Eaton's Energy Transition Overview

Presentation for IEEE SusTech

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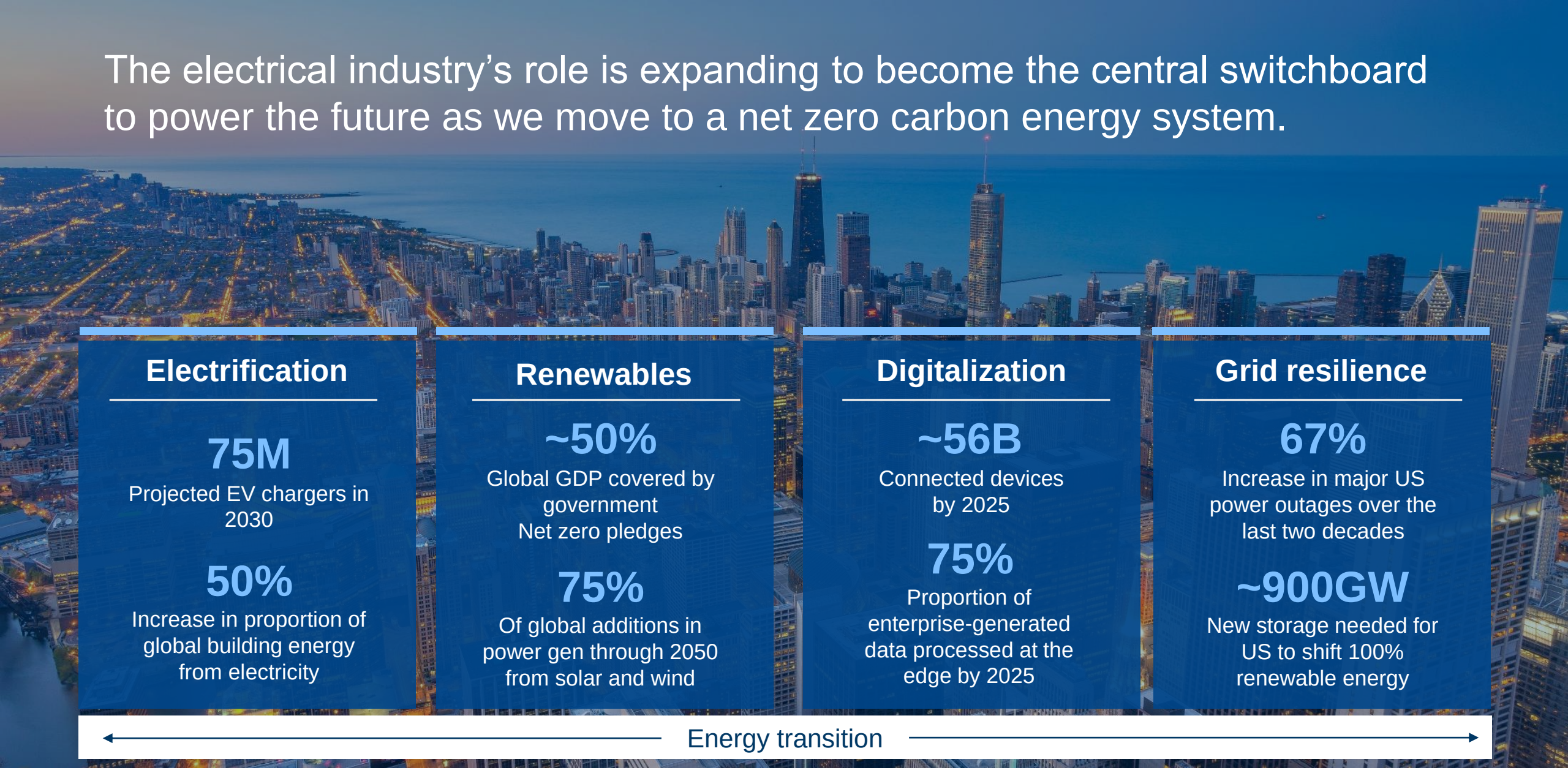
Powering Business Worldwide

The electrical industry's role is expanding to become the central switchboard to power the future as we move to a net zero carbon energy system.



Electrification

75M
Projected EV chargers in 2030

50%
Increase in proportion of global building energy from electricity

Renewables

~50%
Global GDP covered by government Net zero pledges

75%
Of global additions in power gen through 2050 from solar and wind

Digitalization

~56B
Connected devices by 2025

75%
Proportion of enterprise-generated data processed at the edge by 2025

Grid resilience

67%
Increase in major US power outages over the last two decades

~900GW
New storage needed for US to shift 100% renewable energy

Energy transition

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The energy transition will require flexible energy systems.

EVERYTHING AS A GRID is our approach to reinventing the way power is distributed, stored and consumed. With advanced technologies and digital intelligence, we are unlocking a low-carbon energy future for all.

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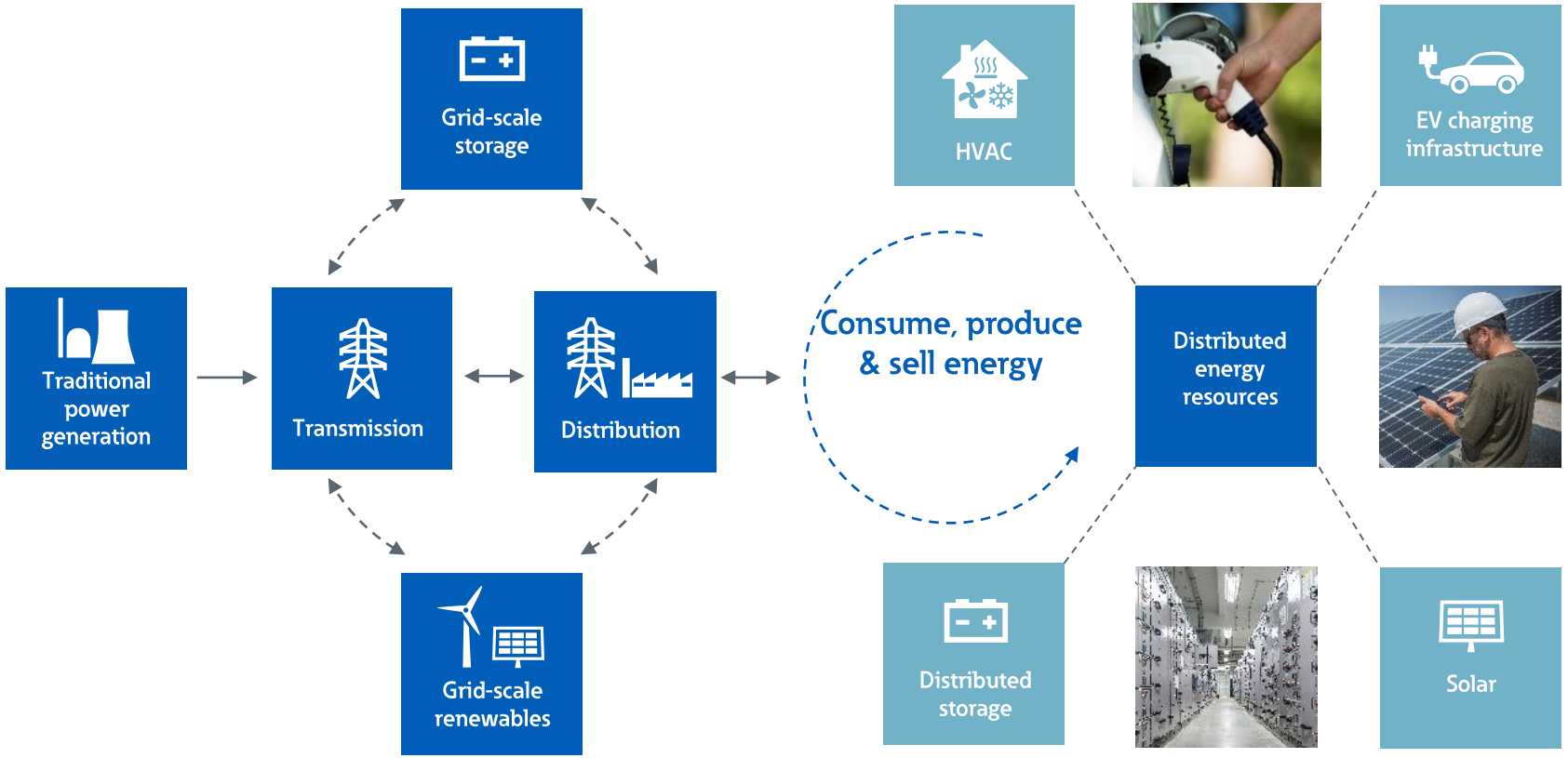
The new power landscape

EVERYTHING AS A GRID



Enabling customers to safely add more renewables, storage and electrical vehicle infrastructure to their energy mix.

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Mining, metals, minerals commercial buildings applications

Reliability and efficiency to maximize ROI and safety

Products, solutions and services to design, build and operate for resiliency and a low-carbon energy future

- Commercial power distribution products
- Backup power, UPS, surge & IT power distribution
- Conduit, cable & wire management solutions
- Intelligent energy management software
- Indoor and outdoor lighting and control solutions
- Microgrid and DER solutions
- EV charging infrastructure
- Service – power systems engineering, turnkey project management
- Furniture for technology-intensive environments

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Brightlayer Industrial suite

A new perspective on scalable software solutions.

Optimize your operations

- Remotely capture data and insights from power equipment in dangerous environments
- Increase power and operational reliability with proactive maintenance

Leverage actionable insights

- Recognize and remediate issues before failure occurs
- Extend equipment life and increase revenue-generating potential

Improve safety and compliance

- Dispatch personnel with the right tools, parts and protective gear
- Capture data to support environmental and sustainability goals

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Buildings require a comprehensive infrastructure solution to enable sustainable, resilient and cost-effective performance

Eaton's comprehensive EV charging infrastructure offerings include equipment, software and engineering services solutions to meet EV charging project requirements.

