INL/CON-24-76797-Revision-0

Designing Hybrid Systems to Optimize Resilience

February 2024

Changing the World's Energy Future

Megan Jordan Culler

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On Site Wind for Rural Load Centers

Applications for hybrid systems

- Case studies
- Opportunities

Justifying the cost of hybrid systems

- Valuation framework

Using renewable resources to enhance resilience

- Resilience framework

Tools to design hybrid systems

- Resilience application
- Hybrid Optimization and Performance Platform (HOPP)

Funding opportunities

- Opportunities and technical assistance

Residential

Industrial

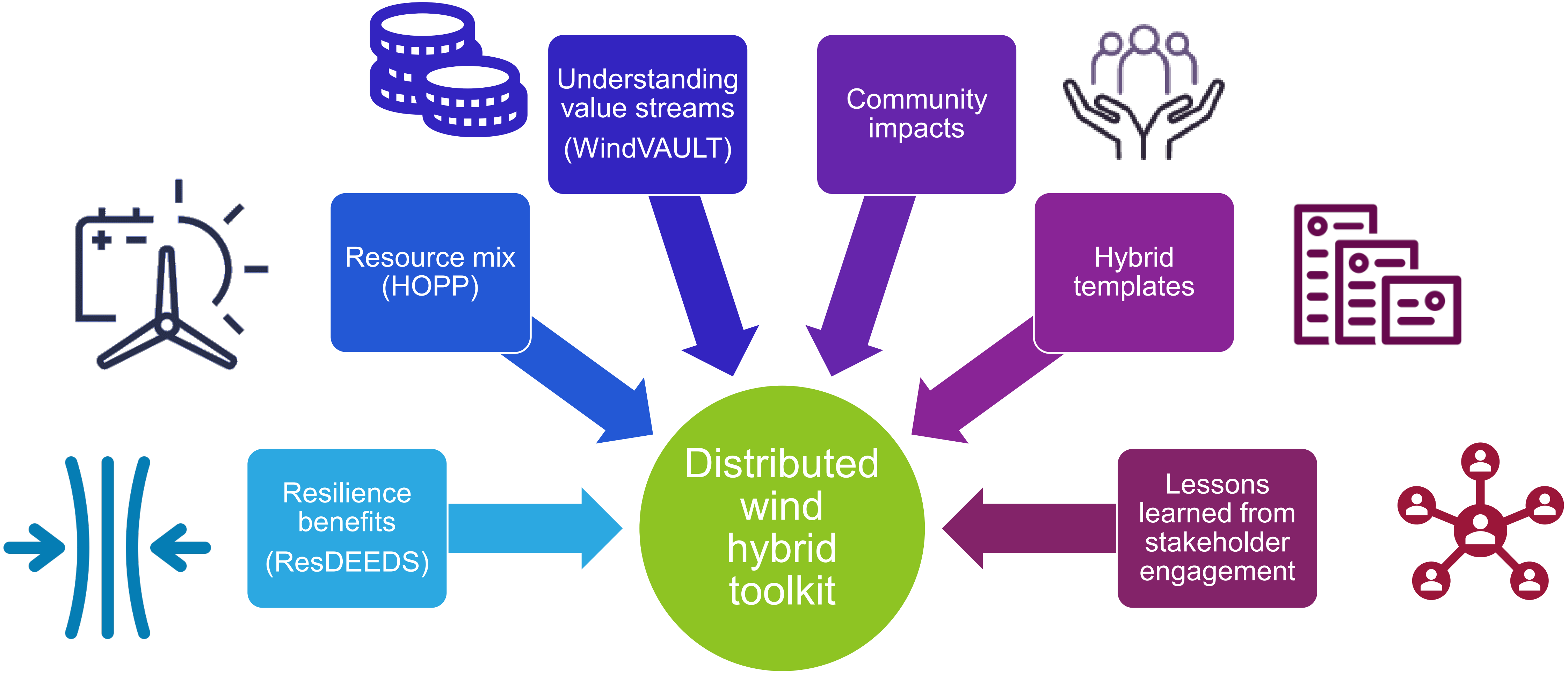
Commercial

Agricultural

Funded by the Wind Energy Technologies Office

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Distributed Wind Hybrid Toolkit



