Performance Optimization for Power and Energy Systems in Remote and Isolated Electric Grids / Microgrids

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Emerging Priorities in Energy Research

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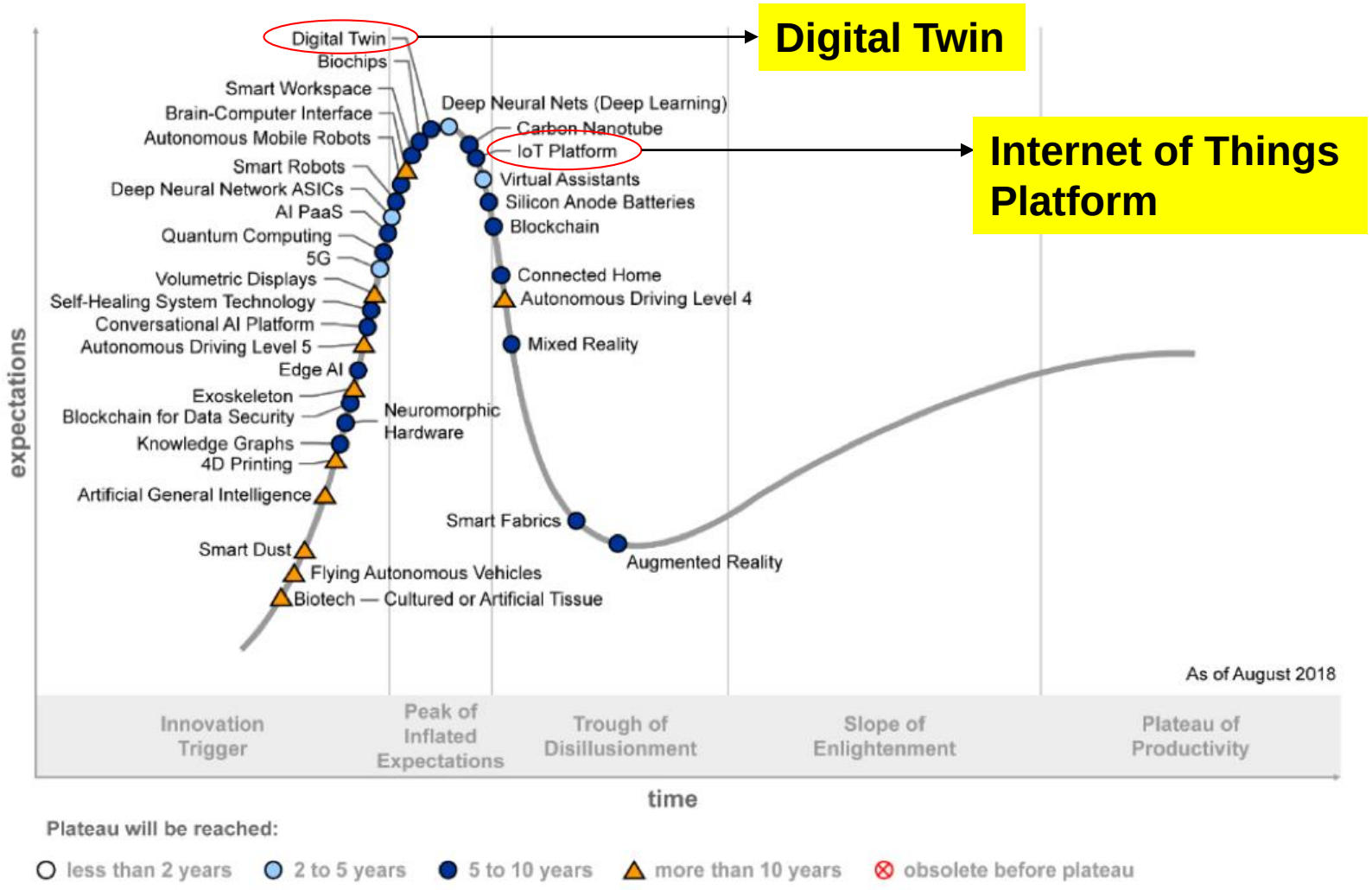
Emerging Technologies – Timeline of Expectations



Digital Twin

Internet of Things Platform

Source: from Gartner, Inc. website

Power and Energy Real-Time Laboratory (PERL)

Opal RT, FPGA Development Environment (IEEE 1394 and MIL 1553)

High Performance Computing (~1800 compute nodes)

Controllers (Siemens, SEL RTAC)

100+ RISC-based programmable cards for emulating hardware devices (Electric Vehicles, Wind Turbines)