EV charging
AC Level 2 and DC level 3 fast chargers for residential, commercial, and fleet operations

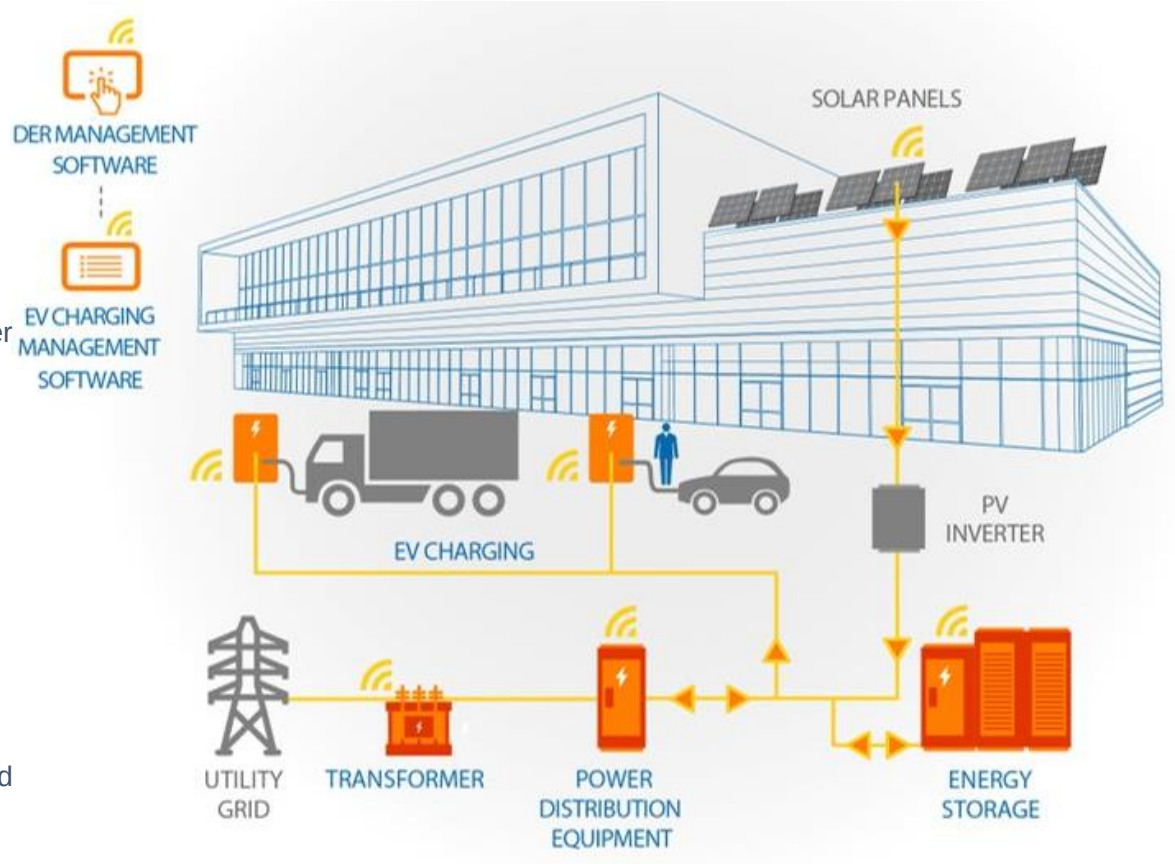
Battery storage
Eaton xStorage Battery Energy Storage System (BESS) includes batteries, inverters and management software to shave peak demand cost for EV charging applications

EV Charge management software
Enables users to operate a network of charging stations, from charging point management and power management to financial rules

Microgrids and Distributed Energy Resource (DER) integration
Incorporate local solar photovoltaics and other renewables into new or existing infrastructure to maximize charger deployment and help meet sustainability goals

Power distribution equipment and grid connection upgrades
Installation and upgrades of electrical equipment, including transformers, switchgear, switchboards, and panelboards

Electrical engineering services
Includes feasibility analysis of planned EV deployment sites, power systems analysis of electrical infrastructure, electrical system conceptual design and configurations, system protection analysis and recommendations, automation and control solutions and turnkey electrical services



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Eaton's full EV Charging Infrastructure portfolio works together to simplify fleet electrification & enables lower TCO

	AC charger range			DC charger range	Power distribution equipment	Energy storage	Digital solutions	
	Eaton Green Motion EV Smart Breaker Charger	**Eaton Green Motion Building Series**	**Eaton Green Motion Fleet Series**	**Eaton DC Fast Charger**	**Eaton Broad Portfolio of Power Distribution Equipment**	**Eaton xStorage BESS**	**Eaton Green Motion EV Charger Manager app**	**Eaton EV Charging Network Manager (CNM)**
								
Max output power rating	7.7 kW @ 240 Vac	7.7 -11.5 kW @ 240 Vac	19.2 kW @ 240 Vac	50kW to 150 kW @ 480Vac	120 Vac – 38 kVac	250kW-1MW / 250kWh/340kWhr rating		
Residential private	●				●		●	
Multi-tenant residential	●	●	●		●	●		●
Workplace and Community		●	●	●	●	●		●
Fleet and Highways			●	●	●	●		●

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AC vs DC Charging

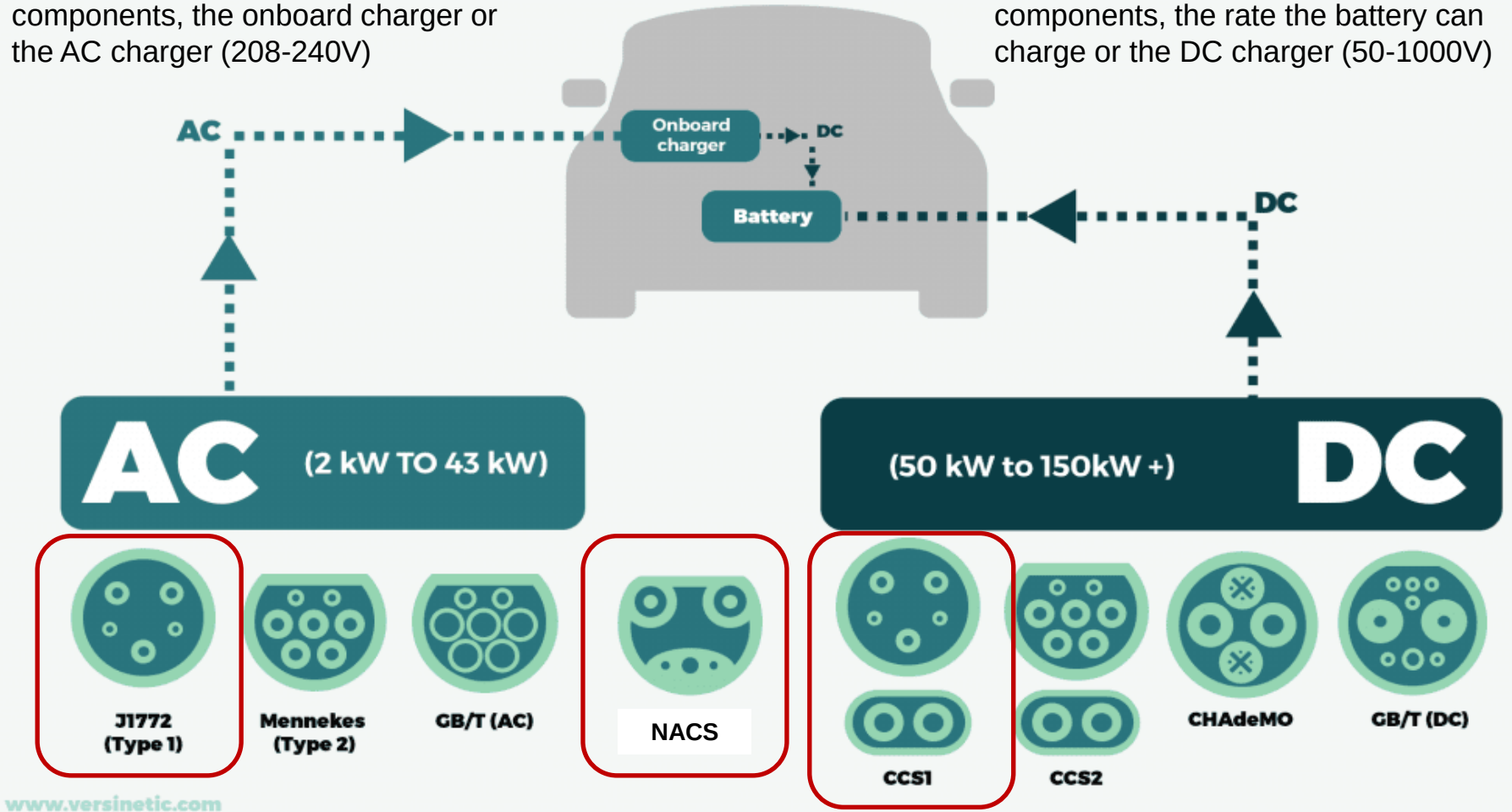
AC Level 1
- 120V
- Home
- Up to 2.4kW

AC Level 2
- 240V
- Home / Public / Fleet
- Up to 19.2kW

Fast DC
- 400-1000V
- Public / Fleet
- 50kW and higher

AC is limited by the lowest of the two components, the onboard charger or the AC charger (208-240V)

DC is limited by the lowest of the two components, the rate the battery can charge or the DC charger (50-1000V)



Note: All but Stellates and Volkswagen are offering NACS, it is assumed they will adopt

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Vehicle charging example

90 kWh battery (typically charge 20% to 80%)
Time (h) = 0.6 x 90 kWh / (rating of charger)

Rating of charger	Location	Charger Type	Charger Ampacity	240V Charge Time	208V Charge Time	30 Miles Charge Time
7.7kW	Home	Level 2	32A	7.0 hours	8.1 hours	1.3 hours
9.6kW	Work / Public	Level 2	40A	5.5 hours	6.5 hours	1.0 hours
11.5 kW	Work / Public	Level 2	48A	4.75 hours	5.4 hours	0.9 hours
19.2 kW	Fleet / Public	Level 2	80A	2.75 hours *	3.2 hours	0.5 hours
Rating of charger	**Location**	**Charger Type**		**400-1000VDC**		**30 Miles Charge Time**
50 kW	Public	Fast DC		1.0 hours		12 minutes
150 kW	Public	Fast DC		30 minutes		4 minutes

