# ENERGY STAR® ICT Product Road-Mapping Informing Document

## TRACK 2: ICT-ENABLED INTELLIGENT EFFICIENCY SOLUTIONS AND ENERGY STAR

## MARCH 2013

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**BACKGROUND/INFORMING DOCUMENT PURPOSE**

An EPA/ITI jointly sponsored ENERGY STAR ICT Product Road-mapping Workshop was held on July 10, 2012 in Washington DC. The Workshop consisted of three tracks focused on ICT products and ICT enabled solutions. Each track engaged in brainstorming dialog in separate breakout sessions and came up with key focus areas, to address in group discussions over the remainder of the year. The focus of Track 2 has been on helping shape the vision for ENERGY STAR's engagement with ICT-enabled intelligent efficiency solutions and the US economy's increased reliance on ICT-enabled architectures, with a focus on the next 3-5 years.

*"System efficiency opportunities produce energy savings that dwarf component-based efficiency improvements by an order of magnitude. System efficiency is performance-based, optimizing the performance of the system overall—its components, their relationships to one another, and their relationships to human operators. One of the cornerstones of systems-based efficiency is information and communication technologies, such as the Internet, affordable sensors, and computing capacity that are the foundation upon which systems efficiency are built…If homeowners and businesses were to take advantage of currently available information and communications technologies that enable system efficiencies, the United States could reduce its energy use by about 12-22 percent and realize tens or hundreds of billions of dollars in energy savings and productivity gains."* (ACEEE Report, "A Defining Framework for Intelligent Efficiency," June 5, 2012)

The purpose of this document is to present a framework for EPA and stakeholders to work together to encourage and promote intelligent efficiency in the next three to five years. The outcomes of this longer term work may affect ENERGY STAR specifications, program design, or the information that EPA provides to consumers.

We start by defining system efficiency and the related concept of intelligent efficiency, for the purposes of this document. Others have put considerable thought into these definitions, and we reflect this work in our usage below. We will follow with discussion of how the efficiencies under discussion can be encouraged using existing elements of the ENERGY STAR program, including product and building labeling programs, and purchaser education. This approach reflects the fact that many best practices improve efficiency in ways that do not lend themselves to a ranking system. We will also consider the kind of programmatic changes that would need to be considered to reward a wider range of intelligent efficiency. The document ends with a few case studies taken from various sources.

## DISCUSSION

### Definition of Systems Efficiency and of Intelligent Efficiency

Systems efficiency is reduced use of energy based on how components are connected and used together, rather than based on the efficiency of the components themselves. Intelligent efficiency is a related concept, specifically referring to system efficiency based on the use of sensors, automatic control, and effective interaction with operators to achieve efficient operations. In cases where system efficiency is purely a function of system design, such as a well designed hot water heating and distribution system, it is not intelligent efficiency. For the purposes of ENERGY STAR, intelligent efficiency within a product (see Appendix 1A) would not be considered systems efficiency.  Other than these few examples, the overlap is broad.

Advances in information and communication technologies are opening new realms of intelligent efficiency, based on how products are operated as a system, such as the integration of lighting systems and HVAC systems.  One of the hallmarks of intelligent efficiency and its system effect is that the interactions between the components result in greater efficiency than would be achieved by the individual parts.  In many cases, such applications involve the repurposing of devices first intended for office, personal or data center use for use with other, more disparate products to provide an integrated, system level solution to improve energy efficiency of a complex system.  In some cases, there is a trade off between highly efficient products and products which work together to make highly efficient systems.  In addition, investments in system efficiency may yield more energy savings per dollar than investments in the efficiency of individual products.

There are an enormous variety of systems that can use less energy when considered in this holistic light. For our purposes, we propose a taxonomy to help identify areas of opportunity for EPA through the ENERGY STAR program.