Typhoon HIL for Testing Advanced Power Electronics

Linux Servers for communication layer, Real-time Data Analytics

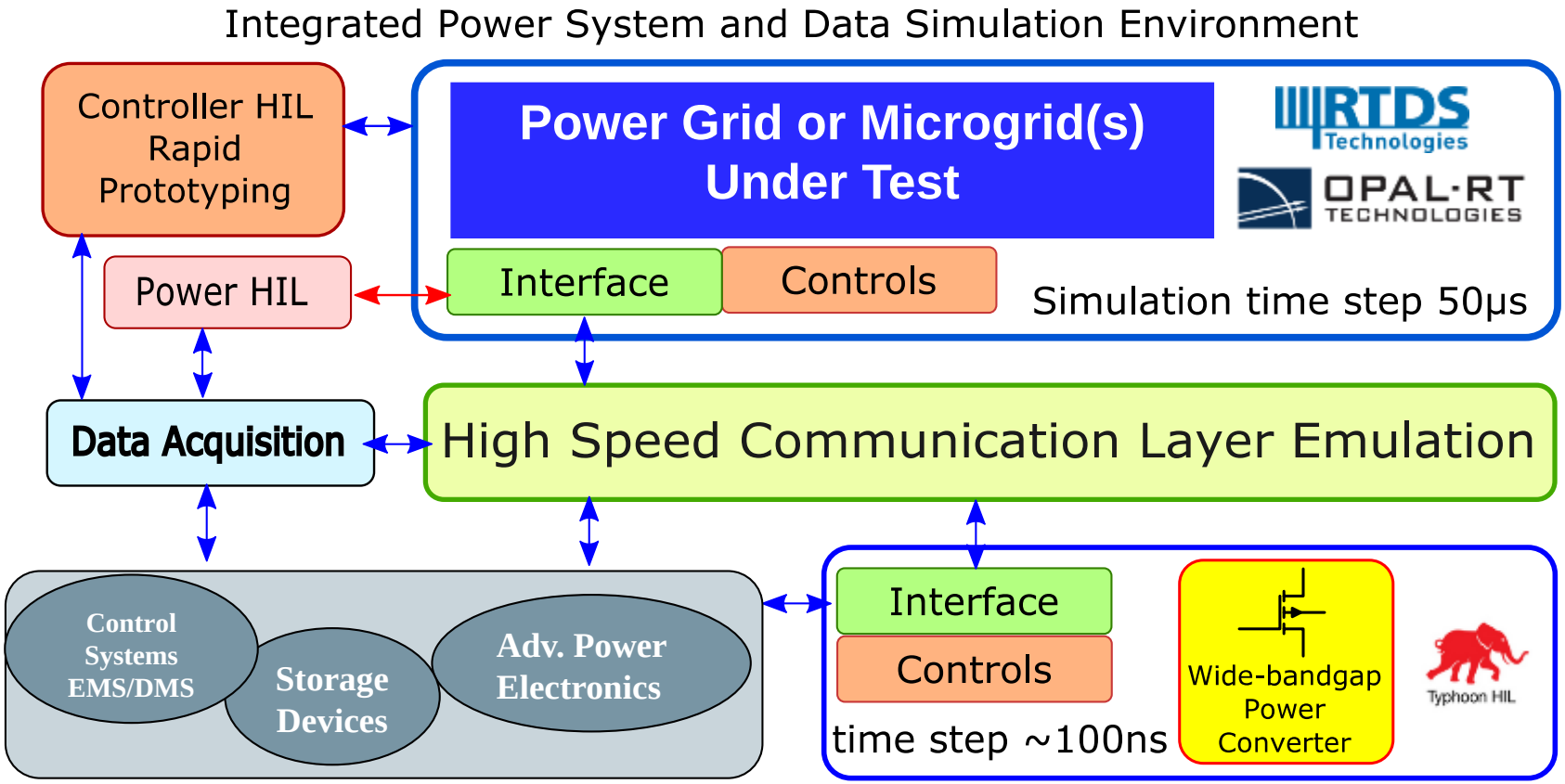
Real-Time Digital Simulator

Programmable V & I-Amplifiers

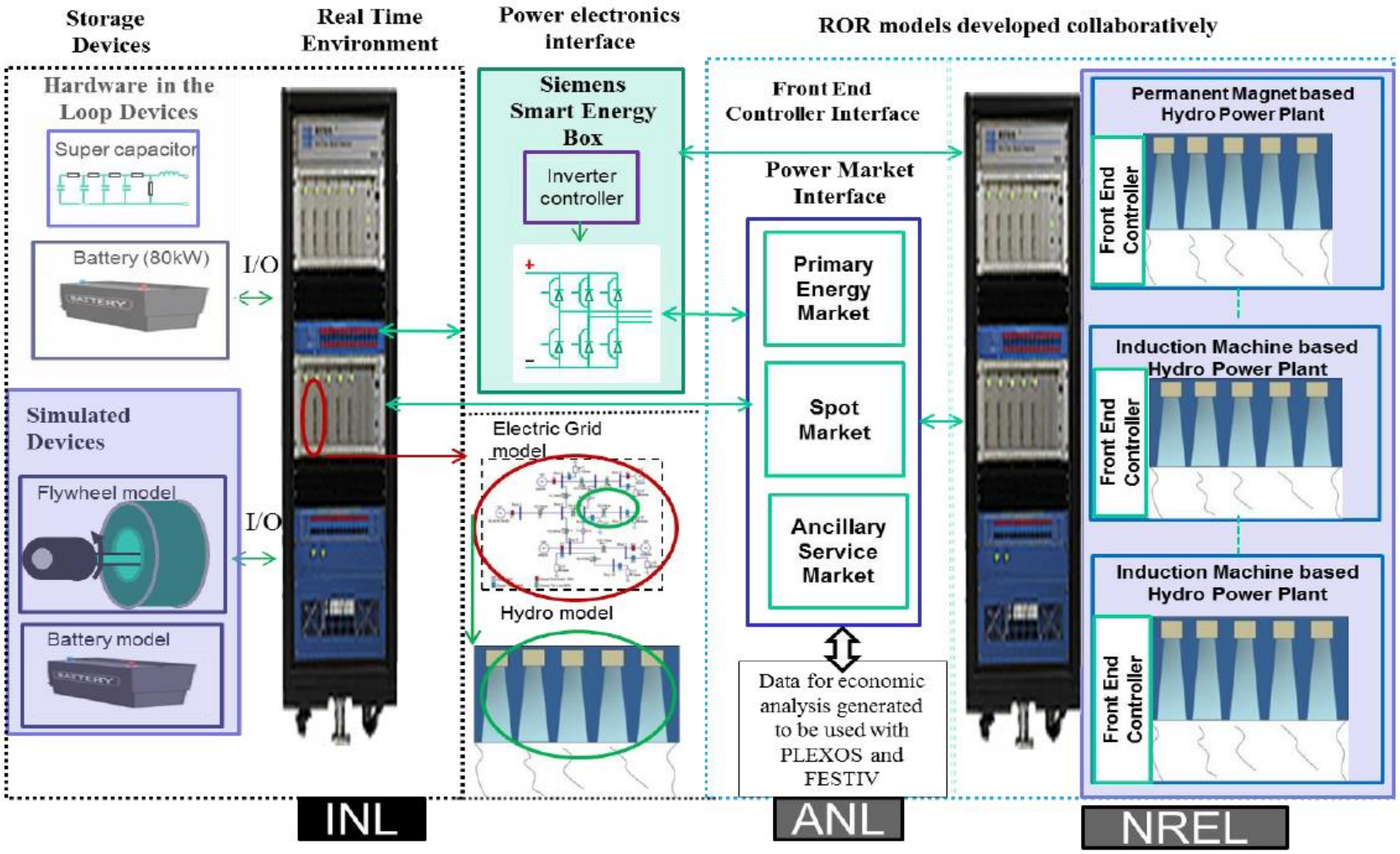
Micro-PMUs

Protection Relays

Co-simulation for power systems, power electronics, and communication



Integrated Hybrid Energy Storage for Hydro



GMLC RADIANCE – Energy Storage Optimization

- ROR HPP Modeling – dynamic and transient evaluation in real-time simulation
- ROR HPP applications in microgrids/weak distribution grid that provide support / reliability / resiliency

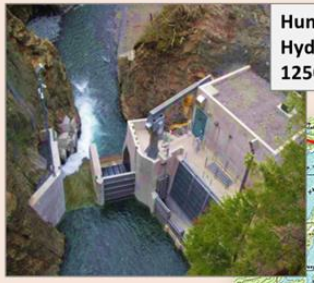
Energy Storage Optimization for
- Multi-timescale (Super-Capacitor, Flywheel, Batteries) response coordination for grid support
- PHIL-based characterization of ESS under dynamic conditions

ROR HPP Modeling – dynamic and transient evaluation in Real-time Simulation

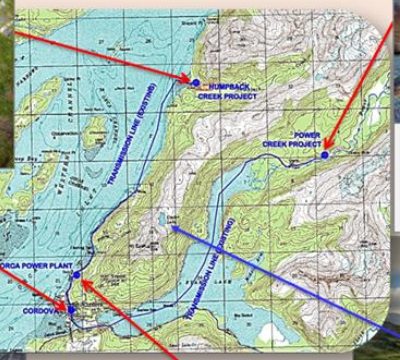
GMLC RADIANCE project outcomes from Run-of-the-river and Pumped Storage Hydro research

a) ROR as a resource for rotational inertia and regulation in coordination with **microgrid controller** and **Energy Storage Optimization** Toolbox (ESOT)
