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iHOMES and BUILDINGS

THE MAGAZINE OF THE CONTINENTAL AUTOMATED BUILDINGS ASSOCIATION

CABA™ Connect to what's next™

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Association Office

Continental Automated Buildings Association
1173 Cyrville Road, Suite 210
Ottawa, Ontario, Canada
K1J 7S6

Tel: 613.686.1814; 888.798.CABA (2222) Fax: 613.744.7833

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Ken Wacks' Perspectives

AI for Energy Management

By Ken Wacks

I described the framework for Demand Response (DR) in the Autumn 2017 issue of CABA's *iHomes and Buildings* magazine. The progression from direct load control to indirect customer motivations with time-varying rates and event notices was explained. This article focuses on the state-of-the art DR called Distributed Load Control. The materials presented are based on the international standard for demand response energy management, designated ISO/IEC 15067-3[1]. I proposed and edited this standard, which was approved and published in 2012.

Distributed Load Control shifts appliance operating decisions from the utility, as in Direct Load Control, to the customer. The result is much increased flexibility and customer control. Artificial intelligence (AI) is the tool by which Distributed Load Control makes energy management control decisions automatically, based on customer preferences.

Comparison of DR methods

Direct Load Control, as described in the previous article, has some fundamental limitations:

- Customers must agree to participate.
- Customer discomfort varies.
- Controlled devices might not be in use.
- Many potential points of system failure exist.

This type of Demand Side Management (DSM) treats all customer equipment in a territory the same regardless of usage, age, or efficiency. For example, many new air conditioners include variable speed control so they could reduce power consumption without being turned off. Turning down an air conditioner would allow longer control intervals with minimal customer discomfort. Yet, most Direct Load Control programs turn off air conditioners rather than slowing them down.

The fundamental questions for utilities implementing direct load control are:

- Is the load shape improved so supply costs and availability are managed well?
- How do the system operating and maintenance costs compare with the benefits of load shaping?
- Does the customer compensation offset any perception of discomfort?
- Does the program enhance customer goodwill?
- Is the utility prepared to service the controlled appliances, since the utility is likely to be blamed for any problems with these appliances?

Distributed load control

Much more effective DR is possible by exploiting microprocessor-based intelligence at the customer premises using Distributed Load Control. The utility has the opportunity to change prices when a peak demand is expected. Eventually, utility policy makers would like to adjust prices according to the wholesale market price of electricity to reflect actual utility costs. Appropriately designed smart appliances respond with minimal user involvement or inconvenience.

As shown in Figure 1, the utility sends pricing data electronically to all houses in real-time over a network such as the Internet. This pricing signal enters the house through a residential gateway. This gateway interconnects a public network using telephone, cable TV, power lines, or radio with a home network. The gateway may be a separate device, as shown in Figure 1, or could be integrated with other gateways, controllers, or even inside an electric meter.