> Physical span: Some systems are located in a single physical space, such as an industrial campus, building, or home, for which a single measure of energy input can, in principle, be identified. Others (e.g. transportation networks) span large areas and, in addition, have no single point at which energy inputs might be measured.
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> Design vs. operation: While operations will affect the efficiency of virtually all systems, there are some for which designing the system for overall energy efficiency, rather than looking for efficient components only, can yield significant gains.  For instance, a data center cooling strategy designed as a system can achieve far more than one that is not.  Intelligent efficiency, however, includes both automatic decision making and developing information for operators that can lead to dramatically lower energy use in operation in the field, while maintaining or enhancing system performance.
>
> Market characteristics: A system may be sold as a package by a single vendor, or may be assembled in the field by an installer.

**Observations on the current situation**

In our initial discussions, the team made the following observations on the current state of energy efficiency products and programs:

1) While there are still achievable savings for some products, the new frontier of low hanging fruit is in system efficiency and in intelligent efficiency which is ICT enabled.
2) Currently, when people purchase products or services that can offer intelligent efficiency it is usually not for the energy efficiency benefit but for some other functionality or increased amenity.

We will expand on these observations as we look at our conclusions and recommendations.

**Encouraging increased focus on, and contribution to, Intelligent Efficiency via a product lens**

There are multiple roles that EPA and the ENERGY STAR program can play in the realm of Intelligent Efficiency. One critical area to explore is the role of product efficiency programs and their impact on those products participating in systems efficiency.  This area intersects and interacts with the Track 1 work stream, and coordination/collaboration will be needed by the two tracks here.

Our primary conclusions include:

1) Labeling programs are not practical for systems which deliver energy efficiency unless the system is physically confined (products, buildings or their subsystems). EPA already encourages intelligent efficiency in cases where it fits well into our current existing programs. For example, in cases where intelligent efficiency leads to a more efficient product, as in the refrigerator case study in Appendix 1.1, the products program will reward it. The ENERGY STAR Buildings program bases recognition on actual energy bills, compared to other similar buildings, thus capturing all types of system efficiency, including intelligent efficiency through automated decision making and through delivering better information to operators. Examples of this building scale intelligent efficiency can be found in Appendices 1.3 and 1.4. In addition, the ENERGY STAR Portfolio Manager tool is capable of accepting machine readable data on a monthly basis, and in fact there are multiple market offerings that use this capability.

   There are two areas of intelligent efficiency that are more difficult for EPA to reward within the current ENERGY STAR program elements. The first is when efficiency is based on how products are combined, at a scale larger than an individual product but smaller than an entire building. To reward such efficiency requires taking the energy use measurement out of the laboratory and into the field. The second is when efficiency in a residence is based on improving operation through automatic decision making and/or interactions with operators. This is captured for larger buildings through Portfolio Manager, but there is no similar offering for residences. In addition to field energy use measurements, this would require measurement of energy use on an ongoing basis, unlike the current homes and products program models where energy use is considered at one point in time. EPA and stakeholders will continue to discuss opportunities to use newly available ICT-based capability to encourage efficient operation of homes. For this and other opportunities, EPA will consider their costs, benefits, and implications.

2) There are a number of opportunities to encourage intelligent efficiency through product specification requirements. One way EPA already does this, is by encouraging the use of energy-efficient connectivity technology. For instance, Energy Efficient Ethernet is encouraged in ENERGY STAR ICT product specifications. EPA has the opportunity to sharpen the focus on exploiting such opportunities. This would include
   a. refinement of product specifications/test methods to avoid disincentivizing capacity for system efficiency.
   b. encourage "connected" functionality for appliances and other devices where doing so presents a consumer and societal benefit. EPA can and should encourage product features that lead to system-based energy efficiency, where those features also provide immediate benefit or add minimal expense, even when the inclusion of those features may slightly reduce the energy efficiency optimization of the specific product.

   Interoperability and open standards are to be encouraged for connected functionality; at the same time, ENERGY STAR should remain technology neutral. One of the valuable effects of the ENERGY STAR program has been the innovation that results as different manufacturers and integrators look for unique approaches to improving energy efficiency in their solutions.

**Encouraging increased focus on, and contribution to, Intelligent Efficiency via education and guidance**

ENERGY STAR has had its largest influence through programs that focus on improving the energy efficiency of specific products or types of buildings. While some components of Intelligent Efficiency Systems (or the facilities in which they are installed) may be in recognized ENERGY STAR categories, comparisons between these complex systems may not be possible. Instead, ENERGY STAR can contribute to the development and adoption of these systems in other ways.