* If onboard converter is 11.5 kW then the time will be 4.7 hours

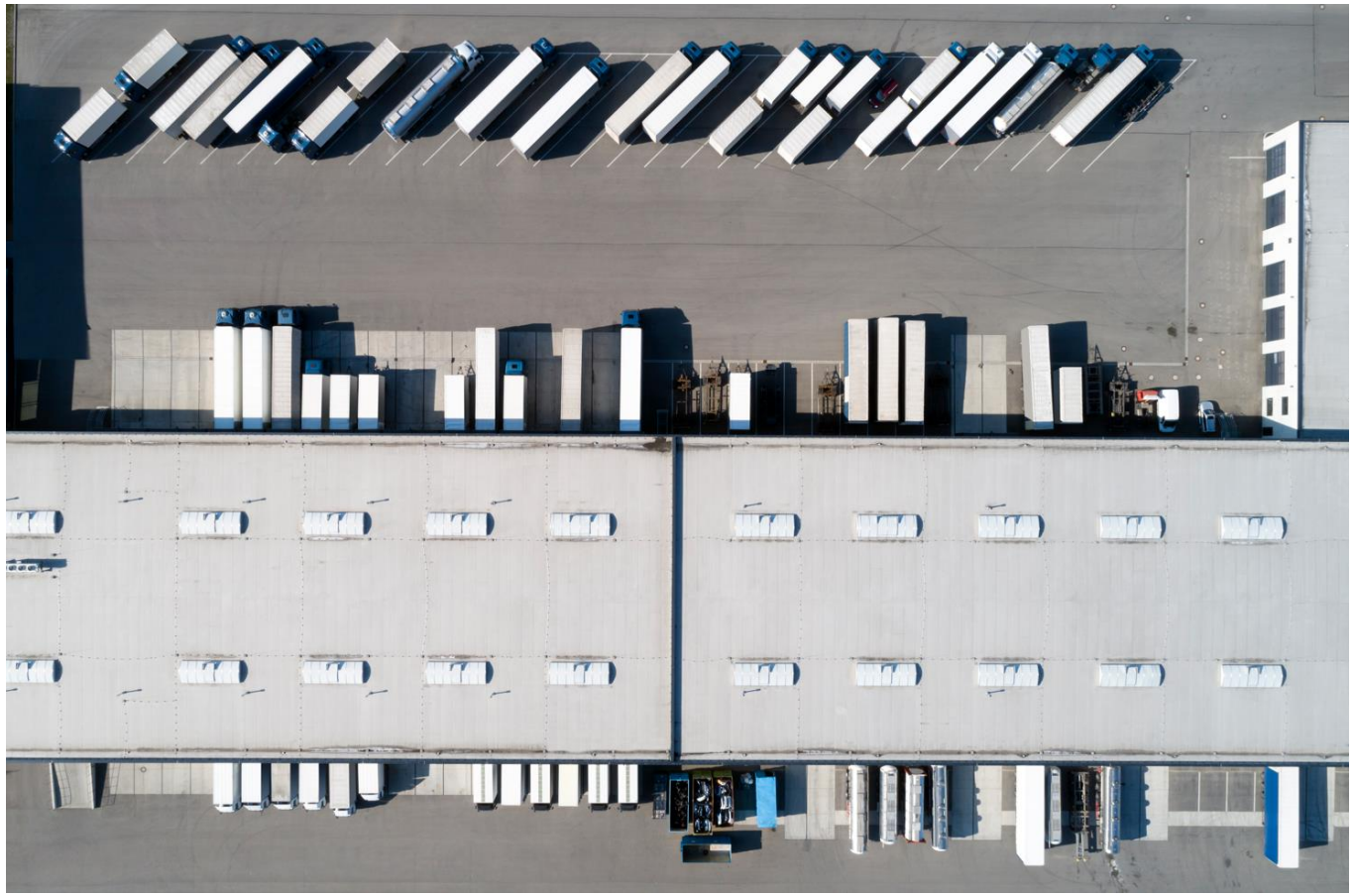
Case study: Impact of truck electrification on the grid

Depot Characteristics:

- 100 Class 6 trucks
- 30 Class 8 trucks
- Site load today ~ **500 KW**

Electrified Depot:

- Class 6 trucks: ~ 100 kWh per day
  - 10,000 KWh in 8 hours = **1250 kW** (@ 100% LF)
- Class 8 trucks: ~ 400 kWh per day
  - Overnight charging
    - 12,000 kWh in 8 hours = **1.5 MW**
  - Slip-seating (multi-shift)
    - 400 kWh in 45 min = ~550 kW per vehicle
    - Assume 4-6 vehicles charging = **2 – 3 MW**



Depot's load on the grid can go from 2.5X to 6 times based on charging deployed

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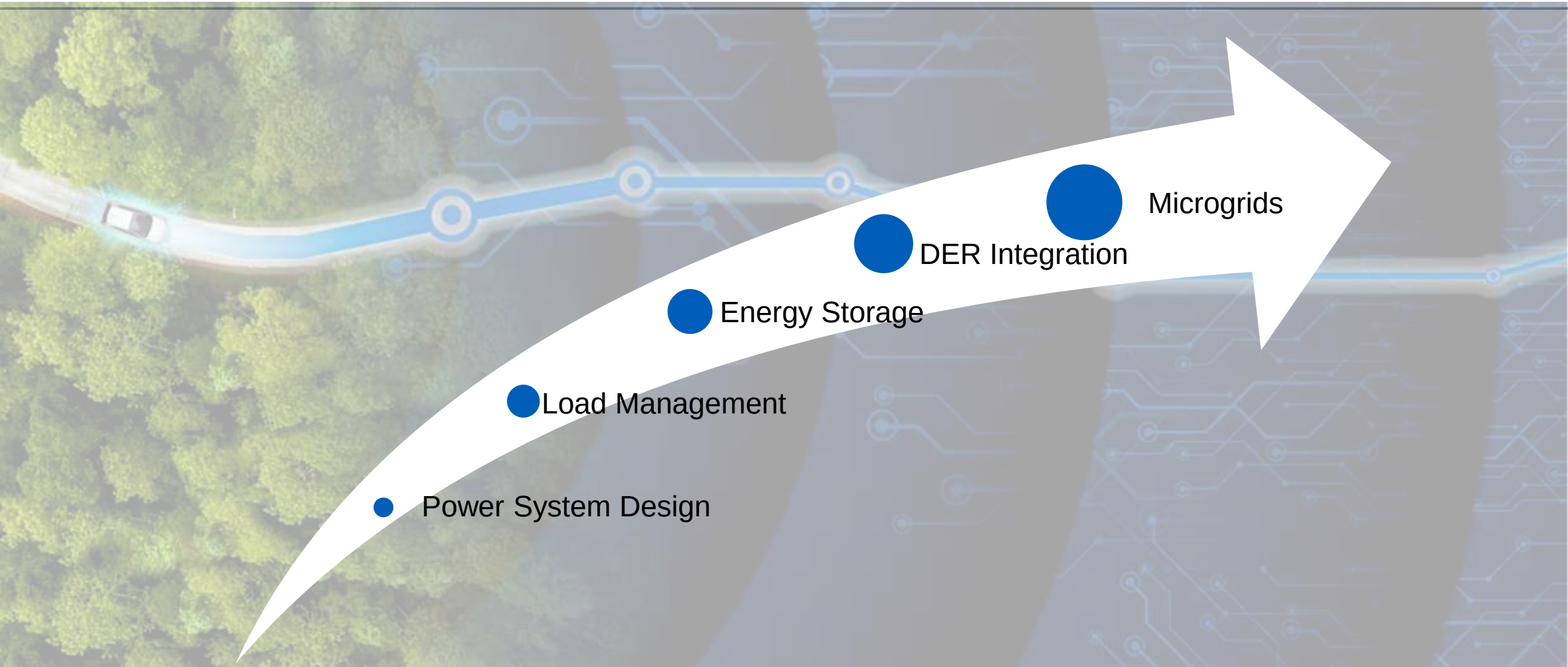
Hierarchy of Dealing with Power Scarcity



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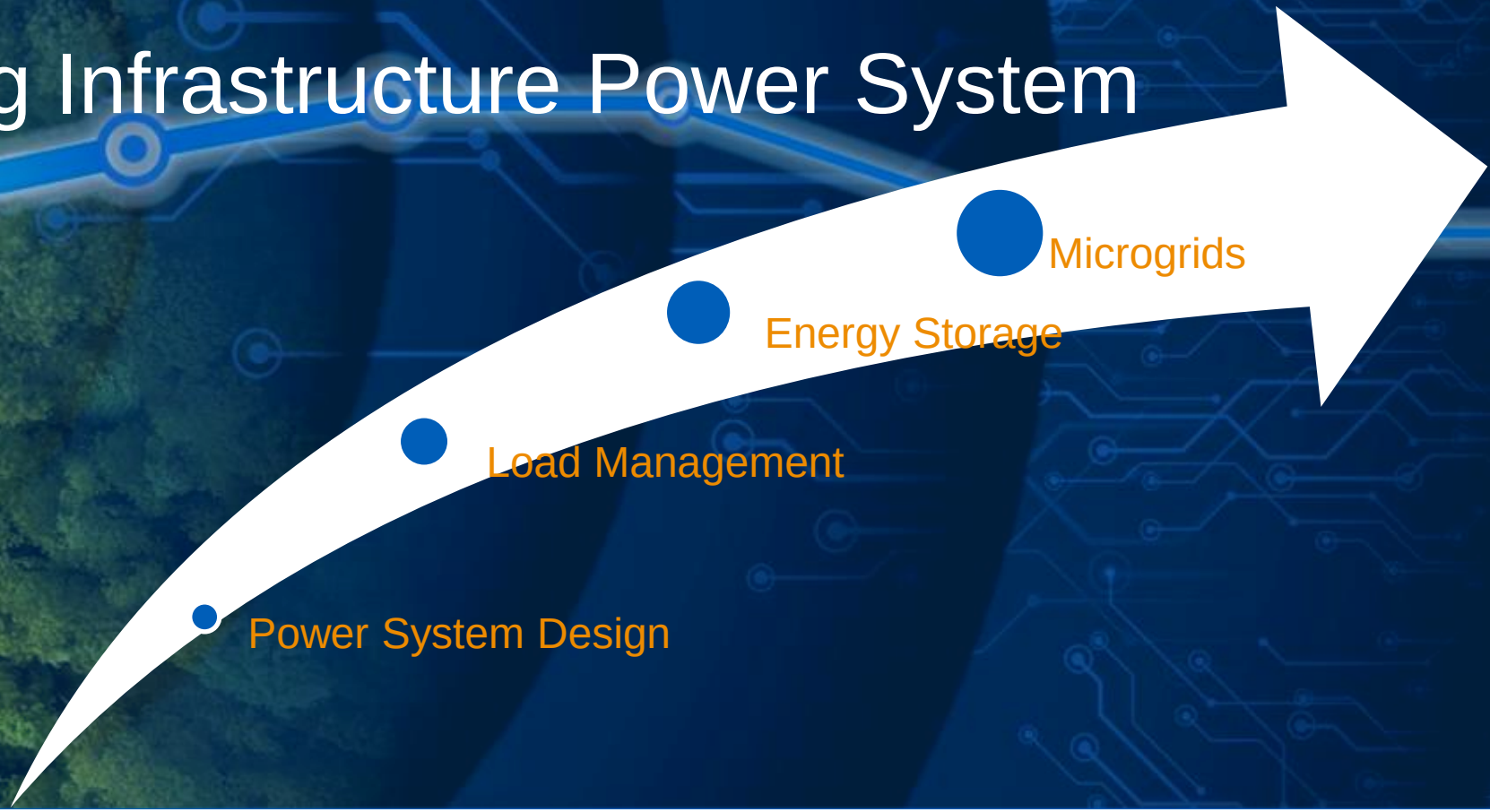
EV Charging Infrastructure Power System Design



