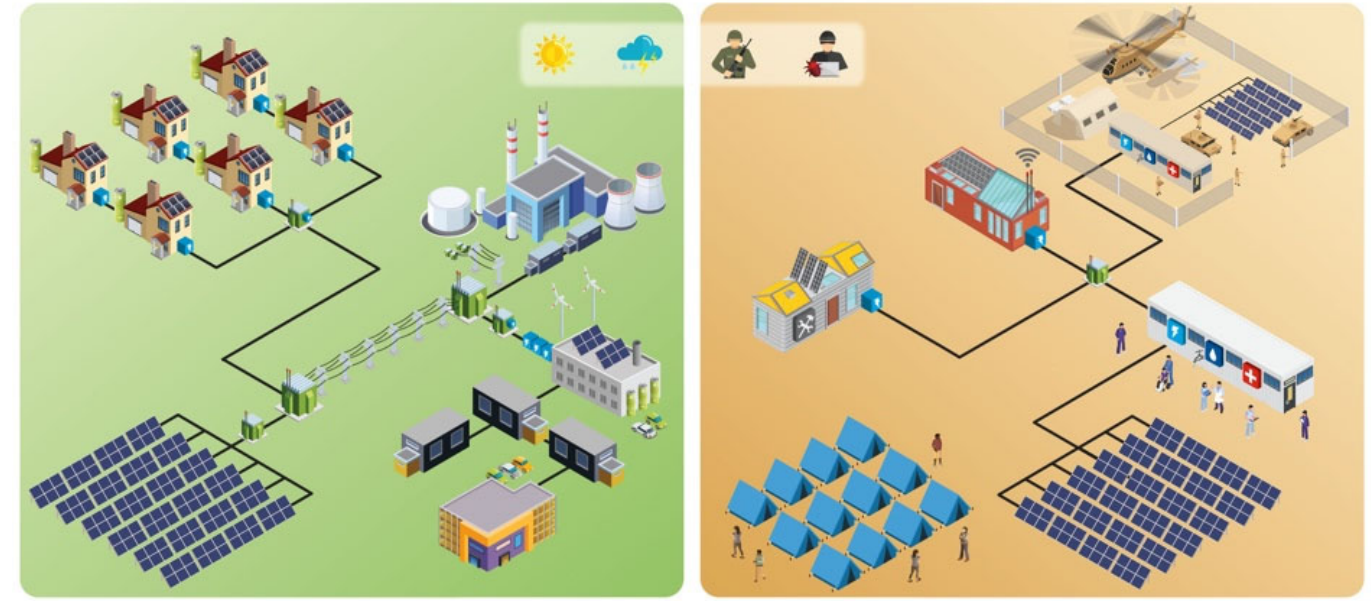


Microgrid Deployment for Cost Savings, Resilience, and Sustainability



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**Grid
Modernization**

Scalable controls from circuits
to system



**Global Energy
Access**