1) EPA has an opportunity to influence markets through education. Some possible examples are:

    a. Highlighting case studies of ICT-enabled system efficiency on energystar.gov
    b. Directing purchasers to system energy savings associated with an ENERGY STAR product (e.g. hot water distribution when considering hot water, desuperheaters when considering an HVAC system)
2) EPA and the ENERGY STAR program have multiple opportunities for education about best practices to capture system efficiency.
3) The energystar.gov website can highlight ICT-enabled system efficiency by both teasers running on the home page (e.g. “Did you know that…?”), and by providing links to case studies that showcase some of the opportunities that have been identified.

**Some strategies for assessing approaches**
EPA will investigate system efficiency, including assessing program approaches for piloting one or more "mid-level" (i.e. larger than a single product but smaller than a building) systems.

1) Communication standards and protocols are now widespread in commercial buildings that make it possible to monitor, and to coordinate control of, products that make up systems within those buildings.
2) There are also some possibilities which exist through “extended products”: systems sold at a single time by a single vendor, but made up of disparate components, where the energy use of the system is set more by the system design than by the efficiency of components. These are particularly prevalent in the C&I sectors. One example is that of compressed air systems. Another is highlighted in the Existing Building Case Study (Appendix 1.2), where the use of the protocols cited in item 1, and incremental software and hardware components have been combined to drive increased energy efficiency in a large, existing high-rise office and retail building. Further examples are given in the Accenture Case Studies in Appendix 1.4.
3) In the residential sector, a combination of lower demand for and lower availability of “smart”/connected devices such as appliances have limited growth of solutions parallel to those in 1 and 2. In addition, the equivalent “extended products” (e.g. combined heating/cooling/hot water, or hot water production and distribution) are not generally sold by a single vendor, and may in fact be installed or changed over time. Thus, the extended product or real time monitoring ideas in 1) and 2) above may not have a ready equivalent in the residential sector. One residential focus with potential is the expansion of home management services being marketed by cable and other internet service providers to incorporate energy management. While some already offer the ability to remotely turn on/off lights and appliances and change thermostat settings, this would be taking it to the next level. A second residential focus that could extend to commercial environments is highlighted in the Refrigeration Case Study in Appendix 1.1. It is worth noting that the “consumerization” of efficiency monitoring and management applications for both residential and commercial purposes will emerge as a trend in the reasonably near future. In essence, the explosive growth of smart phones and other mobile devices, coupled with the continuing expansion of online marketplaces for applications download means that both residential and small business customers will eventually expect to use readily available, inexpensive interfaces to monitor and manage energy usage from cloud-based data repositories.
4) The three ideas above focus on product or feature integration, in that the efficiency comes from the way the systems are put together, not how they are used. There is, in addition, a lot of efficiency opportunity available from the way systems are used. The advent of ICT-enabled systems monitoring and control provides additional tools for real time and granular feedback. Such feedback has been shown to change energy use behavior. In addition, the monitoring functions give real time data, which may be useful for verifying the savings from the very behavior change it encourages.
    a. This could apply in the residential sector to homes using WiFi thermostats, all the way up to a much broader scale such as an integrated energy management system on a corporate campus.

b. Another area where this could apply would be in data center management for energy efficiency. This area interacts with Track 3, and the two teams should collaborate to reflect this intersection.
c. The use of Cloud Computing to replace some or all of a business' ICT infrastructure is an additional demonstration of efficiency gained through how products are used. Again, the efficiency of the products involved is valuable, while that contribution is outstripped by the opportunity to eliminate the physical instantiation of some products through shared (Cloud) equipment. This reduction is more significant for the client businesses than incremental improvements in their equipment, providing both environmental and financial savings. The Cloud Computing Case Study in Appendix 1.3 provides more details.