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Green Motion EV Smart Breaker Chargers
Flexible installation and integration options

- 32A (7.7kW @ 240V) AC Level 2 Charger with integral **communications**, **control & revenue grade metering**
  - 2P 40A BR & BAB styles
- Energy Star Certified
- Open approach through cloud APIs and OCPP enables integration with your preferred charging management solution.
  - OCPP = Open Charge Point Protocol
- The universal J1772™ charging connector is compatible with any EV meeting the SAE J1772™ charging standard
- UL listed and tested for electrical safety and features 20mA ground fault protection

EV Smart Breaker Charger

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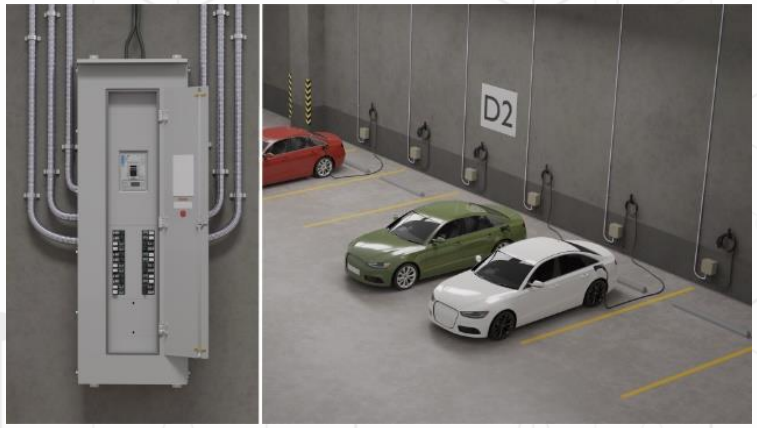
EV charging integrated assemblies for scalable EV Charging deployments



EV Charging integrated Panelboards

- EV Charging Smart Breakers (EV Chargers) integrated in panelboards for cleaner, cost effective installations
- Expandable up to 10 Chargers per Panelboard for PRL3X designs and up to 18+ Chargers in IFS (Integrated Facility System) switchboard
- Better protection against vandalism, expensive components hidden inside a supply closet
- Ideal solution for depot charging where scalable EV systems are needed
- Optional 4G connectivity with external hotspot

EV Charging integrated Busway

- EV Charging integrated Busway designs for cost effective, scalable EV Charging deployments
- Offering for 19.2kW (80A) and 7.7kW (32A) charging
- Utilizes existing plug-in busway
- Expandable up to 25 Chargers per 2500A run.
- New designs improve moisture resistance for plug-in busway
- Ideal solution for depot charging where scalable EV systems are needed
- Optional 4G connectivity with external hotspot

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Green Motion Fast DC

Positioning

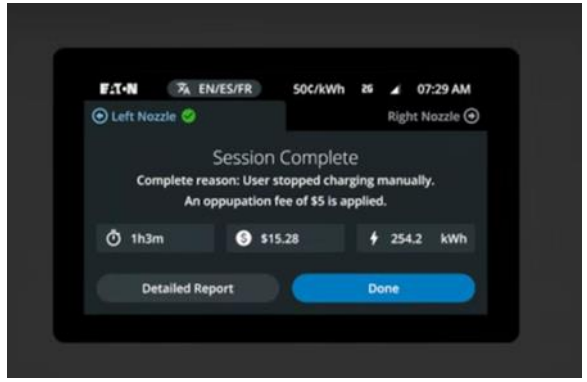
- Fleet and public parking where high output high speed charging is required

Specification

- 50-150kW dual and single nozzle design
- 480V three phase power input
- CCS1 nozzle
- Support current and future EVs with 400-1,000 Vdc charging
- Small footprint at 150 kW when compared to other solutions
- Support OCPP 1.6J (Open Charge Point Protocol)
- Various payment methods available through CNM

Warranty

- 2 years parts



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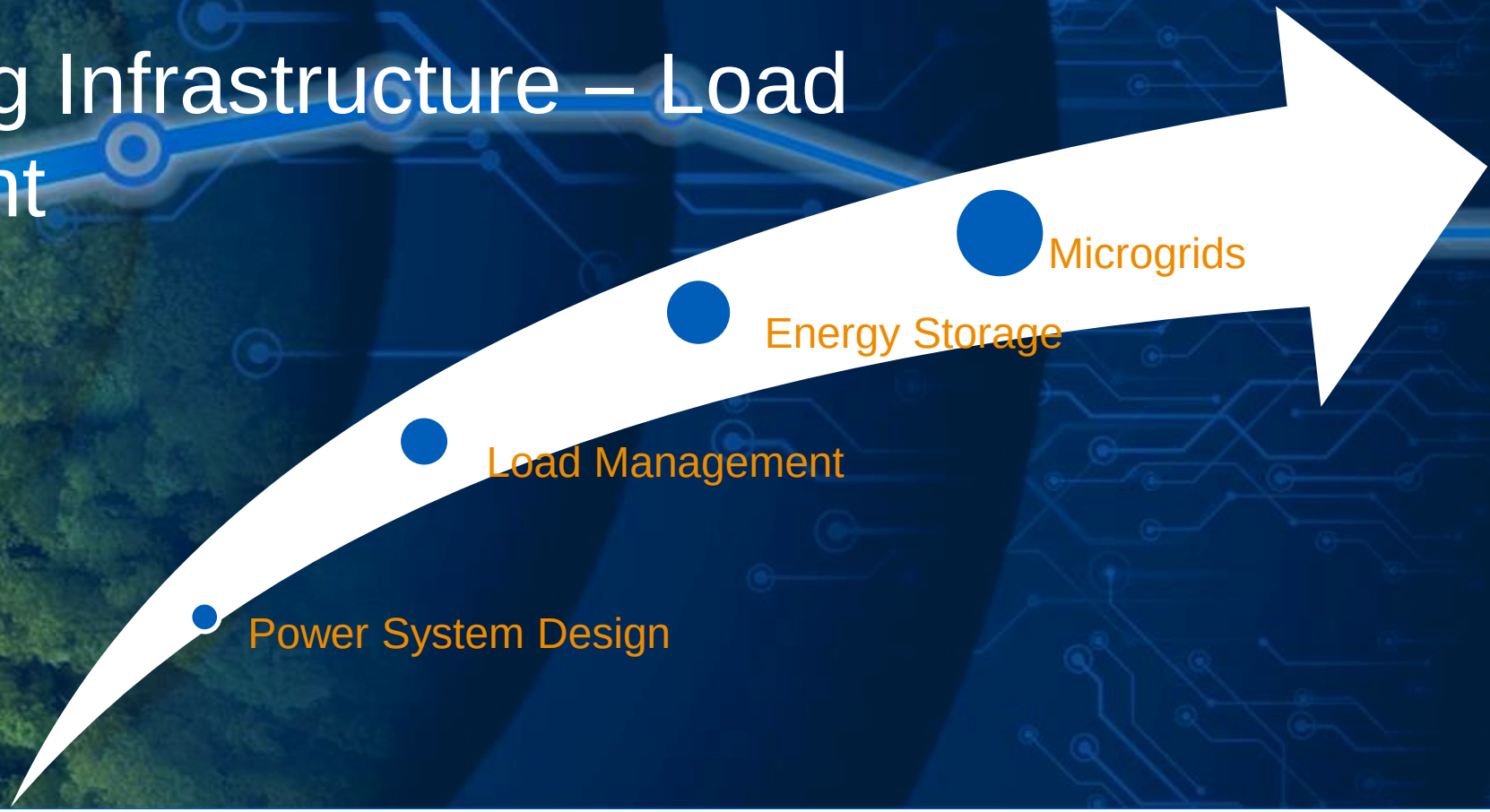
EV Charging Infrastructure – Load Management



