Mobile Microgrid for Disaster Recovery

Microgrids and ES for Emergency Grid Resilience
DOE/Sandia/ISU Webinar December 10, 2021

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Team: Nicholas David, EPRC Engineer**, Dolf Ivener**, SunCrate, **Dan Stieler**, PowerFilm

Col. John Perkins and **Ken Thornton**, Iowa Army National Guard

https://www.ece.iastate.edu/eprc/

IOWA STATE UNIVERSITY
Electric Power Research Center

IOWA
economic development

PowerFilm SOLAR
MADE IN THE USA

SunCrate

IOWA NATIONAL GUARD

Background: IEDA project: mobile microgrid for disaster recovery

Iowa Economic Development Authority funding

SunCrate solar/storage crate to Puerto Rico (w/ Black & Veatch)

PowerFilm Inc. flexible solar materials, military applications.

Iowa Army National Guard provide design requirements for crate performance, contribute expertise on applications

ISU Architecture, Electrical Engineering, Mechanical Engineering profs and students: solar house design/build, battery modeling and testing, microgrid design

Advisory Committee: IA ANG, Alliant, City of Ames, Cedar Falls Utilities, MidAmerican Energy

Earlier microgrid: Solar crate in Puerto Rico, August 2018

Phase 1 Tasks:

- **Design, build, deliver:** mobile microgrid for disaster recovery, to IA ANG requirements
- Provide plans for a *second* crate to serve for human use as office, or housing, based on ISU solar decathlon experience

Phase 2 Tasks: Demonstrate, collaborate and improve the microgrid based on feedback from microgrid advisory committee, Iowa Dept. Homeland Security, County Emergency Managers

Background: EPRC: Started in 1963 as Power Affiliates Program

"Advance research and graduate education in electric power systems; strengthen industry ties"

Industry Members:
Alliant Energy
City of Ames
Cedar Falls Utilities
Central Iowa Power Cooperative
Corn Belt Power Cooperative
International Transmission Company
MidAmerican Energy
MidContinent Independent System Operator
Northwest Iowa Power Cooperative

EPRC: Catalyst for collaboration in ISU-industry-National Laboratories power systems R&D and technology transfer, to strengthen undergraduate and graduate education in energy infrastructure.

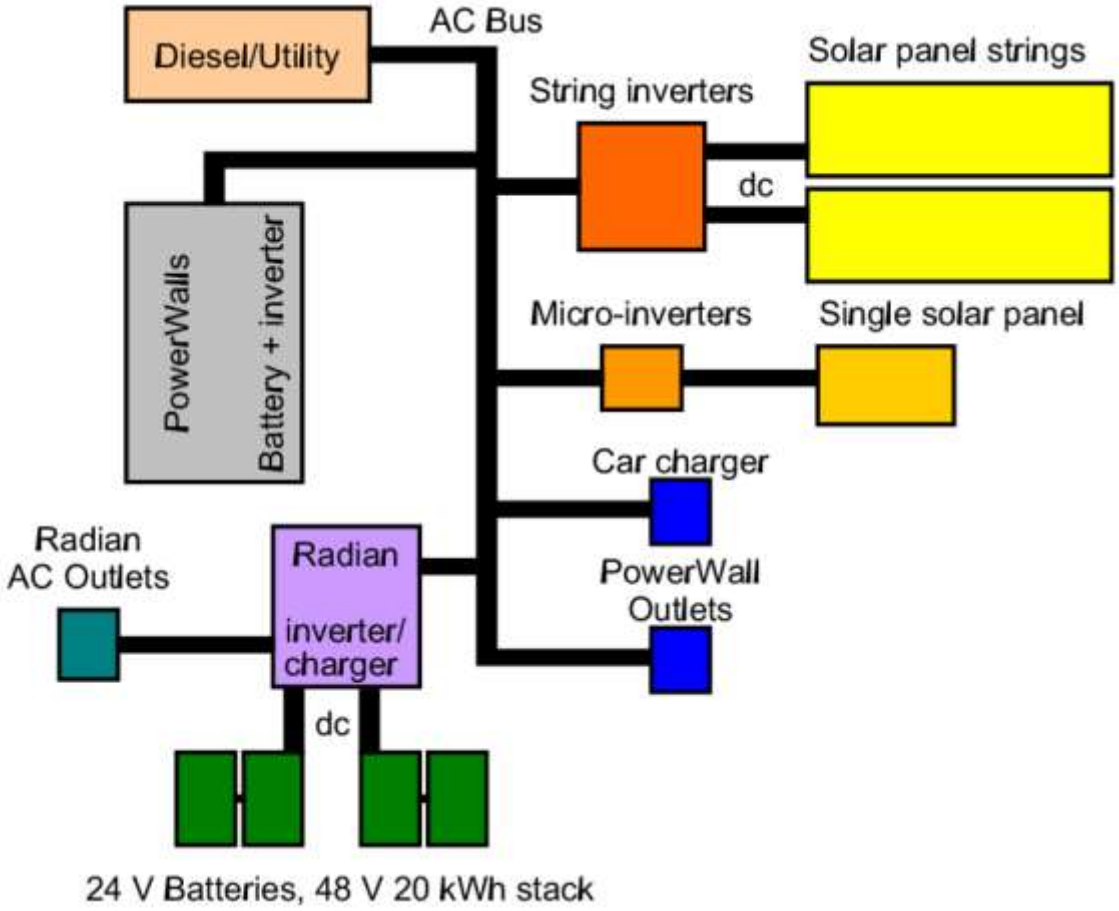
We study power systems from large interconnected transmission grids to microgrid-scale- with strength in fundamental and applied work in transmission and distribution planning and operation, and cybersecurity.