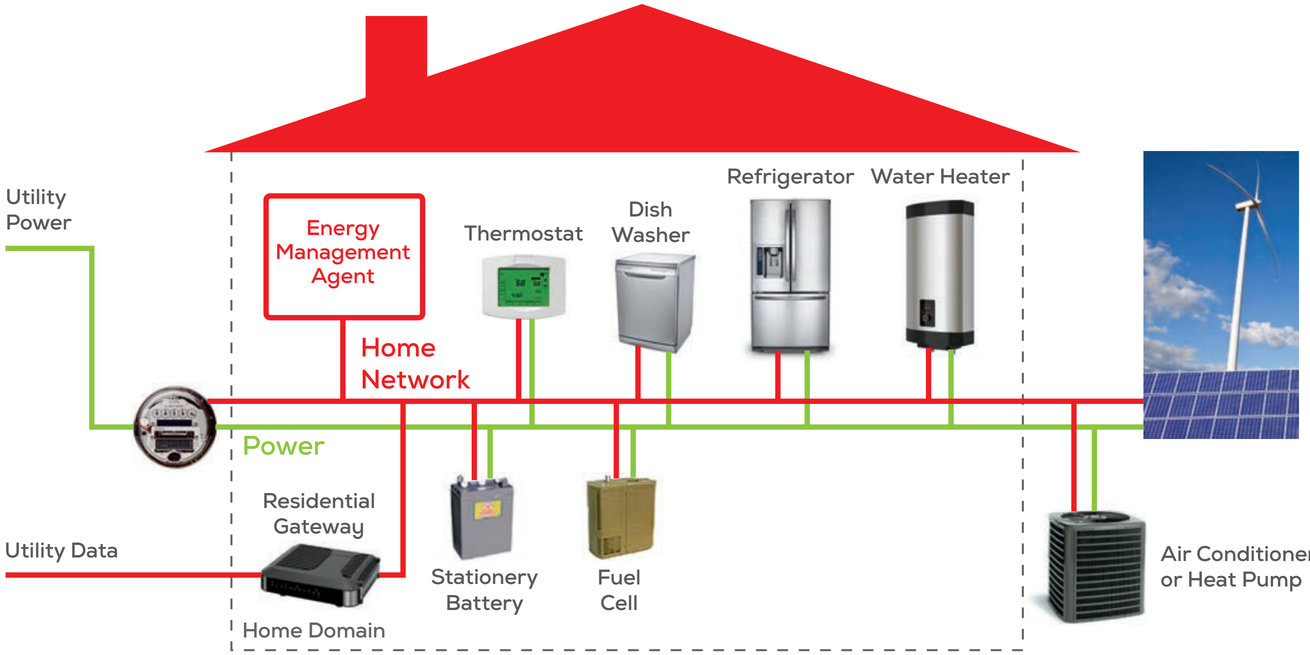
The Energy Management Agent (EMA) is a new intelligent computing element that manages electricity from multiple sources:

- External power from a utility or other energy service provider.
- Locally generated power from solar, wind, etc.
- Locally stored power from a battery.

It may switch energy sources from the public grid to local generators or a battery.

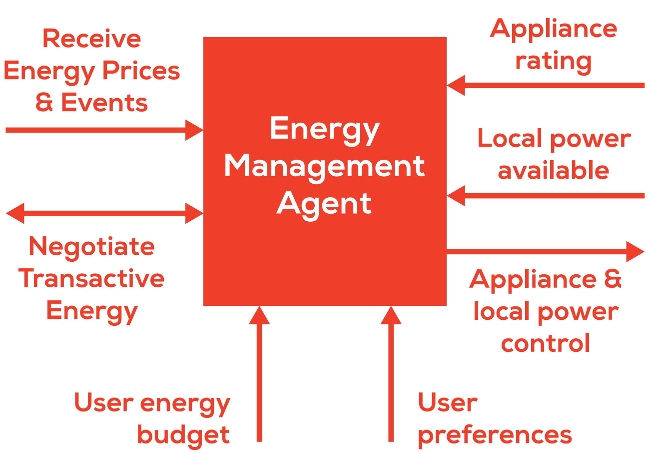
1 ISO/IEC 15067-3 may be purchased in North America at: Canada: http://shop.csa.ca/en/canada/p55/isoiec-15067-32012/invt/055596
US: http://webstore.ansi.org/RecordDetail.aspx?sku=ISO%2fIEC+15067-3%3a2012

Figure 1 – Distributed Load Control



As illustrated in Figure 2 the EMA determines how and when to operate appliances based on the cost of energy, the energy requirements of the appliances, the availability of distributed energy resources (DER – wind, solar, etc.) including stored energy, and user inputs. The user enters preferences into the EMA rather than directly controlling appliance operation to conserve energy. For example, the user might specify a monthly energy budget of perhaps $100 per month and preferences such as showering at 8 AM, air conditioning at 6 PM, clothes washing at 8 PM, etc. After processing these data, the EMA issues signals

Figure 2 – Energy Management Agent



that are distributed over a home network to the relevant appliances. However, the customer should always be able to override decisions of the EMA.

The EMA acts an intelligent agent for the customer. It is programmed with AI algorithms to optimize appliance performance. Smart appliances that can operate in energy conserving modes may improve the effectiveness of a Distributed Load Control system. With smart appliances the EMA could operate these appliances in a conservation mode rather than curtailing them. An EMA includes application software that might be located in a dedicated controller, a personal computer, a cable TV set-top box, or a security system.

