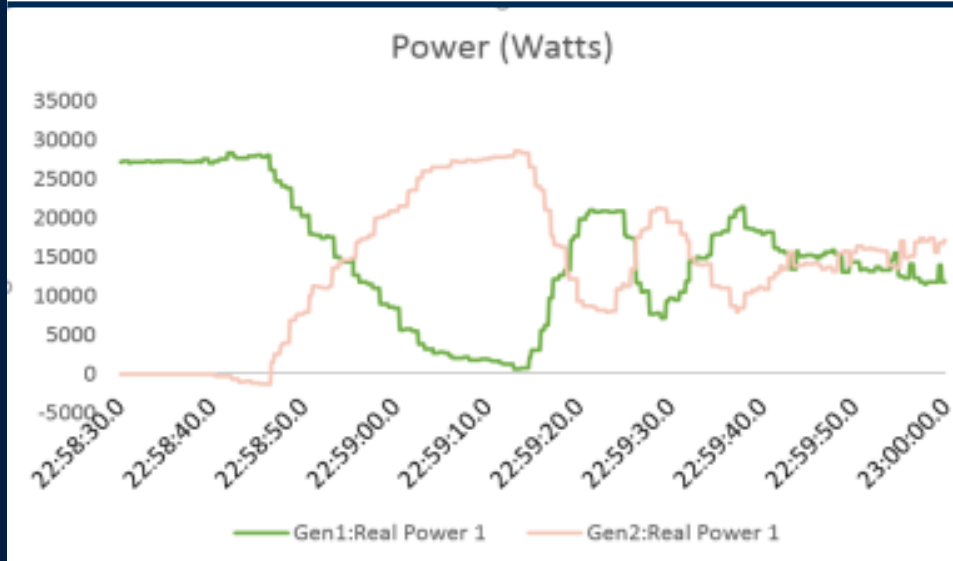
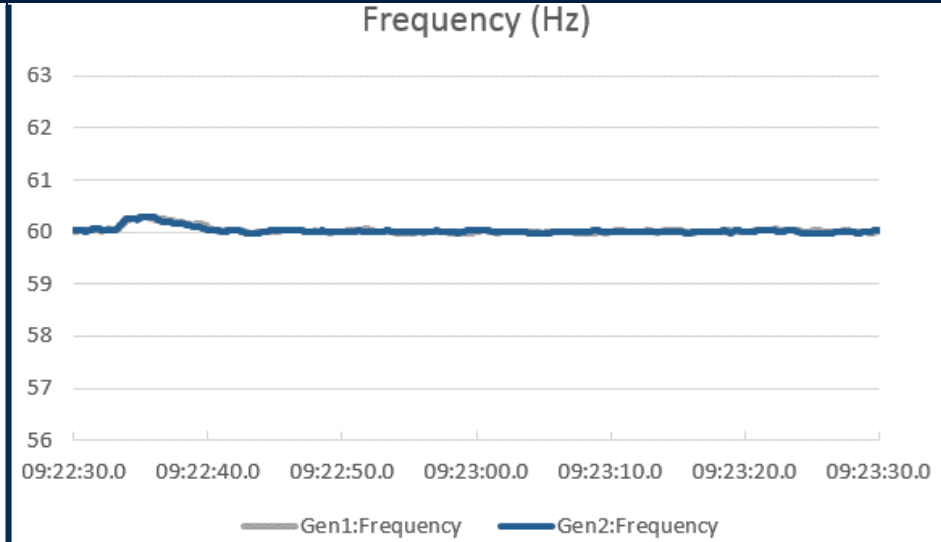


