Modeling Data Centers using CMLD

NERC LMWG

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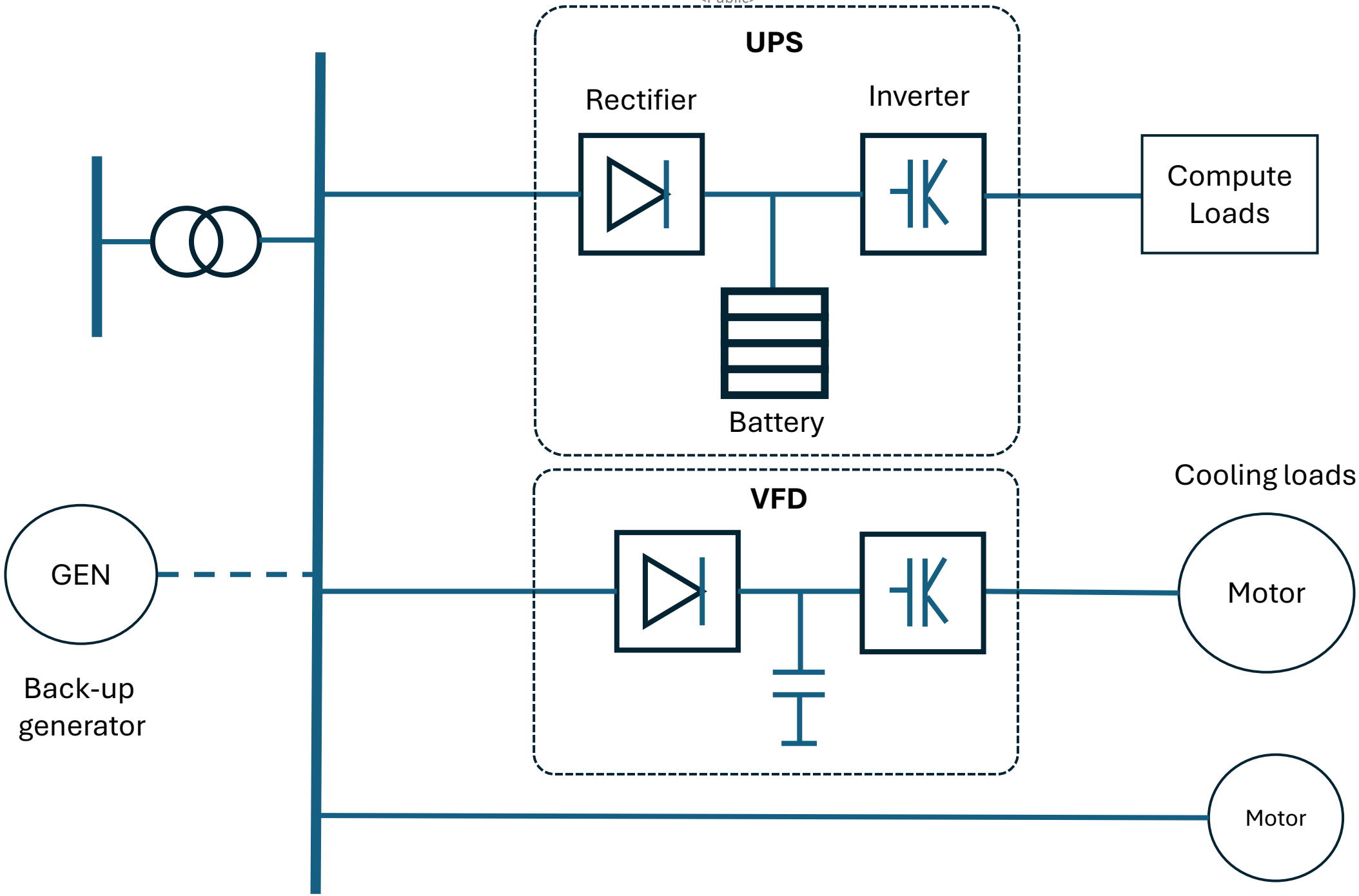
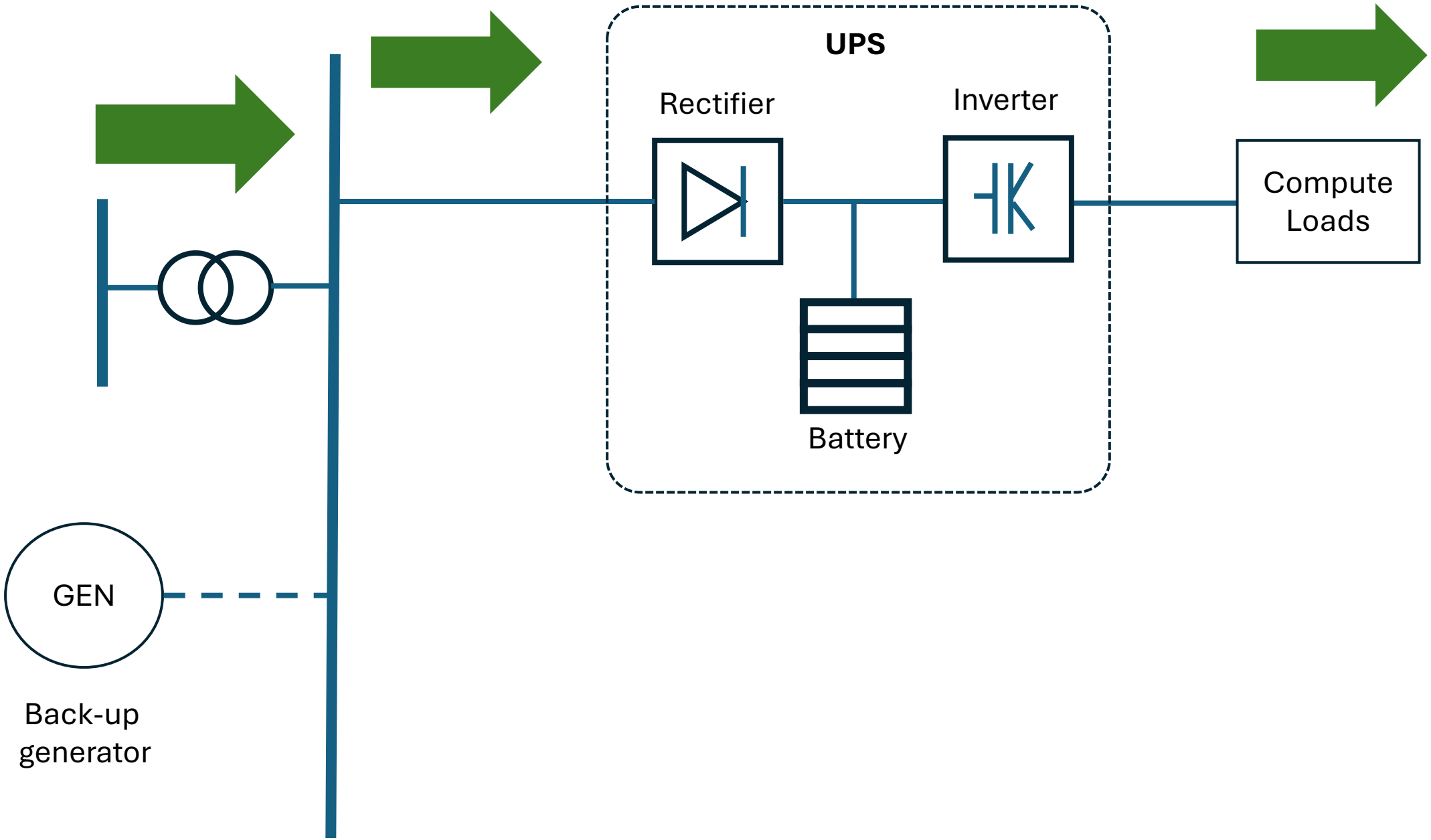
What's inside a data center

