



# **Advanced Load Identification and Management for Buildings**

## **Cooperative Research and Development Final Report**

**CRADA Number: CRD-11-422**

NREL Technical Contact: Luigi Gentile Polese

**NREL is a national laboratory of the U.S. Department of Energy  
Office of Energy Efficiency & Renewable Energy  
Operated by the Alliance for Sustainable Energy, LLC**

This report is available at no cost from the National Renewable Energy  
Laboratory (NREL) at [www.nrel.gov/publications](http://www.nrel.gov/publications).

**CRADA Report**  
NREL/TP-5500-62020  
May 2014

Contract No. DE-AC36-08GO28308

## NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at [www.nrel.gov/publications](http://www.nrel.gov/publications).

Available electronically at <http://www.osti.gov/scitech>

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy  
Office of Scientific and Technical Information  
P.O. Box 62  
Oak Ridge, TN 37831-0062  
phone: 865.576.8401  
fax: 865.576.5728  
email: <mailto:reports@adonis.osti.gov>

Available for sale to the public, in paper, from:

U.S. Department of Commerce  
National Technical Information Service  
5285 Port Royal Road  
Springfield, VA 22161  
phone: 800.553.6847  
fax: 703.605.6900  
email: [orders@ntis.fedworld.gov](mailto:orders@ntis.fedworld.gov)  
online ordering: <http://www.ntis.gov/help/ordermethods.aspx>

*Cover Photos: (left to right) photo by Pat Corkery, NREL 16416, photo from SunEdison, NREL 17423, photo by Pat Corkery, NREL 16560, photo by Dennis Schroeder, NREL 17613, photo by Dean Armstrong, NREL 17436, photo by Pat Corkery, NREL 17721.*



Printed on paper containing at least 50% wastepaper, including 10% post consumer waste.

## Cooperative Research and Development Final Report

In accordance with Requirements set forth in Article XI.A(3) of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

**CRADA Number:** CRD-11-422

**CRADA Title:** Advanced Load Identification and Management for Buildings

**Parties to the Agreement:** Eaton Corporation

### **Joint Work Statement Funding Table Showing DOE Commitment:**

<b>Estimated Costs</b>	<b>NREL Shared Resources</b>
Year 1	\$ 00.00
Year 2	\$ 00.00
Year 3	\$ 00.00
TOTALS	\$ 00.00

### **Abstract of CRADA Work:**

The goal of this CRADA work is to support Eaton Innovation Center (Eaton) efforts to develop advanced load identification, management technologies, and solutions to reduce building energy consumption by providing fine granular visibility of energy usage information and safety protection of miscellaneous electric loads (MELs) in commercial and residential buildings. MELs load identification and prediction technology will be employed in a novel “Smart eOutlet\*” to provide critical intelligence and information to improve the capability and functionality of building load analysis and design tools and building power management systems.

The work scoped in this CRADA involves the following activities:

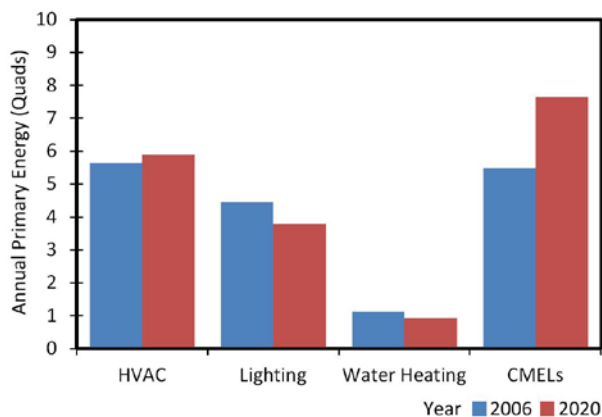
- Development and validation of business value proposition for the proposed technologies through voice of customer investigation, market analysis, and third-party objective assessment
- Development and validation of energy saving impact as well as assessment of environmental and economic benefits
- “Smart eOutlet” concept design, prototyping, and validation
- Field validation of the developed technologies in real building environments.

*(\*Another name denoted as “Smart Power Strip (SPS)” will be used as an alternative of the name “Smart eOutlet” for a clearer definition of the product market position in future work.)*

### **Summary of Research Results:**

Buildings account for 40% of the primary energy consumption in the United States, with 22% consumed by the residential sector and 18% by the commercial sector. Of the primary energy used by commercial buildings, about 30% is used for heating, ventilation, and space cooling (HVAC), 25% for lighting, and 6% for water heating. These main, or primary, end-uses have received most of the attention for energy efficiency research and technology development. About 30% of the primary energy is consumed by

MELs, but this end-use has received far less attention. MELs end-use in commercial buildings includes a wide variety of devices—major categories include electronics, computers, refrigeration, cooking, and “other,” but there are hundreds of device types within these categories (U.S. DOE 2009). Figure 1 shows an estimated breakdown of the energy use for the main end-uses in 2006 along with a forecast for 2020. MELs are an increasingly large percentage of building energy use, projected to grow from 30% to 35% of the commercial building total from 2006 to 2020. This growth is in small part due to advances in the energy efficiency of main building loads.



**Figure 1: Estimates of commercial building primary energy end-uses.**  
(Source: U.S. DOE 2009)

The main goal of the project was to assist Eaton in the development of a potential new product that would enable the effective management of MELs through the use of novel load identification techniques to identify and substantially reduce losses from neglected and standby loads.

The National Renewable Energy Laboratory’s (NREL’s) role in the project was to support Eaton by:

- Helping identify and quantify target opportunities based on NREL’s practical MELs experiences
- Assisting with the definition of the business value proposition for the smart strip/e-Outlet product
- Collecting initial performance data through a prototype field test at NREL’s Research Support Facility (RSF)

NREL supported Eaton in the collection and identification of high-level needs for MELs management for commercial buildings through Voice of Customer (VoC) interviews. Two of the interviews organized by NREL were with the NASA Sustainability Base and with the RSF Building Management Organization.

NREL also provided assistance to Eaton on MELs studies and research results, and provided input on energy saving opportunities through control strategies.

Eaton conducted a live demonstration at NREL’s RSF of the integrated Smart Receptacle system. After a preliminary test with one prototype, NREL conducted a limited field test with eight prototypes for a period of four weeks. The main goal of the field test was to collect internal data for as many live MELs as possible, through rotations of the devices at intervals of 1-2 days. A final project report from Eaton with a summary of research results is currently planned for release to DOE.

**Subject Inventions Listing:** None.

**Report Date:** 4/24/2014

**Responsible Technical Contact at Alliance/NREL:** Luigi Gentile Polese

**This document contains NO confidential, protectable, or proprietary information.**