Research and education driven to improve reliability and security of the grid as more variable and distributed generation resources are connected, and as loads also become more variable.

Other Collaborators: Algona Municipal Utilities, Maquoketa Valley Electric Cooperative, Iowa Lakes Electric Cooperative, Iowa Army National Guard, National Labs, American Public Power Association, SunCrate, PowerFilm

Power Systems Engineering Faculty:

- **Venkataramana Ajjarapu**, Whitney Professor, IEEE Fellow, vajjarap@iastate.edu; voltage stability, T&D co-modeling
- **Chao Hu, Mechanical Engineering;** battery testing, battery state estimation, battery life prediction, chaohu@iastate.edu
- **Ian Dobson**, Sandbulte Professor, IEEE Fellow, Dobson@iastate.edu; voltage collapse, cascading outage
- **Manimaran Govindarasu**, Marston, Harpole Professor, IEEE Fellow, gmani@iastate.edu; cyber security of power systems
- **Jim McCalley**- Marston, London Professor, IEEE Fellow, jdm@iastate.edu; SEAMS project, co-optimization of generation and transmission planning, wind energy integration
- **Hugo Villegas-Pico**, Harpole-Pentair Assistant Professor, Power Systems, Power Electronics and Controls, hvillega@iastate.edu
- **Zhaoyu Wang**, Northrop Grumman Associate Professor, wzy@iastate.edu; Distribution Systems, renewable energy integration



IEDA microgrid is *primarily* "off-grid": it can accept power from utility grid to charge batteries, but in current configuration does not feed back into grid. Can modify controls to allow power to feed back, at the discretion of the local utility and specific use case.

Current configuration includes:

1. Rigid PV panels (14.4 kW) and DC to AC inverters
2. Flexible PV panels (from PowerFilm)- 3 types, total 960 W, with DC to AC inverters
3. 6 Tesla power walls (total 78 kWh, 30 kW)
4. A diesel generator (6.5 kW)
5. A local network and Tesla Gateway controller (the brain)
6. A communications network
7. Three, single phase outlets (2 at 120 V, one 240 V) *and one 3-phase, 230 V*
8. *NEW in July: 8 kW Outback Radian inverter and 20.8 kWh of Hawk Big Battery Lithium Iron Phosphate*

Moving SunCrate to Camp Dodge

Transports:

Flatbed, tow truck
Enhanced Container Handling Unit (ECHU) on Heavy Expanded Mobile Tactical Truck (HEMTT)

Challenges:

