Optimization of Dispatchable Loads for Renewable Energy Integration in Remote Microgrids

Arctic Sustainable Energy Research Conference
April 21, 2021

Daniel Sambor
PhD Candidate, Atmosphere & Energy
Lecturer, Energy Efficient Buildings
Civil and Environmental Engineering, Stanford University

Visiting Researcher, MicroFEWs, ACEP/INE
University of Alaska Fairbanks

Stanford Civil and Environmental Engineering

What Does a Community Need?

Providing Food, Energy, and Water (FEW) Security is Essential

Energy	Electricity	Heat	Transportation
Food	Subsistence Harvests	Market Food Imports	Local Agriculture
Water	Potable Water	Hygiene	Sanitation

Is it Available, Accessible, Preferable, and of good Quality?

Islanded Microgrid Design

Status Quo: Primarily Diesel Generation

Diesel Generation

↓

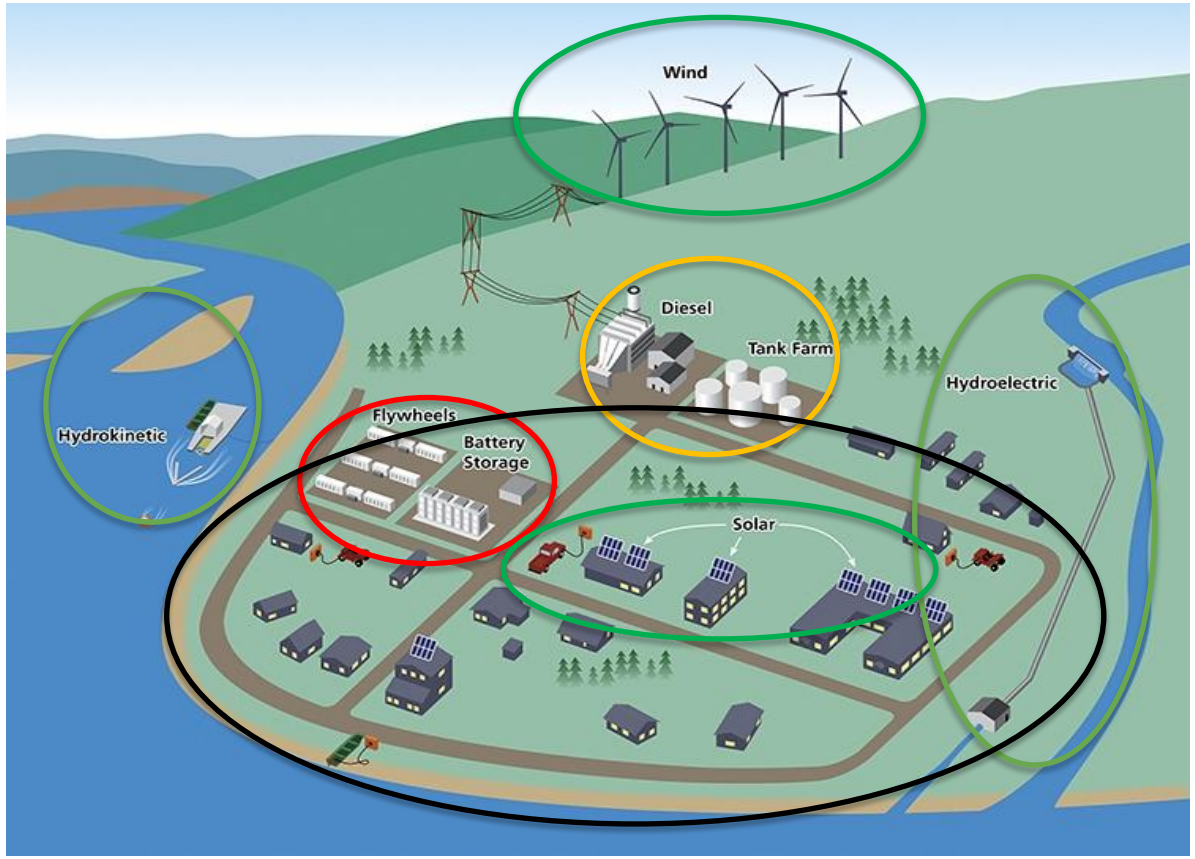
Renewable Energy

↓

Energy Storage

↓

Demand Management



Graphic Courtesy: ACEP

Islanded Microgrid Design

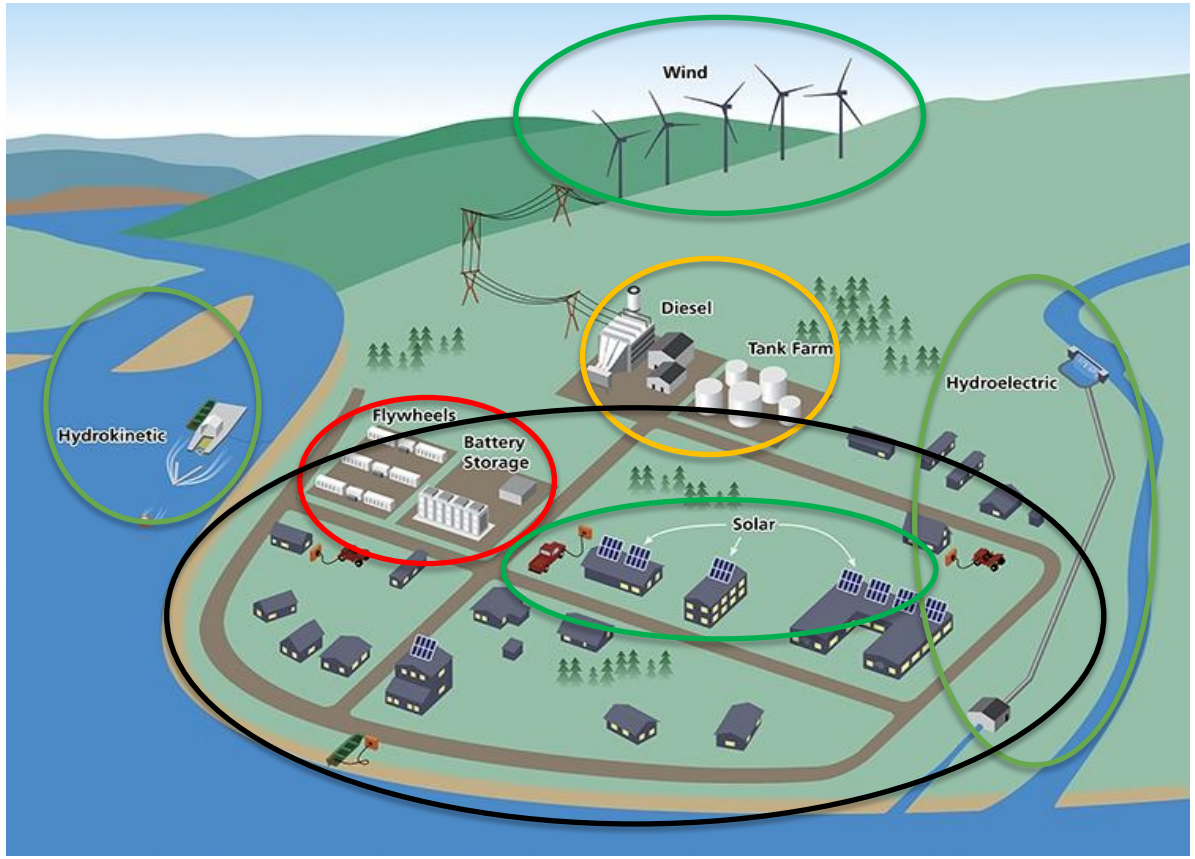
Can select loads be dispatched optimally to further reduce diesel fuel costs?