LREC Example: Hybrid generation mixes

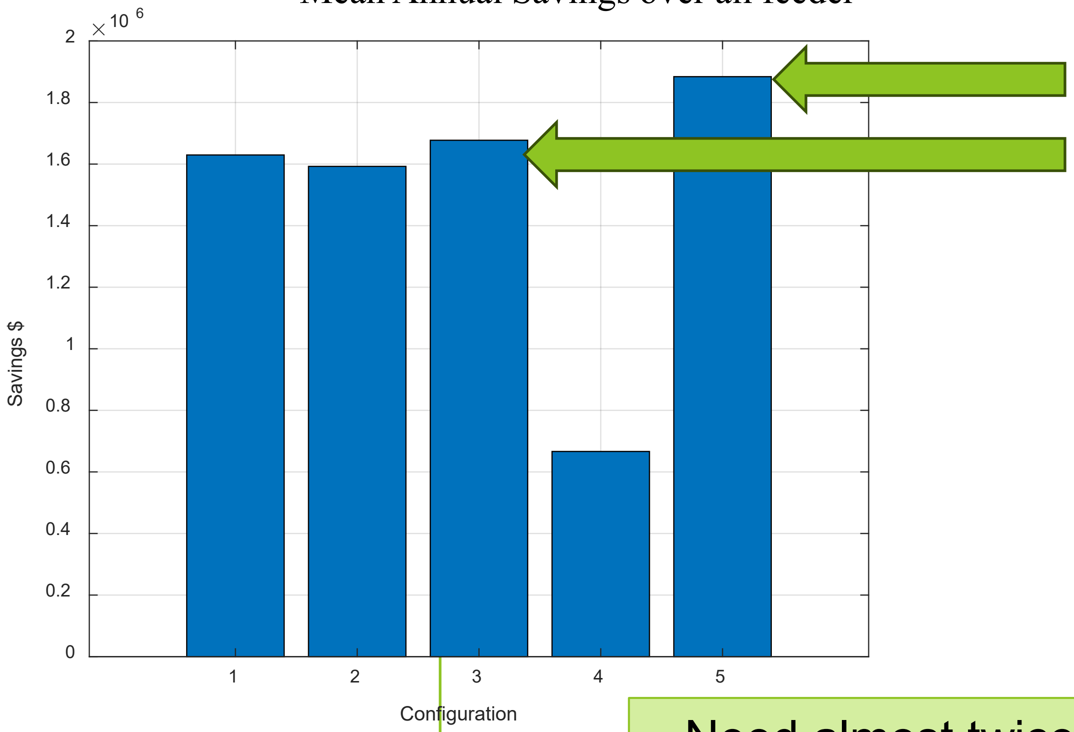
- Original system:
  - Wind: 2.0 MW
  - PV: 500.0 kW
  - Interconnection: 2.0 MW
  - Hybrid Capacity Factor: 32.4 %
  - Percentage of total demand: 1.8%

https://www.cooperative.com/programs-services/bts/radwind/Documents/RADWIND-Case-Study-Lake-Region-May-2021.pdf

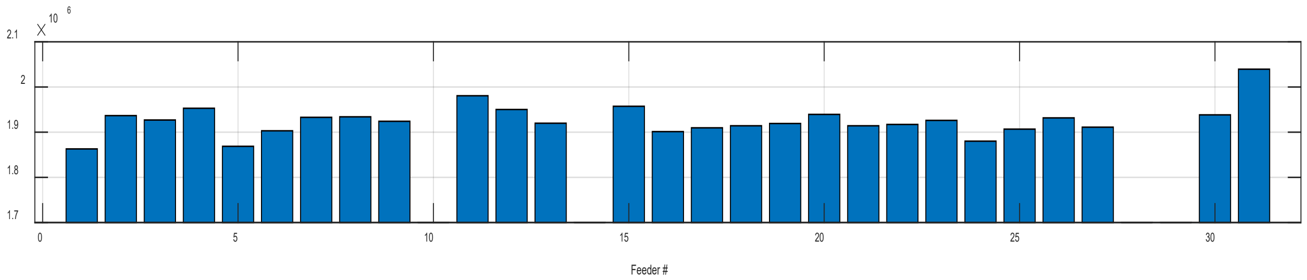
LREC Example: Savings analysis for different configurations and feeders – without storage

	Case summary	Case description
1	Balanced	11.5 MW wind, 3.0 MW solar, 0 MWh battery
2	Balanced	11.5 MW wind, 3.0 MW solar, 0 MWh battery
3	Wind only	13.8 MW wind, 3.0 MW solar, 0 MWh battery
4	Cost Prioritized	4.6 MW wind, 1.0 MW solar, 0 MWh battery
5	PV only	0 MW wind, 25 MW solar, 0 MWh battery