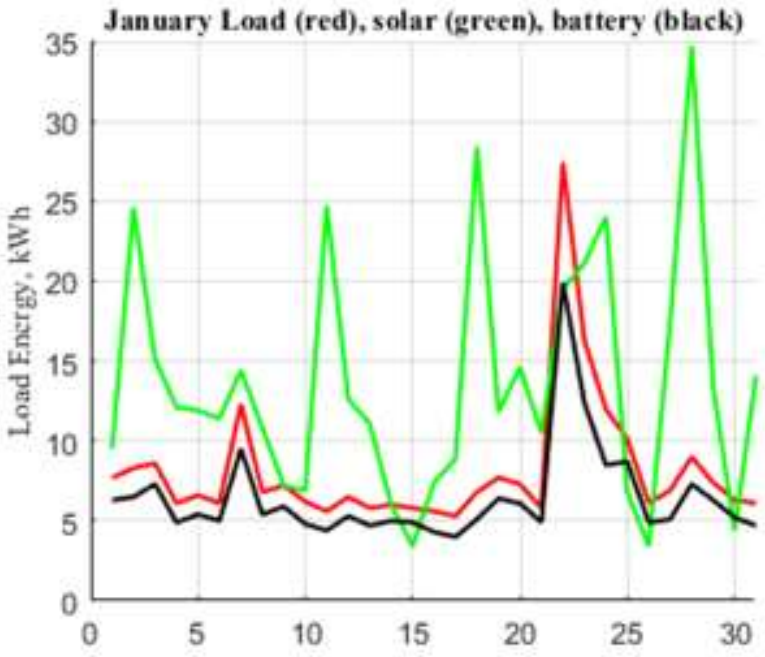
Soil variability, Ergonomics, PV cable management, Secure mounts

January, February 2021

- Solar replenishes night heat load

One-month data:

January

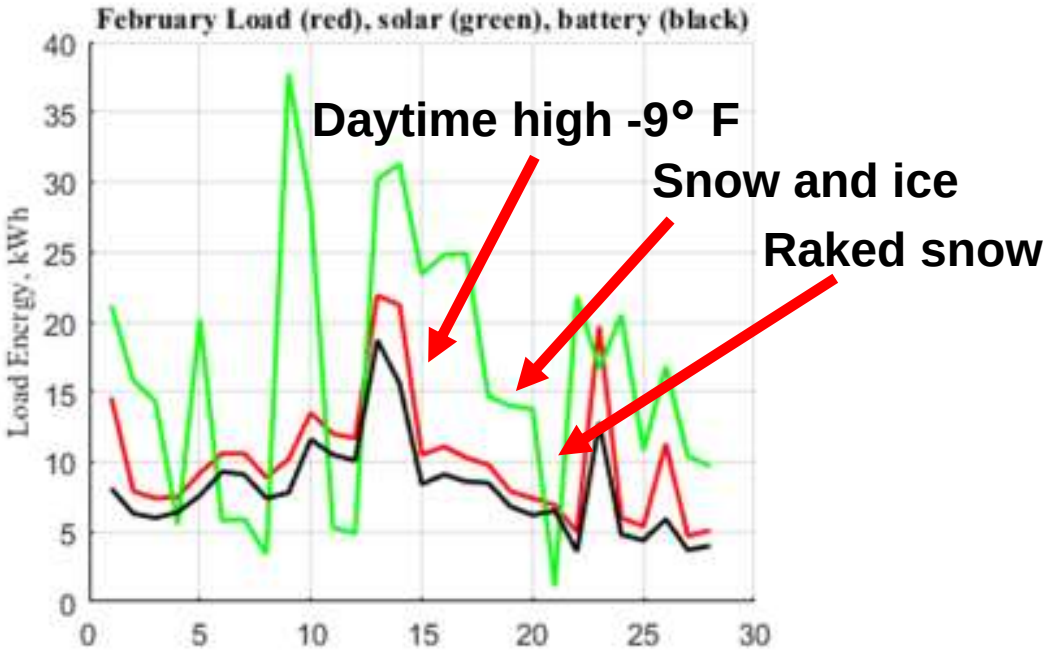


Car charging… Snow… Cold…

One-week polar vortex

- Load increases from added heating

February



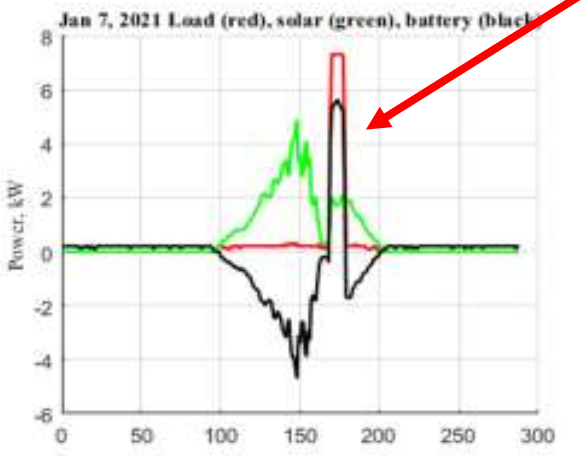
Winter car charging

One-day data:

Ogden veterinarian – Tesla car

City of Ames – Chevy Bolt

Heaters keeping up
Low: -21° F
High: -5° F

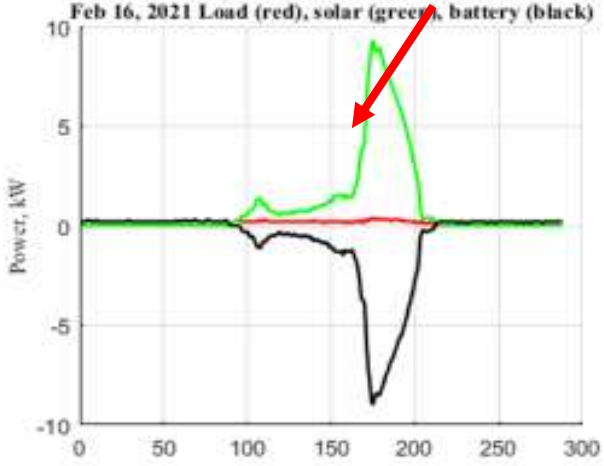


Snow/Hazy morning,
level 2 car charge

Keep the snow cleared,
First snow, then sun melts ice

Car Trickle and refill,
Solar and Battery "load sharing"

Different cars have different profiles



Cells warmed mid-day

In -20° F, internal and
external heaters barely enough

Idea of rapid deployment of mobile microgrids for community resiliency hubs

Idea: Mobile microgrids as “Grid Resilience Assets”

-gas stations
-city hall or community center, red cross shelters, daycares
-critical circuits in grocery stores
-cell towers and communication infrastructure,
-nursing home or health care facilities,
-food trucks, mobile kitchens,
-mobile command center
-water treatment and distribution pumping
-wastewater collection, treatment, discharge:

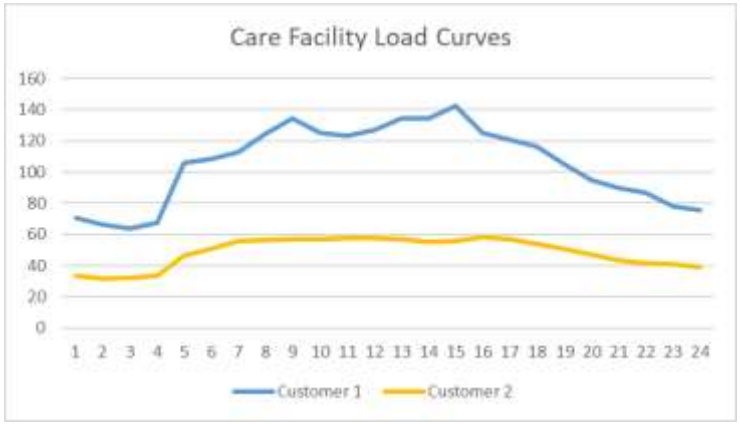
Dow City NH4 removal demonstration with BES and U. Iowa December 2021

