Eaton DOE Review
Energy Efficiency Means Business 2022

Chris Hess

VP, Public Affairs

Powering Business Worldwide

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There is no better time than now to be an **intelligent power management company**.

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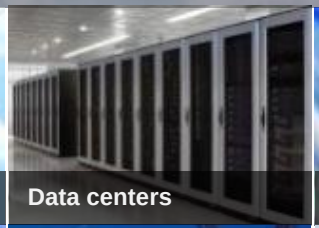
Eaton is solving industry's toughest power management challenges around the world.



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We make delivering your best work.*

ELECTRICAL

- Power distribution and circuit protection
- Power quality, backup power and energy storage
- Life safety and security
- Structural solutions
- Control and automation
- Harsh and hazardous environments solutions

INDUSTRIAL

- Aerospace
- Filtration
- Vehicle
- eMobility

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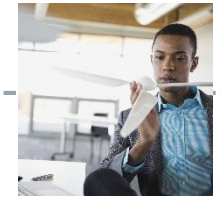
Flexible energy systems will power the future.

Through our **EVERYTHING AS A GRID** approach, advancing technologies and digital intelligence, we are increasing and optimizing the energy the world relies on.

EVERYTHING AS A GRID



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EVERYTHING AS A GRID

Unlocking a low-carbon future for homes, businesses and communities.

Beginning to monetize previously under-used backup power assets.
Eaton and Microsoft's EnergyAware UPS technology pilot project

Reducing downtime and energy costs by 50% via dynamically controlled distributed energy resources through a microgrid.
Eaton Wadeville manufacturing plant in South Africa

Achieving a zero carbon future by increasing consumption of self-generated renewable power.
Catholic University of Lille France

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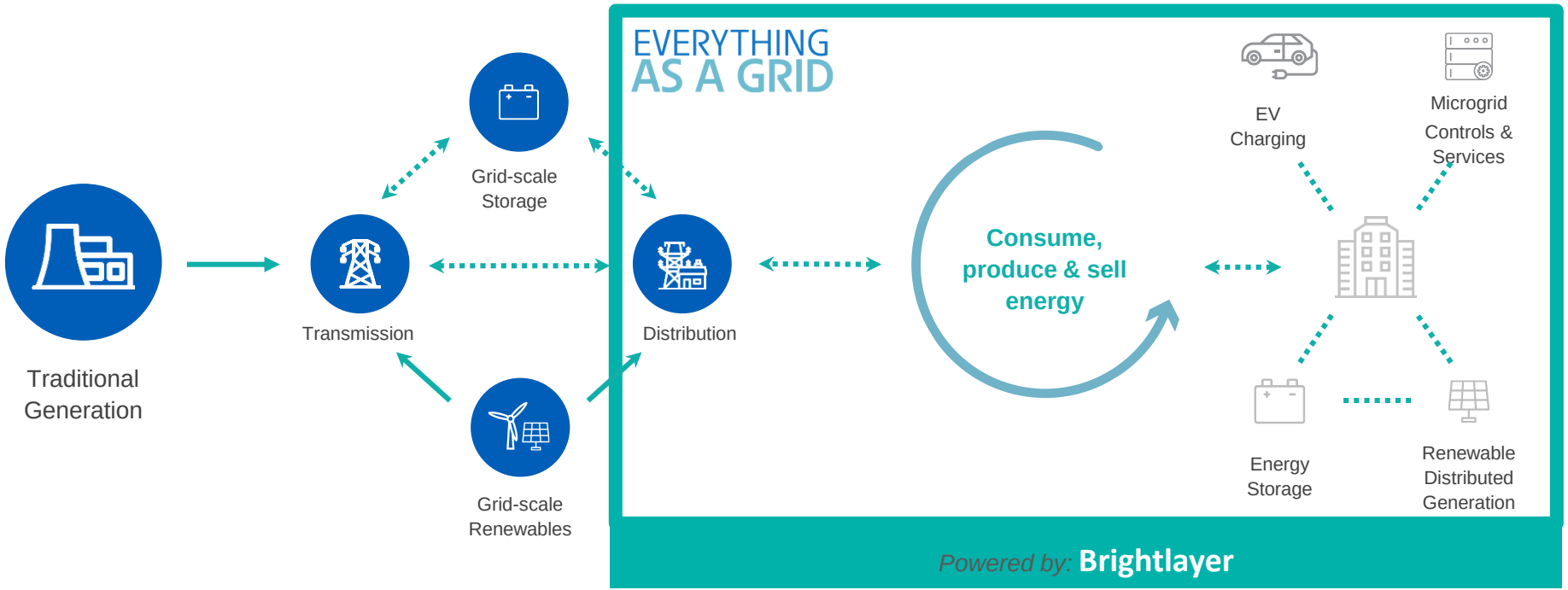
EVERYTHING AS A GRID