Mean Annual Savings over all feeder



Annual Savings per feeder



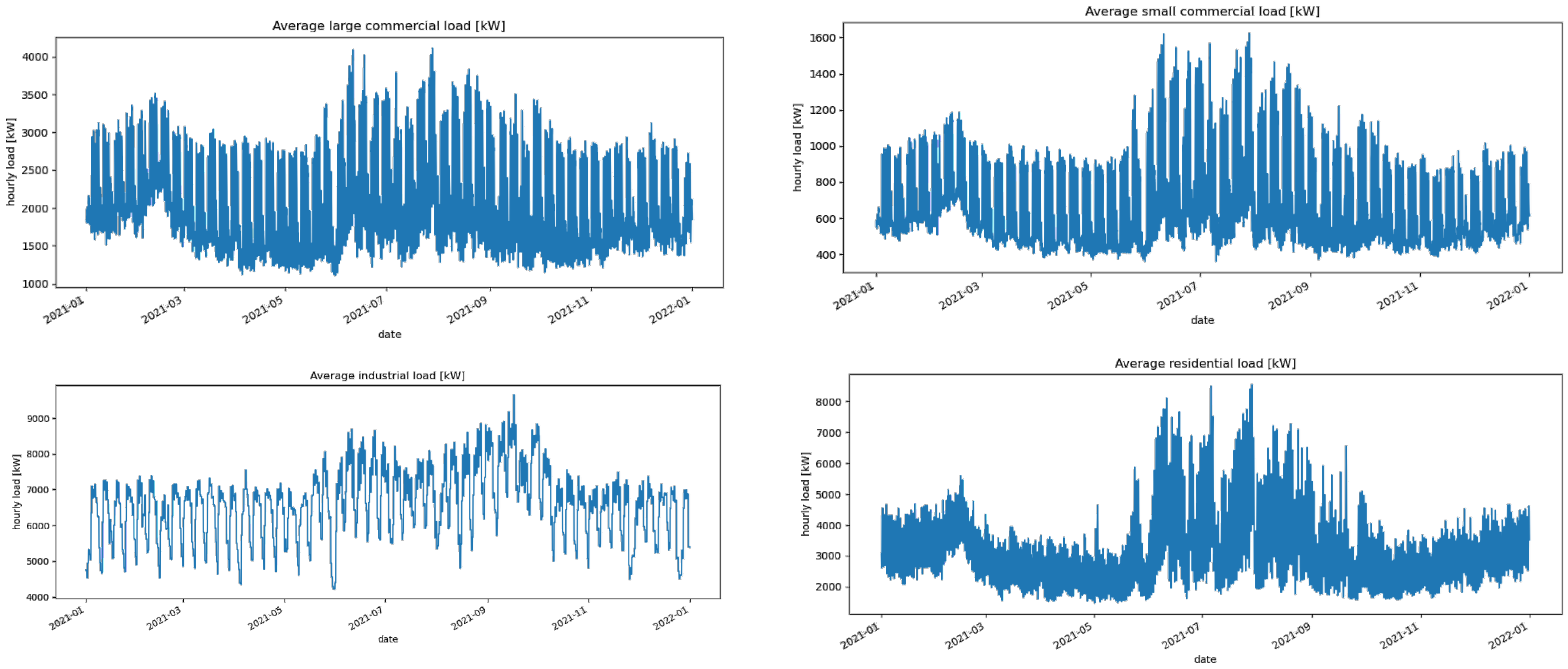
Need almost twice the total system capacity to get the same savings

Resilience through hybrid power systems

- Suit the needs of my community.
- Balance cost AND benefits.
- Economically viable and operationally practical.
- Create a level of self-sustenance.
- Drive system development by local interests.
  - Know the historic events
  - Know the customer needs and flexibilities
  - Know the neighboring communities and mutual aid networks
  - Know the system strengths and weaknesses

Think about the needs, resources, and social capital of your community.

