### Hawaii Renewable Energy Development Venture
### Technology Assessment
# Demand Response and Demand Side Management

## 1. Overview

The terms, demand side management (DSM) and demand response (DR), are sometimes used interchangeably. DSM refers to the management of decreasing energy use generally by the end user, while DR refers pro-active approaches to the decrease of energy use during periods of peak demand by either the end user or the utility. These strategies are focused on decreasing the use of electricity and, therefore, require an approach to the use of more energy efficient end-use technologies. This assessment will discuss potential technological solutions that can lead to reduced energy use by the better management of energy end-use through better sets of technologies, either as being more energy efficient or being part of the "smart grid" set of technologies discussed in another technology assessment paper.

In addition to these strategies, other components of the DR and DSM strategies simply relate to the development and deployment of more efficient end-use appliances and more efficient building envelopes for space conditioning. A major reason why California's per capita use of electricity has not increased since 1975 is because of the development of codes and standards for both building construction and appliances. As a major economic entity, California has the ability to do this. It would be to Hawaii's advantage to utilize codes and standards, where applicable, already developed by California. As a result, most commercial products would be available. This would apply to air conditioners, lighting, washers, dryers, refrigerators, and dishwashers - to name just some of the appliances that we normally use at home.

## 2. Status of Commercial Readiness

There are economic opportunities for demand side management and demand responsive control technologies and strategies for reducing electricity use in buildings. Some of these opportunities will be predicated on legislation or regulatory actions that may eventually lead to dynamic pricing or de-coupling regulations. Some of these dockets are currently in front of the Public Utility Commission. While there are opportunities to work with both the end-user and the utility, this discussion is more focused on the end-user. Thus, economic opportunities focus on advanced controls from a building owner's perspective. Demand response can be defined as electric load response techniques and strategies managed by electric utilities or electric grid operators for reliability purposes, electric load response managed by electric utilities or electric grid operators for procurement cost minimization purposes, and price response managed by end-use customers for bill management.

Efforts are underway to evaluate the capabilities of existing control systems in buildings and to develop a framework to define and establish the links between the response capabilities in buildings and advanced controls that support energy efficient building operations. The various layers of control of building operations include systems, components, controls, and controls strategies. The interaction between these various layers is being developed based on energy efficiency needs. There are a number of examples from around the U.S. that make the case for linking DR, DSM, and energy efficiency to yield better energy savings and to prepare buildings for being closer to zero energy buildings. Building controls systems have been used to reduce electrical peak demands since the 1980s. Peak load management in buildings focused on demand control strategies such as demand limiting, thermal storage and daylighting.

Reliable supplies of affordable electricity have been in the spotlight since the blackouts in California, the grid shutdown events in New England, and terrorist threats nationwide. While the array of generation technologies and transmission safety issues have been widely discussed, capacity requirements and demand side management issues have also been revisited. Utilities develop DR and DSM programs to provide a variety of choices for the customers to manage their utility bills while assisting the utilities in managing their capacity. These programs are managed by the electric utilities in Hawaii.

For the rest of the country, more than 70 utilities offer real-time pricing (RTP) programs with 75% of these states being on the eastern half of the country. The Independent System Operators (ISO) in New York, New England and the Pennsylvania, New Jersey and Maryland Region (PJM) as well as utilities in Baltimore and Georgia lead the RTP program design and implementation in the nation. There are two basic types of programs: price response and reliability. This distinction is related to market design and pricing, and there is a continuum of triggers to obtain demand response. These triggers can be price or system reliability. Both programs have shared goals of improving system reliability and improving the feedback between supply and demand. These programs differ from historical load management programs for reducing peak demand because they are dynamic dispatchable programs. Although there are various designs for price responsive programs nationwide, the underlying goal of these programs is to modify participants' electricity consumption patterns. End-users modify their electricity use when the price is high. New critical peak and real-time pricing programs are examples of price-response programs emerging around the country. The goal of price response is peak load reduction. However, the "success" to an end-use customer is measured by utility bill savings based on the development and execution of a demand response strategy. Reliability (load) responsive programs are driven by the desire to address peak capacity shortage and grid reliability.