b) Coordinated operation with proximal generation as ROR or **Pumped Storage Hydro (PSH)**

a) Assessing **rotational inertia** from the existing ROR plant – resiliency enhancement
b) Modifications by removing deflector plates for rotational inertia in microgrid for **regulation and frequency support**
c) Upgrading hydraulic governors to **digital electronic** for faster, more efficient operation



Humpback Creek Run-of-the-river Hydroelectric Plant
1250kW (2 x 500 kW + 1 x 250 kW)

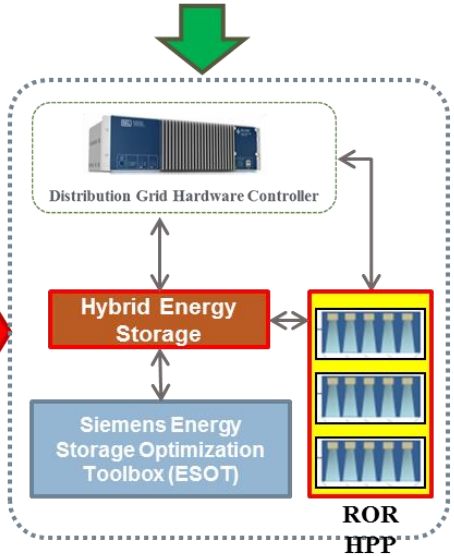


Power Creek Run-of-the-river Hydroelectric Plant
6278kW (2 x 3124 kW)
with Inflatable dams

City of Cordova
1,566 customers, 18MW
One Substation

Orca Power Plant
(10.8MW Diesel) Control Center

Crater Lake Dam Storage
may offset 25% Diesel consumption



a) **Capacity evaluation** for pumped storage hydro (PSH) as energy storage
b) **Evaluation of design configurations** for PSH technologies (multiple vs. single, fixed-speed vs. variable-speed)
c) **Simulation-based testing** of PSH as part of microgrids under dynamic seasonal conditions
d) **Economic analysis** of design configurations and technologies for pumped storage hydro