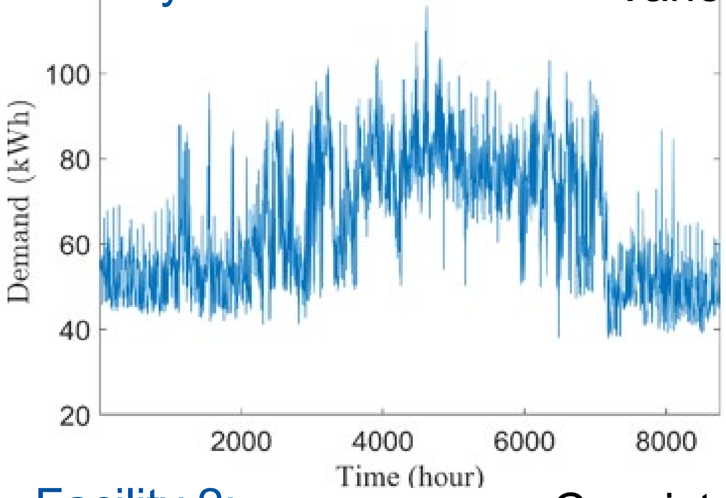
Load Profiles Analysis

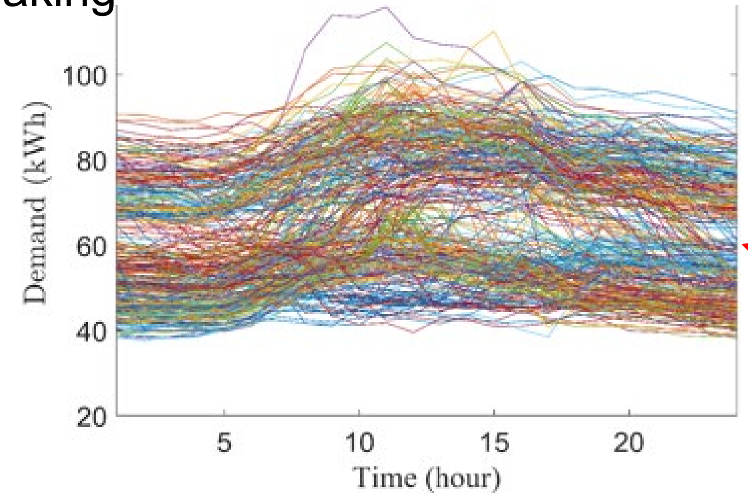


Healthcare facilities (same town)

Facility 1:

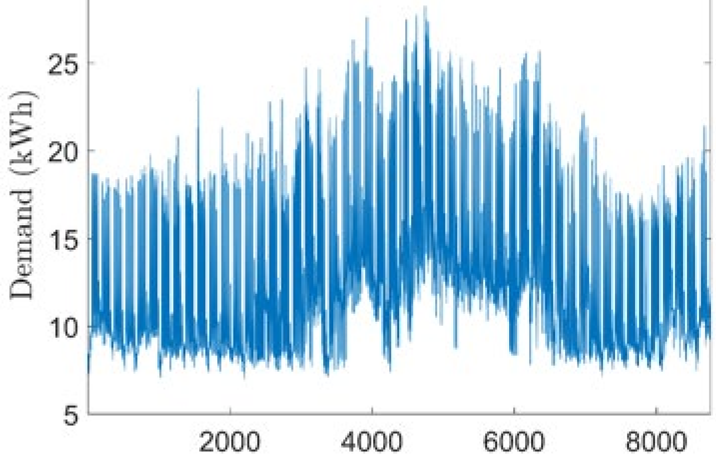
Varied peaking

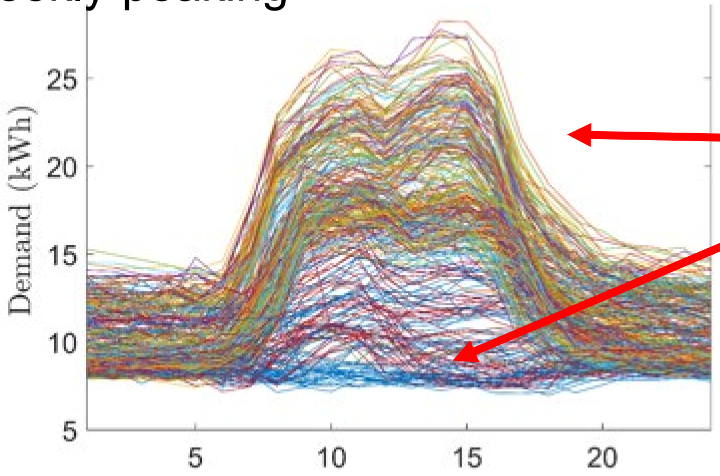




Facility 2:

Consistent weekly peaking





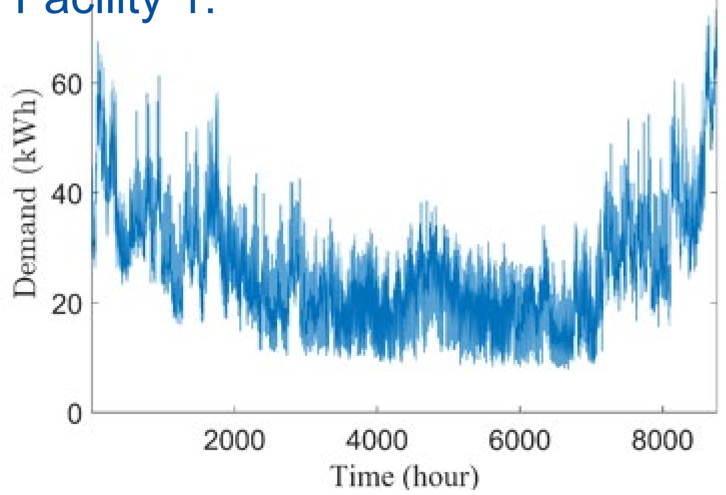
Variance in bed count, heating/cooling method, building efficiency, and type of services.