Solutions that support
sustainable development



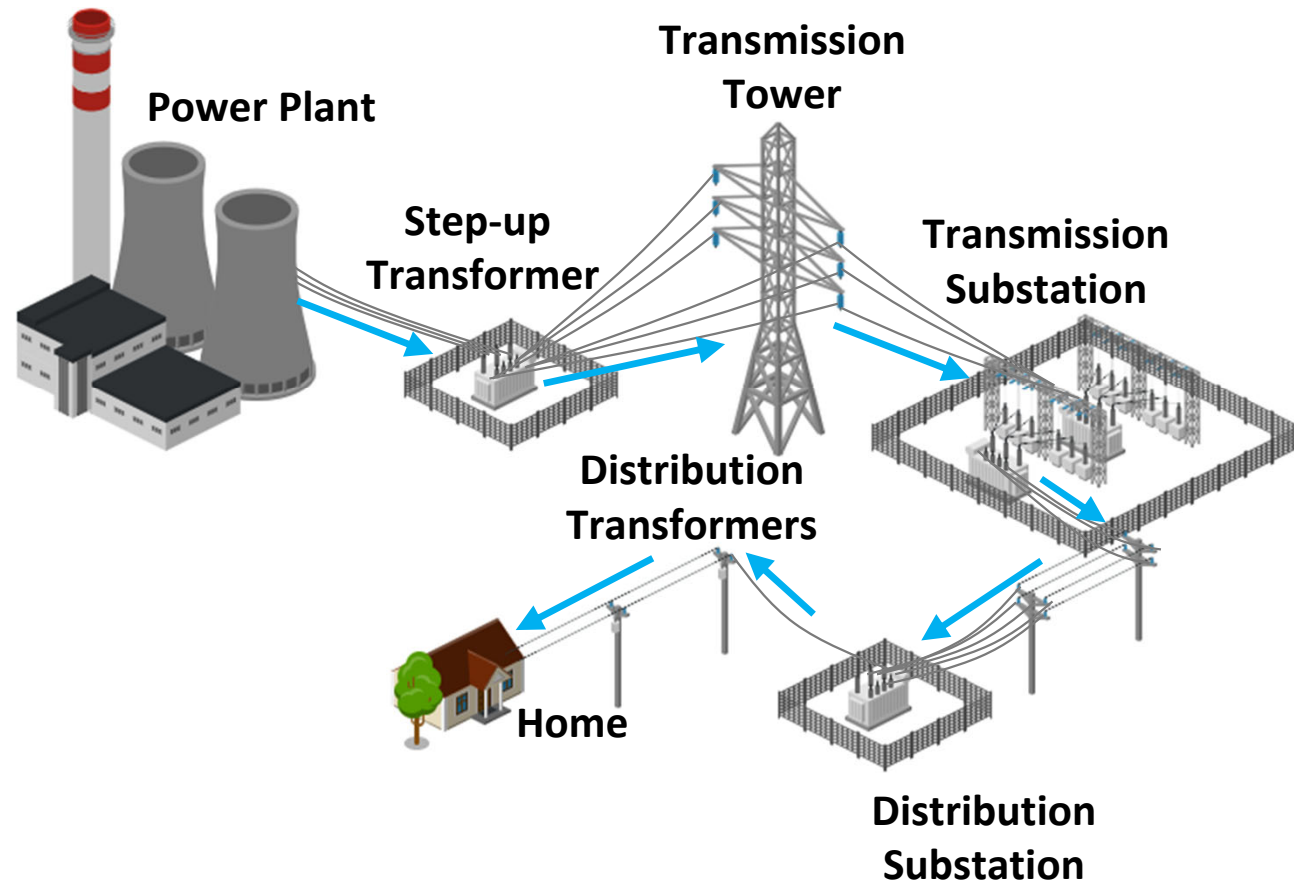
**Workforce
Development**

Education for a changing global
energy economy

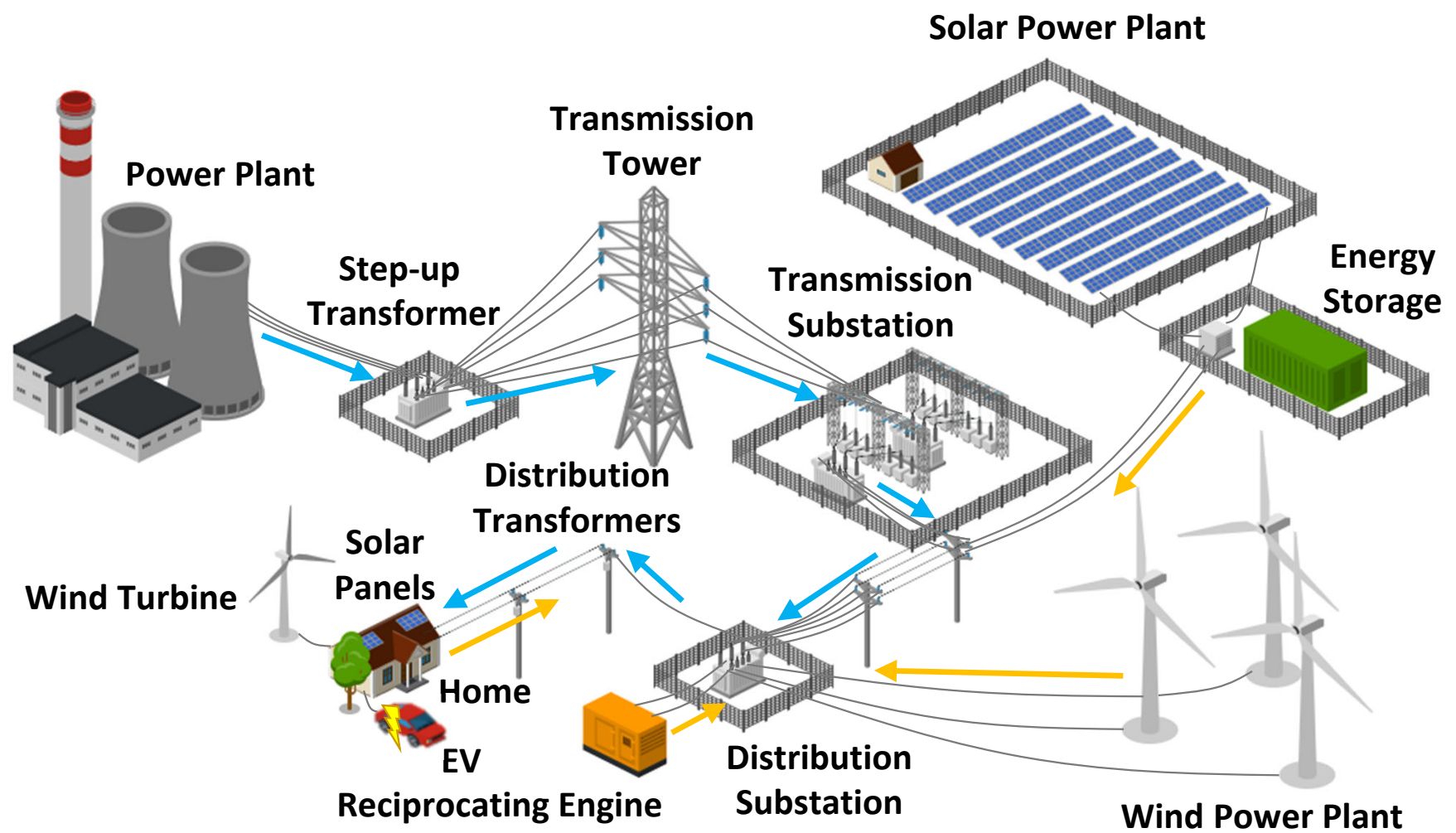
The Entire Energy Marketplace is Changing