Diesel Generation

Renewable Energy

Energy Storage

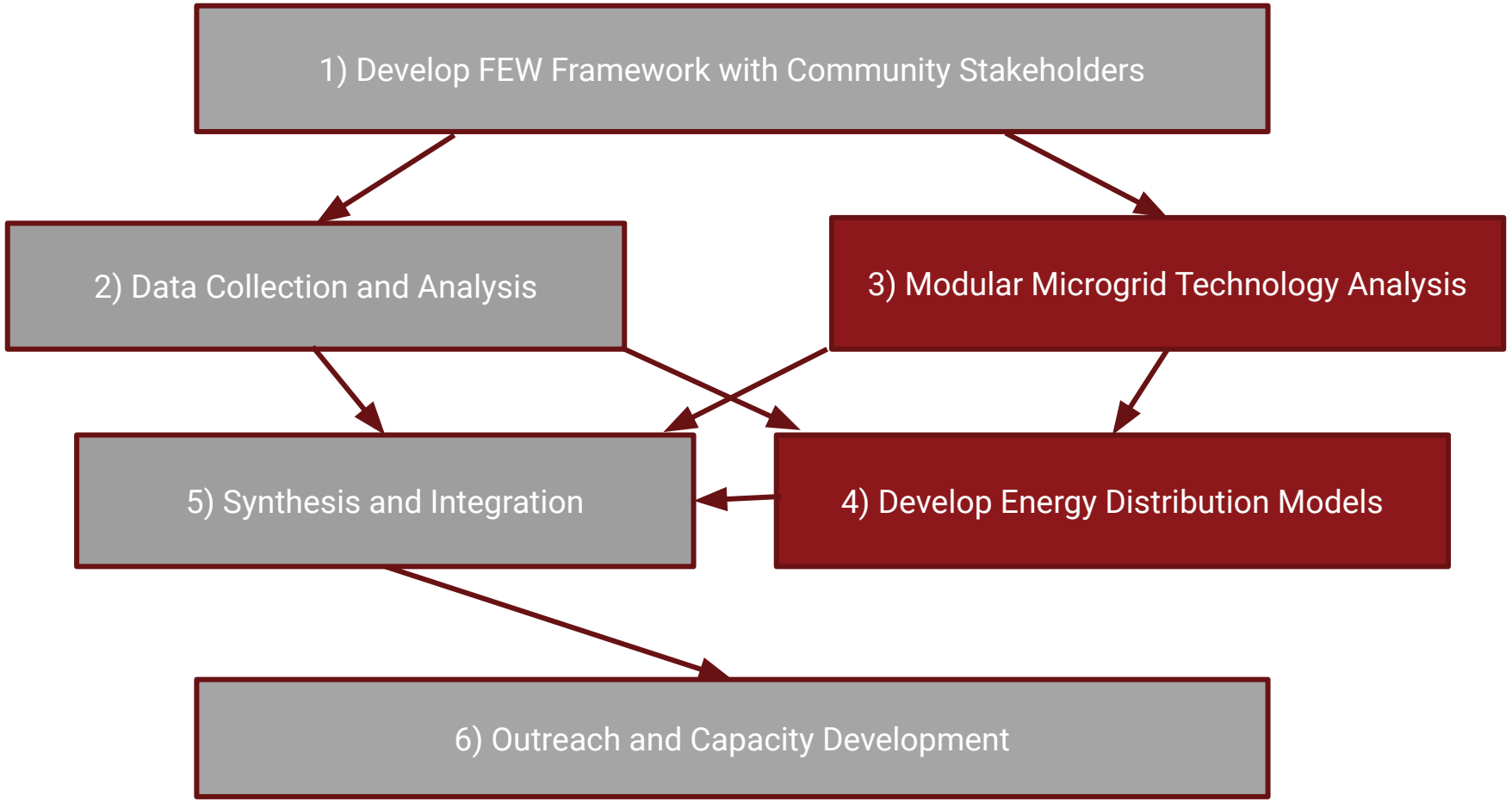
Demand Management



Graphic Courtesy: ACEP