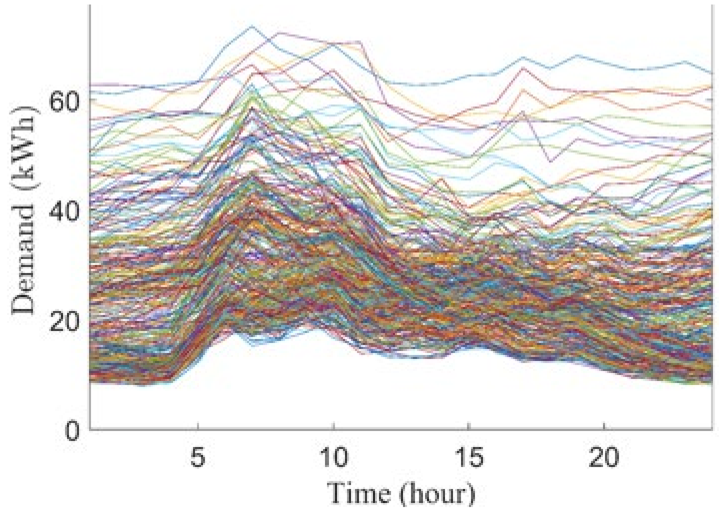
More random peaking,
but relatively constant window.
Notice gap in mid-range power.

High relative daily peaks,
But not all days have peaking.

Living-care facility (same town)

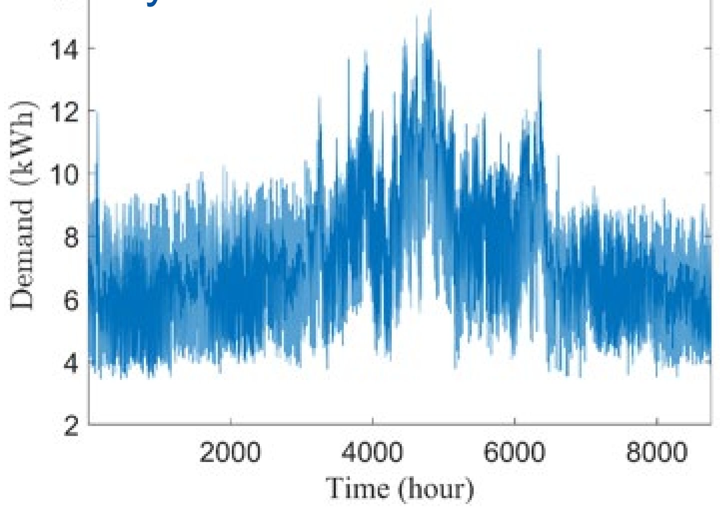
Facility 1:

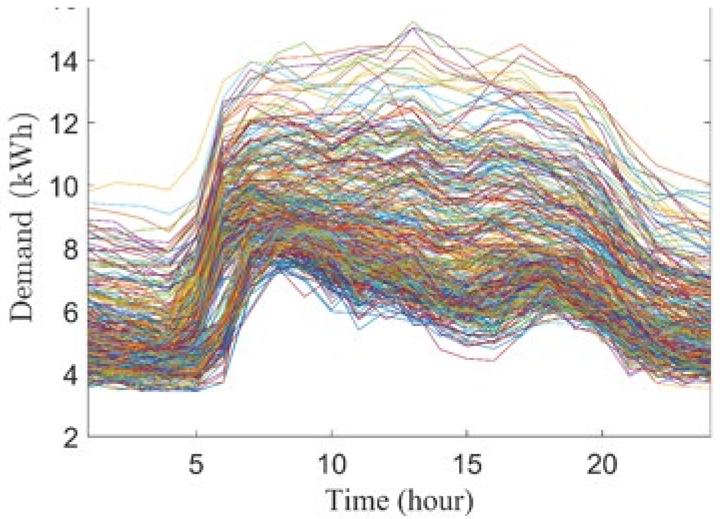




Larger seasonal winter demand

Facility 2:





Larger seasonal summer demand

Community interests

Communities have varied & unique interests.
Resilience is created by serving all of those.

