NREL
Transforming ENERGY

Software Coordinates Multiple Smart Devices and User Preferences, Redefining "Smart" Homes

NREL's innovative software integrates and automates appliances to optimize home performance, demand response, and energy efficiency

Image by Christopher Schwing, NREL

Market Challenge: Smart-home solutions today do not deliver whole-home energy outcomes for the customer

Homes could save more energy—with greater occupant comfort—if smart devices coordinated with each other to prioritize how and when they operate. Until now, it has been nearly impossible for multiple home devices to coordinate to reach a common goal.

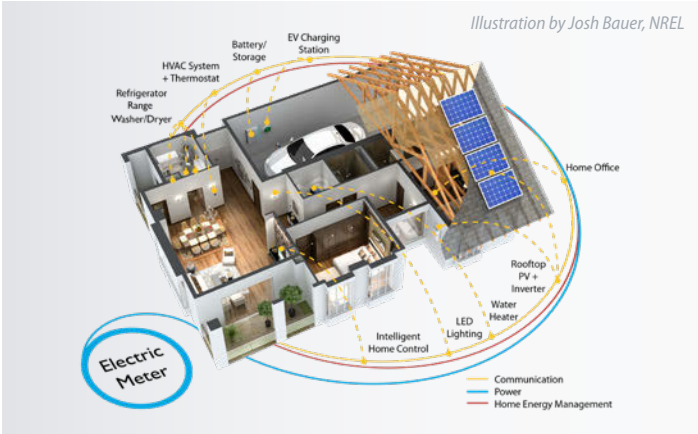
Solution: "Home energy concierge" software continually manages connected devices

NREL developed **foresee™**, an energy management system built to achieve users' preferences while simplifying the coordination of when and how a home's connected appliances and electronics use energy. This reduces complexity and improves the consistency and diversity of whole-home outcomes. These include enhanced comfort, convenience, reduced costs, and lower environmental impact based on input from the homeowner. The software accounts for time-of-use rates and is compatible with smart products from any manufacturer.

Photo by Dennis Schroeder, NREL 45565

Researchers test **foresee** software using Bosch appliances, a solar inverter, and battery in NREL's Energy Systems Integration Facility.

Illustration by Josh Bauer, NREL



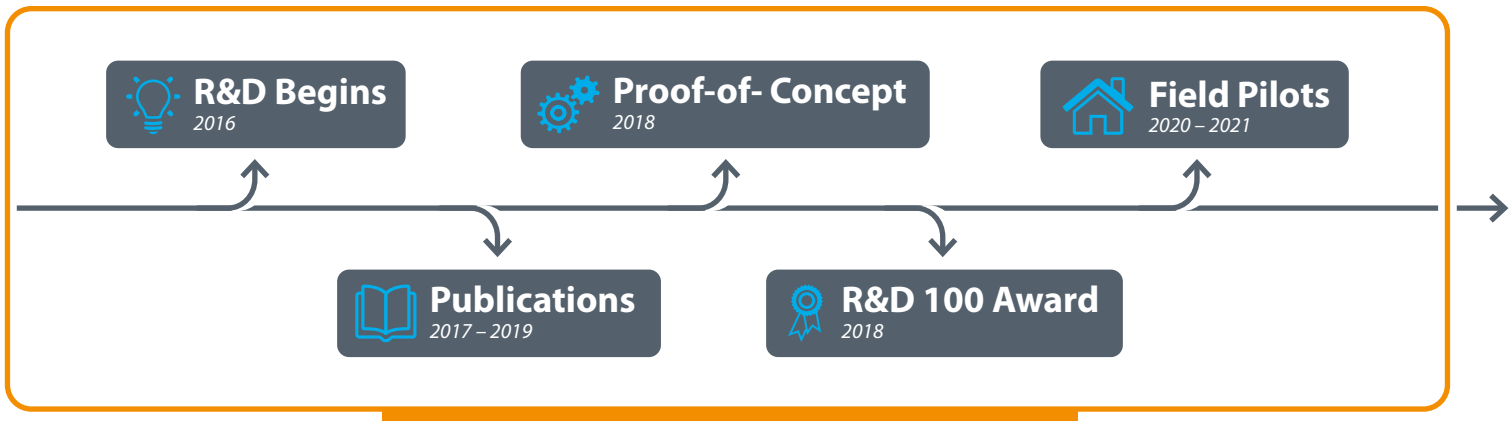
NREL simulated houses with different sets of appliances, both with and without **foresee**, with results indicating 5%–40% daily energy savings. Laboratory experiments verified these simulations, showing an average 10% savings in one home under a variety of conditions.