Communications between the energy provider and the EMA comprises data about the cost of energy and any unusual events requiring a change in demand. These data are sent by the utility or a third-party energy service provider using cybersecurity features that ensure the data originated from the utility or the service provider. This level of security entails authentication to confirm that the data are from the real source and has not been altered during transmission. It is not necessary to encrypt such data since pricing and event data are public.

The following scenario is an example of how a user might interact with an integrated Distributed Load Control system. It is 4 PM and the user is about to run the dishwasher. The options in Figure 3 might appear on an appliance display panel.

The user makes a simple decision based on criteria that are understandable: "Do I need the dishes cleaned in the next three hours (perhaps for a dinner party at 7 PM), or can I wait and save some money?" This makes buying energy as simple as shopping at a retail store.

Figure 3 – Simple Consumer Choices

1. Wash dishes now.
2. Delay wash 3 hours & save 25¢.
3. Delay wash 6 hours & save 50¢.

EMAs for MDUs

The Energy Management Agent concept is gaining an international following. South Korea proposed extending it to a campus-like complex consisting of multiple apartment buildings. Each apartment has an EMA, as does each building. An overall EMA for the complex may be located on premises or in a remote server. This is noted in Figure 4 as a "Cloud-based Supplemental EMA."

The standards development process starts with a proposal followed by a working draft standard, then a committee-approved draft, followed by a draft international standard, and a final draft international standard. The text is then scrutinized by a professional editor and finally published. Ballots require a super majority vote by the member nations for approval. A super majority is specified as at least two-thirds YES votes and less than one-quarter NO votes among those casting ballots.

The Apartment Complex EMAs specification just passed the second stage as an approved Committee Draft Standard. Comments from the voting nations have been resolved and the ballot for a Draft International Standard has been started. An additional standard for messaging among EMAs is planned.

DR and Transactive Energy

The functions of the Energy Management Agent could be extended to accommodate Transactive Energy. I introduced Transactive Energy in the summer 2013 issue of *iHomes and Buildings*. Transactive Energy blurs the distinction between power producers and power consumers. Consumers with excess locally generated power from solar panel and wind turbines will be able to sell the excess to buyers who may live in a house or manage an office building in the community. There are many technology and business issues that must be resolved before Transactive Energy to becomes a reality. Among these are:

- A market for buyers and sellers of power to find each other.
- A financial system to price electricity delivered now (spot market) and later (futures market).
- A delivery pathway from seller to buyer, such as using the existing distribution grid.
- A possible transport price for using the distribution grid or a private grid.
- A system with data security for settling (paying for) transactions.
- A legal framework to allow Transactive Energy (generally not permitted now).