- What is fiscally feasible?
- What is politically easy?
- What is technically achievable?
- Ownership benefits are rate dependent.
  - Commercial owners?
  - Residential owners?
  - Utility owners?
- Beyond conventional use
  - disaster response plans for critical loads

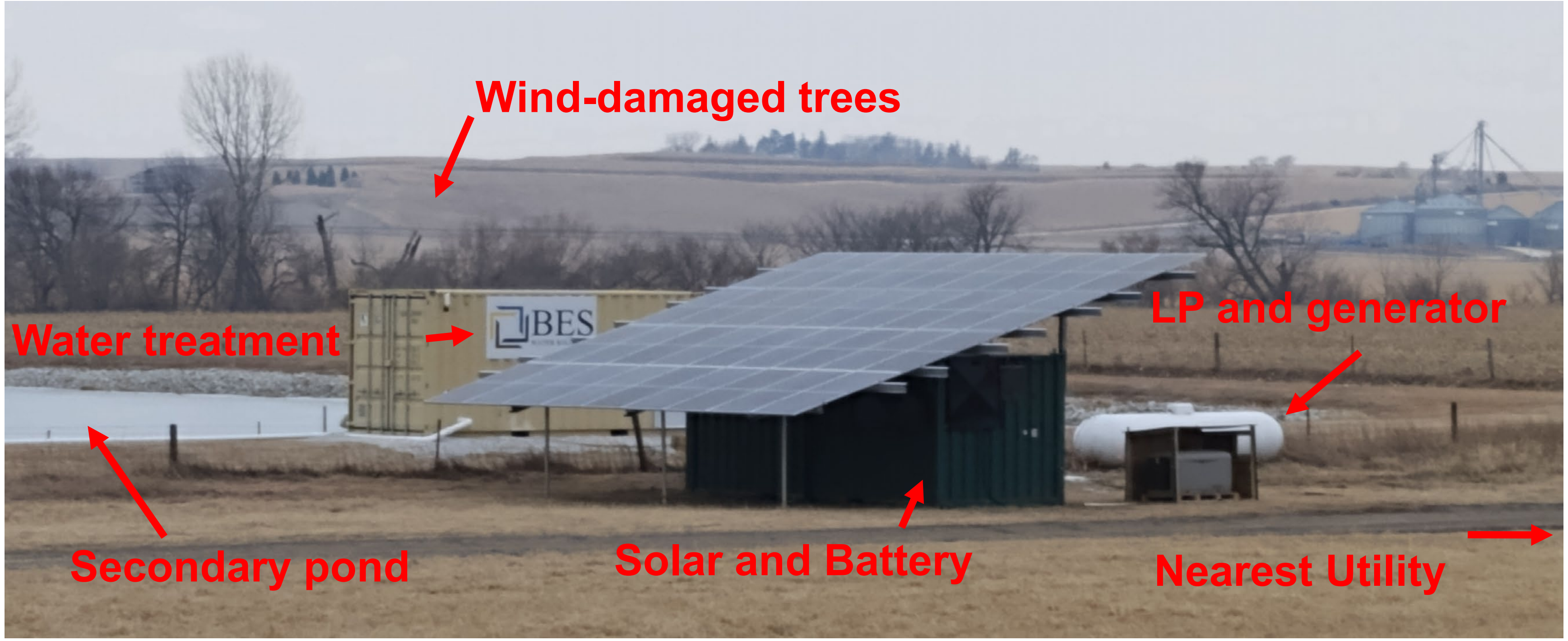
Business operations

Hybrids can provide cost-effective process solutions.
Local energy storage can avoid critical shutdowns.
Modular and mobile units for remote interim power.

- Habits may change to match available resources.
  - Machines paired with a rich natural resource.
  - Processes located to capture onsite energy.
- Markets may shift with evolution of energy systems.
  - Forecasting is as important as historical views.

It is important to have a mix of resources. Each type has a role.
The amount of generation needed to match load is finite and may have numerous contributors.
Each rate class may experience benefit differently – What ownership model brings the most community benefit?
Use the natural resource as it is available. Cache energy in storage mechanisms to fill gaps in natural resource.

SunCrate Mobile Microgrid powering BES Water Solutions' wastewater treatment



Constant pumping and aeration to stimulate biologic activity; 3-5 kW. Improve rural water quality.