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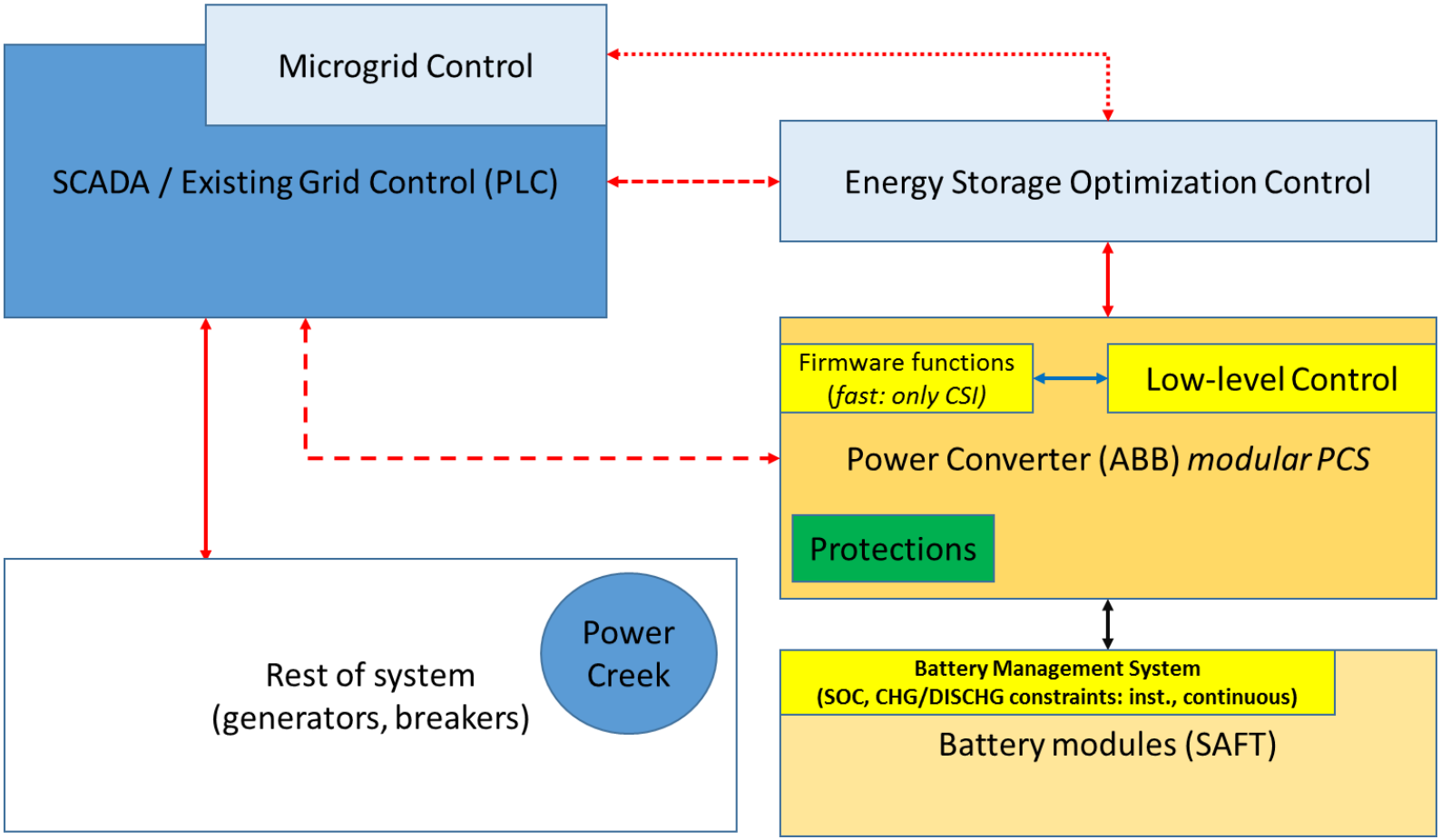
Sandia National Laboratories
ACEP Alaska Center for Energy and Power
NRECA America's Electric Cooperatives
AVEC Alaska Village Electric Cooperative

