DATELINE: SEPTEMBER 19TH MORGANTOWN, WEST VIRGINIA

SUPERLAB 2.0 HARNESSES THE POWER OF FIVE FEDERAL LABS –

IT CREATED A "VIRTUAL POWER PLANT" SIMULATING REAL-WORLD GRID CHALLENGES AND INTEGRATED DER RESPONSES

With an international audience of researchers and industry representatives, the lead researchers of five prominent federal laboratories joined forces to present "SuperLab 2.0" – an unprecedented demonstration of both cutting-edge power generation technologies and the capacity to harness these technologies together virtually across the U.S.

The event took place on September 19th at the HyPer (Hybrid Performance) Lab facilities of the National Energy Technology Laboratory (NETL) in Morgantown, WV. The two principal hosts were Dr. David Tucker, Senior Research Scientist, HyPer Lab and Dr. Rob Hovsapian, ARIES lead scientist and principal investigator at National Renewable Energy Lab (NREL).

The purpose of SuperLab 2.0 was to demonstrate how diverse yet integrated generation assets can be fully responsive to abrupt changes in the demand for electricity in the power grid, such as when storms and fires cause black-outs or when heat-waves cause an urgent spike in the need for air-conditioning. These scenarios are not only increasing in terms of frequency, but with each passing day there is increasing demand for power, with the ever-mounting pressure for "electrification" in all sectors of the economy. And climate change is further pushing the limits of grid resilience, exacerbated by the retirement of aging fossil fuel plants.

Distributed, Dispatchable & Dynamic Energy -

Cutting-edge "Virtual Power Plant" on Display at SuperLab 2.0

All of the power generation assets that were on display during this demonstration represent some of the latest advances in clean power being developed and tested at federal labs: hydrogen-powered hybrid generation at NETL, small modular nuclear power at INL, wind and generation at NREL, along with "digital real-time simulators" integrated through NREL's ARIES platform.

To quote Dr. Hovsapian, the ARIES lead researcher and organizational leader of SuperLab 2.0:

"Innovation without implementation is merely an idea, but at-scale validation is the bridge that makes ideas a reality."

Here is a synopsis of what each of the five federal labs brought to the table for SuperLab 2.0 on September 19th:

1. **NETL – National Energy Technology Lab** – Specifically, the HyPer (Hybrid Performance) Lab at the Morgantown, WV facility. Hydrogen-powered Hybrid Power Generation System which is capable of load-following and is fully dispatchable (by a utility operator). In this test-run, it operated at 30 megawatts (MW)– 15MW of turbine power and 15MW from a pressurized Solid Oxide Fuel Cell (SOFC), all of which was simulated by cyber-physical means. In addition, the tightly coupled hybrid involved a 30 MW Solid Oxide Electrolyzer with 800 kg/hour Green Hydrogen production (with capacity for electrolysis provided by the renewables at NREL).

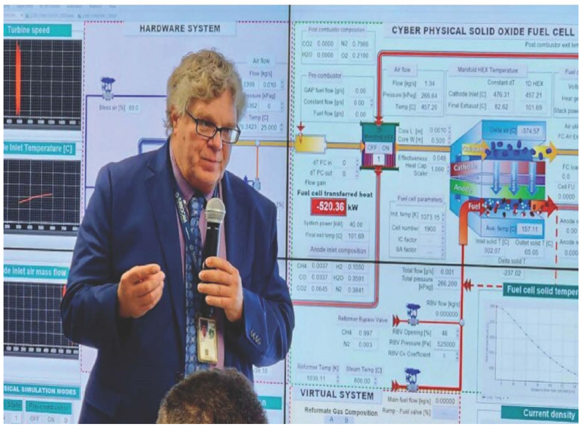
   The Hydrogen-powered Hybrid Generation System (dubbed "H2PWR Microgrid") deftly demonstrated stunning capability in both "in-load" step-up and ramp-down rates, as tabulated below:

   Step-up in Load:

Gas Turbine (modified):	+11 MG in 100ms (.01 second)
SOFC (Fuel Cell):	+13 MW in 30 seconds or 26 MW/s ramp
SOEC (Electrolyzer):	- 28 MW in 20 s or 84 MW/s ramp

Ramp-down in Load:

Gas Turbine:	- 11 MW in 30 s or 22 MW/s ramp
SOFC:	+ 13 MW in 30 s or 26 MW/s ramp
SOEC:	+ 28 MW in 20 s or 84 MW/s ramp



NETL hosted the SuperLab 2.0 event on September 19th. Above, Dr. David Tucker.

All photos shown courtesy of NETL. Photo credit: Tim Ford

2. **INL – Idaho National Lab – Small Modular Nuclear Reactor** – INL was producing about 200MW (during the demonstration). The INL facility also used thermal energy from the reactor to produce about 20kg/hour of hydrogen with their Solid Oxide Electrolyzer, using about 1MW of energy in the process (during the 1 ½ hour demonstration).

3. **NREL (National Renewable Energy Lab) – engaging the Lab's ARIES platform.** NREL produced 61 MW of wind power and 20 MW of "Low-Temperature Electrolysis" (LTE), coupled with 79 MW of PV Solar and 50MWh of BESS (battery energy storage system). In addition to its variable load bank, NREL's platform performed the co-simulation of severe grid variations: first, a 125 MW step increase in loads and followed by a 125 MW step decrease in load demand.

4. **SANDIA NATIONAL LABS –** Sandia provided a microgrid simulator with approximately 30 MW of power generation and BESS (Battery Storage) capable of charging/discharging at a rate of 20 MW/hr.