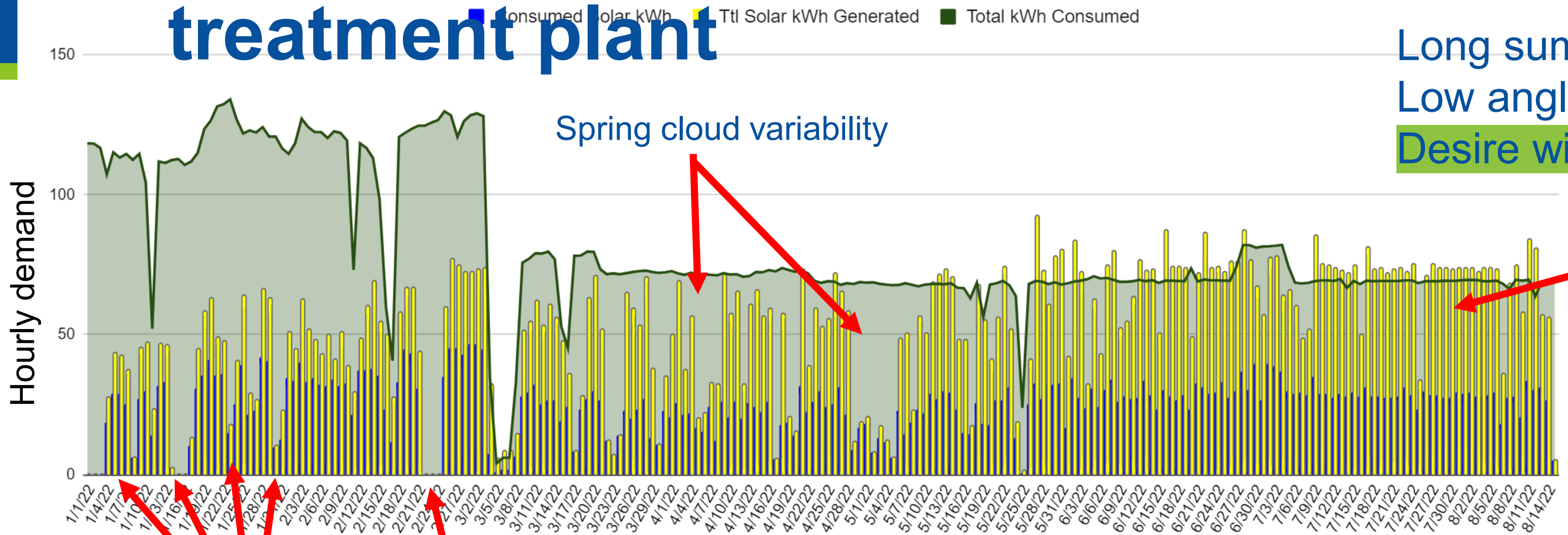
Serve load and be available for relocation with 10-hour+ at 7.5 kW.

Led to second design:
PowerPallet –
Battery+converters, 12 kW, 90 kWh

Battery served 50-60% of the time.
If use propane alone (2 gal/hr, $2/gal): $21,792 for 8 months.
Actual generator fuel cost: $3,904 (976 hours of runtime)
Fuel-cost savings by adding PV+Battery: $17,888.

Onboard propane used for setup, extreme cold, and night operation.
The addition of wind power would further reduce fuel usage.

Suncrate Mobile Microgrid powering BES Wastewater treatment plant



Long summer days are mostly self-powered.
Low angle in winter reduces PV power.
Desire wind power for winter and spring.