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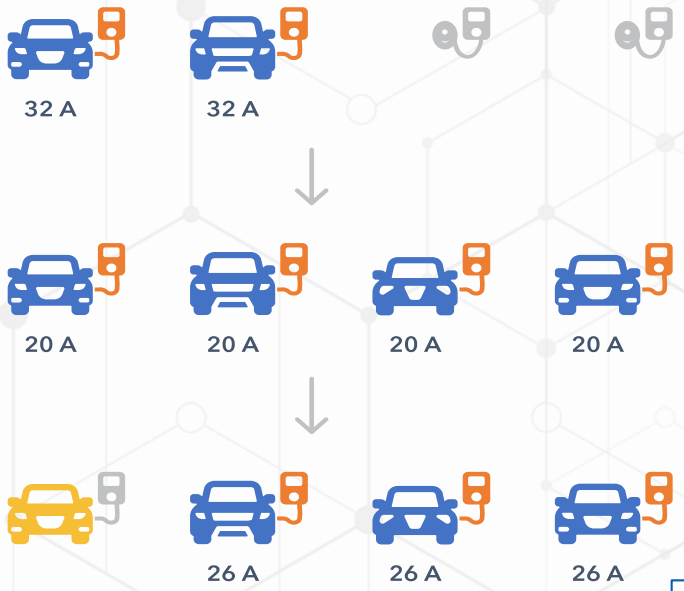
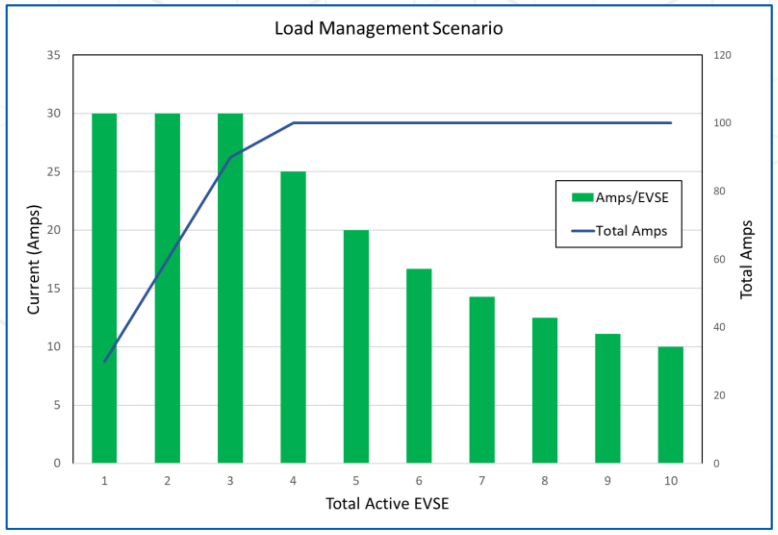
Power Management





- Creates a virtual twin electrical panel with both EVSE and uncontrolled loads
- Allows site hosts to install more chargers on a limited electrical service
- Output amperage is automatically adjusted based on the number of vehicles plugged in to a group of chargers

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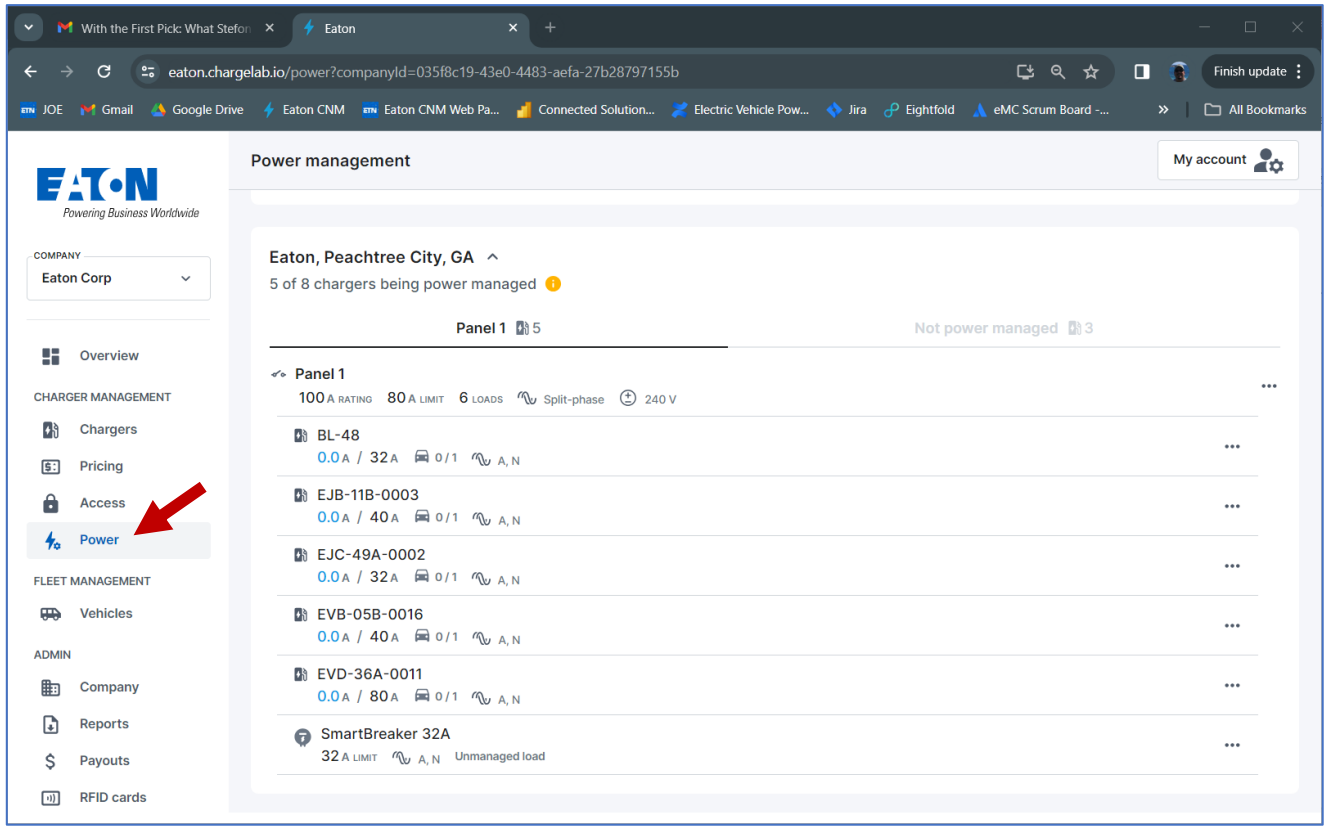
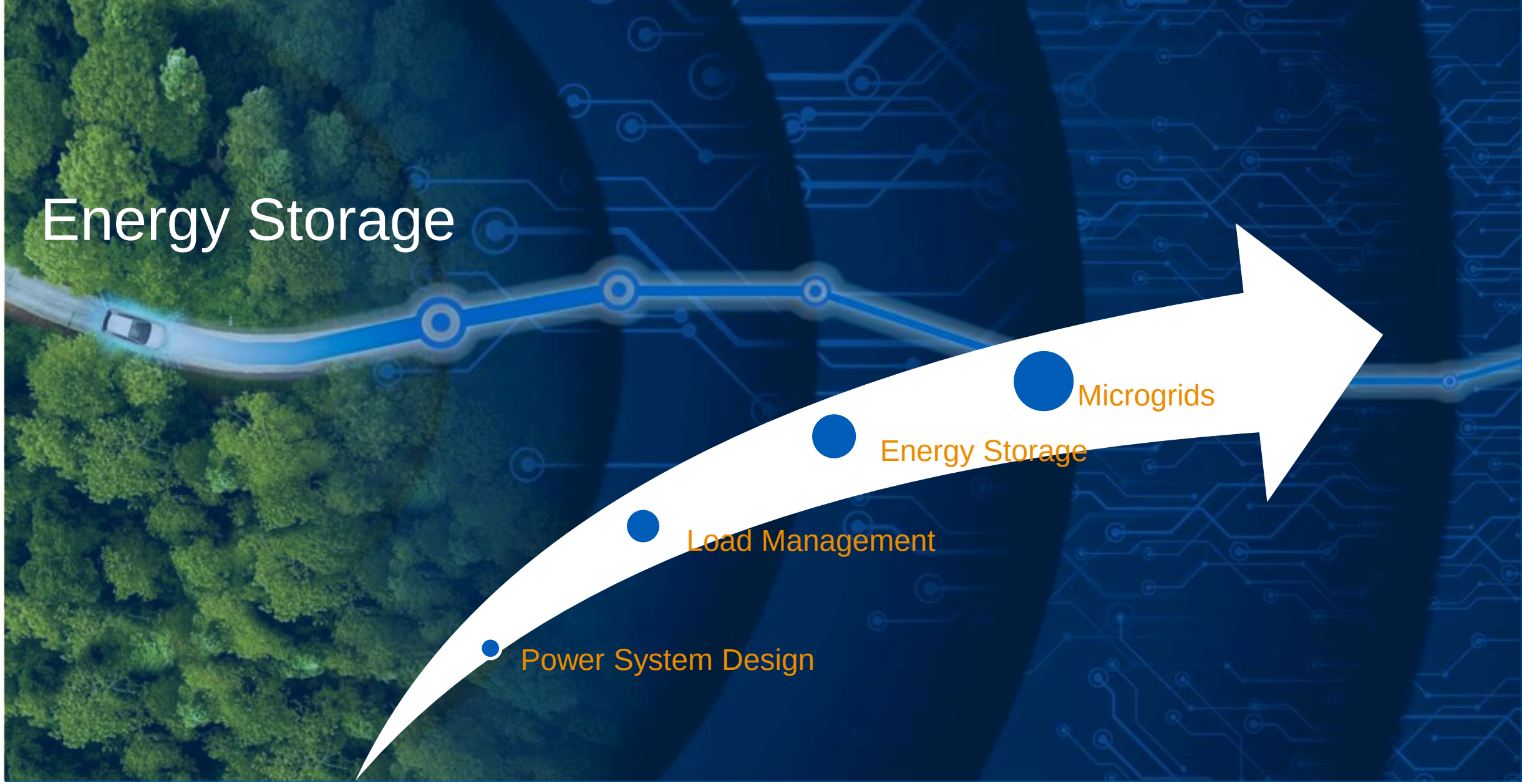
CNM Features Delivered

- Power Management
  - Proportional sharing across a group of EVSE
  - Single phase and 3 phase
  - Load leasing model to protect in event of network outage
  - Accommodation for reserved loads
  - Requires assisted setup process



Energy Storage



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xStorage 250-1000 BESS

Product overview

Power: 250 to 350kW
Usable energy: 250 or 340kWh
Installed energy: 279 or 372kWh

Power: 250 to 700kW
Usable energy: 500 or 680kWh
Installed energy: 559 or 744kWh

Power: 250 to 1,000kW
Usable energy: 750 or 1,020kWh
Installed energy: 839 or 1,117kWh

Applications	Energy functions	Environment	Listings
• EV fast charging • Community buildings • Commercial buildings • Industrial facilities • Microgrids	• Peak shaving • Load shifting • Backup power • Solar self-consumption • Demand response	• Enclosures: IP54/NEMA 3R • Temperature: -25°C to 55°C • Humidity: 5% to 100% non-condensing • Elevation: 1000m without derating	• System: UL 9540 • PCS: UL 1741 SA,SB IEEE1547 • Batteries: UL 1973, 9540A

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xStorage

Storage / Operation Optimization / Financial Optimization

xStorage features:

- FFR, grid code compliance
- DR
- Peak shaving
- Arbitrage
- Islanding
- PV integration

xStorage BESS **+ Power Xpert microgrid controller**

Base Storage

xStorage BESS

Inverter

Energy battery

Service contract

Monitoring software

GSEC

Higher level controller

xStorage BESS **+ Enel X DER.OS**

xStorage w/ Aggregation features:

- FFR
- DR Peak shaving, arbitrage

Optimization

xStorage BESS

Inverter

Energy battery

Service contract

Monitoring software

GSEC

Higher level controller

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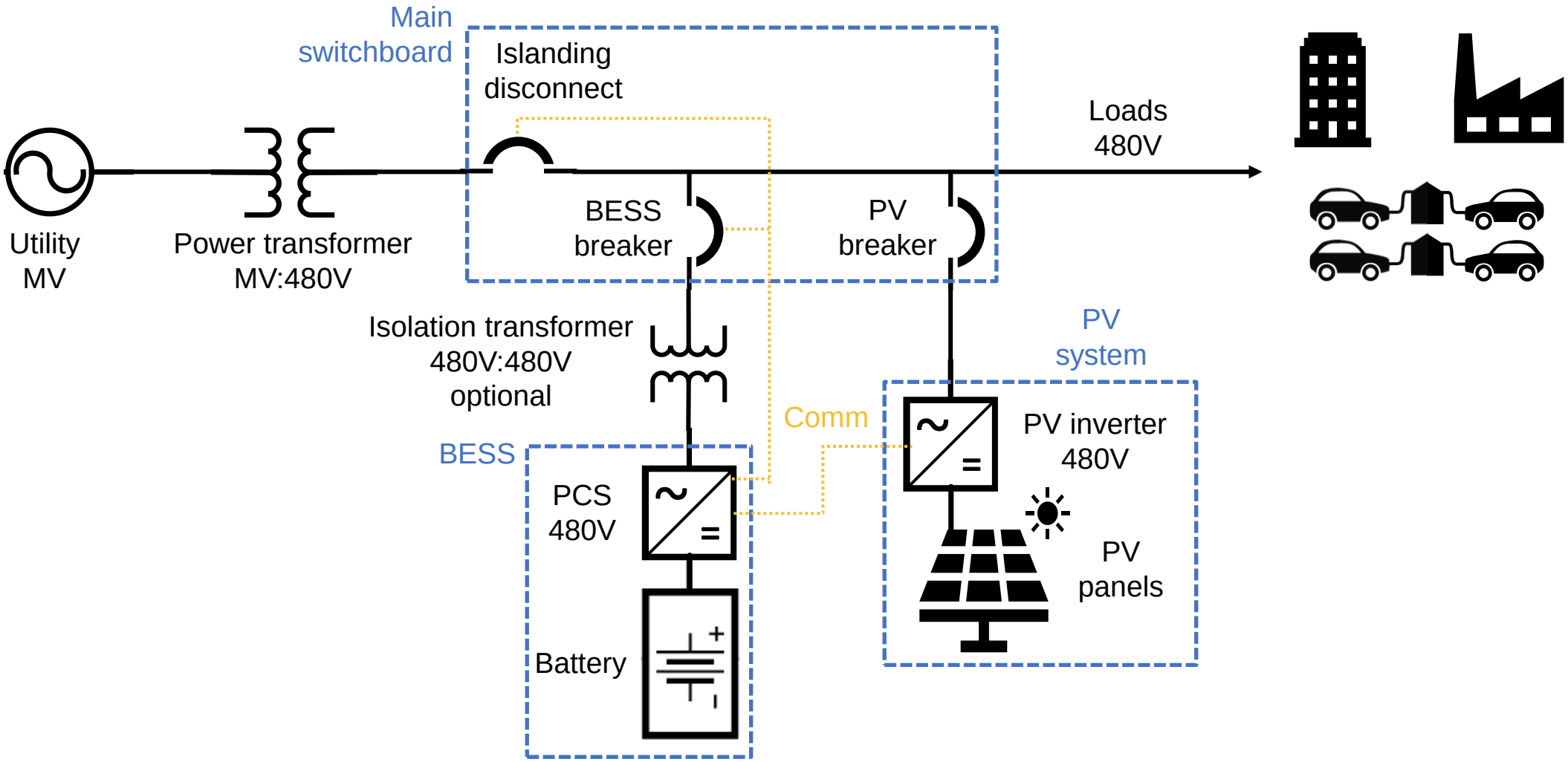
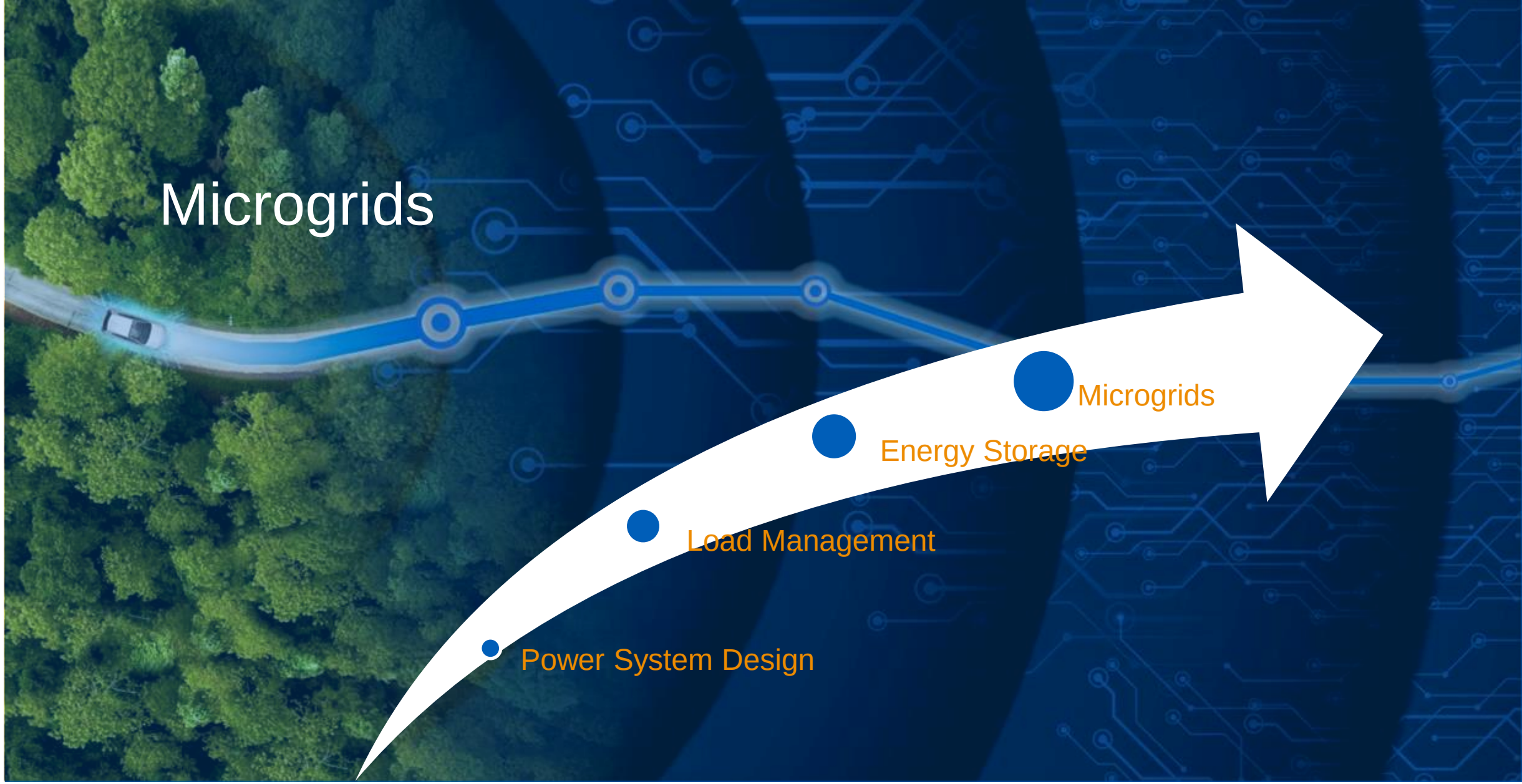
BESS simple one-line



Microgrids



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Eaton’s broad microgrid capabilities

Make us your easy button

Feasibility studies

Feasibility study to evaluate the economic and resilience impact of your microgrid project

Design, build & construct

Leading turnkey services and **power systems engineering** capability for technical microgrid project development

Hardware deployment

Expansive electrical portfolio and robust supply chain to procure solar PV and battery energy storage

Microgrid software

Intelligent microgrid controls paired with economic **optimization software** to deliver energy savings

Market services

Unlock additional value from your DER assets by enrolling in **flexibility programs** such as demand response

Operations & maintenance

Ongoing system maintenance from Eaton’s highly trained team of dedicated **field services personnel**

Eaton offers customers the ability to **fund projects as an operational expense**

Energy as a Service

by seamlessly structuring deals with trusted financing partners

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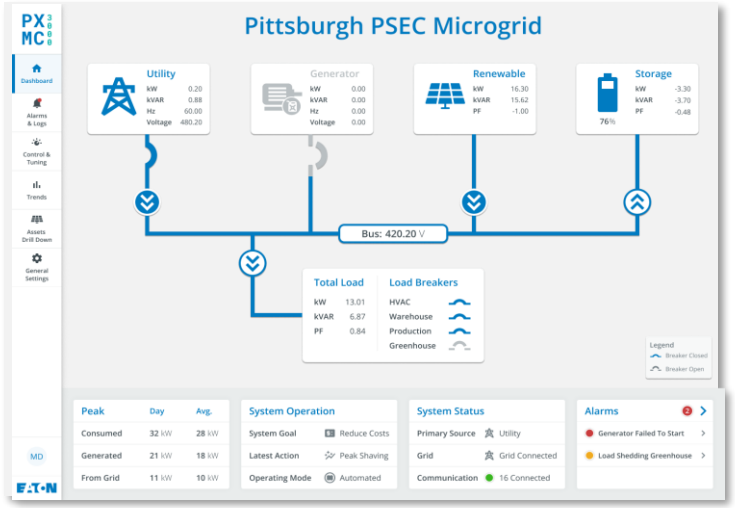
Eaton's Power Xpert Microgrid Controller (PXMC)