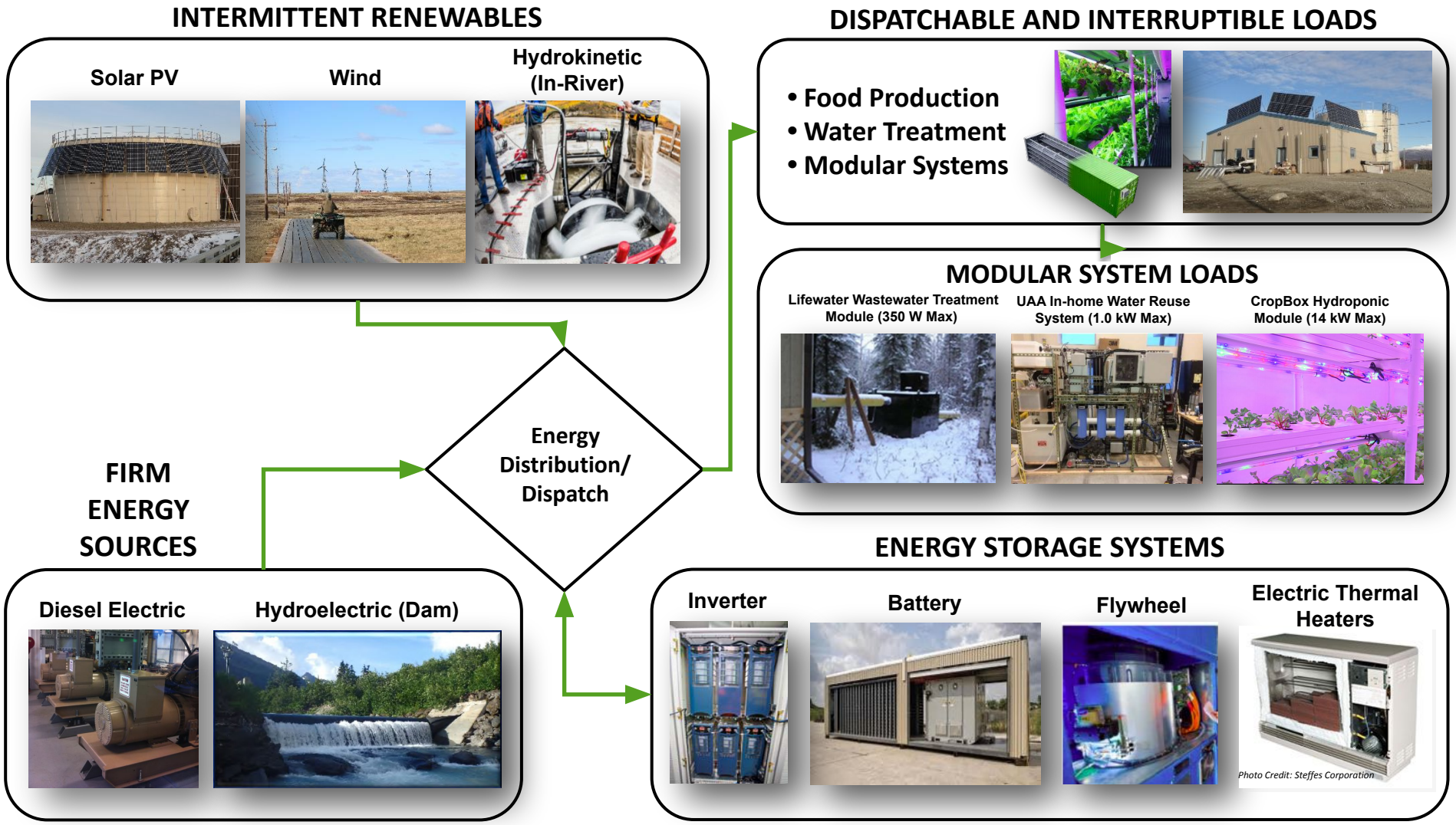
NSF MicroFEWs Project

Collaborating with four rural Alaska communities to study Food-Energy-Water systems



