






Eaton Corporate Research & Technology

# Microgrids – from Promise to Mainstream

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Powering Business Worldwide

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# Powering Business Worldwide For Over 100 Years

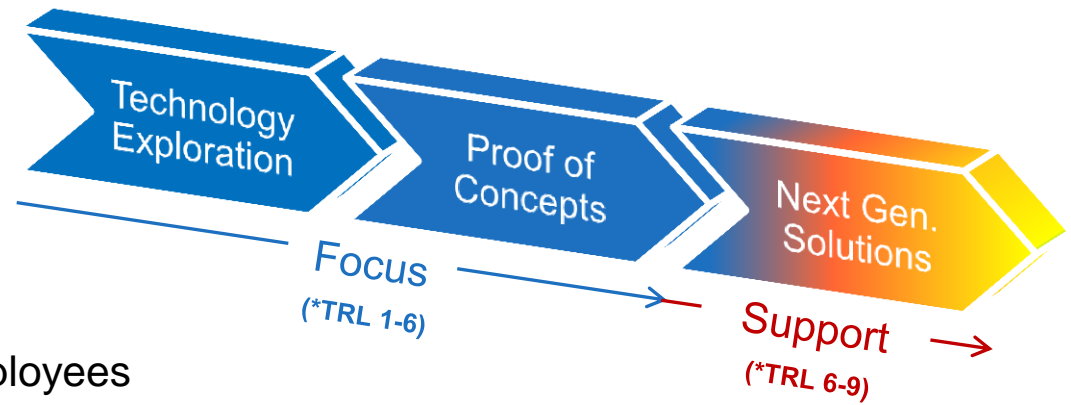
Eaton

is helping the world use electrical, fluid and mechanical power more efficiently, reliably, safely and sustainably.

- 2012 sales of \$21.8 billion
- 50% of sales in the U.S.
- Approximately 103,000 employees

## Eaton Corporate Research & Technology

- Focused on the front end of innovation
- Partnering with Eaton businesses globally
- Solving customer's important power management needs



# Microgrids – A Promise

## Vision

Microgrids carry a promise to be a (disruptive) change in how energy is going to be delivered to the customer

## Problem

- 7B people have greater energy needs than their parents\*
- 1.5B people have no electricity today, 1.5B people have very poor electricity\*\*
- US grid infrastructure, valued at \$1T, is aging and inefficient\*
- US imports \$1B in fuel each day to power transportation and provide energy\*
- US military consumed 3.8TWh and spent \$4.1B on energy and fuel in 2008\*\*
- Renewable energy – intermittent and mandatory

## Value proposition trends (changing the success metrics!)

- *Electrical efficiency* becomes **resource efficiency**
- *Reliability* becomes **resilience**
- *Cost* becomes **total cost of ownership (TCO)**

# Eaton's Microgrid Track Record

## Managing transients

Managing natural gas generators to seamlessly supply loads during islanding transitions

## Decreasing total cost of ownership

Managing loads and renewable/diesel DER with minimum DES

## Seamless integration

Dynamic load sharing and reliable comms/control of multiple DER & DES

## Resilience via islanding

Fast fault detection at MV and seamless transition of a 4MW feeder to DES

## Robust operation

Load shedding in islanded mode w/o communication

## Fuel saving

Managing legacy generators with renewable DER generation



Legend:

DER – distributed energy resources

DES – distributed energy storage

MV – medium voltage

# Microgrids – toward Mainstream

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## Customer archetypes

- Military (net zero basis, mobile power) as a great early adopter
- Commercial, industrial and institutional (research, green PR, standalone cost eff.)
- Utilities and DNOs (VWV management on LV distribution side)
- Remote/off-grid microgrids to electrify villages, mines, pipelines, transportation...

## Adoption maturity

- All customer archetypes are still early adopters
- Past definition stage – initial microgrid technologies and value props validated
- Scalability as the main driver into mainstream customer adoption
- Military and (remote) Telecom microgrids seem to adopt ahead of the others

## What can we learn from early adoption successes?

- Microgrid is NOT a product! Microgrid is a solution to tough energy problems
- Solutions for end users with repeatable energy and empowerment needs
- Commercialization of new microgrid technologies creates new business models

# Technical Enablers

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## Microgrid-based energy, power and fault management

- Medium voltage (MV) solid state devices to empower bi-directional energy flow
- Power distribution system analysis – modeling & architectures
- Synergetic integration of distributed energy generation and storage to maximize system-level capacity factors

## Interoperability

- Seamless integration with legacy infrastructure and various brands/protocols
- Modular system architectures to allow layered control and distributed intelligence
- Cyber security (including resilient bi-directional transfer of raw data)

## Fault-tolerance and safety

- Self-diagnosing, self-healing and self-optimizing systems
- Handling and managing big data
- Forecasting energy resources, generation and consumption to empower transactive interaction with the grid and energy consumers

# Non-Technical Enablers

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## Scalable business models

- Developing potentially disruptive technology as one – new technologies will develop new business models, which will spark creation of new markets and new customer needs
- Regulators and market stakeholders
  - Developing sustainable markets and their value chains
  - Maturing technology toward cost-effectiveness
- Adoption of common protocols and standards

## Open innovation

- Collaborative way to test and learn together among all stakeholders – research community, manufacturers, suppliers and end users
- Ecosystem alignment will dictate the change of the mindsets and sharpen “competitive edge” in each stakeholder
- Agile development – addressing technology scalability (manufacturing and deployment) in early stages; frequent customer feedback and validations



# Summary

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- Microgrids are solutions to provide cost-effective energy, power quality and energy independence
- Early adopters have successfully validated initial microgrid technologies and value propositions
- Microgrids will deliver on their disruptive promise when adopted by mainstream customers
- To get to the mainstream, we need solutions for both technical and non-technical enablers

Thank you.

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