## NEXT STEPS

Throughout the Discussion section, we have identified a number of recommendations for ways ENERGY STAR can encourage and monitor ICT-enabled Intelligent Efficiency solutions. In addition, we've noted some trends that the Working Group believes will accelerate the development and adoption of these types of solutions. The Track 2 working group believes that we should continue to meet at least quarterly in 2013 to ensure we continue our coordination with the Track 1 and Track 3 efforts. In addition, this will give us further opportunities to review and update our recommendations, and to observe the marketplace and identify additional or evolved trends worth noting.

## Appendix 1: Case Studies

### Appendix 1.1 *Residential Refrigerator Case Study: Smart Controls, Links to Electric Grid*

Home appliances are increasingly making use of *intelligent efficiency* to gain greater levels of energy efficiency. Residential refrigerator energy use peaked in 1975 and has been declining steadily since then. Efficiency gains have been driven by minimum efficiency standards, performance and labeling programs such as Energy Star™, utility incentives, and higher energy prices. Technologically, they have been achieved almost exclusively through component optimization.

<u>Component Improvements</u>

- Shift from fiberglass to foam insulation
- Improved foam insulation formulations
- Improved door gaskets
- Better compressors.
- Adaptive Defrost Cycle

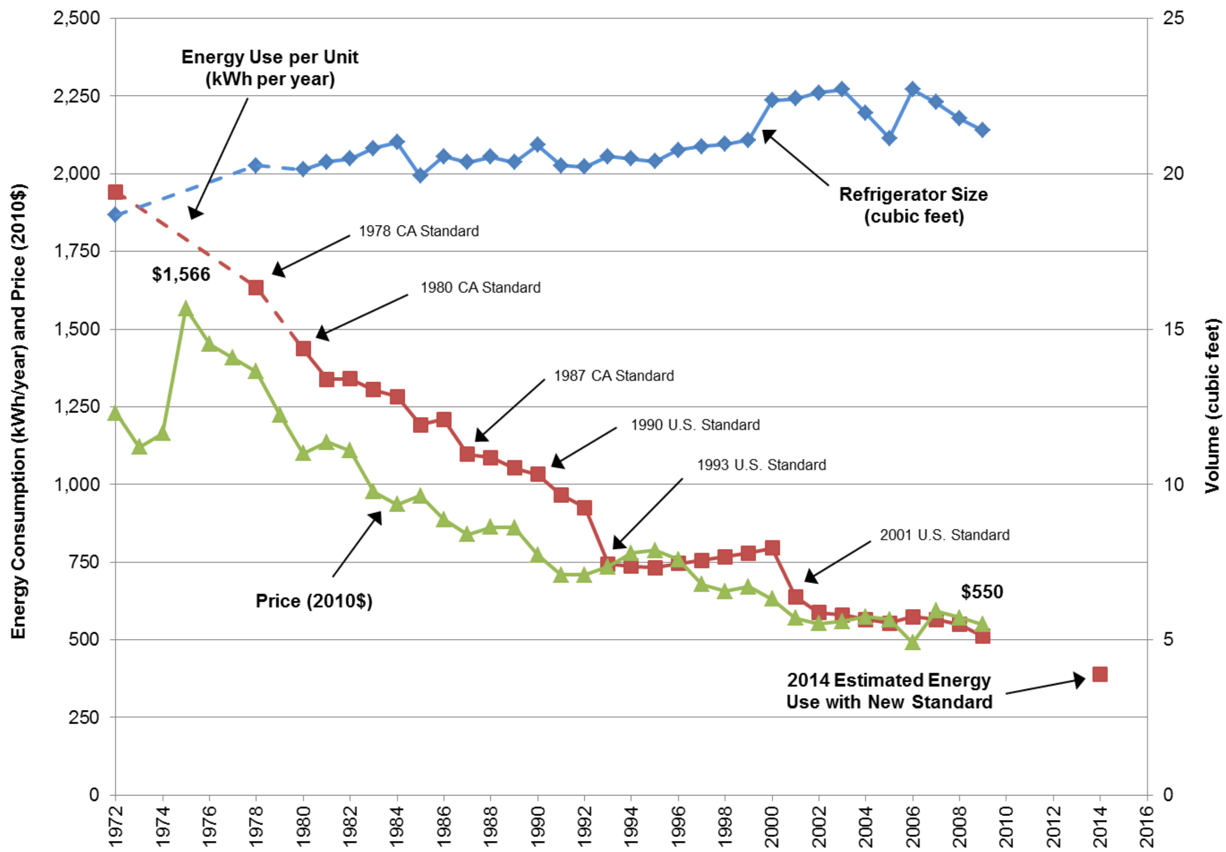
To meet new federal refrigerator standards to take effect in 2014, some refrigerators will take advantage of smarter technologies that use sensors and information from the grid and/or users to adjust speed and other parameters in order to optimize energy-efficient operation.