Adapted: MicroFEWs

MicroFEWs Energy Distribution Modeling Technologies

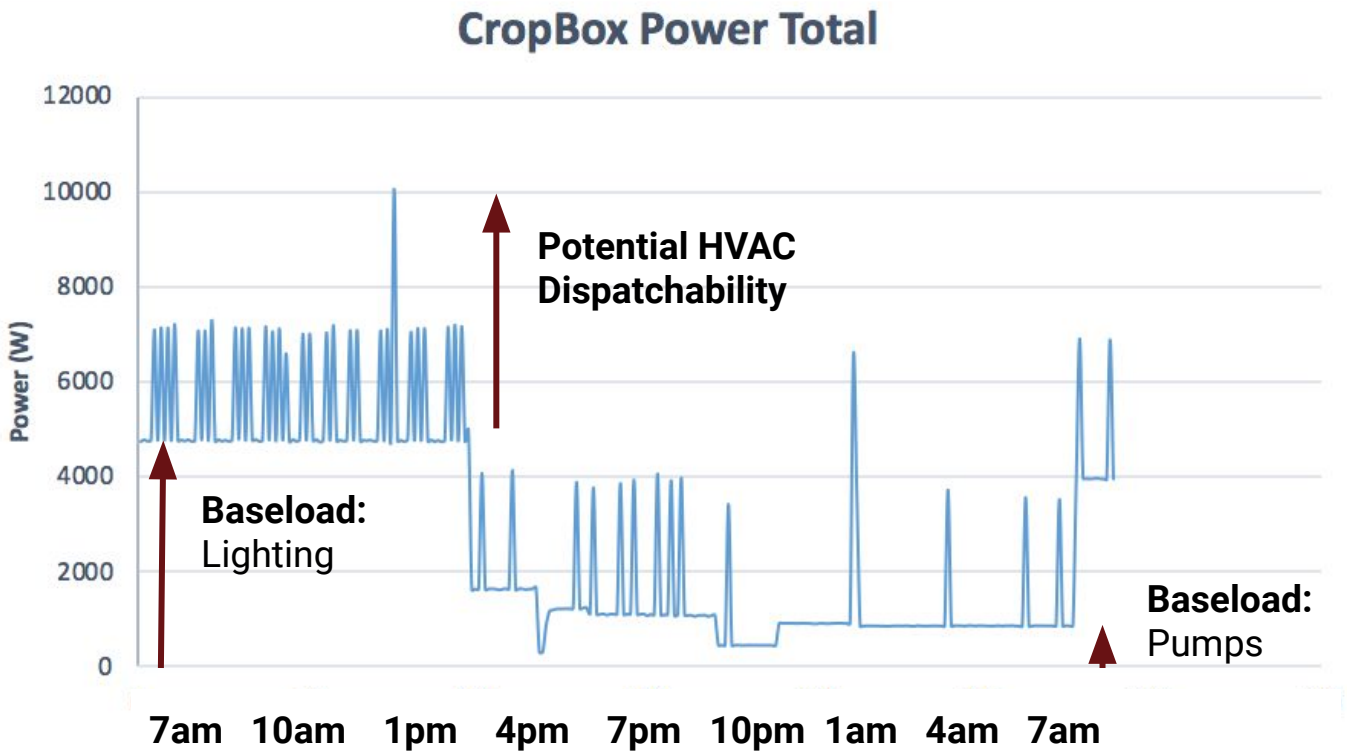


Graphic Courtesy: Rich Wies, MicroFEWs

Food Dispatchable Loads

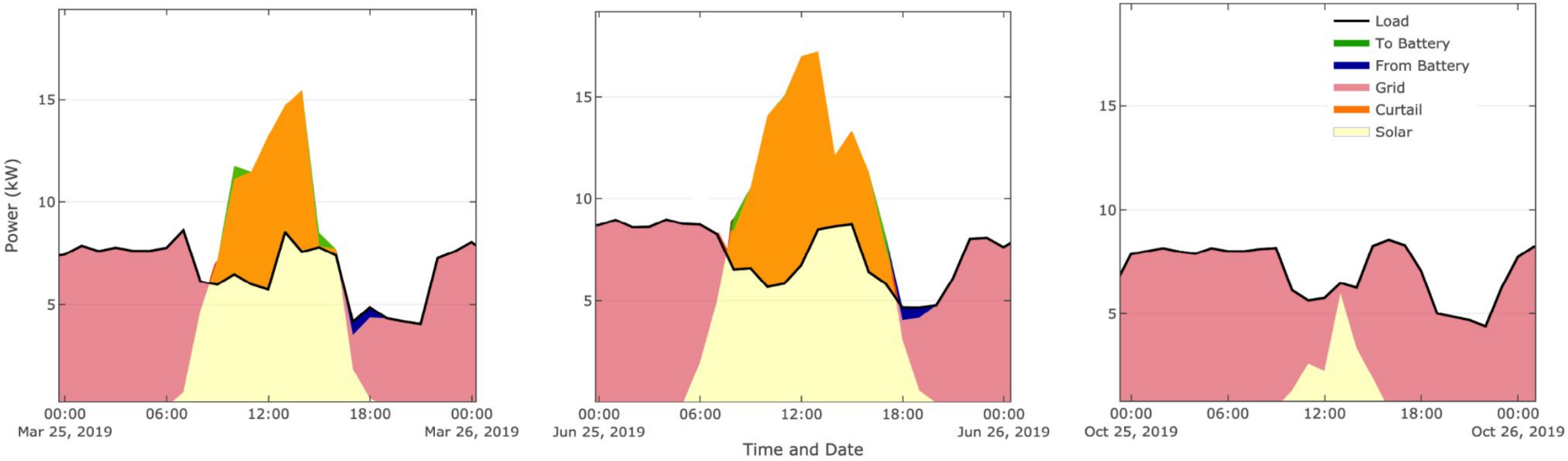
Using Indoor Agriculture as a Dispatchable Load