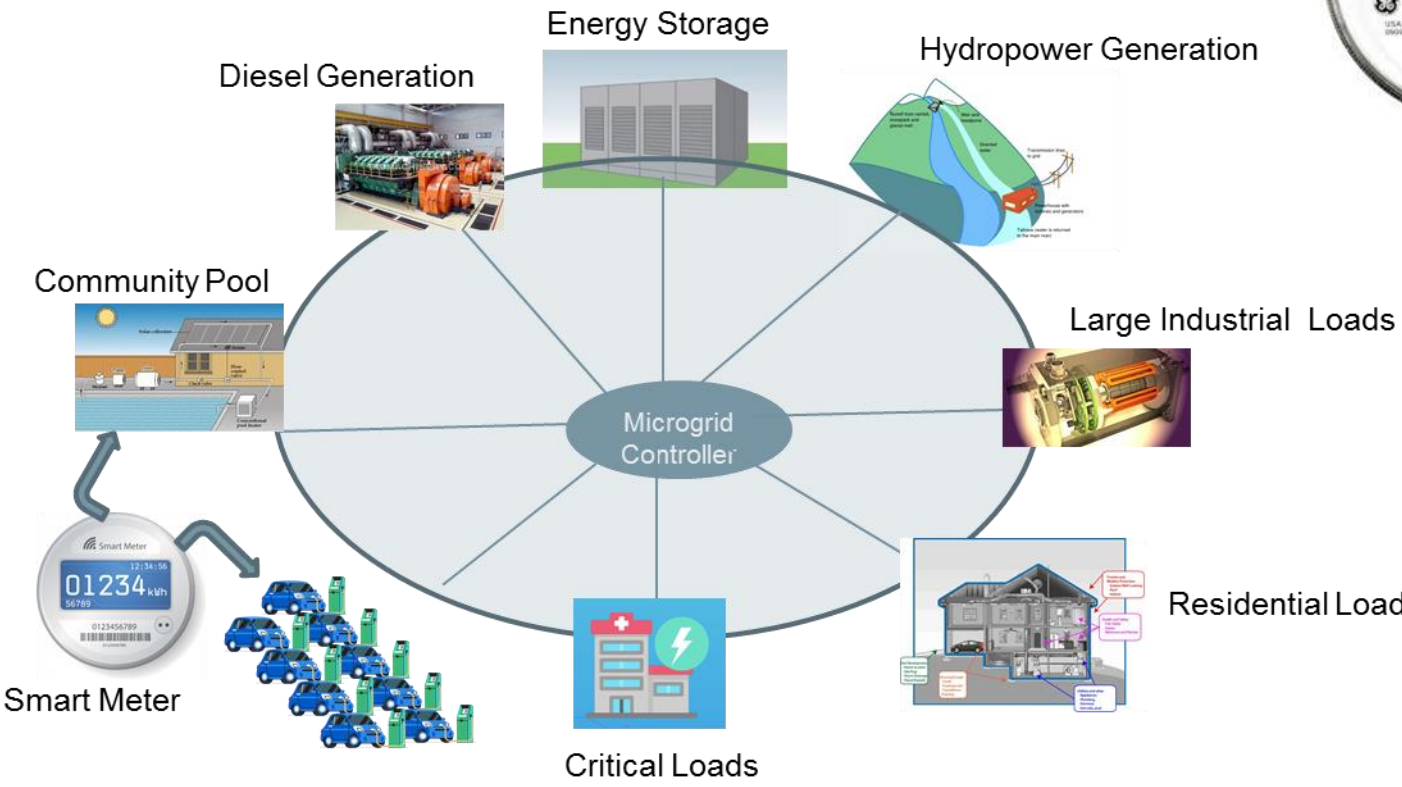
RADIANCE - Energy Storage Optimization Toolbox



RADIANCE - Integrated Advanced Metering Infrastructure

Advantages/Opportunities of Smart Meter

- Controllable EV Charging
- Reduce Hydro Spilling
- Maximizing Diesel Generation efficiency
- Optimize time of day usage



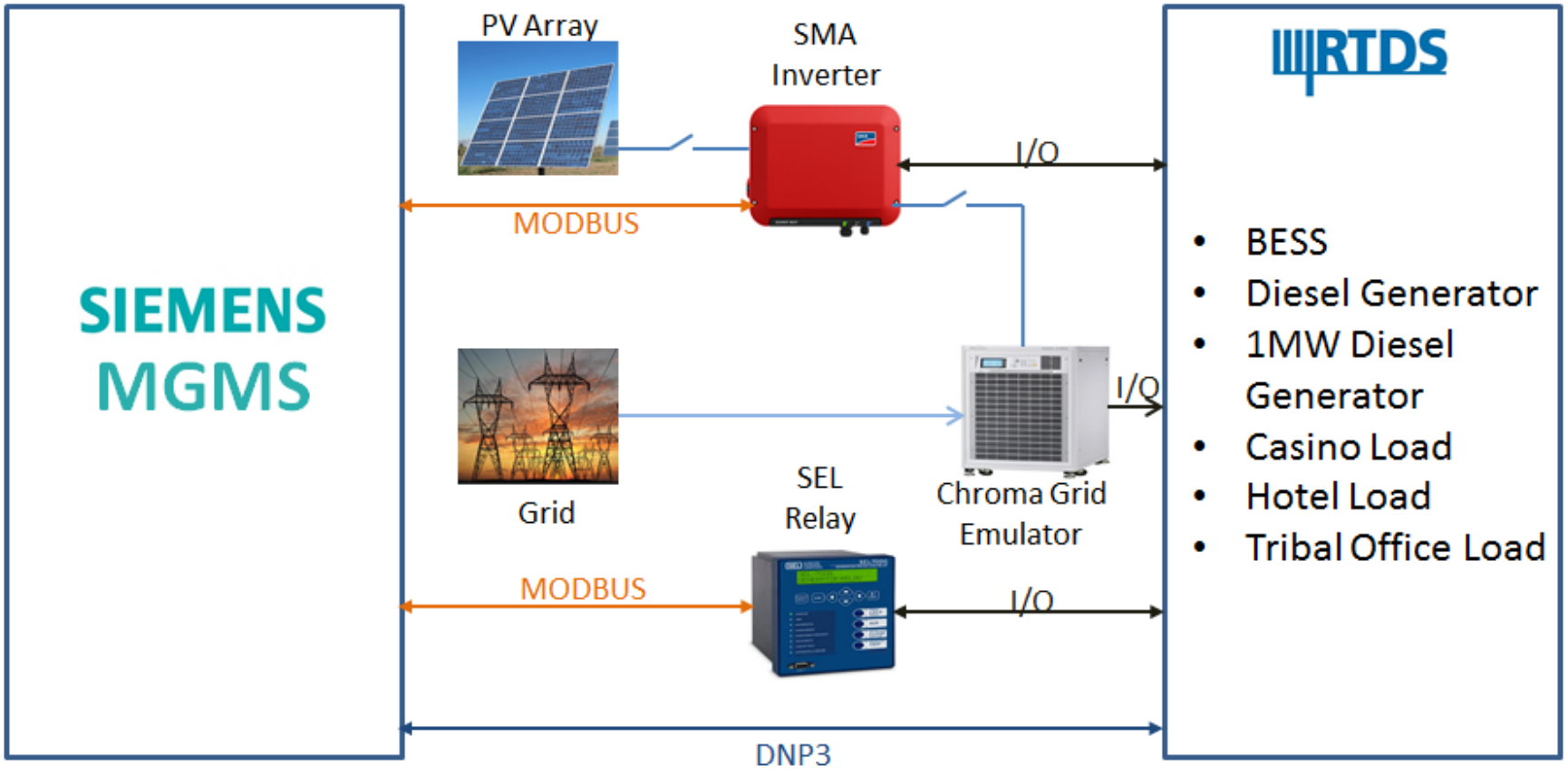
California Energy Commission's Blue Lake Rancheria Microgrid