Based on presentation given by Stephen Jenkins at PNM:

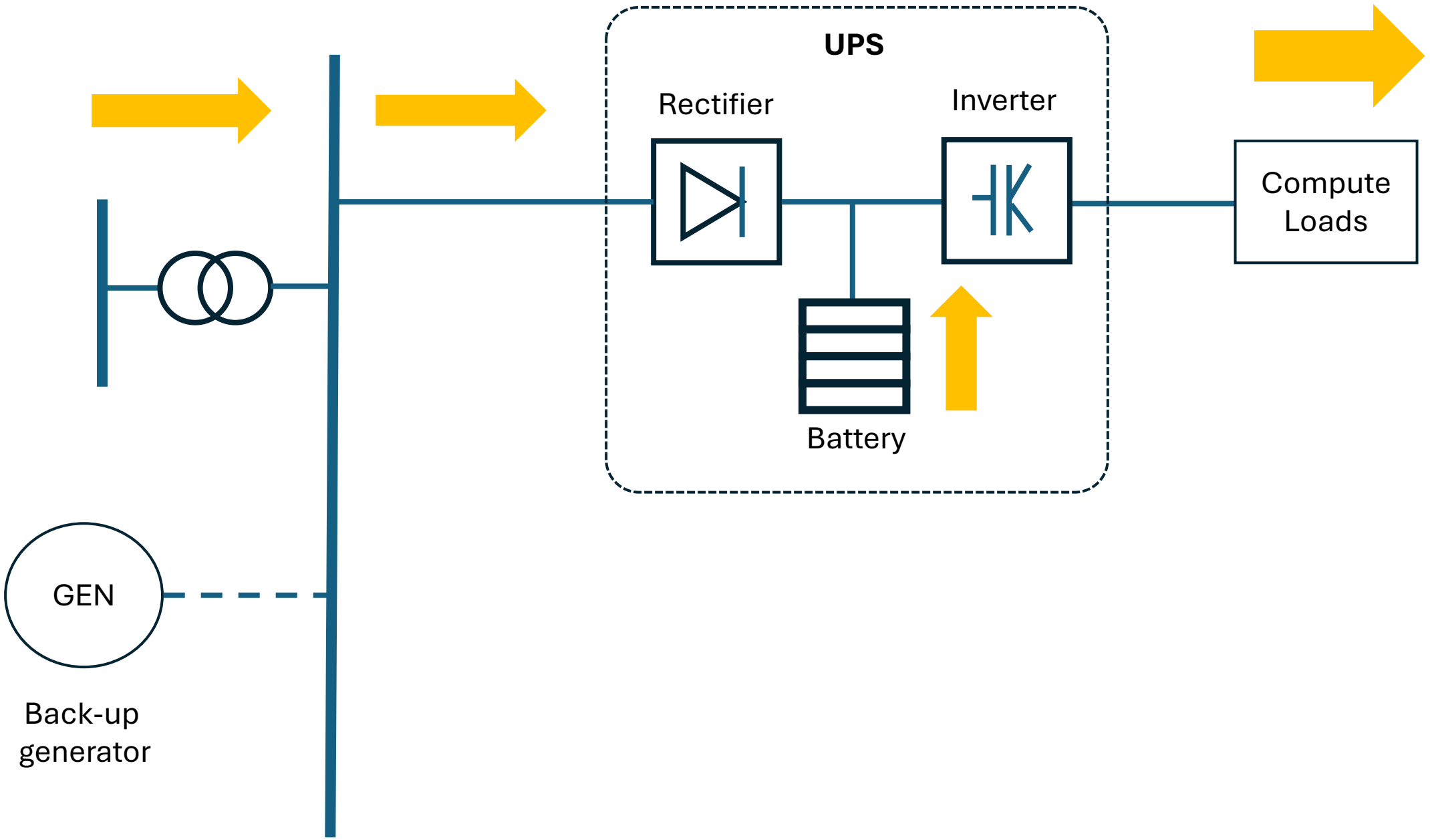
- Server and network loads are the majority, 90% plus,
  - Backed up by UPS (network and local)
- Cooling loads are 5% to 10%
  - Evaporative (direct adiabatic) cooling is the most economical and common to use, 100% VFD driven fans and pumps
  - Indirect adiabatic cooling is the next most common combines two evaporative stages , also 100% VFD driven fans and pumps
  - Air-conditioning is most inefficient but is used where high humidity is a concern


UPS
Rectifier
Inverter
Compute Loads
Battery
VFD
Cooling loads
GEN
Motor
Back-up generator
Motor