Energy transition creates new business models and opportunities across the value chain



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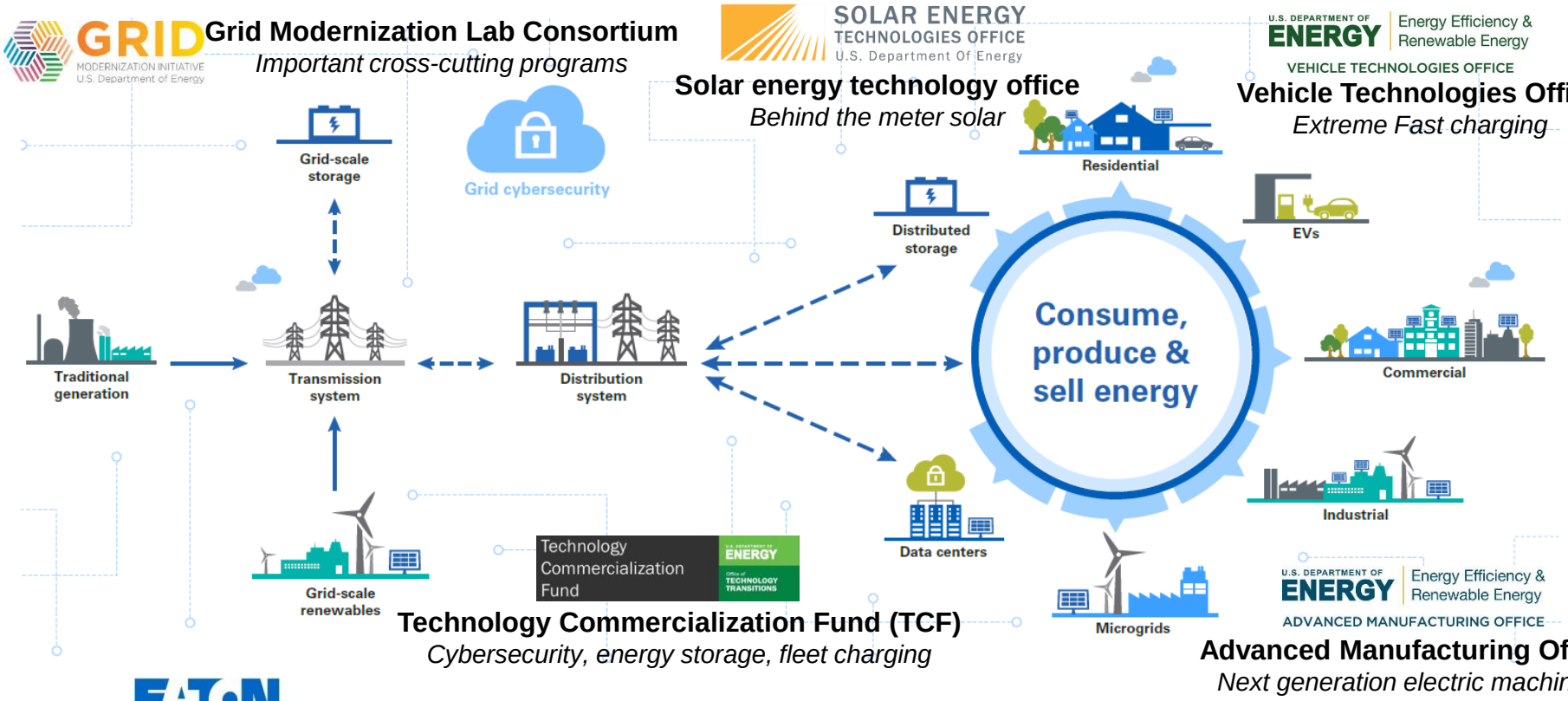
EERE is making important investments that broadly create energy efficiency and jobs