Recent efforts have explored these strategies at the building level to reduce peak demand. Levels of automation can be defined as follows:

1. Manual Demand Response involves a labor-intensive approach such as turning off unwanted lights or equipment.
2. Semi-Automated Demand Response involves the use of controls for load shedding, with a person initiating a pre-programmed load shedding strategy.
3. Fully-Automated Demand Response does not involve human intervention, but is initiated at a home, building, or facility through receipt of an external communications signal.

There is an increased awareness of the need to implement multiple modes of operations in buildings. Not only building control systems have limitations that vary daily with occupancy, but facilities are starting to prepare for electric grid overloading as well as disaster and emergency situations. In addition, with new funding for the US DOE’s Zero Energy buildings concepts, there are opportunities for additional federal funding.

Energy efficiency programs offered by utilities promote the installation of efficient equipment. In California, four investor-owned utilities created the Express Efficiency program where cash rebates are available for energy efficient lighting, refrigeration and HVAC equipment. However, efficient equipment provides energy savings only if the systems are properly installed, operated, and maintained. New technologies and practices to provide energy efficiency include commissioning, fault detection, advanced controls, and feedback to operators. In building operations, the overlap between DR, DSM, and energy efficiency in a building occurs at the energy management and control systems (EMCS) level. EMCS provides customers with the ability to centrally monitor, analyze, and control their facilities’ building systems and equipment to achieve energy-efficient operation. According to the 2003 Commercial Buildings Energy Consumption Survey, 7% of commercial buildings, making up 31% area nationwide, have EMCS. Seventy percent (70%) of all commercial buildings with EMCS have 50,000 square feet or more floor space. Day-to-day energy savings potential of EMCS is estimated to be 10-20%. EMCS also provide ample opportunities for peak load reduction with their monitoring, control and feedback features.

An example of EMCS functionality follows. The buildings in the inventory are categorized as “advanced”, “common” and “basic” buildings. “Advanced” buildings refer to newer or larger buildings with sophisticated EMCS. “Common” buildings refer to the average size and age buildings with standard EMCS. “Basic” buildings are older and tend to be smaller in floor space with limited or dated EMCS capabilities.

"Advanced" buildings typically use Direct Digital Controls (DDC). DDC contains networked microprocessor-based controllers, which are connected to sensors and actuators. DDC is the most common EMCS technology currently being installed. These systems are scalable, and employ precise sensors and accurate controls. DDC is easily integrated or bundled with other building systems with user-friendly interfaces and provide ease of monitoring, maintenance and controls, which as a result reduce maintenance and calibration costs. EMCS built upon DDCs establishes the potential for real-time monitoring of all sensor, control, and data points from a central location. The data can be logged, trended, used for fault detection, and serve as feedback to refine system operation and energy usage. EMCS and DDC implementation enables sophisticated control strategies to maximize operational efficiency and remote connection via Internet. In addition, EMCS functions for DDC type controls include DR strategy implementation and data analysis tools for energy accounting, making "advanced" buildings the ideal target for DR.

"Common" buildings utilize either pneumatic or electrical control infrastructures. Pneumatic systems employ an air compressor that supplies pressurized air through a system of distribution lines to sensors and devices like thermostats, valves, dampers, and actuators to control operations. Pneumatic systems are reliable and the least expensive. Electric control systems are comprised of electric system controllers, sensors, thermostats, switches, relays, and actuators connected by electrical wiring. However, both systems require preventive maintenance and are hard to modify and expand. EMCS in "common" buildings have limited capabilities. These monitor only selected sensors, collect limited trend records and provide rudimentary preset strategies such as economizers, variable speed drives, and night ventilation. These systems do not typically include energy use data.