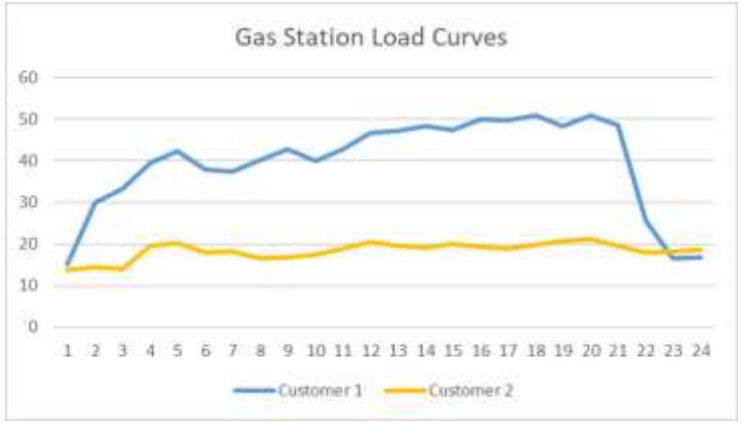
“daisy-chained” plug and play systems: pallet designs

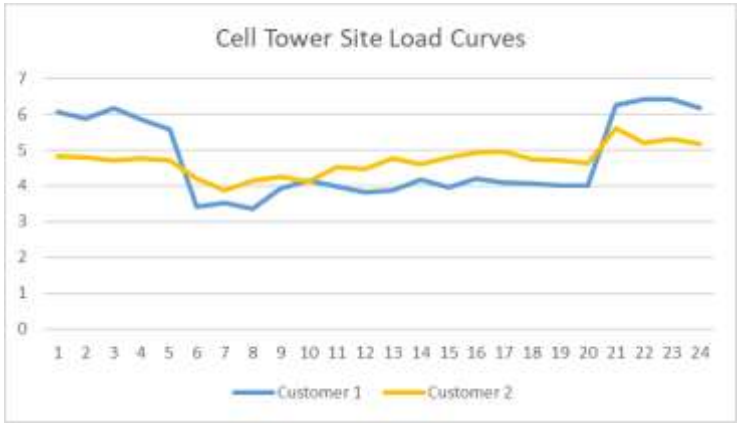
Delivered fully charged: immediate power supply for utility and community resource

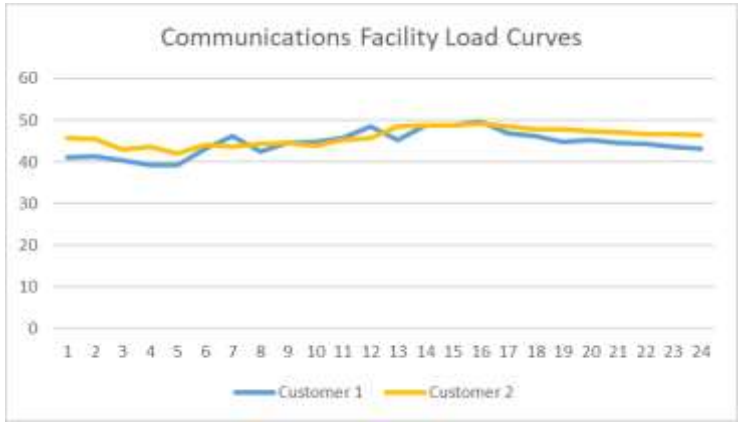
Derecho damage Aug 8 2020
photo by Kayley Lain, City of Ames