Technology and customer demand is driving change in business models and regulation

Traditional Structure



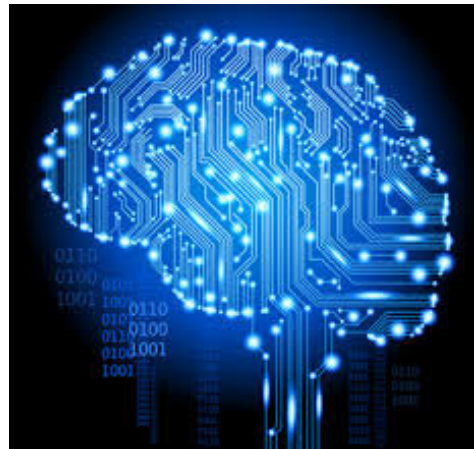
Distributed Resources and Microgrids



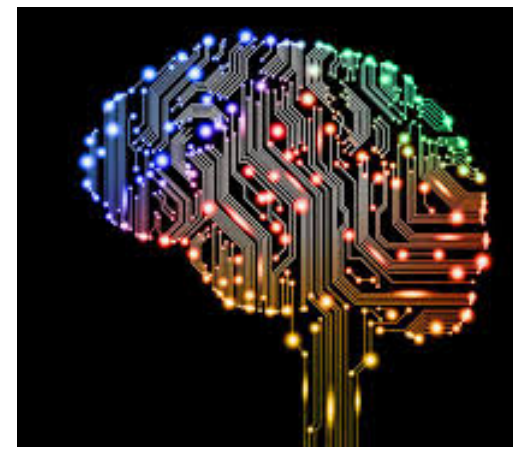
The Microgrid Control Problem

Each microgrid is unique and requires customized control systems to effectively achieve the economic and resilience goals of customers

Microgrid 1



Microgrid 2



Microgrid 3



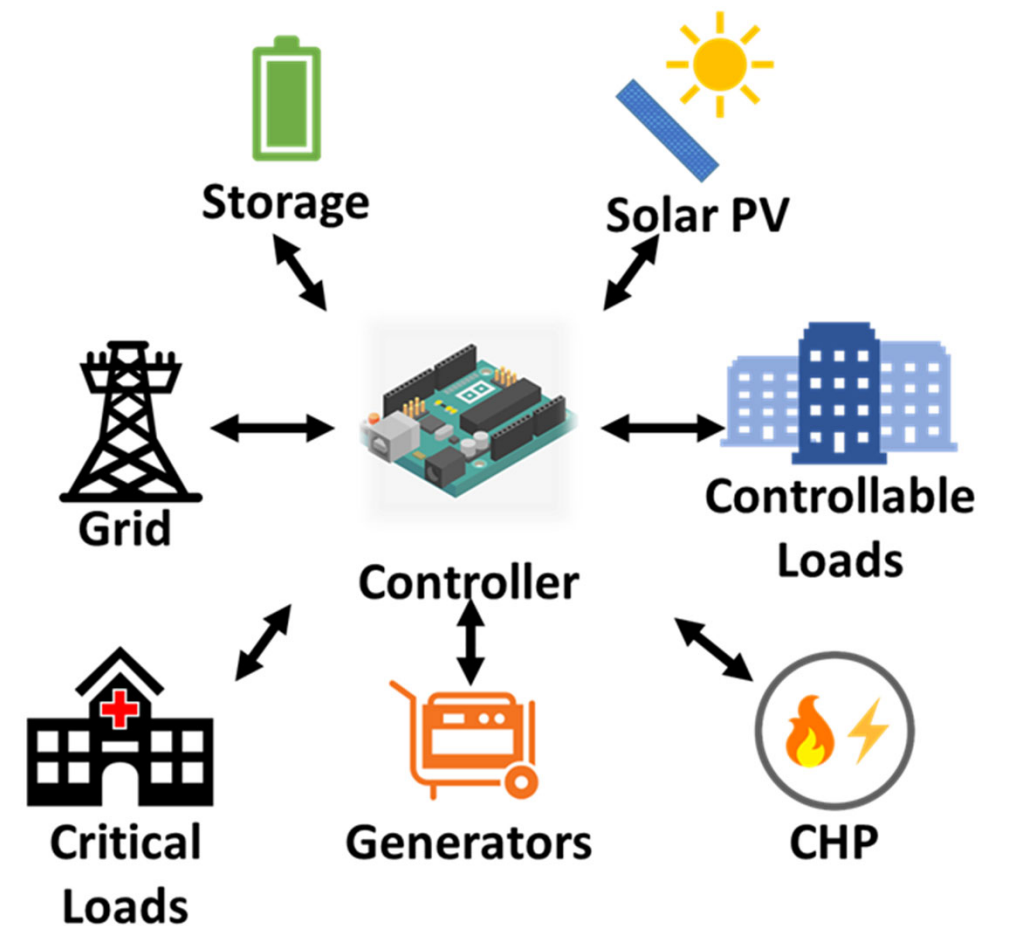
Microgrid N



Adaptive Control of Energy Systems (ACES)