CropBox Shipping Container Farm



Food-Energy-Water Microgrid Optimization with Renewable Energy (FEWMORE)

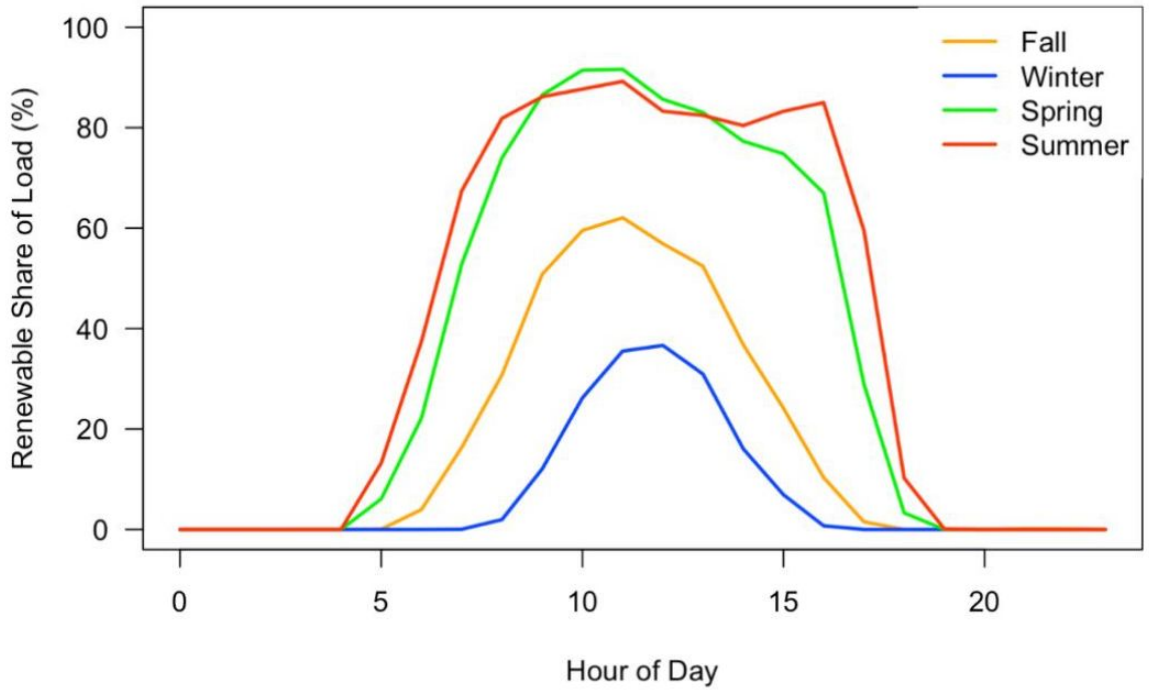
Adding 17 kW of Solar and 1 kWh of Battery Storage Reduces Operating Costs by 15%