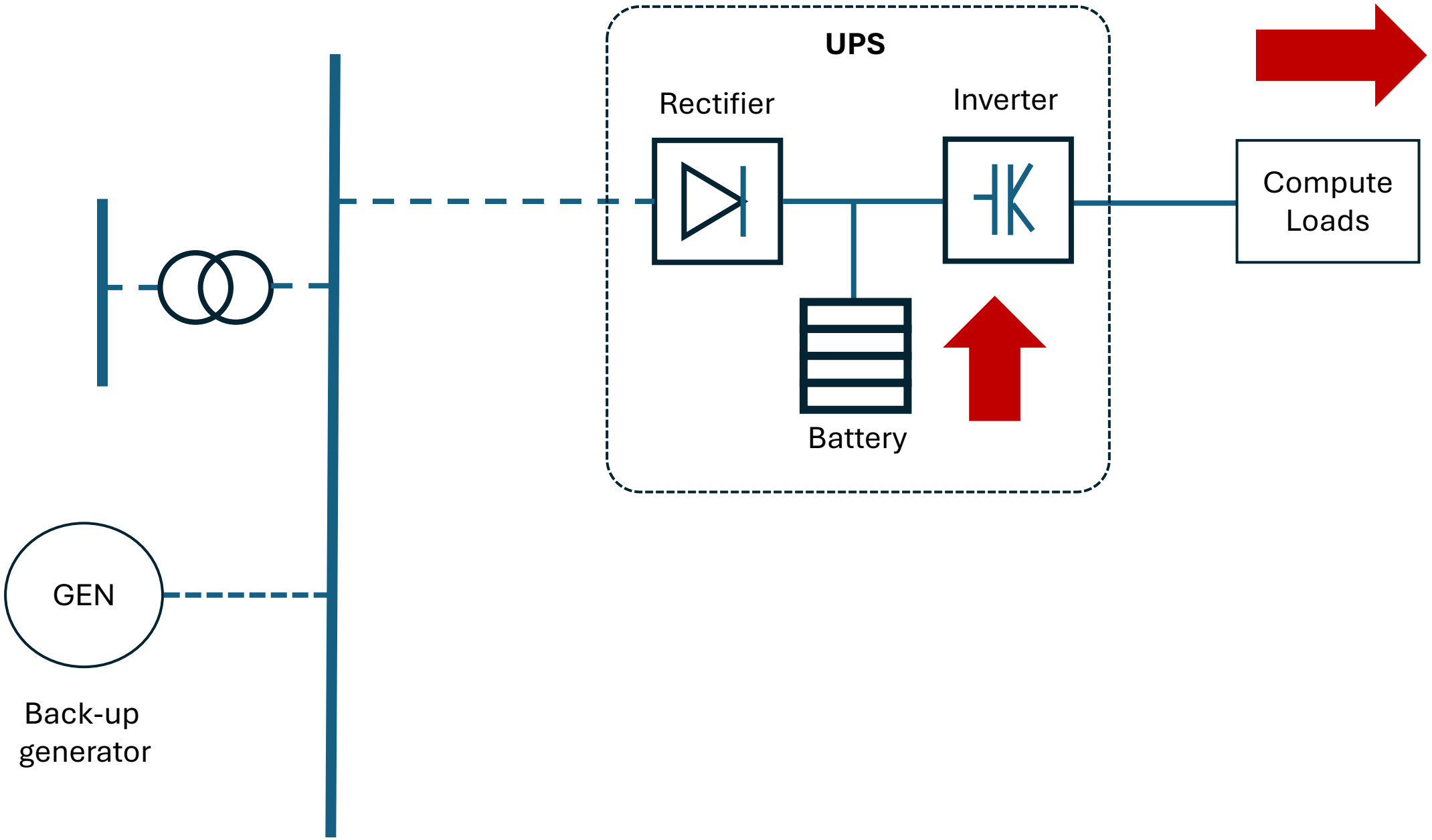
“Normal” Voltage 85 to 110%



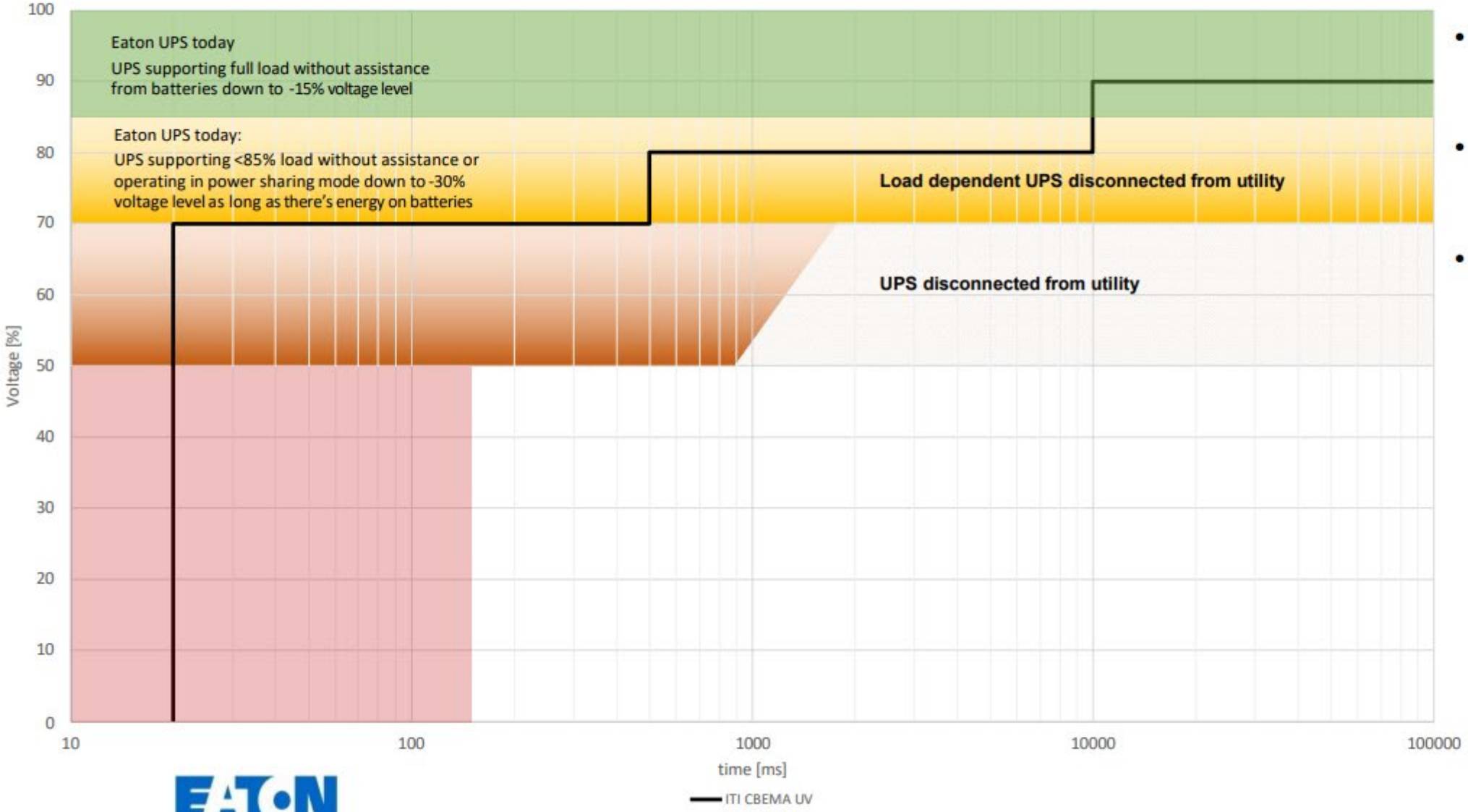
Low Voltage 70 to 85% power sharing mode



Very Low Voltage below 50-60% for several cycles



UPS Operation - Typical



- Designed to protect critical load from power anomalies
- Disconnect from utility and use batteries to support load
- Reconnect to utility or generator when voltage/frequency stabilized

Powering Business Worldwide

Data Center Modeling Using CMLD

Load Composition for dry climate (with evaporative cooling)

- Set “Fma”, “Fmb”, “Fmc”, Fmd” to 0
- Set “Fel” to 1.0 (representing both UPS and VFD loads)

Load Composition for humid climate (with air-conditioning cooling)

- Set “Fma” to 0.1 (representing air-conditioner chillers)
- Set “Fmb”, “Fmc”, Fmd” to 0
- “Fel” is set to 0.9 (representing both UPS and VFD loads)

Data Center Modeling Using CMLD

Power Electronic Component Model

- “Pfel” is set to 1.0 load power factor
- “Vd1” is set to 0.85 voltage at which progressive disconnection starts (compute load is starting to be supplemented with battery)
- “Vd2” is set to 0.5 (?) voltage at which progressive disconnection ends (compute load is supplied by battery, UPS is disconnected from the grid)
- “Frcel” represents how much of power electronic load is restored following voltage recovery.
  - CMLD assumes instantaneous load recovery as voltages are restored, while UPS will have a time delay to make sure grid voltages are stable before transferring load to the grid, and the transfer will include a ramp
  - It will be very instructive to see what happens if all the load comes back at once “Frcel” = 1.0, or when the compute load stays connected to battery, “Frcel” = 0 as book ends of system performance.

Future Model Developments

- Transition to modular CMLD is required to enable more accurate data center modeling
- More accurate dynamic CMLD component models need to be developed and implemented for UPS and VFD loads:
  - Retain progressive load disconnection
  - Adding time delays for UPS load recovery
  - Adding ramp rates for UPS load recovery
  - …