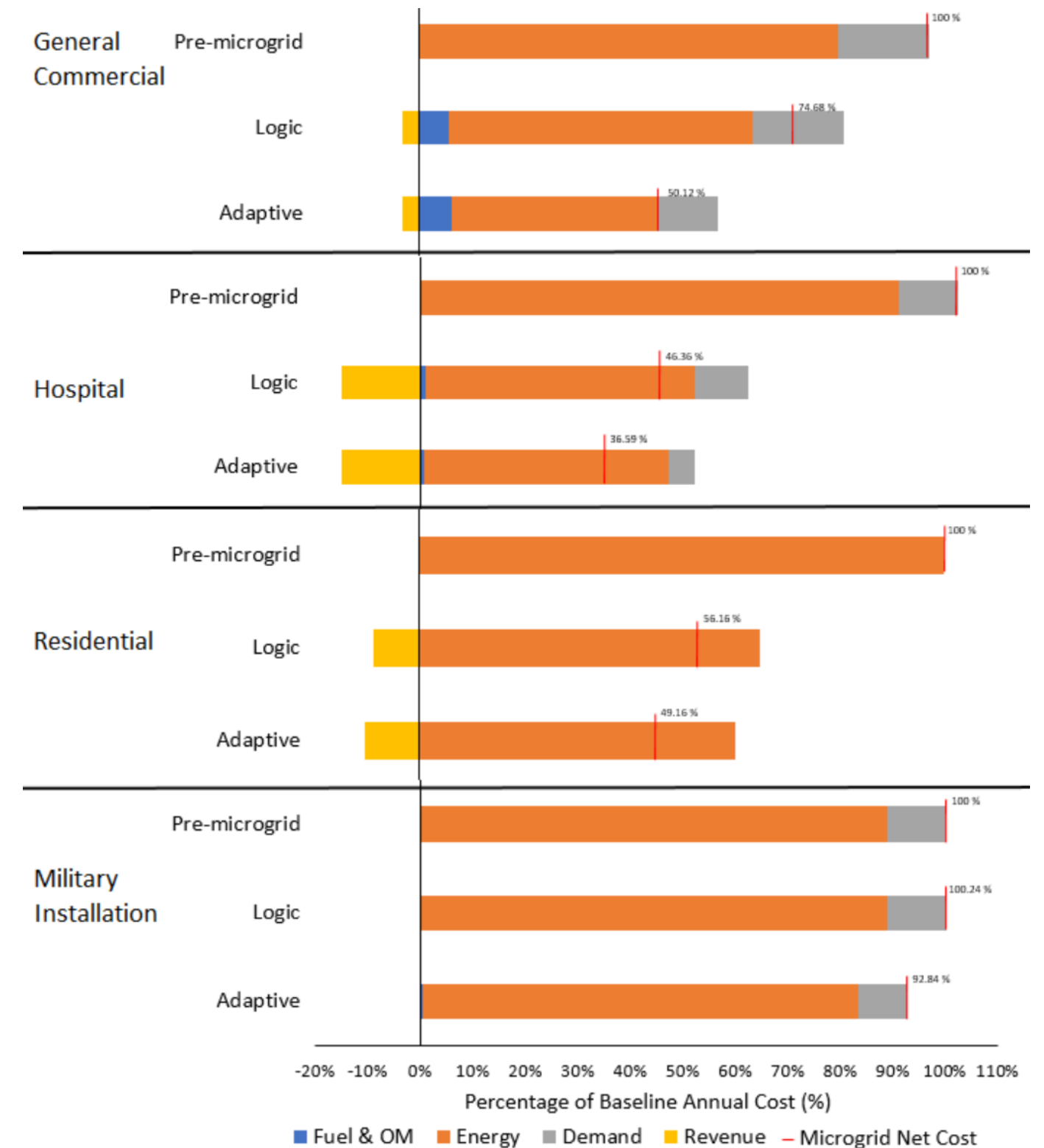
Microgrid control software that reduces development time/costs, is technology agnostic, and adapts operations to achieve customers goals

- ⇒ 50%-80% decrease in controls development time
- ⇒ Modular and scalable to avoid vendor lock-in
- ⇒ 10%-30% net operational costs savings
- ⇒ Turns cost centers into revenue centers
- ⇒ 10%-50% improvement in resilience



ACES for Grid-Connected Cost Savings

Adaptive controls can significantly reduce operating costs of microgrids without requiring costly hardware investments.