Sambor, D.; Wilber, M.; Whitney, E.; Jacobson, M. Development of a Tool for Optimizing Solar and Battery Storage for Container Farming in a Remote Arctic Microgrid. Energies 2020, 13 (19), 5143. https://doi.org/10.3390/en13195143.

Food-Energy-Water Microgrid Optimization with Renewable Energy (FEWMORE)

Optimally Managing Heating, Ventilation, and Dehumidification Decreases Costs by 20%



Sambor, D.; Wilber, M.; Whitney, E.; Jacobson, M. Development of a Tool for Optimizing Solar and Battery Storage for Container Farming in a Remote Arctic Microgrid. Energies 2020, 13 (19), 5143. https://doi.org/10.3390/en13195143.

Water Treatment Dispatchable Loads

UAA Water Reuse System

- “Store” energy in treated greywater
- Peak dispatch (on-mode): ~1 kW
- Key loads: CF/NF/RO, pumps, heating

Credit: MicroFEWs

Lifewater Sewage Treatment

- “Store” energy by treating blackwater
- Peak Power Draw: ~ 0.2 kW
- Key loads: Air blower/diffuser, UV/Ozone, Pumps

Credit: Lifewater Engineering

Thermal Dispatchable Loads

Treat Building Systems as a Dispatchable Load while Ensuring Thermal Comfort and Services

Electro-thermal Storage (ETS)

- Store energy by heating ceramic bricks
- Example: 6 kW power, 33 kWh of storage

Hot Water Heating

- Store energy by heating water
- Example: ~1 kW power, 5 kWh of potential energy storage

Conclusion: MicroFEWs Community Synthesis

Community Inputs

How does the community value … ?

- Renewable Energy
- Food Security
- Water Security
- Energy Security

Data Inputs

What are the quantitative pieces of info required?

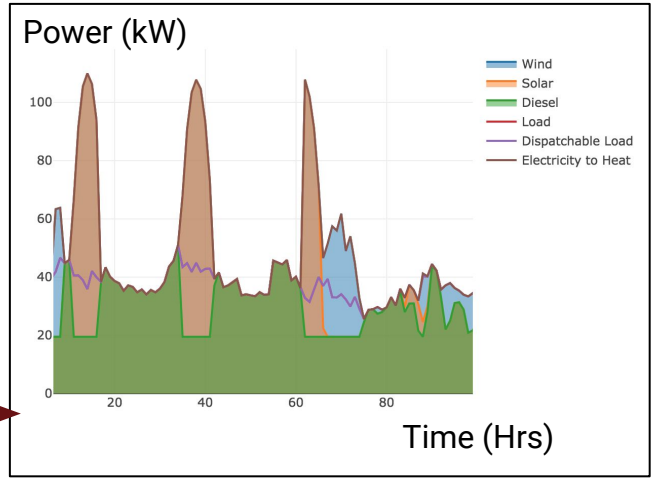
- Powerhouse Electric Loads
- Dispatchable Load Profiles
- Renewable Resource
- Heating Loads

EDM Outputs

What are the desired data outputs?

- Number of Dispatchable Loads
- Additional Renewable Capacity
- Time Series of Dispatch
- Total Outputs of Heating, Water, Food

Result Synthesis



- How best to use excess renewables?
- Can demand profiles align better with renewables?

<u>Iteration:</u> Given resulting energy output and costs does this lead to other questions?

dsambor@stanford.edu

Kluane Lake Research Station, Photo: Dan Sambor