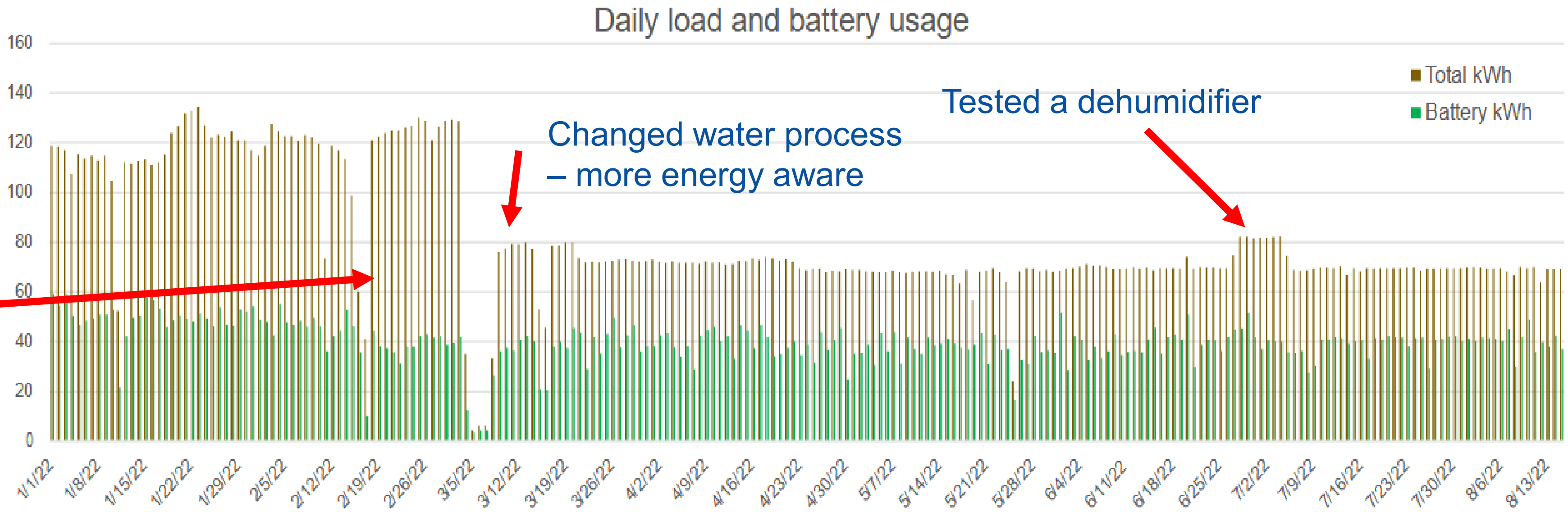
Spring cloud variability

Self-powered with PV+Battery

Use of battery is relatively constant throughout duration.

Generator is used more in winter and during cloudy spring days.

Snow covered PV; ran gen exclusively



Tested a dehumidifier

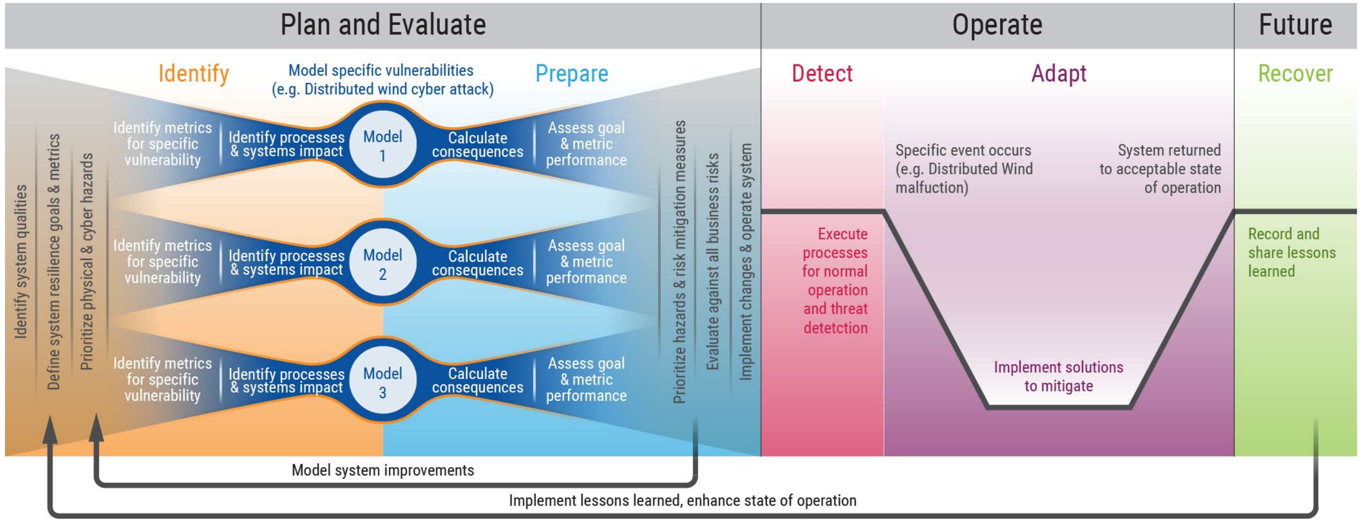
Changed water process – more energy aware

Blizzard and extreme cold reduced the PV generation and small battery heaters couldn't keep up.

Conditions and limitations

Match the resource and the load with goals of the locality and constraints of the region.

- What drives the load/generation profiles and development constraints?
  - Environment suitability – fires/floods, land cost/use (e.g. ag, housing), right-of-ways
  - Community values, social and economic activity
  - Infrastructure (power lines, pipelines, roads, rails, ports…)
- What drives how resource and load are paired?
  - Location of load center, and surrounding landscape
  - Space, surface area, height, setbacks
  - Distribution network
  - Costs of repowering machines or facilities
- What are the resilience needs of the community
  - Critical loads
  - Understand emergency response plan



Resilience Framework for Electric Energy Delivery Systems

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