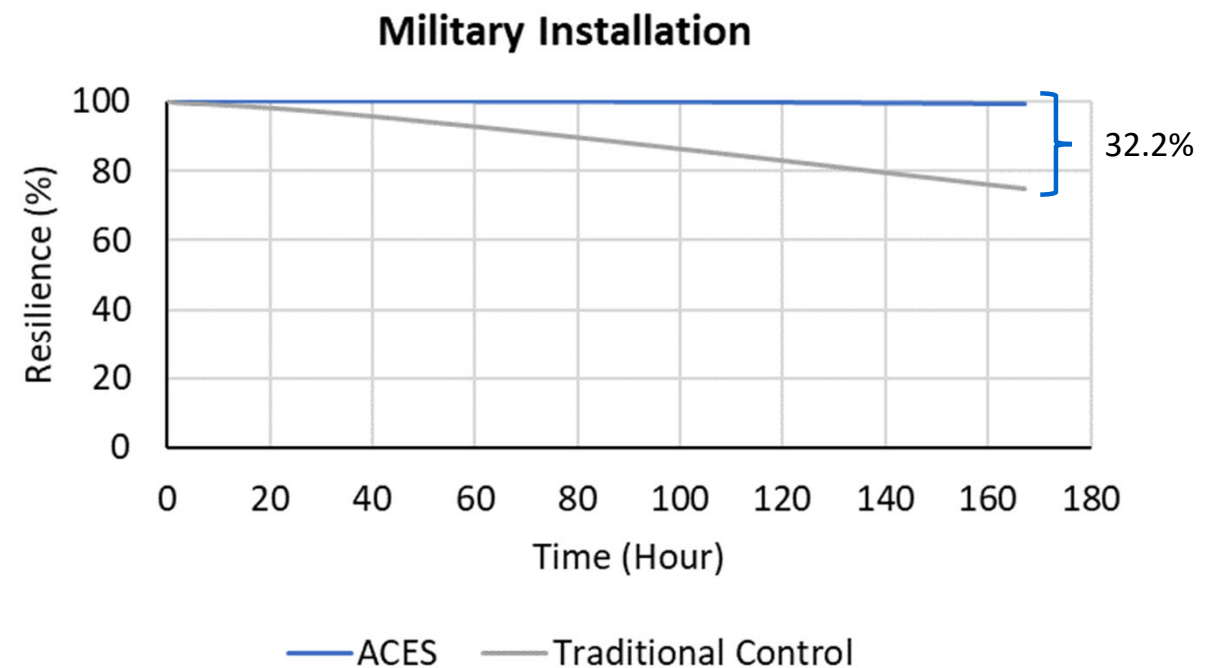
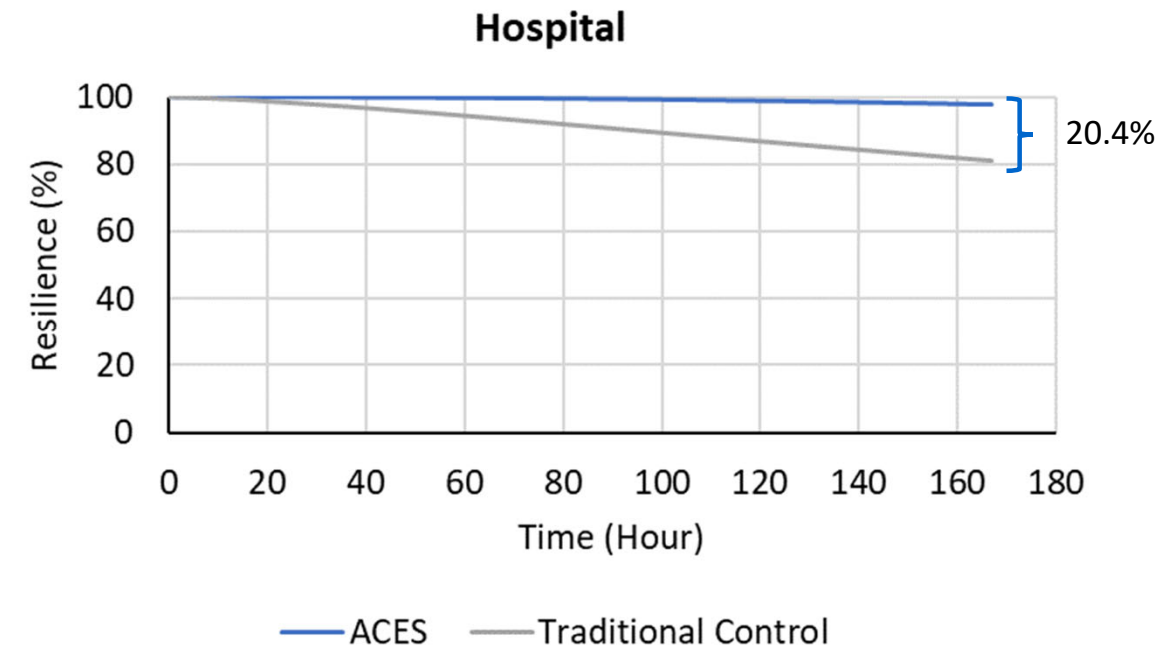


Microgrids for Islanded Resilience during Utility Outages

ACES energy management software can provide additional value to customers by improving the resilience of microgrids.