Use cases: Summer peak day demand profiles for critical customer loads

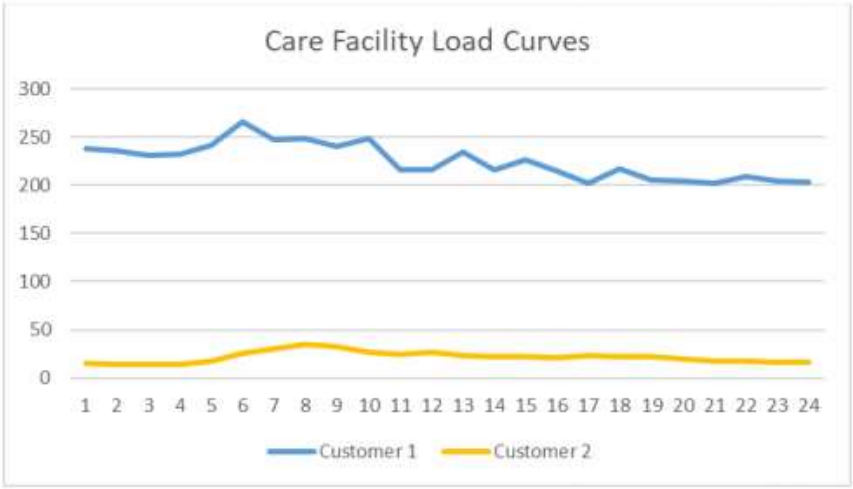


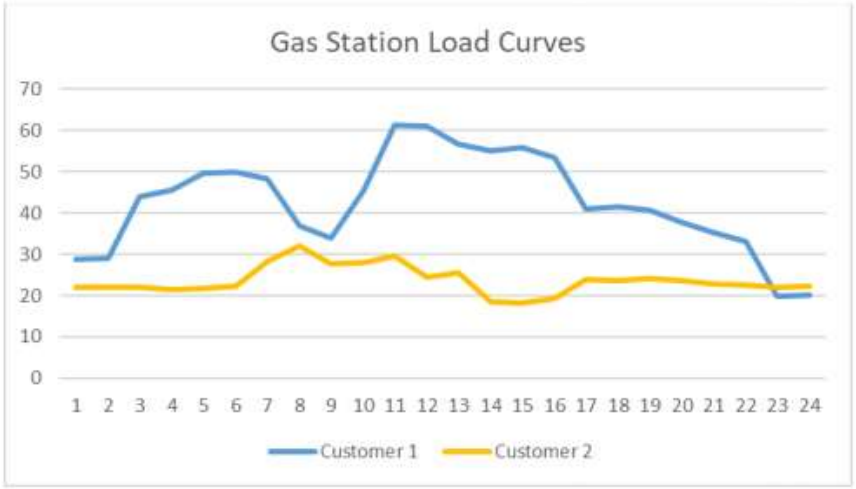


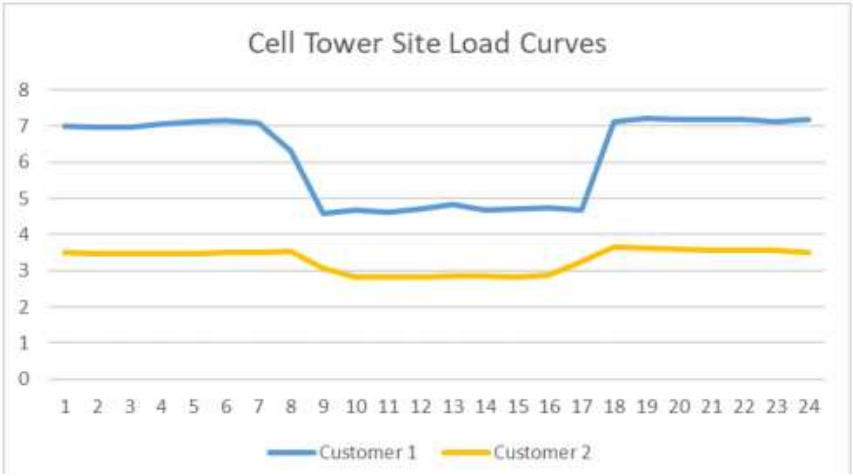


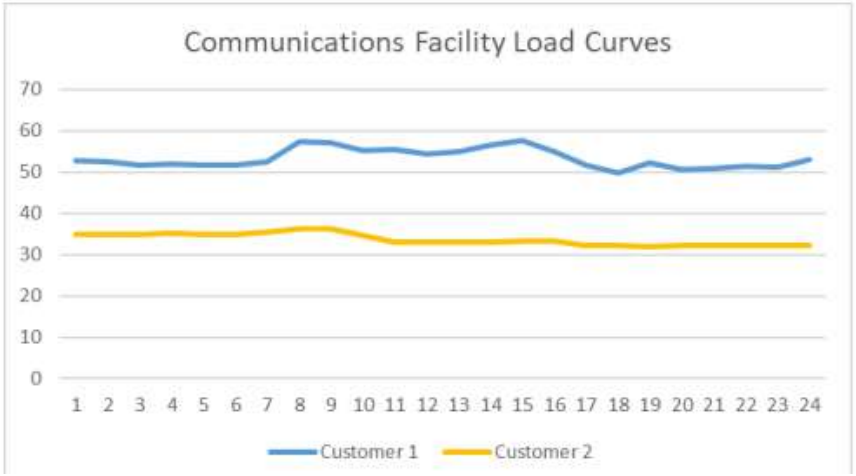


Winter peak day demand profiles for critical customer loads