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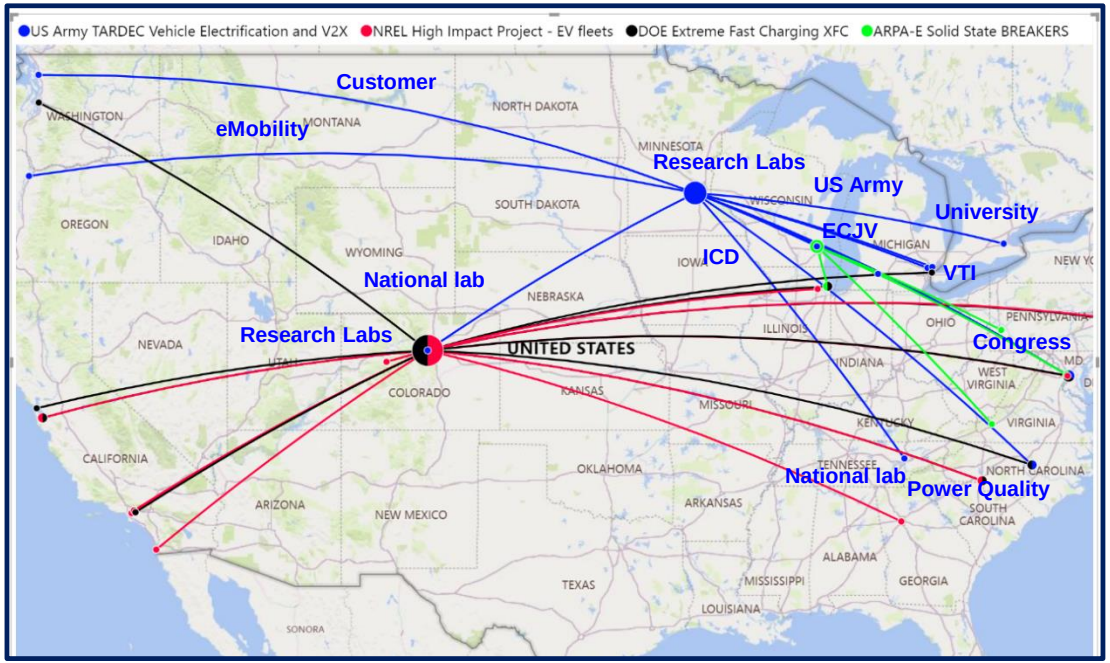
Dept of Energy EERE enables unique partnerships

This collaboration only occurs on government programs

Partnership flow map for four different government programs

Partnering with Dept of Energy, customers, universities and national labs.



Partnering on DOE Solar program

Maximizing use of behind the meter solar energy

ComEd · provo POWER · EPRI ELECTRIC POWER RESEARCH INSTITUTE · PECAN STREET · NREL NATIONAL RENEWABLE ENERGY LABORATORY

Partnering on joint DOD/ DOD program

Solving challenges in vehicle electrification for commercial and military applications

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

VEHICLE TECHNOLOGIES OFFICE

OAK RIDGE National Laboratory · NREL Transforming ENERGY

U.S. ARMY · DEVCOM GROUND VEHICLE SYSTEMS CENTER

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Eaton in Colorado & NREL Partnership!

Corporate research team first ever to be located at NREL ESIF in 2018

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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NREL, Eaton Partner on Innovative Energy Solutions

January 24, 2018

On January 15, Eaton, a power management company dedicated to improving the quality of life and the environment through the use of power management technologies and services, entered into a cooperative agreement with the National Renewable Energy Laboratory (NREL). The partnership, designed to expedite research and commercialization of new energy-related technologies, includes co-locating approximately 15 members of Eaton's Corporate Research and Technology team at NREL's Energy Systems Integration Facility (ESIF) in Golden, Colorado.

"NREL's industry partnerships are integral to the advanced energy research revolutionizing the global energy landscape," said NREL Director Martin Keller. "This on-site, direct collaboration allows our fully-integrated teams to expand knowledge related to grid integration and power management."

For more than a decade, Eaton and NREL have collaborated on a comprehensive portfolio of joint programs that includes optimizing energy systems for microgrids, buildings and communities, and developing a predictive battery management system for hybrid electric vehicles. This new agreement augments this relationship by enabling both organizations to collaborate closely on the evolving state of energy solutions such as microgrids, energy storage systems and grid intelligence.

Twenty Eaton engineers work on-site at NREL's Energy Systems Integration Facility (ESIF) in Golden, Colorado to research and commercialize new energy-related technologies. This co-location is the first of its kind for Eaton and NREL.