Survivability – Probability to serve critical load

Autonomy – Duration of time microgrid can serve 100% of critical load



Model Predictive Control for Microgrid Benefits

- ACES employs model predictive control (MPC) to schedule and dispatch individual DERs and controllable loads to accomplish financial goals (on-grid mode) and resilience goals (islanded mode)
- Two optimization functions are bounded by 40+ constraints

Economic Dispatch (on-grid mode)

$$\begin{aligned}
 J = & \sum_{t=1}^{T_h} \left(\underbrace{\left(\sum_{b=0}^{N^b} C_{OM}^b P_c^b(t, b) + C_{OM}^b P_d^b(t, b) \right)}_{\text{Battery O\&M}} t_{hf} + \underbrace{\left(C_{e,buy}^g(t) P_{buy}^g(t) - C_{e,sell}^g(t) P_{sell}^g(t) \right)}_{\text{Grid Energy Exchange}} t_{hf} + \underbrace{\left(C_{OM}^{ev} P_c^{ev}(t, b) + C_{OM}^{ev} P_d^{ev}(t, b) \right)}_{\text{Electric Vehicle Charging}} t_{hf} \right. \\
 & \left. + \underbrace{\left(\sum_{z=1}^Z \rho_z^{therm} (\tau_{sch,z}^b(t) - \tau_z^b(t)) \right)}_{\text{Controllable Thermal Loads}} t_{hf} + \underbrace{\left(\sum_{l=1}^L \rho_l^{cont} (P_{for,l}^{cont}(t) - P_l^{cont}(t)) \right)}_{\text{Controllable Electrical Loads}} t_{hf} \right) + \underbrace{\frac{T_h}{T_{bp}} \sum_{n=1}^{N_{TOU}} C_{dem,n}^g P_{max,n}^g}_{\text{Grid Demand Charges}}
 \end{aligned}$$

Resilience Dispatch (islanded mode)

$$J = \sum_{t=0}^T \left[\underbrace{\omega_{bat} \frac{P_{d,max}^b}{E_{max}^b} \left(\sum_{b=0}^{N^b} (E^b(t, b)) \right)}_{\text{Contingency Reserves}} - \underbrace{\omega_{fuel} \frac{P_{max}^{dg}}{P_{max}^{dg} t_{hf}} \left(\sum_{dg=0}^{N^{dg}} (F^{dg}(t, dg) F_{LHV}^{dg}) \right)}_{\text{Fuel Conservation}} - \underbrace{\frac{\omega_{load}}{t} (P_{us}^{crit}(t))}_{\text{Critical Loads}} \right]$$

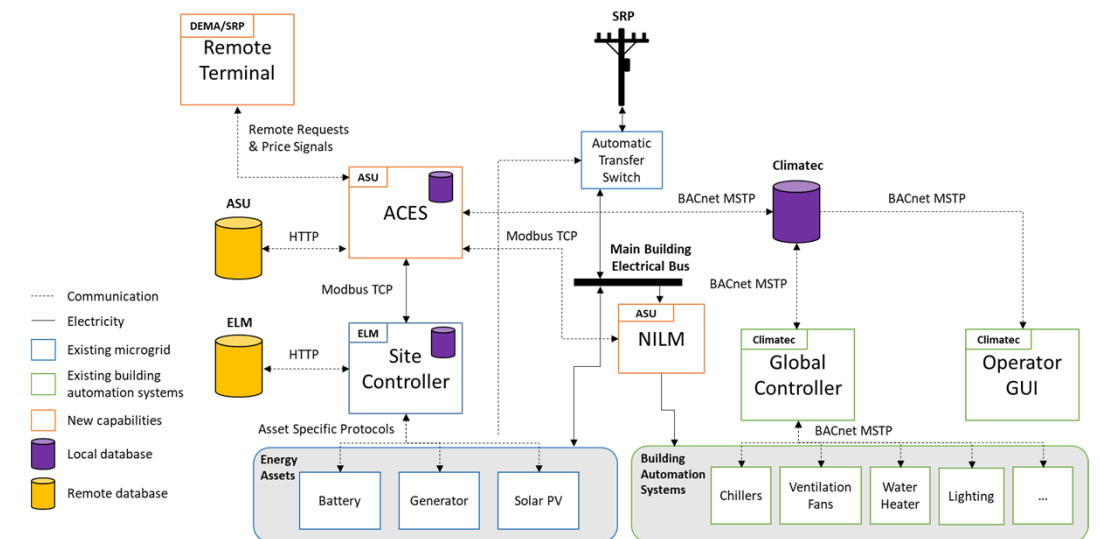
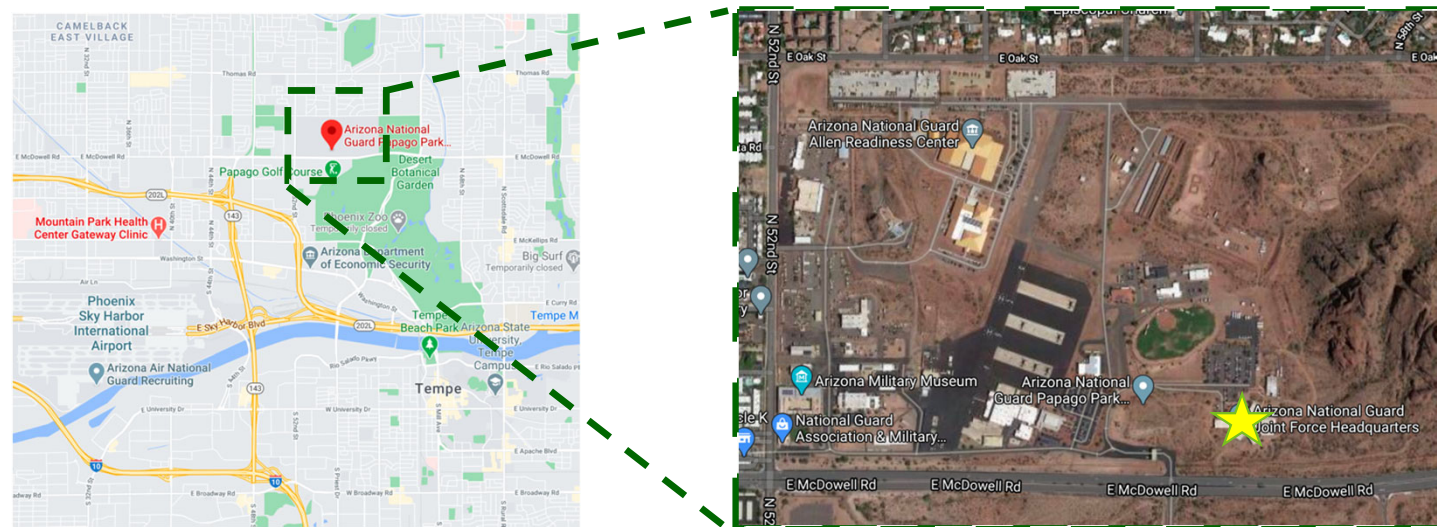
ACES Site Demonstration

