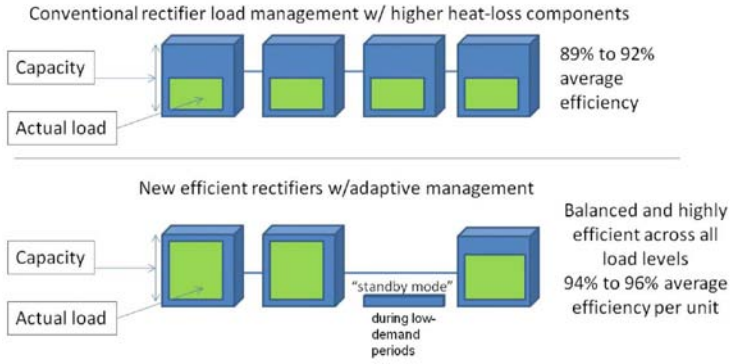
High-Efficiency, Wideband Three-Phase Rectifiers and Adaptive Rectifier Management for Telecom Central Office and Large Data Center Applications

High-efficiency, wideband, three-phase rectifiers and active rectifier management for ICT centers.



New materials, efficiency algorithms, and active management for power rectifiers.

Illustration courtesy of U.S. Department of Energy's Industrial Technologies Program.

Introduction

Rectifiers are part of the "power supply chain" that represents 25% of energy consumed in data centers and even more consumed in telecommunications centers. Rectifiers are responsible for converting Alternating Current (AC) electricity supplied by electricity utilities to the Direct Current (DC) electricity required to run most of the equipment used in ICT centers. Rectifiers lose significant efficiency during times of low electricity demand.

This project is developing and will test a new, more efficient power rectifier. This rectifier will operate at high efficiency levels over the entire electricity use range whether demand is at peak or not. As a separate part of this project, software is being developed to keep, existing conventional rectifiers operating at their highest efficiency. To do this, it will place certain rectifiers into a standby mode so that the remaining rectifiers can operate ata high level and at peak efficiency.

Benefits for Our Industry and Our Nation

ICT facilities consume 3% of our nation's electricity with growth in energy consumption estimated to double every five years. These facilities lose significant energy to heat loss from inefficient power conversion. This project will provide a path for rectifier equipment designed with new materials and software that can raise the efficiency of power conversion by about 10%; the upgrade to rectifier components and management will reduce energy and cooling use and increase economic productivity for datacenter and telecommunications services.

Applications in Our Nation's Industry

This technology will be valuable for equipment replacement and new equipment installations at ICT facilities. The promise of lower energy bills and the optimization of power conversion equipment for large organizations will lead to rapid uptake of the technology after its successful validation. Industries that will be most affected include the following:

- Internet application and service providers and other organizations with large data centers
- Manufacturers and distributors of AC/DC electronics power distribution, supply, and management components
- Telecommunications service providers

Project Description

Servers and communication equipment require front-end rectifiers to convert AC power to DC power. Due to the mission-critical nature of telecommunications central office facilities and the need for backup battery recharging, these facilities are designed with high levels of rectifier redundancy (extra rectifiers are put into service to account for emergencies and failures). They are also typically over engineered in order to accommodate future load growth, requiring rectifier operation at only a fraction of its total capacity. Unfortunately, rectifier technologies have very poor efficiencies at low utilization (measured by percentage of total rectifier output capacity), exactly the range in which they operate in telecommunications facilities. Lineage Power has developed new rectifier technology based on a combination of low-voltage synchronous rectification and true three-phase, bridgeless power factor correction. Recent advances in semiconductor devices, magnetic materials, and digital signal processing (DSP) controls have enabled this technology, which is designed to achieve 96% efficiency over an extremely wide utilization range. The rectifier will be developed to meet the form, fit, and function of existing power trains to enable simple in-plant upgrades and to achieve 8%–21% efficiency gains, depending on the load and rectifier type.

In the meantime, many telecommunications centers will also face pressure to extend the life of their installed infrastructure. To address this immediate energy-efficiency opportunity, this project will verify the results of Active Rectifier Management (ARM). This ARM is a new control technology to systematically place selected existing rectifiers into standby mode, effectively shutting them down, and forcing the remaining rectifiers to operate at higher utilization and higher overall efficiency (a 4%–13% efficiency gain, depending upon load and product). The standby rectifiers are available to return to service when load increases or system alarm events occur; the ARM algorithm will give priority to the higher efficiency rectifiers in a hybrid plant of mixed technologies.

Barriers

Conventional data centers and telecommunications facilities do not have rectifier equipment that provides central information on, or control over, how the equipment uses electricity. In a market that lacks opportunities to purchase equipment with significant operating cost savings, facilities opt to extend the life of existing, less efficient equipment. This project will test technologies that will provide interim software for controlling current rectifier efficiency and will be a viable, cost-effective hardware option that will provide greater efficiency in the future.

Pathways

This project includes the following developments:

- High-Efficiency Switched-mode Rectifiers (HE SMR) development, testing, and certification against the Network Equipment Building System standards
- ARM software development, system integration testing, and lab testing of the ARM system
- Prototype field testing and performance validation, testing and analysis of HE SMR and ARM system performance at telecommunications facilities

Milestones

- Completion of the initial HE SMR prototype (Completed); ARM installation
- Completion of the intermediate SMR prototype (Completed); ARM site baselines
- Analysis of the HE SMR final prototype; ARM commercial feasibility
- Analysis of the HE SMR commercial feasibility

Commercialization

Commercialization activities will immediately follow the completion of the project, including the information dissemination of case studies, product briefs, and presentations to customers and at industry conferences.

Project Partners

GE Lineage Power
Plano, TX
Principal Investigator: Mark Johnson
E-mail: mark.johnson@lineagepower.com

Verizon
New York, NY

For additional information, please contact

Gideon Varga
Technology Manager
U.S. Department of Energy
Industrial Technologies Program
Phone: (202) 586-0082
E-mail: Gideon.Varga@ee.doe.gov

Information & Communications Technology

Power Supply Chain

Research & Development

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

EERE Information Center
1-877-EERE-INFO (1-877-337-3463)
eere.energy.gov/informationcenter

DOE/EE-0500 • May 2011