5. **LAWRENCE BERKELEY LAB –** Home of the ESnet platform. The Lab also provided building load, storage and curtailment. The building load used in the simulation was about 30 MW of demand. There was also a nominal amount of PV Solar (about 8 MW) and about 4 MW-h of BESS.

This SuperLab 2.0 demonstrated "(the) integrated use of diverse generation assets in a controlled experiment...(which) allows us to better understand how these systems can mutually support a varying energy demand before major investments are decided," stated Shannon Bragg-Sitton of INL.

Harnessing the Power of Five Federal Labs: The Role of ESnet (an immensely powerful DOE platform)

Again, as an introduction, each technology represented at each of the five labs was introduced by a representative from that facility; a brief overview of each lab's capability was given.

Then the participating federal labs were interconnected virtually, and a simulation of real grid conditions began; this was made possible through the technological harness and integrator called the ESnet – the Energy Sciences Network.

ESnet is described as a DOE "National Platform for Science Discovery." This is how ESNET is presented on-line:

> "The Energy Sciences Network (ESnet) is a high-performance, unclassified national network built to support scientific research. Funded by the US Department of Energy's Office of Science (SC) and managed by Lawrence Berkeley National Lab, ESnet provides services to more than 50 DOE research sites, including the entire National Laboratory system, its supercomputing facilities and its major scientific instruments. ESnet also peers with more than 270 research and commercial networks, permitting DOE-funded scientists to productively collaborate with partners around the world."
>
> The speed of communication and processing is immense: ESnet can move data at an incredible speed of 100 gigabits per second. To put that into perspective, this speed is about 15,000 times as fast as typical home internet speeds."

NETL's host at the SuperLab 2.0 event, Dr. Tucker, stated that the labs communicated seamlessly at speeds roughly 8 to 25 milliseconds.

ESnet – Gathering Strength and Capacity for Decades

As background, ESnet has been evolving as a research tool and platform for the past 40 years. It has only been within the past decade that it has reached the maturity whereby it had the capacity to “orchestrate” the SuperLab’s combination grid simulation and “virtual power plant” project. As a matter of fact, the first successful SuperLab 2.0 was just conducted last year. (An earlier attempt was made in 2017, in pre-COVID times, but “varying latency” made it impossible to “co-simulate power signals requiring milli-second sensitivity.”)

According to Connor O’Neil, Renewable Energy Integration, NREL, the first truly successful attempt at this “merging” of several federal lab’s generation capabilities was hosted in the West in early 2023, when two labs participated: INL (Idaho National Lab) of Idaho Falls, Idaho and NREL (National Renewable Energy Lab) of Golden, Colorado. The addition of NETL and the Hydrogen Hybrid Microgrid made it possible to add dispatchable and true dynamic load-following capabilities to the mix of generation assets.

SuperLab 2.0 – The Latest Generation of Grid Simulation

Three grid simulation scenarios were demonstrated; one was largely based upon the real-world grid experiences of EPCOT (Texas) during the disastrous winter storm which caused wide-spread power failures. In all cases, the focus of the demonstration focused upon vital DISPATCHABILITY and LOAD-FOLLOWING capabilities that have been integrated into the power generating technologies, NREL grid simulation capabilities and the ESnet communications protocols.

The SuperLab 2.0 event convincingly simulated power swings – severe loss of power in events such as cascading failures and hefty surges typical during severe heat and cold. The shifting loads were simulated at the NREL facility; the power generation systems were able to be either quickly dispatched or “ramped down” – effectively “following the load.” This capacity can make the difference between grid failure (either brown-outs and black-outs) and shifting power production quickly, maintaining critical loads. Currently, large centralized power plants – such as nuclear plants -- are not capable of load-following; they operate best at a “steady state.”

And, just as importantly, most renewables (such as wind and PV solar and, for that matter, single-site microgrids) – when installed on the “consumer-side” or “behind-the-meter” – are non-dispatchable assets: meaning simply that the utility has no control of when the power is on-line or not.

SPOTLIGHT ON HYDROGEN MICROGRID POWER AT NETL’S HYPER LAB IN MORGANTOWN WV

For the purpose of the SuperLab 2.0 demo, the H2PWR provided 30 megawatts of power When a black-out scenario was simulated, it was HHM’s job to produce power to critical loads of 6 megawatts, acting as a stand-alone power supply (microgrid) and not simply shutting down. As outlined briefly above, the time taken to achieve this "step down" in power output was a mere **30 seconds** for both the SOFC and the modified NG turbine.

When the power was to be restored to its optimal 30 megawatts, on the "step up" process, the modified gas turbine went from 4MW to 15MW within roughly **0.1 seconds.** The SOFC ramped up **from 2 MWs to 15 MWs in 30 seconds.** This was achieved with the pre-arranged LOAD-SIMULATION signals sent over the ESnet platform by load simulators at NREL.

It is important to note that these results were achieved with cyber-physical test-bed methods, enhanced by the super-fast data transmission speeds of the ESnet. Further work is being undertaken to forecast what speeds will be attainable practically in a fully functional physical prototype.

Even more ambitious plans are being discussed for the next SuperLab – where organizers plan to integrate and synchronize additional "devices" in one demonstration. No further details on those plans are available at this time.

About RPW

Resilient Power Works, LLC (RPW) has ten-years of involvement with the design and more recently the commercialization of microgrids, specifically the Hydrogen Hybrid Microgrid ("H2PWR Microgrids") developed in collaboration with the National Energy Technology Lab (NETL). RPW is focusing specifically on microgrids which are dispatchable DERs and are deployed on the "utility-side of the meter." RPW has been in the vanguard of further designing the hybrid system for utility-scale applications and taking into account key factors of the US Department of Energy (DOE) Adoption Readiness Level (ARL) matrix, including the issues of scalability, relative ease of operation and various workforce training requirements.

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