AZ Department of Emergency and Military Affairs – Over 8,000 personnel across 20 sites in Arizona.

Papago Park Military Reservation (Phoenix, AZ) – Two feeders supplying DEMA from SRP. Carport Solar and BESS onsite with ELM sight controller. Backup generator to be installed.

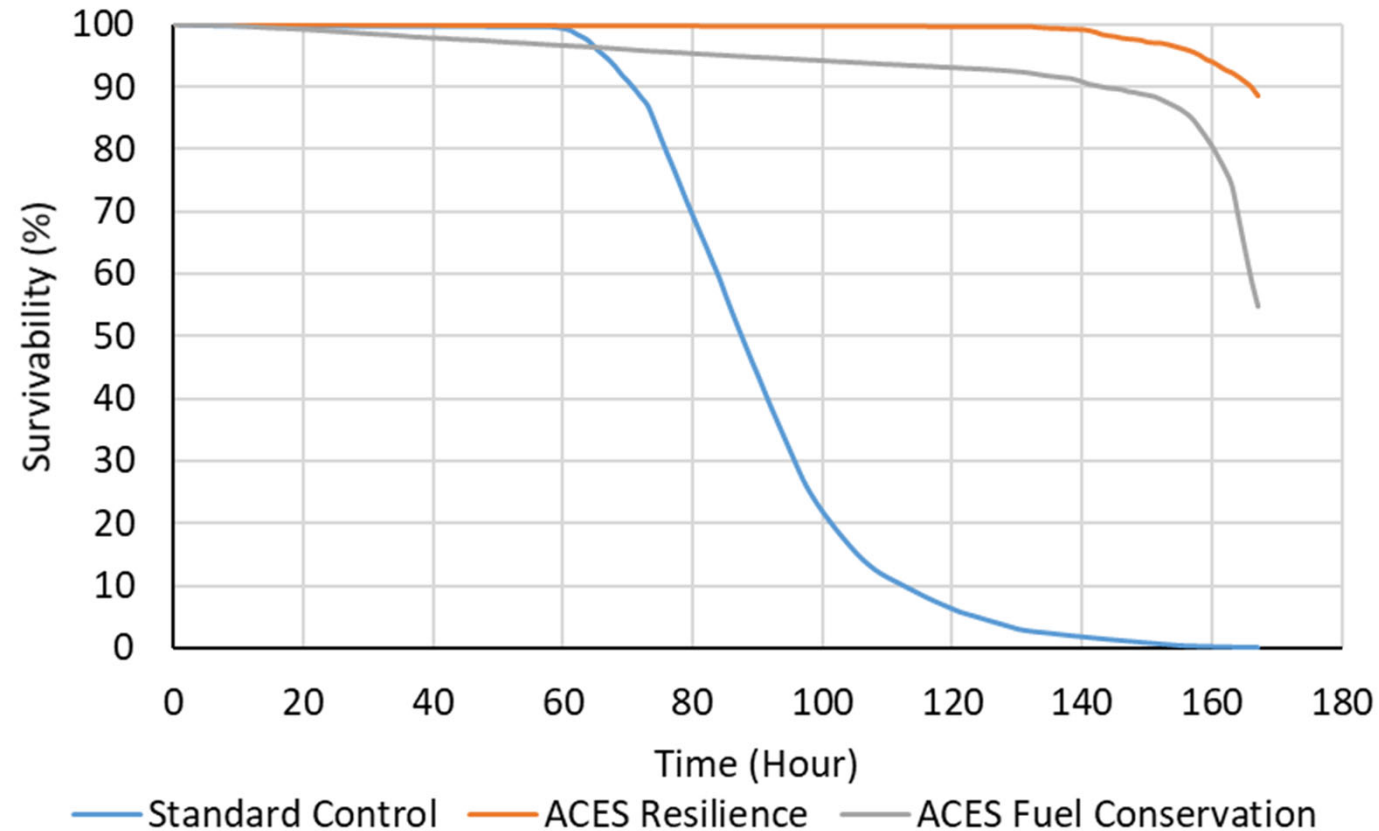


AZ DEMA HQ (demonstration site) – Climatec BAS for building load control



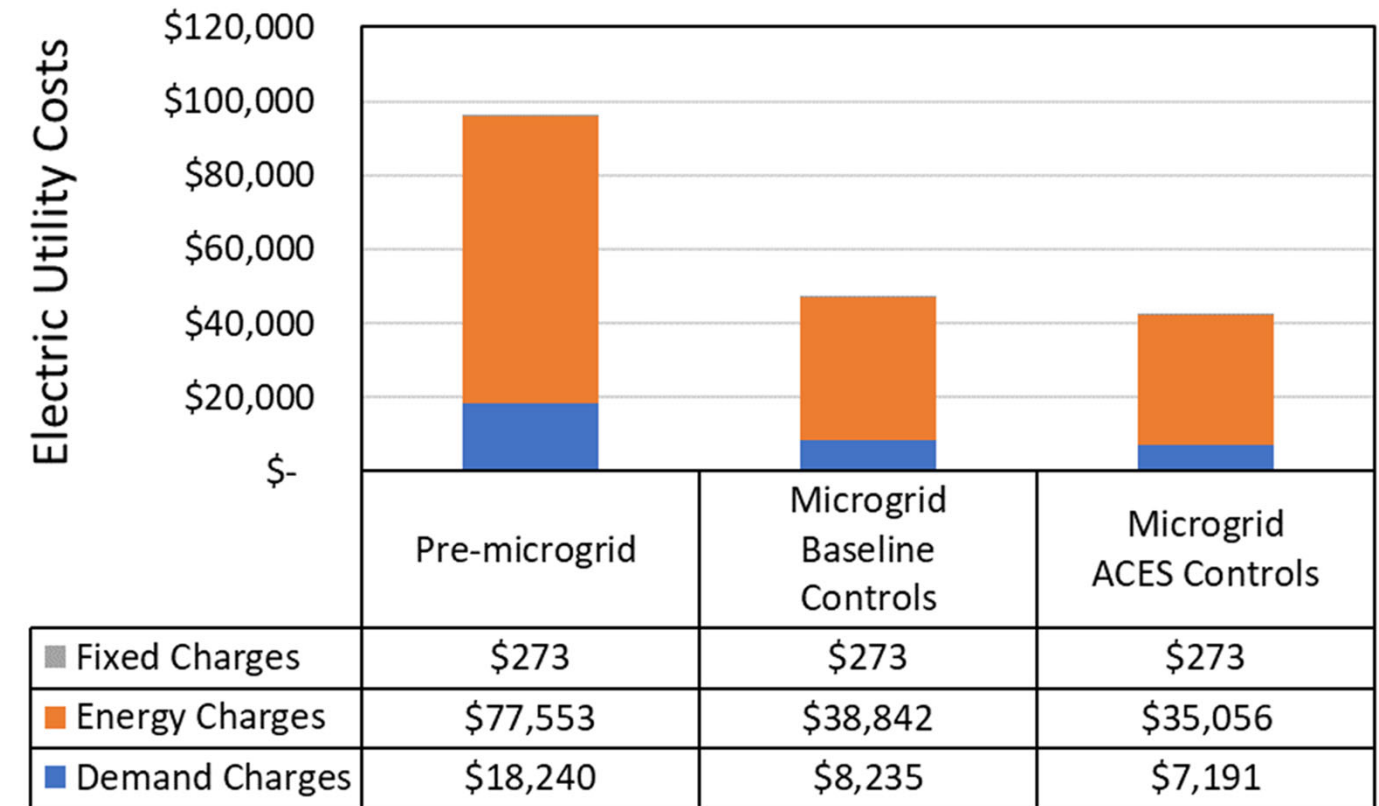
Benefits of Optimized Control

Resilience Benefits



Control Method	Autonomy (hrs)	Fuel Use (gal)
Standard Control	81	1000
ACES Resilience	168	843
ACES Fuel Conservation	168	744

Economic Benefits



\$25,200 / yr



333 kW



250 kW / 250 kWh



114 kW avg.



350 kW

ACES Commissioning



- Integrated ACES with site load monitoring, climate control, and microgrid control
- 1 year of monitoring/testing to collect data for forecasting
- 1 year validation of benefits from ACES controls




Thank you!

For more information, please contact:



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