Energy Management and Sustainability on the Road to 10G

Mission Critical Microgrids: Securing a Better Energy Future through the Power of Choice

Dan Middleton
Senior Vice President, Americas
Bloom Energy
EXTREME WEATHER IS INCREASING GRID DISRUPTION

WILDFIRES

WINTER STORMS

HURRICANES

ROLLING BLACKOUTS

PUBLIC SAFETY POWER SHUTOFFS

‘once in a lifetime’ events are becoming increasingly common.
Climate risk has created a set of ‘resiliency zones’

Key regions across the nation are susceptible to the impacts from ever growing natural disasters, raising the need for resilient power solutions that can provide coverage through outages.

- **Drought and Fires**
  - PSPS events in 2019 left 3 million Californians without power, many for multiple days.
  - PSPS events expected to continue for next 10 years.

- **Severe & Winter Storms**
  - In 2021, severe winter storms crippled Texas’ energy system and left ~4.5 million without power.

- **Hurricanes**
  - In 2020, Hurricane Isaias and Zeta left 6.8 and 2.6 million respectively without power.
  - Number and intensity of hurricanes expected to increase in the coming years.
HARDENING AT-RISK GRID INFRASTRUCTURE IS EXPENSIVE

Sample Costs for Distribution Hardening Projects

<table>
<thead>
<tr>
<th>Type</th>
<th>Cost Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacements</td>
<td>Up to $33,000 each</td>
</tr>
<tr>
<td>Undergrounding</td>
<td>$3-5 million/mile</td>
</tr>
<tr>
<td>Insulation</td>
<td>$1.2 million/mile</td>
</tr>
</tbody>
</table>

1. REDUNDANCY
Secondary system or extra components that become instantly operational, so any failure in primary system doesn’t result in mission failure.

2. FLEXIBILITY
Capacity to scale up or down to support evolving business needs without operational interruption or significant change in physical footprint.

3. MAINTAINABILITY
Ability to perform routine operation and maintenance on any component without affecting mission or processes of vital business functions.

4. HARDENING
Protection from physical forces and natural disasters where the electrical grid is unlikely to stand up to a disaster that could cause a power failure.

5. SECURITY
Built-in safeguarding from security breaches and man-made threats and the serious risks they pose to critical equipment and business processes.

MISSION CRITICAL KEY CONSIDERATIONS
THE RESILIENCY CHALLENGE: ELIMINATING TRADEOFFS

RESILIENCY

SUSTAINABILITY

PREDICTABILITY
FUEL CELLS: COMBUSTION FREE ELECTRICITY

COMBUSTION-FREE ELECTRICITY

- OXYGEN
- Cathode
- Electrolyte
- Anode
- FUEL

OXYGEN IONS REACT WITH THE FUEL IN THE FUEL CELL TO PRODUCE ELECTRICITY.

SIMPLE PLATFORM ARCHITECTURE

- ELECTRICITY OUTPUT
- FUEL INPUT

32 ft.

4 ft.

BENEFITS OF FUEL CELL MICROGRIDS

- RESILIENT
  - Uninterrupted power without compromise
- PREDICTABLE
  - Lock in predictable costs
- SUSTAINABLE
  - Decarbonized power for the digital world
- TURNKEY
  - ‘Plug and play’ power with comprehensive customer care
Fuel cells provide a critical foundation for microgrids of varying complexity:

- Fuel cell system serves baseload primarily with ability to modulate output
- Solar and wind used as much as possible
- Battery covers short peaks and enables load shifting
- Utility can be used for peak shaving when available
- Optional generator is used sparingly for extended peaks

24 hour load profile when islanded:

- FACILITY LOAD
- FUEL CELL
MISSION CRITICAL RELIABILITY

Highly Available Generation

Mission Critical Grade Power

Reliable Fuel Delivery

**KEY DESIGN ELEMENTS**
- Multiple levels of redundancy
- No single point of failure
- Concurrent maintainability
- Simple air-cooled design
- 24/7 monitoring & proactive maintenance

**KEY DESIGN ELEMENTS**
- Grid independent inverters
- Load following
- Energy storage
- Digital power quality

**KEY DESIGN ELEMENTS**
- Network design without single points of failure
- Minimal physical exposure, leverages underground infrastructure

Failure Occurrence
CASE STUDY

During CA wildfire season last year, the microgrid powered the facility through a **5.5 day PSPS event**.

- **300 kW Solar**
- **4.3 MW Fuel Cell**
- **Utility 15 kV**
Thank You!

Dan Middleton
Senior Vice President, Americas
Bloom Energy
Dan.Middleton@bloomenergy.com