<u>System Improvements</u>

- Variable-speed compressors
- Variable-speed fans
- Electronically controlled refrigerant expansion values
- Variable anti-sweat heaters

In November 2011, the U.S. Environmental Protection Agency (EPA) proposed providing a 5% energy use credit in its new Energy Star™ specification for "connected" refrigerators that optimize performance with information from the grid and user interfaces. These new standards will reduce energy use in the most popular product classes by 25% compared to the 2001 standards.

Figure 1. Average Household Refrigerator Energy Use, Price and Volume over Time




Source: Lowenberger et al. 2012

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Geller, H. and D. Goldstein. 1998. “Equipment Efficiency Standards: Mitigating Global Climate Change at a Profit.” (Szilard Lecture). College Park, MD: American Physical Society.

Sastry, C., R. Pratt, V. Srivastava and S. Li. 2010. Use of Residential Smart Appliances for Peak-Load Shifting and Spinning Reserves, Cost/Benefit Analysis. PNNL-19083. Richland, WA: Pacific Northwest National Laboratory.

**Appendix 1.2** ***Existing Building Case Study: Tenant Energy Management System by Johnson Controls***[1]

The web-based Tenant Energy Management system currently being demonstrated in the Empire State Building provides each tenant with an online micro-website that enables them to track, manage, and compare their energy use. Though still in a state of development, the system will ultimately be able to respond to internal information from on-site meters and sensors, external data from utilities and weather forecasts, and input from end users. The system calculates and displays key performance indicators for tenants, such as energy consumption per square foot or energy consumed per occupied hour.

The system also supports benchmarking of energy performance to inform and encourage energy-saving behavior from tenants. The benchmarking program allows tenants to opt into a group of similar tenants (e.g., accounting firms) so that they can compare their percentile efficiency ranking within the group. The lease structure was changed to encourage tenants to reduce their energy use by offering incentives for meeting or exceeding energy efficiency targets.

The Tenant Energy Management System, along with "intelligent" building management capabilities such as active daylighting control, occupancy-based control of temperature and plug-loads, demand-controlled ventilation, wireless sensing, and continuous fault detection, results in significant additional energy savings over spaces designed and built only to minimum code requirements.

Reference

Elliott, N., M. Molina, and D. Trombley. 2012. A Defining Framework for Intelligent Efficiency http://aceee.org/research-report/ie061 Washington, D.C.: American Council for an Energy-Efficient Economy.

[1] Conversation with Clay Nesler, Johnson Controls. 6 May 2011.

**Appendix 1.3** ***Cloud Computing Case Study***

Most businesses and organizations support employees' personal computers through a dedicated, local computer network, however, a growing alternative is to provide many services through "cloud computing," meaning large servers, typically in data centers, that provide the computing, storage, and software services connected to the user via the Internet. The cloud platform achieves these savings by enabling higher utilization of servers, more efficient matching of server capacity to server demand, and "multitenancy" to serve thousands of organizations with one set of shared information technology (IT) infrastructure. When all servers are not needed, some can be turned off and loads rerouted to other units.

Google (2011) estimated the relative energy use per user for e-mail, comparing small, medium, and large businesses with their own servers (with 50, 500, and 10,000 users, respectively) to using cloud-based e-mail (e.g., Gmail). They estimate that energy savings can be over 50% for large users and well over 95% for small users. Some of the gains are from more efficient equipment (shown in the second column) but much of the gain is from improved power use effectiveness (PUE) (shown in the third column), which means less energy spent to house and cool the computers inside a building.