- First digital blueprint developed and used for HIL testing at INL
- A Red Cross Evacuation Route

"2017 FEMA Whole Community Preparedness Award"

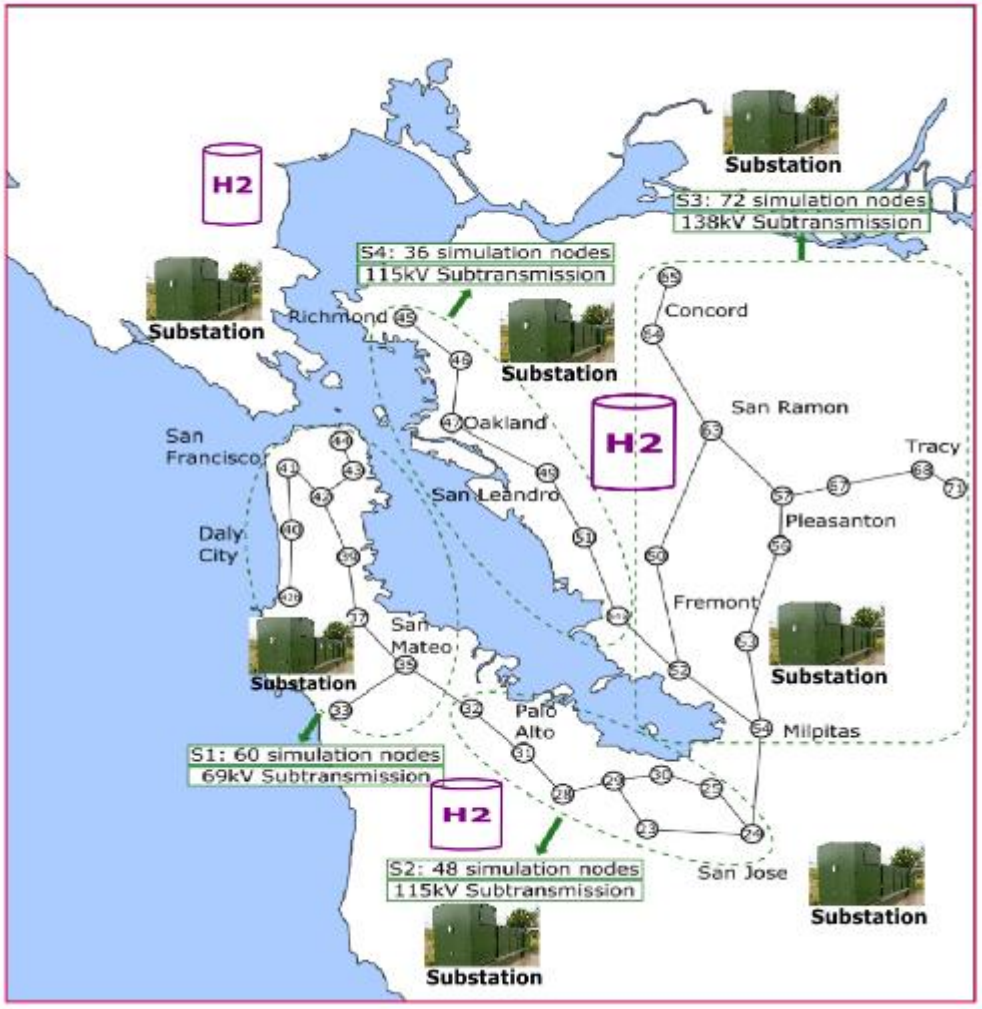
"2018 POWERGRID International and DistribuTECH Project of the Year Award"

