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Q: Could you please explain what microgrid control system you presently use?

A: We use a custom SCADA for specific testing. This system can handle either full dispatch of all resources, or can dispatch those resources classically not controlled, i.e., loads, and raw wind and solar power. With the latter configuration, typically fully controllable units, i.e., energy storage and diesel, can be controlled via any other control system.

The power system controller available in the lab that is setup like a typical islanded microgrid is an ABB M+ architecture with MGC controllers for diesel, energy storage, wind power, solar power, and feeder control.

Our data acquisition system utilizes mainly Shark 100 B/T meters on a Modbus protocol with poll rates between 3 to 5 Samples/s. Secondary data is retrieved from local control units, e.g., EasyGen 3100 for diesel, inverter and battery management PLCs. Analog/digital hardwire signals can be fed into the controls via ADAM I/O to Modbus converters.

As to control paradigms, we have had excellent results utilizing various droop schemes for interaction of diesel and energy storage systems, but isochronous setups can also be utilized. The PV inverter generally operates as a current source and thus latches onto the current grid frequency. The wind turbine emulator, an induction generator, operates with a slight slip to export power (note that some frequency oscillations can upset this system and cause issues with power sharing).

Q: In your experiences what are some of the most important technical barriers around microgrid controls?

A: There is quite a large diversity in terms of the kinds of systems that are in the field in Alaska. It's not a cookie-cutter setup where you have the same manufacturer / model / size everywhere. And different grids will, of course, have differences in the characteristics of the loads they serve, the degree to which heat recovery systems are incorporated, the attributes of the distribution systems to which they are connected, etc. So being able to develop systems that will accommodate a range of different kinds of hardware combinations and operating conditions is a challenge. And, as is the case with any microgrid connected to renewable energy sources – whether in Alaska, or elsewhere - variability in the renewable resource (e.g., changes in wind speed / direction, shadow movement over solar arrays, surges and lapses in water flow rates) can be a significant requirement for microgrid controllers. Diesel gensets tend to have a power setting range where they operate at their best efficiency, operating them outside that results in less than optimal usage of the diesel fuel and can sometimes accelerate wear on the system. This establishes another requirement for the microgrid controller– finding a way to operate the genset(s) close to their peak operating efficiency, in the context of a system with variable renewable energy generation, varying loads, possibly with some storage capacity. And, these are small, semi-fragile grids. There are also issues with respect to communication - many of these systems have limited connectivity to the outside world (intermittent availability, bandwidth limitations, etc.). It can be difficult to monitor systems from an off-site location, so the control system needs to operate in a robust, semi-autonomous capability. This also impacts the options available for remote trouble-shooting and operator support.

There are many aspects of control systems that could be improved. To name a few issues, some particular to remote regions:
1) Accurate state estimates: most control systems for remote islanded microgrids work with predefined states to determine dispatch. This requires tuning during commissioning, as components often do not perform quite as promised by the spec sheet.
2) 'Forecasting': in remote islanded grids forecasting of demand, and production is quite difficult. Unlike in large grids, where the number of users allows for averaging approaches to work well, and changes, relative to demand and variable production are slow, this is not the case in small systems where single loads can be large relative to the total load, and renewable power penetration is quite high. In addition, due to remoteness and sparsity of data, weather forecasting often inaccurate and unreliable.
3) Distributed resources and grid balancing: distributed generation and demand response are highly viable options to increase renewable penetration and achieve higher efficiency in an islanded microgrid. However, distributed resources need to be carefully controlled to meet competing objectives - maximum utilization of RE power, least cost operation, equitable distribution of power to controlled loads, and, importantly, phase balancing of the grid. The latter objective has two primary functions: a) ensure grid stability; b) improve efficiency, as phase imbalances cause efficiency losses both on the diesel generation side, and the distribution side.
Many approaches to solve these and other issues may prove viable. However, developers should consider such that can operate on robust hardware and are light weight regarding their 'outside' data requirements. Reconciling capabilities of robust local hardware with computing requirements for advanced control algorithms, e.g., artificial intelligence, agent-based systems, neural network and other optimization approaches, is a major challenge and increasing performance and robustness of local hardware provides additional room for development. On the other hand, one could dispense with much of the computing hardware requirement if either a reliable broadband connection is available, or if the control system can get by with 'shipping' minimal amounts of data to the cloud to re-compute system settings. Here, there is room, for innovative data compression, developing composite data points that provide the necessary information to the control algorithms to make good decisions, and for advanced broadband communications solutions.