Superior Load Sharing and Frequency Control

Engine Manufacturer



TMS Solution

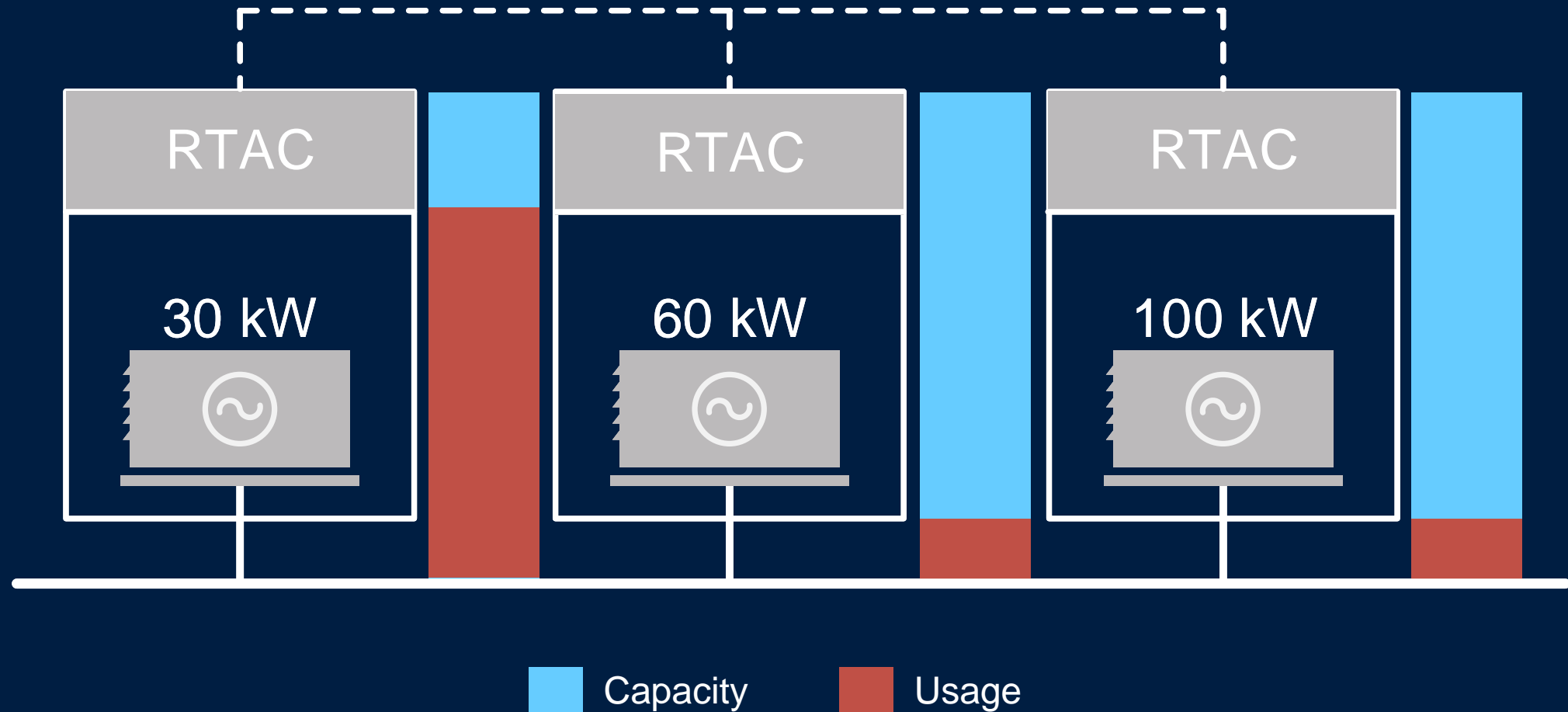


No overshoot
No integral windup
No oscillations
No tuning
Fully interoperable

TMS Considers RMF Compliance

- Software-defined network
- Embedded, whitelisted controllers
- Secure supply chain
- U.S. manufactured electronics
- Policy, plan, and procedure
- Mature processes

Wet-Stacking Correction Strategy Does Not Burn Extra Fuel



Microgrid Consumes Less Fuel



30 kW



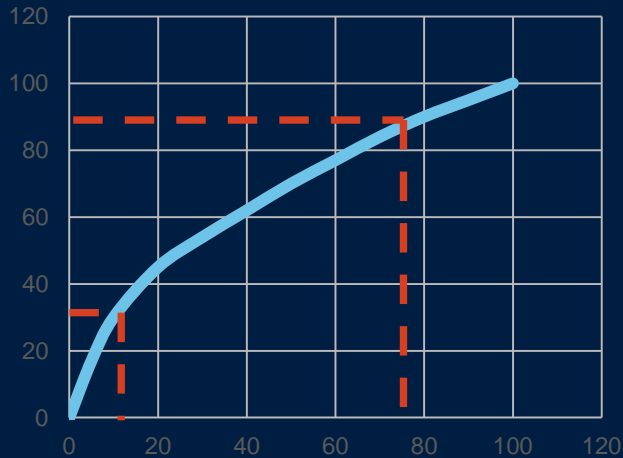
60 kW



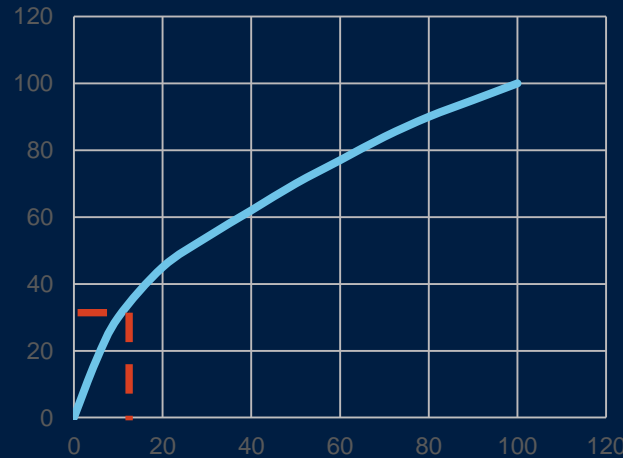
100 kW



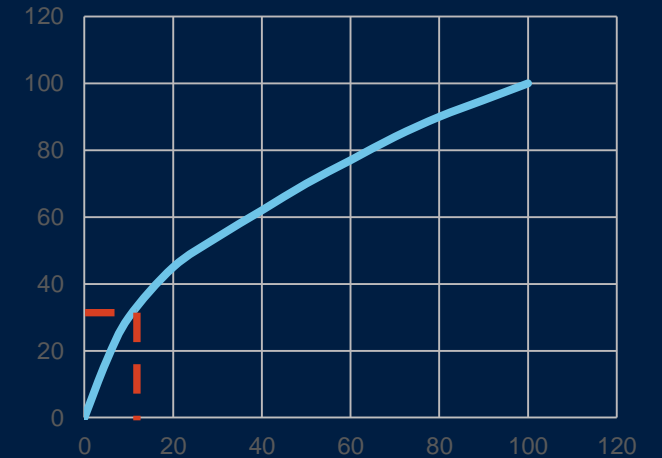
90% Efficient



30% Efficient



30% Efficient



Conclusion

- Interoperable DDS solution
- Cyber-secure, scalable networks
- No single point of failure
- Time-synchronized condition monitoring
- Superior load sharing and frequency regulation
- Any size or manufacturer of generator
- Reduced fuel use
- Reduced emissions
- Automatic wet-stack mitigation

TMS Team Collaboration

- Schweitzer Engineering Laboratories, Inc.
- Lincoln Laboratory, Massachusetts Institute of Technology
- HG Engineers
- CERDEC, U.S. Army Research, Development and Engineering Command
- U.S. Army Corps of Engineers