Blue Lake Rancheria Microgrid



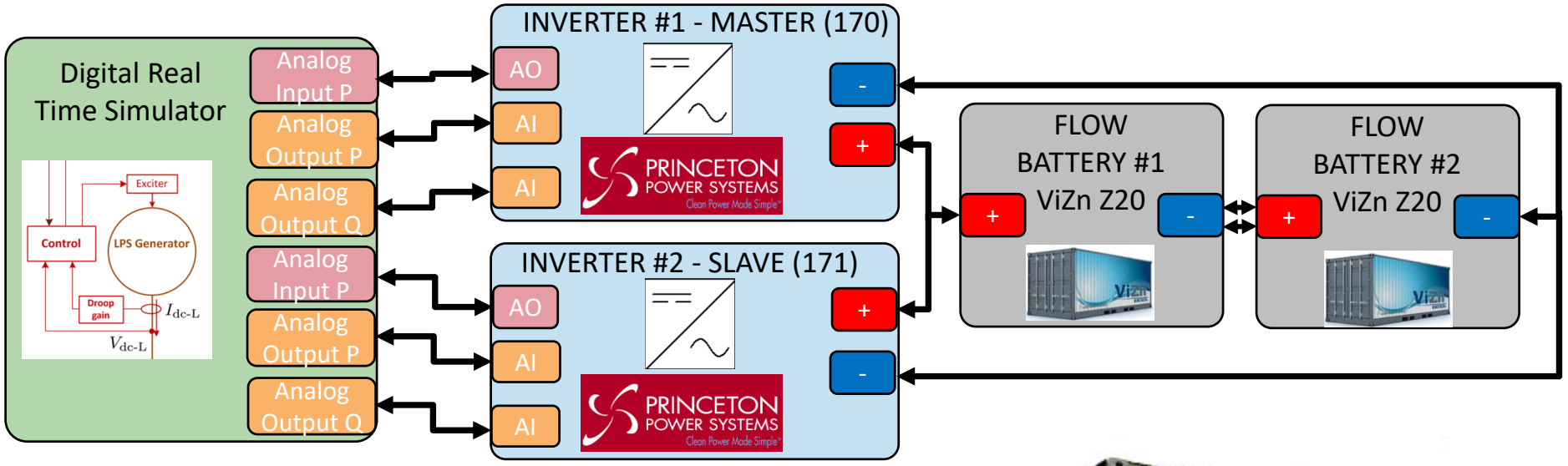
Project Report: Real-time Modeling and Testing of Microgrid Management System for the Blue Lake Rancheria-Performance Assurance Report, M Mohanpurkar, Y Luo, R Hovsapian, A Medam, Idaho National Lab. (INL), Idaho Falls, ID (United States)
https://www.osti.gov/servlets/purl/1426889

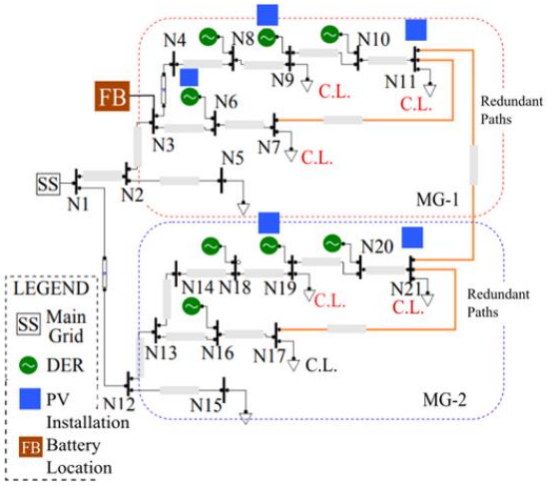
Distributed Grid Assets – H_2 Refueling Stations / Electrolyzer in California

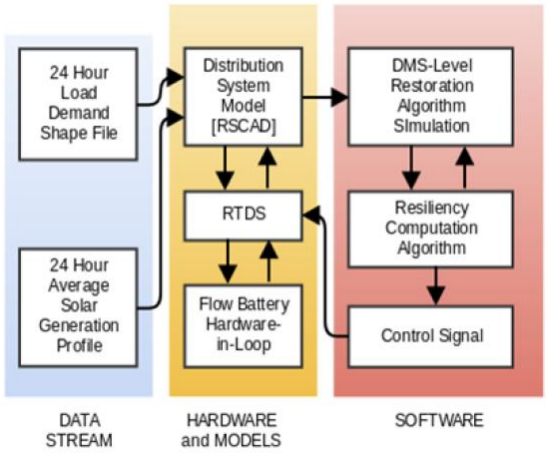


- PG&E territory stretches from Northern California to central California
- Several current and future locations of the hydrogen refueling stations are generated from earlier NREL studies
- PG&E infrastructure associated with these locations is studied
- Network synthesis and modeling in real-time simulator at INL, represents the PG&E infrastructure
- It spans major distribution and coupling transmission lines (from 69 kV to 138 kV) associated with the hydrogen refueling infrastructure
- Serves as a testbed for testing grid services and stability of connecting electrolyzers in utility systems