- Locating Eaton researchers at this User Facility provides access to world-class facilities and NREL personnel, faster value prop testing, increased customer co-development and reduced capital investment.
- NREL is the only Department of Energy national lab chartered solely around renewable energy.
- The Energy Systems Integration Facility (ESIF) is a unique $140M+ grid integration testing facility.

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Advanced Fuel Cell Air Systems

The Problem: Fuel Cells not ready for Heavy Duty freight – too much Hydrogen wasted

- High Hydrogen consumption: barrier to zero-emissions HD freight (6% of US CO2 emissions today)
- The Air System is the highest power consumer – up to 20% of Fuel Cell electrical production used to move air

Key Idea: step change improvement in Fuel Cell system efficiency

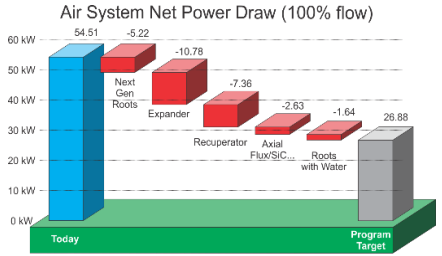
- New technology: reduce Air System draw by 50%
- Implication: reduce Fuel Cell Hydrogen consumption by up to 10%

Solution: DoE program to bring together new technology with key players

- New Systems Architecture: efficiency and affordability
- New components, enabling the new architecture
- Best in World Team:
  - **Eaton:** Air Compressors leader
  - **Ballard:** Global leader in Fuel Cells for transportation
  - **NREL:** National Hydrogen center of excellence

Eaton Next Gen Air Compressor, just 1 of the 6 new technologies developed in the program

Simulation: achieving 50% reduction in Air System electrical power, results in ~9% less Hydrogen used for HD truck power



Best in Class team to develop and demonstrate the new technology, building on decades of experience in Hydrogen

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Low GHG Off-Road powertrains

The Problem: Heavy off-road machinery is hard to decarbonize, a bridge solution is needed

- Battery solutions not feasible (too much energy use), Hydrogen solutions not ready (technology and infrastructure barriers)
- Contribute >1% of US GHG emissions and 50% of NOx, concentrated in economically disadvantaged areas

Key Idea: simultaneous 10% CO2 and 90% NOx reduction implemented quickly as bridge to Hydrogen

- No regulatory pull for lower GHG or NOx
- On-road technology is not applicable: rapid innovation needed

Solution: Develop new engine and aftertreatment solutions focused on off-road duty cycles

- New technology packages
- Testing under off-road duty cycles
- Best in Class team:
  - **Eaton**: technology leader in emissions reduction
  - **CNH**: global leader in Agriculture and Construction machinery
  - **ORNL:** nation's premier vehicle technology center

New systems use high efficiency, low NOx technologies recently developed by Eaton

HD agricultural and construction equipment are targeted for significant NOx and GHG reduction : program demo focused on Ag tractor with diverse use cases

Best in Class team to develop and demonstrate the new technology, with path to rapid deployment in the US and technology leadership globally

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EERE and Eaton Vehicle Group impact

Simultaneous efficiency and low emissions for commercial vehicles

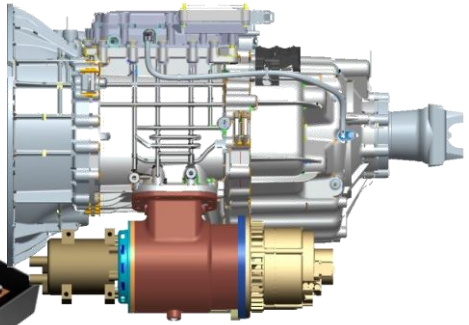
EV transmissions for MD/HD

50% EV powertrain weight reduction

70% electric motor reduction

20% increased EV range

High Voltage Flexible Power Distribution



HD 48V Mild Hybrid

8% fuel reduction

20% lower NOx

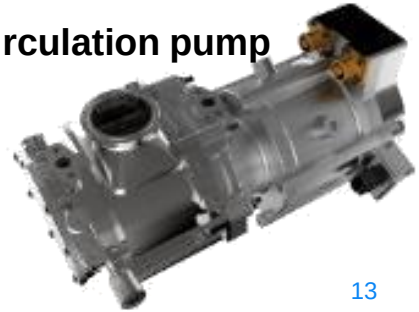
SUPERTRUCK

NREL High Impact Project: School bus Charging Services

Exhaust Gas Recirculation pump

3% fuel reduction

10% lower NOx



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