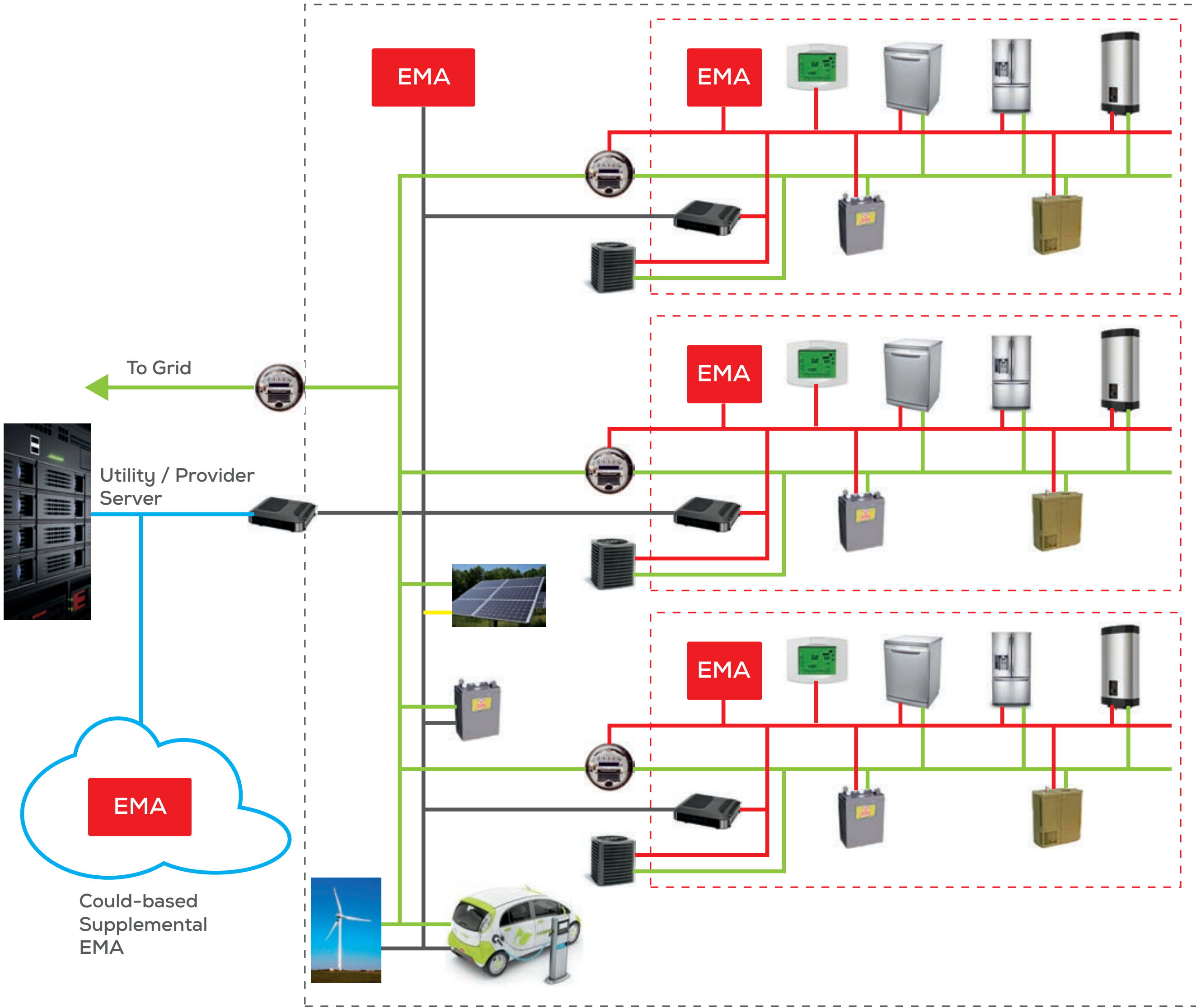
Consumers will probably not be involved in trading power like stocks and bonds. Automation will act as agents for residential customers and building managers. Such functions could be built into the EMA thereby expanding the options for locating power to meet customer preferences within the customer's budget. As shown in Figure 2, Transactive Energy data would be an additional source of external energy data for the EMA allocation algorithm.

Effective DR

Consumers may cooperate with most DR programs in the short run if they perceive there is a crisis. However, in the long run DR should be an automatic daily activity that integrates with appliance operation. An effective DR program would achieve a high level of adoption with an operating scenario that is almost invisible so it does not interfere with consumer comfort and convenience.

The concept of an Energy Management Agent relieves the customer of learning technical details. Instead of engineering parameters such as kWh and market tenders for Transactive Energy, consumers are presented with a few choices. Whether these choices resulted from a simple DR program or a complex market-based

Figure 4 – Apartment Complex EMAs



Transactive Energy system is not important to the customer. Technology-based solutions pervade our daily lives. The best technology delivers useful functions without apparent complexity. The Energy Management Agent offers consumers a simple system for energy even with the advent of price fluctuation and Transactive Energy.

DR coupled with the local intelligence of an EMA and a home network should increase residential customer cooperation. A properly designed energy management system can achieve customer buy-in provided that it seamlessly blends utility supply data with information about local supply options, automation embedded in appliances or appliance agents, and a simple user interface. The decisions are simple, while consumer privacy and convenience are not compromised. Buying energy should be no more complex than shopping at a store. ●

Dr. Kenneth Wacks has been a pioneer in establishing the home systems industry. He advises manufacturers and utilities worldwide on business opportunities, network alternatives, and product development in home and building systems. The United States Department of Energy appointed him to the GridWise® Architecture Council to guide the electric industry toward smart grids. For further information, please contact Ken at 781.662.6211; kenn@alum.mit.edu; www.kenwacks.com.