Digital Real Time Testing for Flow Batteries

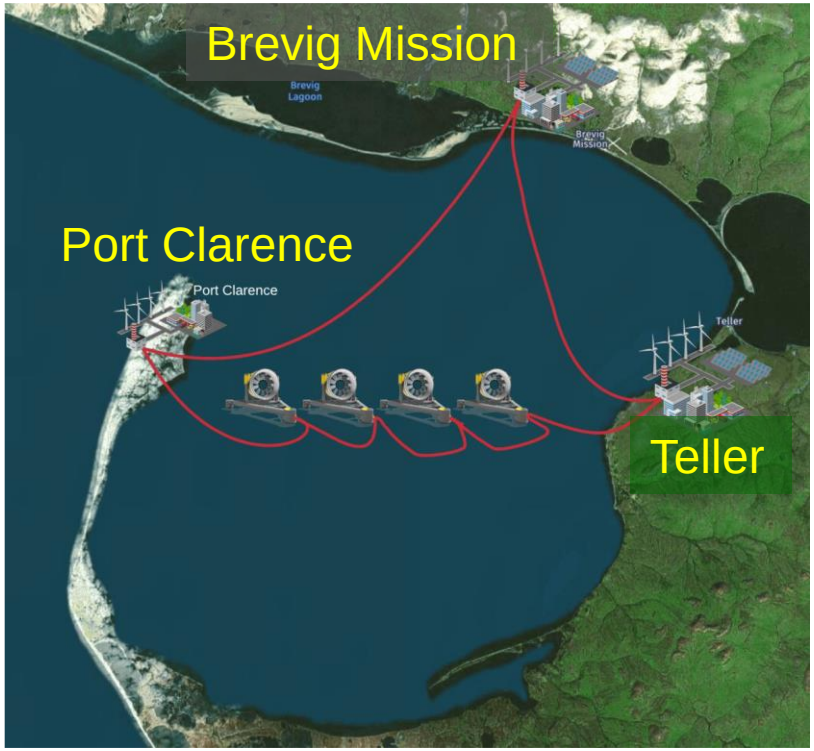


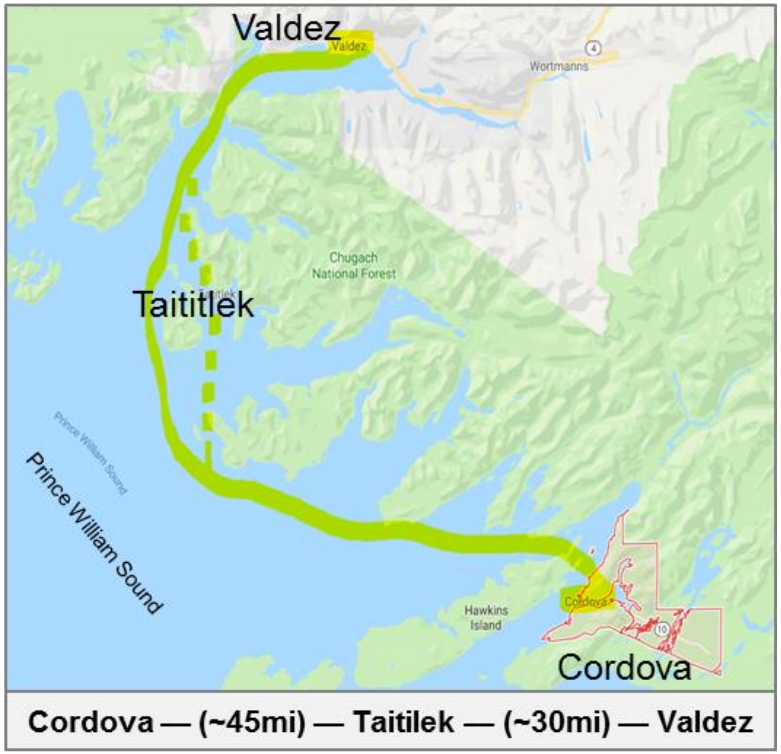




Maximum Power **64 kW**
Maximum Energy Storage Capacity **160 kWh**
Nominal Power **22 kW**

ORCA – assessment of marine hydrOkinetic-based reliable and Resilient electrifiCation in Alaska





ORCA Phase 1 – A high level schematic of assessing the feasibility of interconnecting rural grids in Western Alaska and Southeastern Alaska

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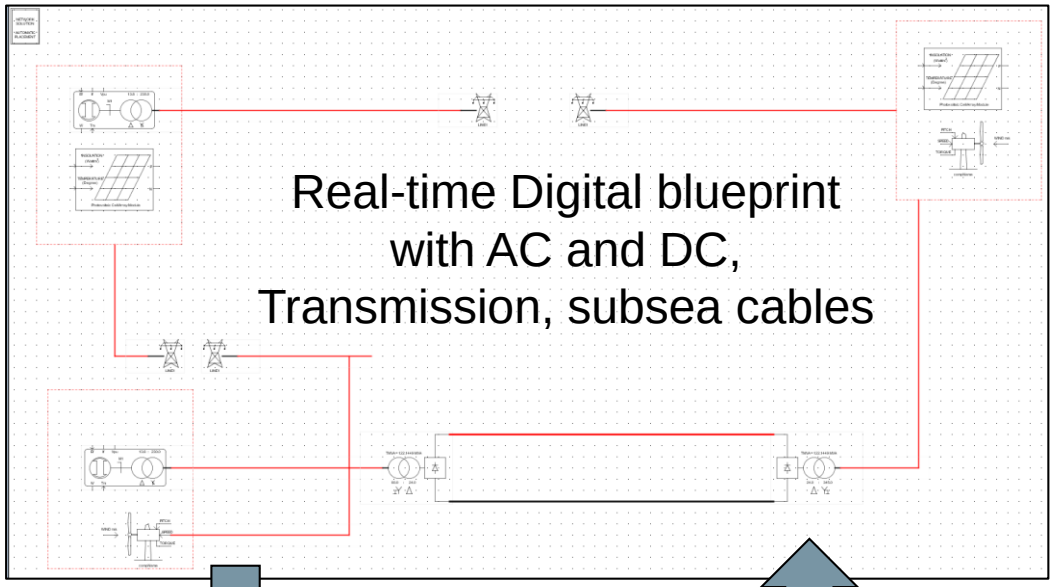
ACEP Alaska Center for Energy and Power

PRINCE WILLIAM SOUND SCIENCE CENTER

Interconnection of Remote and Isolated Microgrids

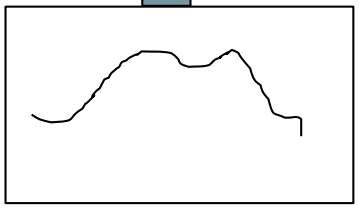
- Advanced AC and DC transmission and distribution technologies for interconnecting multiple remote and isolated microgrids

Actual power system data, profiles, topology, etc.



Field Implementation

Hardware Controller



Actual Dynamic Profiles

Thank you

Questions?

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