"Basic" buildings utilize pneumatic or electrical controls with limited EMCS capability. The EMCS in "basic" building types monitor pre-selected data points and display limited alarms, trends or sometimes energy use data. The control algorithms are based on fixed parameters and modifications to control strategies are hard to implement.

The cost of the EMCS depends on the type of building systems and implementation of the associated controls. As systems diverge from the standard, their costs increase. Simpler systems, with no or little customization options and that simply run the building without collecting information for analysis, are the least expensive. Innovative systems that require more sophisticated implementation are more expensive, but the additional features allow for more effective and efficient use of the buildings. Therefore, the additional cost of the more advanced EMCS may be justified by reduction in utility bills due to timely fault detection and maintenance, energy savings and labor costs.

The success of control strategies for DR and DSM depends on three factors: frequency, duration, and depth. According to the California Energy Commission's Demand Analysis Office findings, commercial and residential air conditioning and commercial lighting contribute 40% of peak load. Similar cooling end-use loads drive peak demand in much of the country. Therefore, DR and DSM strategies often target space conditioning and lighting equipment. The choice of DR, DSM, and energy efficiency strategies is limited by the type of equipment and type of controls in a building. For example, daylighting with photocell-based controls can be achieved with local closed-loop controls. Implementation does not allow control over the dimmable ballast and prevents them from being used for these strategies. The marginal cost of an addition of a central dimming feature to an already dimmable lighting controls system can be justified by the extended benefits of DR implementation. However, the current cost of centrally controllable dimmable ballasts, such as DALI or Zigbee, prohibit their wide adoption leaving the deployment of disruptive switching options for lights as the only option.

Depending on the pricing structure, these strategies may result in utility bill savings. Examples of these strategies are those that shift thermal loads using active thermal storage or passive building mass storage. Thermal storage can be used for daily peak load management or dispatchable, event driven strategies. It is important to note that while there are specific controls for HVAC and lighting that just work for energy efficiency or DR, there are some overlapping controls that cater to both goals. For example, equipment lockout, pre-cooling, thermal energy storage, cooling load reduction and direct fan, pump or chiller quantity reductions provide DR capability. Duct static pressure reduction and global set point adjustments are the only recommended controls that are able to fulfill the goals of DR, DSM and energy efficiency strategies. Global set point "relaxation" is an ideal strategy using HVAC (space conditioning) systems. This is a term used for increasing the cooling set point or – on the mainland – decreasing the heating set point. The acceptability of these set points is determined by the people that reside or work in these buildings.

## 3. Appropriateness to Hawaii

Development and deployment of end-use energy efficient technologies can help reduce electricity consumption and the state's dependence on oil. These technologies and their deployment can be done for relatively small expenditures as long as these systems are sufficiently close to the market. In this regard, state-based projects are more appropriate than national projects in that state-based projects can move closer to the marketplace in meeting end-user and customer needs. Thus, there are ample opportunities for new technologies to be demonstrated and accepted by consumers and the utilities in support of existing programs and in the interests of reducing oil consumption.

Where the insertion of these technologies is limited is in concert with an aggressive demand response program. Hawaii needs to develop better rules and initiatives for demand response. While some rules and systems are in place, more aggressive approaches remain to be developed by the state. Thus, in the near term, newer demand response technologies may be limited by economics. An exception is the treatment of demand response technologies as part of integrated Smart Grid packages. This discussion is covered in another paper.

## 4. Considerations

The cost of development for any of these technologies is relatively small, compared to larger systems related to electricity generation and storage. Furthermore, funding these technologies may require simply a final push to get them into the hands of end-users, either utilities or their customers. While each individual system (for example, a new, less expensive type of LED lighting system) may only contribute a few kilowatts a year to reduced energy use, widespread adoption of these systems can significantly reduce the overall use of electricity. This is the case in California where codes and standards – and their aggressive enforcement – have stabilized per capita electricity use since 1975. In conclusion, there should be nothing to hold back the development and deployment of these systems that can be modified to meet the specific needs of Hawaii.