PXMC system features

- ✓ **Intelligent system-level controller** that interfaces with device-level local controllers
- ✓ **Web-based user interface** for monitoring & control (optional HMI screen)
- ✓ **Automated system sequence of operations** based on user-defined parameters
- ✓ **Control strategies** such as renewable firming, peak shaving, and islanding
- ✓ **Self-consumption** – maximize energy consumption from on-site and renewable sources
- ✓ **Manage transition functions** including load shedding and grid reconnect – black start
- ✓ **Modular system architecture** that can be scaled to the application
- ✓ **Software suite** for system configuration and commissioning
- ✓ **Alarm** and event management
- ✓ **Historian data logging** of system events (optional)

Industrial-grade Gateway platform	Programmable logic (Soft PLC) IEEE 2030.7 / 1547 and IEC 61850 / 61131.3 compliant Over 80 communication protocols supported including Modbus and DNP3 Client/Server
Built-in Cybersecurity	Meets all IEEE and IEC requirements for substation-grade equipment (IEEE 1686 and IEC 62351) Embedded cybersecurity • Built-in firewall • TLS encryption • AES 128/256 • X.509 malware protection Compliant with UL-2900-1 • NERC CIP • NIST Smart Grid security guidelines

Right-sized solution for your application
Built on Eaton's industrial-grade gateway platform



PXMC 5000
Fully customizable engineered-to-order solution

PXMC 3000
Configurable solution based on a select list of pre-validated DER assets

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Pow-R-Line Xpert microgrid switchboard (or switchgear)

A fully integrated intelligent, scalable, and efficient solution for your microgrid infrastructure

Intelligent

Eaton's family of Power Xpert Microgrid Controllers provide a **right-sized control solution** for any microgrid application

Optional external monetization interface give a facility the ability to unlock additional revenue streams from their flexible generation assets

Scalable

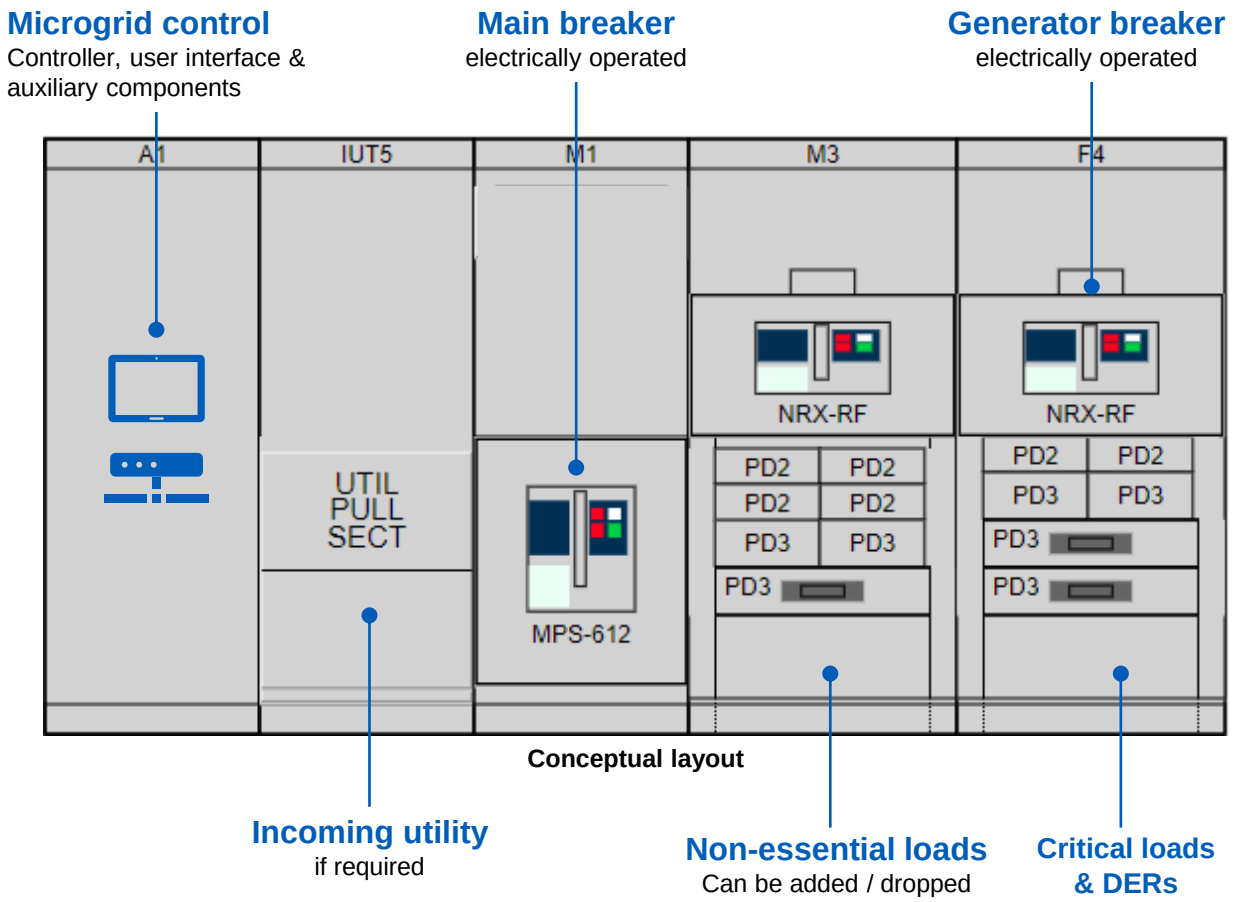
The microgrid control components are contained in a single panel structure to **future-proof the design** and easily add new DERs and loads

A wide range of switchboard integrated metering, protection and control options offer a solution customized to any application.

Efficient

Cost and lead time are always a factor, Eaton supports a **configurable built-to-order approach** reducing microgrid control design and manufacturing time.

All control and protection aspects of the integrated solution are factory assembled, integrated, and tested to ensure smooth field installation and commissioning.



Conceptual layout

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Meet customers where they are on their energy transition journey:
Option to "future proof" their power system design to add DERs at a later phase

TO:
Fully integrated control solution

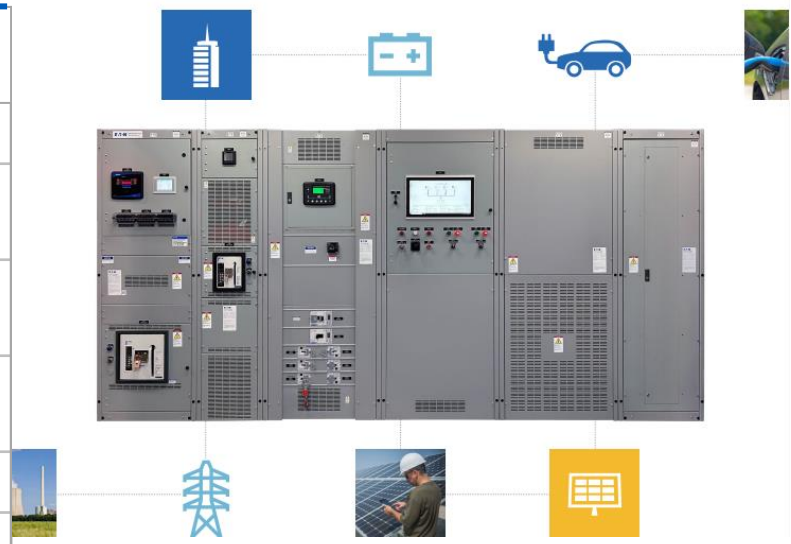
Optional interim step if planning ahead & DERs unknown

FROM:
Baseline reference

Commercial Switchboard/Switchgear
Busway with single utility connection
Main feeder circuit breaker (2000A)
Branch air or molded case circuit breakers are not networked or communicating

"Microgrid Ready" Switchgear
Kitted out switchboard section with sensing and metrology
Add switchboard section for the microgrid and DER controls
Set aside space for DER circuit breakers, e.g. generator, solar, BESS
Upsize the bus to add DERs
Main breaker electrically operated for remote operation
Communicating breakers & trip units
Auxiliary contacts for breakers
Line and load PTs & load CTs at main breaker (wired to terminal blocks)
Control power transformer

Pow-R-Line Xpert™ Microgrid Switchboard
Fully integrated Microgrid & DER controls with meters and relays
Install microgrid / DER controller
Additional device DER controllers connected and wired into the system
Power supply and UPS backup for microgrid control system
Point-to-point wiring engineered and installed throughout switchboard
Network switches and gateways
Utility relay (anti-islanding)
Local HMI screen (optional)



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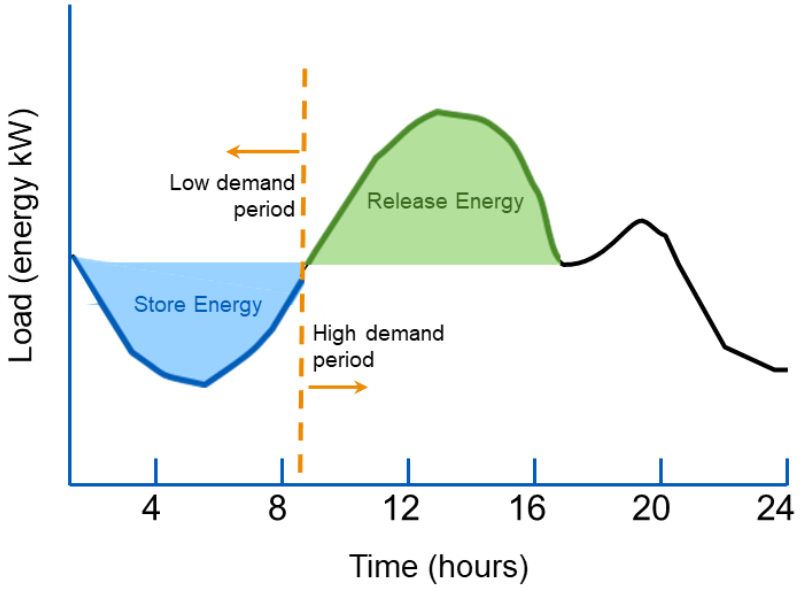
Battery storage basic use cases