Q: What software is used for modeling of energy storage?

A: A variety of software packages that have been used historically. In terms of sizing and configuration analysis, HOMER is one of those. MATLAB/Simulink has also been used.

We also work with several national laboratories and academic institutions that have developed particular systems to model specific energy storage systems. Often, model selection depends on the specific question that is to be answered. For example, chemical degradation considerations for lithium-type batteries require a model of the specific cell chemistry. Sizing the same battery requires a grid energy balance model. However, often such models can be stacked such that degradation under the expected cycling regime can be assessed.

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Q: How many applications do you expect?

A: We do not know with certainty, but we do expect between 15 and 35 applications at this point.

Q: What sensor data does the lab have available? Battery banks, wind simulation, etc. Can I get a list of the connected devices with names and units?

A: The Lab collects sensor data from the Diesel Generator, Wind Turbine Emulator, DC Battery, the Inverter, the PV Emulator and the two load banks.

Q: What protocols are they using for pulling in data from devices? Modbus, etc.

A: For SCADA purposes, it is almost exclusively Modbus TCP. Other protocols are converted, e.g., diesel generator CAN to Modbus TCP. Visualization is broadcast using UDP. Necessary UDP filters are installed to avoid issues with some devices on message overload. A GPS time server is available with NTP/SNTP protocols.

Q: Can they provide some graph or visual of how their platform is connected? I'm looking for something that would show what software they are using from receiving sensor data to the SCADA control interface.

A: We built our own software from a Modbus TCP API (FieldTalk Libraries) and use Qt for the visualization and display.

Q: What are the current control capabilities?

A: Because we built the software ourselves, we are not really constrained to certain control hard limits, what limits us on the SCADA are either the hardware capabilities or the lower level controls. Aside our SCADA, we also control the Wind Turbine Simulator as well as the PV Simulator through third-party software. For more information on our hardware/software capabilities feel free to browse our brochure: http://acep.uaf.edu/media/174758/ACEP-PSI-2016-04-26-A-2-web.pdf

Q: Can you provide a table of connected devices? Maybe a sample NetCDF file?

A: A list of the (presently) connected devices is provided below. We do not anticipate that a NetCDF file is required for the purpose of the application, and will defer on making it available.

- Diesel Generator (Sensor)
- Diesel Generator's Esegen/EasyGen 3100
- Wind Turbine Simulator (Sensor)
- Wind Turbine Simulator Controller
- DC Battery (through the battery management system, on ABB AC500 PLC)
- Inverter - ABB PCS100 (on ABB AC800 PLC)

- Inverter Auxiliary Power (Sensor)
- PV Simulator (Sensor)
- PV Simulator Controller
- PV Inverter
- Load Bank 1 (Sensor)
- Load Bank 1 Controller
- Load Bank 2 (Sensor)
- Bus (Sensor)
- Several motorized breakers (Diesel, Energy storage, Load Bank 1)

Q: Can you simulate the wind speed and offset angle? Can you simulate a solar altitude and azimuth?

A: We have the option to either simulate output power levels (kW) or load a wind turbine profile such as a NorthWind 100, and the wind speed (m/s). To simulate the solar power availability, we use the Irradiance (W/m^2) and Temperature (°C). We can specify wind speed and solar irradiance based on field-recorded data.