**Table 1. Relative Energy Use for E-Mail for Different Size Businesses**

| Business Type | IT Power per User | PUE | Total Power per User | Annual Energy Use per User |
|---|---|---|---|---|
| Small | 8 W | 2.5 | 20 W | 175 kWh |
| Medium | 1.8 W | 1.8 | 3.2 W | 28.4 kWh |
| Large | 0.54 W | 1.6 | 0.9 W | 7.6 kWh |
| Gmail | <0.22 W | 1.16 | <0.25 W | <2.2 kWh |

Source: Google 2011

Though there are some situations in which cloud computing uses more energy than traditional, on-site servers—specifically, in situations involving computationally intensive tasks that require a great deal of data transport (Baliga et al. 2011), in most instances, cloud computing is the more efficient option.

If cloud computing were adopted by most of the nation's large computers, collectively, they could reduce their IT-related CO2 emissions by an estimated 50% by 2020 (Carbon Disclosure Project 2011). For example, a typical food and beverage firm transitioning its human resources application from a dedicated IT system to a public cloud could:

- achieve savings with a net present value (NPV) of $10.1 million,
- reduce CO2 emissions by 30,000 metric tons over five years, and
- achieve an economic payback of one year.

This example of energy savings from cloud computing reflects the promise of intelligent efficiency. By rethinking the systems used to meet each specific need, the country has the opportunity to improve the use of energy in every aspect of every sector of the economy.

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Holler, Anne. 2010. "The Green Cloud: How Cloud Computing Can Reduce Datacenter Power Consumption." Presentation at SustainIT10, Feb. 22, 2010, San Jose, CA. http://www.usenix.org/event/sustainit10/tech/slides/holler.pdf .

**Appendix 1.4** ***Accenture Sustainability Services Case Studies***

***Microsoft***

A report which has been provided separately highlights an initiative undertaken in 2011 by Microsoft's Real Estate & Facilities organization to evaluate smart building applications from three vendors across 13 buildings within the company's main 118-building campus. Microsoft's experience demonstrated that "a smart building solution can be established with an upfront investment of less than 10 percent of annual energy expenditure, with an expected payback period of less than two years. By collecting and analyzing millions of data points (samples) per day, the company has been able to embark on multiple improvements that are reshaping the way its buildings are managed. Microsoft's building engineers have become far more productive: instead of 'walking around' to find issues, they're now 'walking to' the problems that have the greatest impact on cost or comfort. By itself, the ability to continuously identify issues and optimize the performance of building equipment is expected to deliver annual savings of more than one million dollars. Furthermore, as building engineers can analyze data collected over time and occupants become more aware of individual energy use, Microsoft hopes to save several million dollars by optimizing base load (from building systems directly controlled by the building engineers) and by reducing plug load (from devices used by occupants) across its building portfolio."

***Net App***

As presented at the 12th Annual Energy Summit for the Silicon Valley Leadership Group in June 2012, Net App realized significant value through implementation of Accenture Smart Building Solutions. In pursuing the smart buildings initiative, Net App had objectives to reduce energy consumption in line with ISO 14001 goals, to discover hidden savings opportunities, to optimize equipment operations, and to make incremental improvements to already efficient buildings. Net App implemented ASBS in a 121,385 square foot office building constructed in 2004. The building contained a 2 mW engineering laboratory and had an annual energy spend of $2.7M. Through implementation of ASBS, Net App realized the following accomplishments:

- Decreased the building's required warmup time by ~50% (between 2-4 hours reduction per day, depending on outside air temperature)
- Coordinated separate systems to drive efficiency (Boiler and AHU schedules)
- Identified malfunctioning components (AHU economizer actuator)
- Reduced cycling and instability of controls logic (FCU cooling coils, AHU return fan)
- Contributed to best practice in BAS setup and controls logic across other NetApp buildings
- Identified limitations of the current controls system setup (PID loops for VAVs, Chiller supply temperature, AHU individual control, etc.).