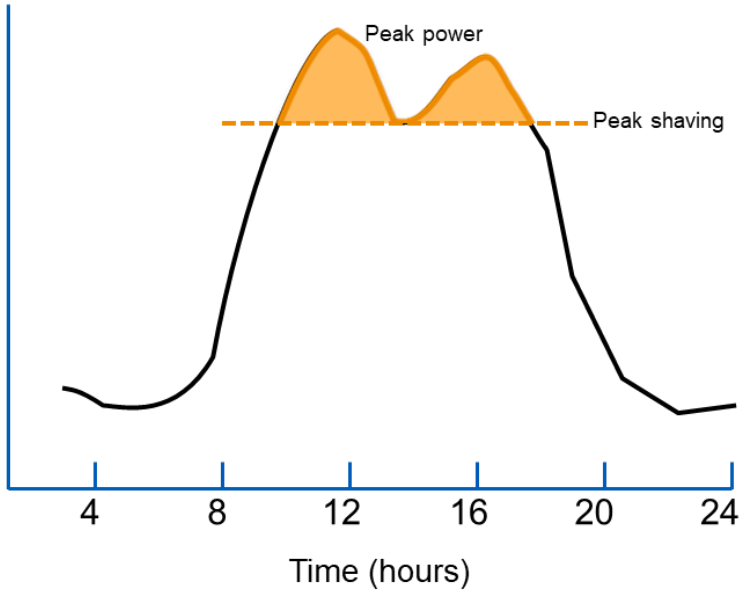
Energy arbitrage

Store energy in off-peak hours when utility rates are lowest, use stored energy when utility rates are highest



Peak shaving

Dispatch battery to lower peak loads to reduce utility demand charges – highest 15 min power usage per month



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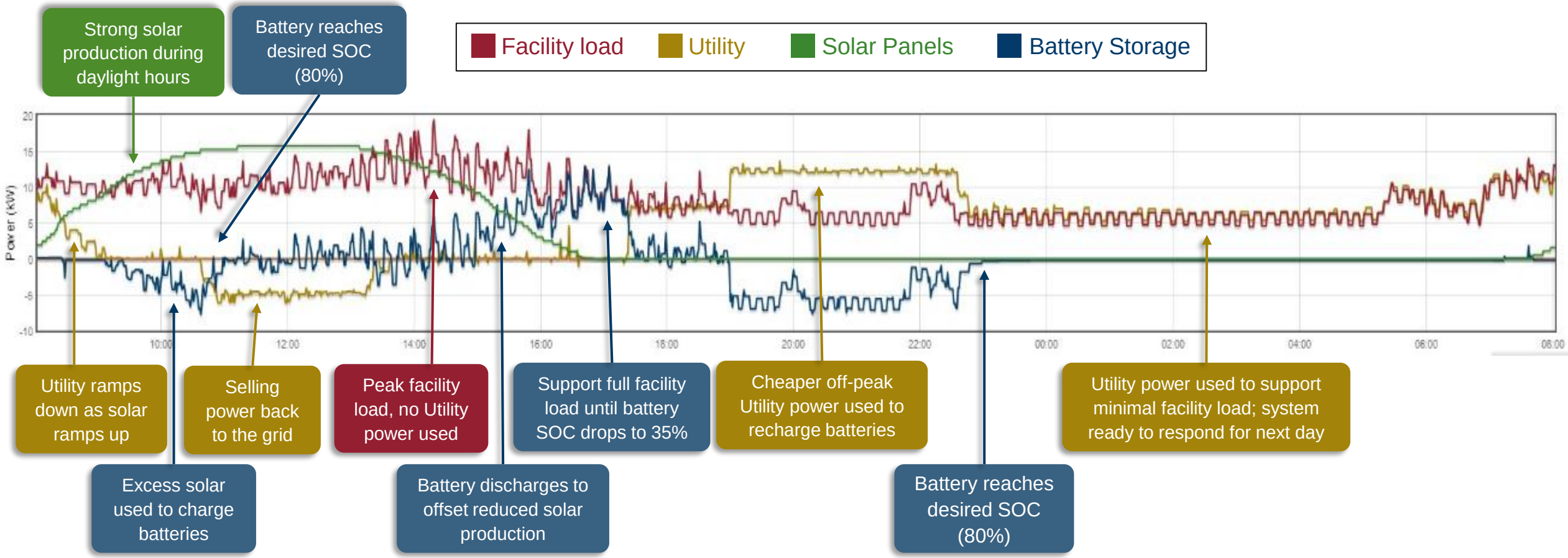
Actual microgrid performance – 24 hour period

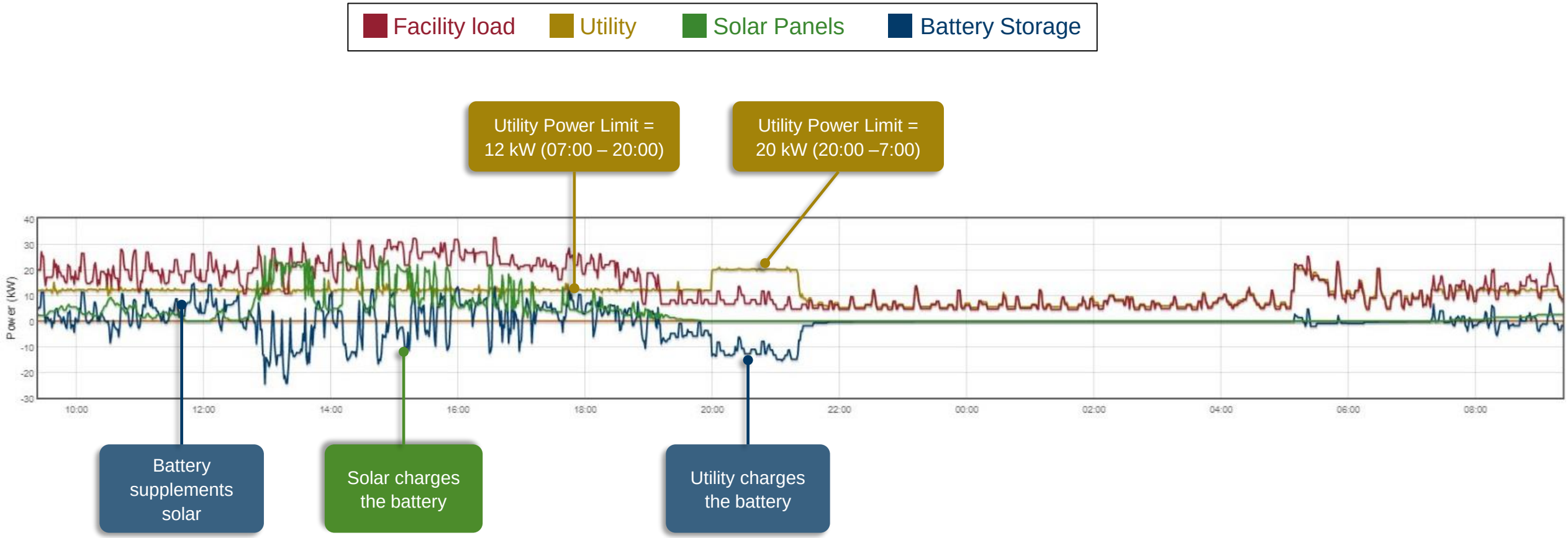
Sunny winter day: solar and battery support the load 100% with excess solar capacity charging battery then sold back to grid



SOC = state of charge

Microgrid peak shaving functions

Cloudy to partly cloudy summer day: Scheduled operation to limit utility power throughout the day - avoid demand charges



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Case Study:
Microgrid at Eaton's circuit breaker factory in Arecibo, Puerto Rico

Solution:

Eaton and Enel X partnered to develop and finance a microgrid at the site by leveraging our respective intelligent power management capabilities.

The microgrid solution contributes to local sustainability and resiliency efforts while delivering cost savings and additional revenue streams with DER monetization.

Energy as a Service (EaaS) financing provided by Enel X through a 20-yr PPA

Watch the video:
Eaton.com/MicrogridProjects

"A postcard from the future for islands and other centralized grid systems transitioning toward more distributed resources."

— Wood MacKenzie analyst Isaac Maze-Rothstein, commenting on the microgrid project in *Greentech Media*

Result:

Balance business goals by fully integrating the microgrid and on-site power generation with more renewables enabling two-way power flow with decentralized generation.

Integrated **5MW solar + 1.1MWh battery energy storage** into the power infrastructure

Transformed Eaton's operations to become more **sustainable** and **resilient…**

…all while **reducing energy costs by >12%**

CAT 5

Microgrid designed to withstand hurricanes

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Success Spotlight

Eaton's Arecibo Puerto Rico microgrid

Link to NEW Arecibo microgrid video

Solar panels in adjacent fields secured with in-ground racking

Batteries provide ride-thru power when clouds pass over the solar panels

Two solar inverters convert DC to AC power from >19,000 solar panels

MV switch sends power from inverters to each building to tie them together

Success Spotlight

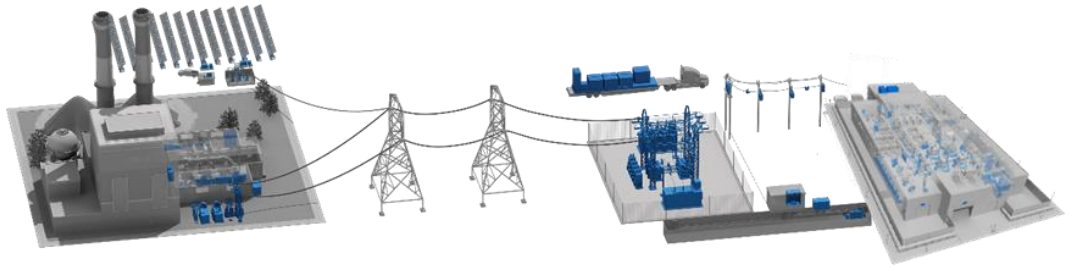
Arecibo microgrid
Power Distribution Equipment and controls

Installed new conduits to route power sources to the centralized switchgear and controls

Economic optimization software paired with intelligent microgrid controls manage DERs and utility power

Replaced Eaton's aging switchgear with intelligent power distribution equipment that has paralleling capability

Microgrid complements utility power from **LUMA**



- **Net metering** – credit for exporting excess clean power generated to the local power grid
- **Reduces strain on the power grid** during peak demand periods on the island

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