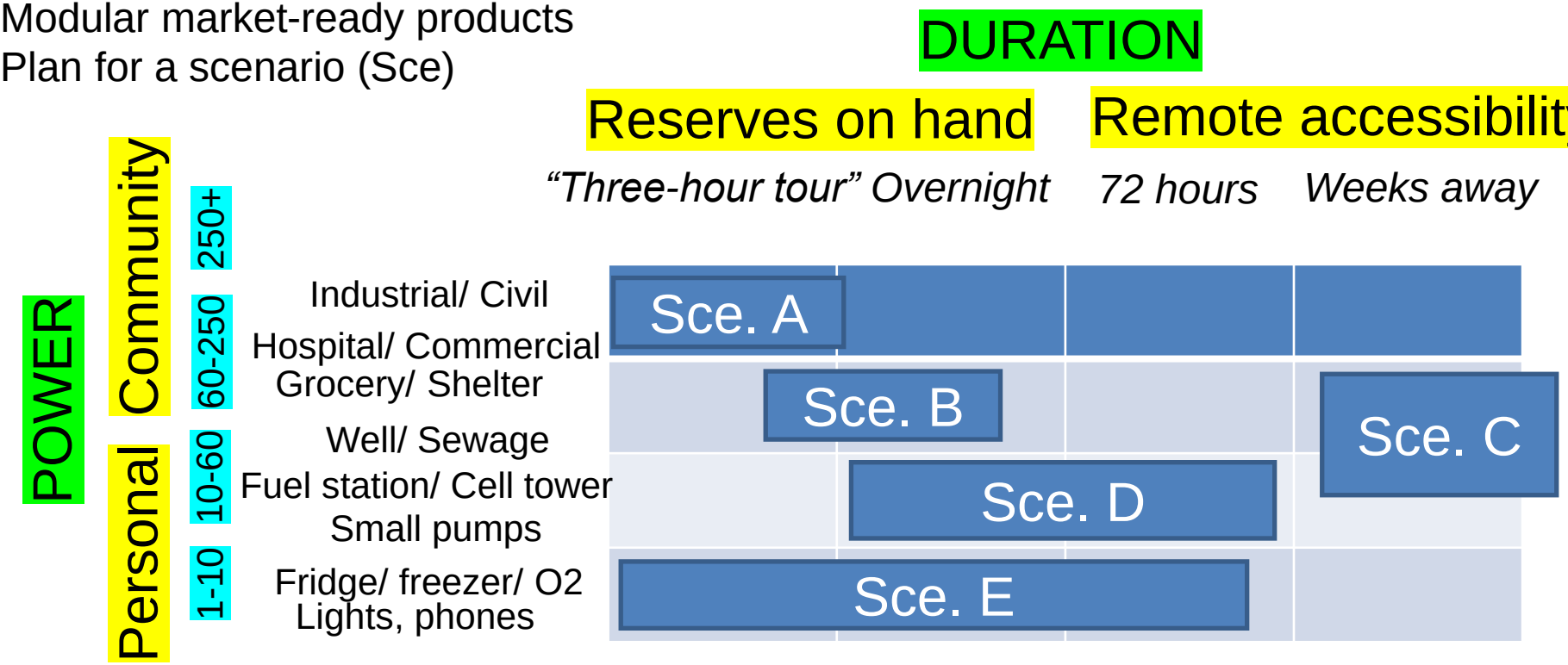




Recommendation

- Design for a "Class of applications"
  - Application-specific is too precise and tedious
  - Modular market-ready products
  - Plan for a scenario (Sce)

- Application (power) with Risks (duration)



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