Industry Partners: Leading manufacturers, utilities, and research institutions

To build **foresee**, NREL partnered with Bosch—a major manufacturer of home appliances and an expert on embedded cybersecurity—and Colorado State University to build on prior work on preference-driven building automation. Technology development and laboratory experiments were supported by the Bonneville Power Administration and the U.S. Department of Energy.

Path to Commercialization: Licensing to utilities and product manufacturers

The software is copyrighted and available for licensing to integrate within homes via multiple paths. For instance, manufacturers can embed **foresee** as an application within smart devices, and utilities can deploy **foresee** on a smart meter or in the cloud for customer-centric demand flexibility.



World-class R&D from concept to commercialization.
NREL brings technologies from basic science research to market.

Delivering Value from Scientific Research to Market Strategy

NREL brought **foresee** from basic science research to proof-of-concept, leveraging resources found nowhere else in the world. Key R&D innovations include foundational machine learning algorithms for operation of diverse home electronics and appliances, novel strategies for continuous multicriterion-decision-making model predictive control, and methods to apply grid-level cybersecurity and resiliency requirements to end-use devices.

Building technology expertise and one-of-a-kind lab space. NREL brings together leading experts on building-to-grid integration, data-driven automation and analytics, connected building loads, home energy management devices, demand response, distributed energy resources, and sensors and controls. Building simulation research is performed in NREL's one-of-a-kind Energy Systems Integration Facility, which connects appliances in an end-to-end energy ecosystem for advanced metering, residential batteries, and energy management systems research.

Visibility and significant results. In 2018, **foresee** earned an R&D 100 Award, and research published in Applied Energy demonstrated 7.6% whole-home energy savings—without behavior change—and up to 7.0-kW load reductions and 13.5-kW load increases for demand response. The refined software is expected to provide an average of 10% energy cost savings and demand flexibility for utility programs, leading to $200 in annual utility savings and a 1-year simple payback without risk of homeowner discomfort.

Refining research. In 2020, field trials and pilot demonstrations will validate laboratory results and provide additional data to support a commercial rollout.

Learn More: **nrel.gov/buildings/foresee.html**

Why NREL?

NREL's world-class researchers and facilities catalyze cutting-edge innovations while lowering industry risk for new technology investment. We enable industry, government, research, and nonprofit partners to conceive innovative ideas and develop concepts into prototypes. NREL can help you bring your idea to market. Here's why:

We are results-driven: Backed by 42 years of achievement, NREL leads the way in helping to meet the growing demand for energy innovation. NREL is a neutral, trusted technical resource.

We are relevant: Every day, NREL helps our partners—businesses, nonprofits, educational institutions, and governments—solve their energy challenges.

We are focused: NREL is America's only federal laboratory entirely dedicated to research, development, commercialization, and deployment of renewable energy and energy efficiency technologies.

We have the resources: NREL's distinctive expertise, state-of-the-art laboratories, and testing and partnering facilities for developing commercially viable products can help you.

We have the track record: With more than 750 active industry partnerships and a robust history of successful technology transition to the private sector, NREL has many options for collaboration and commercialization.

Partner With Us:
Learn how NREL can collaborate with your team to jumpstart your concept. Contact **tech.partnerships@nrel.gov**.

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