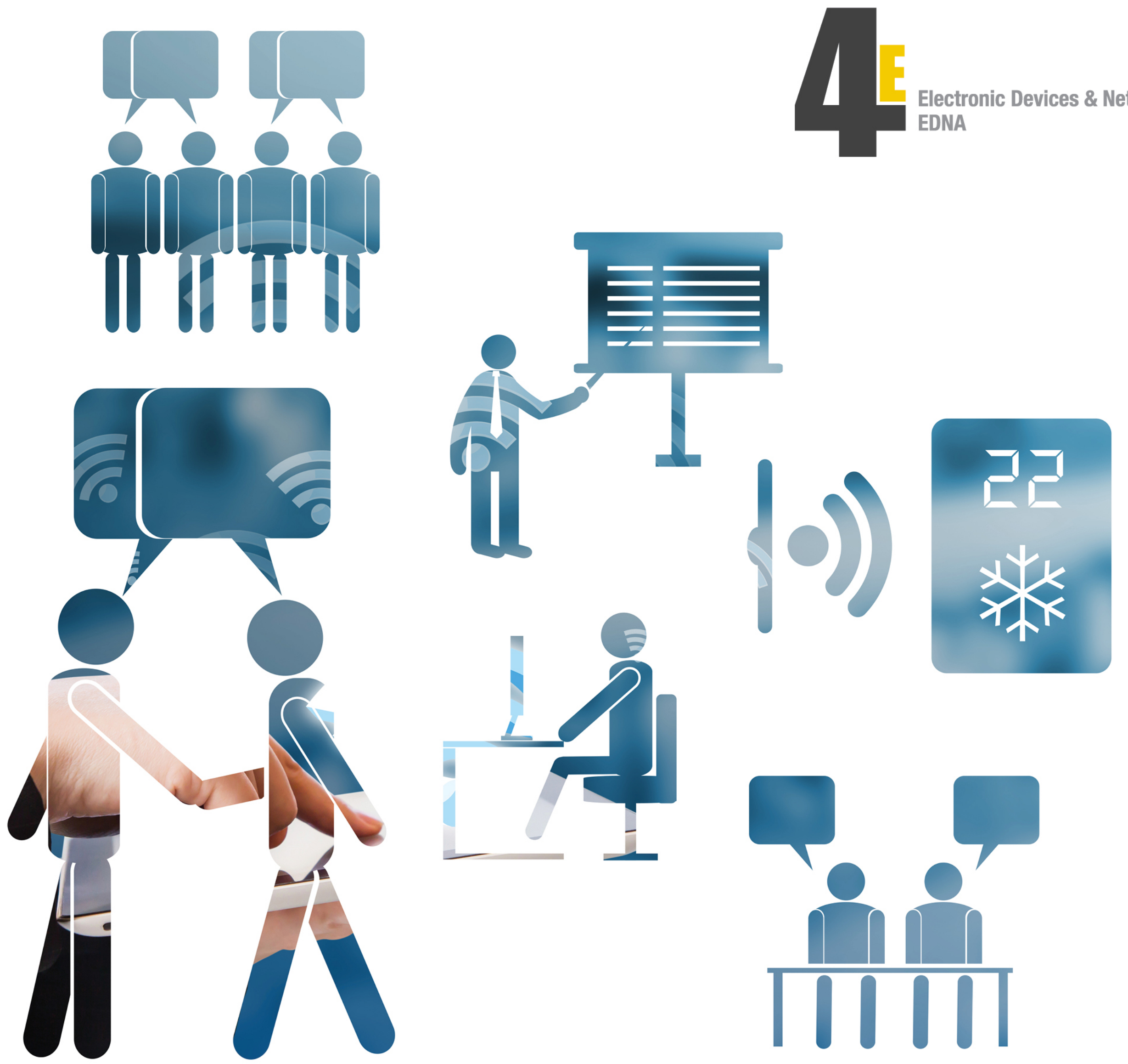
Electronic Devices & Networks Annex
EDNA



Encouraging Intelligent Efficiency

Study of Policy Opportunities

APRIL 2017

connected devices
ALLIANCE

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Study of Policy Opportunities

Report Prepared for IEA 4E EDNA

April 2017

Electronic Devices & Networks Annex
EDNA

The Implementing Agreement on Energy Efficient End-Use Equipment (4E) is an International Energy Agency (IEA) Collaborative Technology Programme established in 2008 to support governments to co-ordinate effective energy efficiency policies. Twelve countries have joined under the 4E platform to exchange technical and policy information focused on increasing the production and trade in efficient end-use equipment. However, 4E is more than a forum for sharing information – it pools resources and expertise on a wide a range of projects designed to meet the policy needs of participating governments. Participants find that is not only an efficient use of available funds, but results in outcomes that are far more comprehensive and authoritative than can be achieved by individual jurisdictions.

Current members of 4E are Australia, Austria, Canada, Denmark, France, Japan, Korea, Netherlands, Switzerland, Sweden, UK and USA.

Further information on the 4E Implementing Agreement is available from: **www.iea-4e.org**

Network connected devices, including the Internet of Things, are growing rapidly and offer enormous opportunities for improved energy management. At the same time, there is a responsibility to ensure that these devices use a minimal amount of energy to stay connected. 4E's Electronic Devices and Networks Annex (EDNA) works to align government policies in this area and keep participating countries informed as markets for network-connected devices develop.

Further information on EDNA is available at: **edna.iea-4e.org**

Authors

This report is authored by Ethan Rogers, Chetana Kallakuri and Jennifer King of the American Council for an Energy-Efficient Economy (ACEEE), a US- based non-profit 501(c)(3) organization, that acts as a catalyst to advance energy efficiency policies, programs, technologies, investments, and behaviours. ACEEE believes that the United States can harness the full potential of energy efficiency to achieve greater economic prosperity, energy security, and environmental protection for all its people. ACEEE carries out its mission by:

- Conducting in-depth technical and policy analyses
- Advising policymakers and program managers
- Working collaboratively with businesses, government officials, public interest groups, and other organizations
- Convening conferences and workshops, primarily for energy efficiency professionals
- Assisting and encouraging traditional and new media to cover energy efficiency policy and technology issues
- Educating consumers and businesses through reports, books, conference proceedings, press activities, and websites

ACEEE was founded in 1980 by leading researchers in the energy field. Since then ACEEE has grown to a staff of about 50. Projects are carried out by ACEEE staff and collaborators from government, the private sector, research institutions, and other non-profit organizations. ACEEE focuses on federal, state, and local energy policy. It also publishes a biennial International Energy Efficiency Scorecard report that compares the energy efficiency policies of 23 of the world's top energy-consuming countries.

Research Team

Ethan Rogers, Industry Program director, directed the research and preparation of the reports in this project and served as the liaison with representatives from 4E-EDNA. Chetana Kallakuri, Federal Policy Program research analyst, conducted research on the policies that could affect the uptake of intelligent efficiency in target countries, and Jennifer King, Buildings Program senior research analyst, conducted research on the regulations that affect connected devices in the residential and commercial sectors in targeted countries. Lowell Ungar, senior policy advisor, advised the research team and participated in the scoping of research activities and review of reports and R. Neal Elliott, senior director for research, provided overarching guidance of research activities and report review.

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Executive Summary

This research project investigated the policy and program opportunities for governments to encourage greater investments in network connected devices and their application in reducing energy consumption in residential, commercial and institutional buildings. Particular interest was focused on device-specific energy performance standards and labelling schemes. The policies of as many countries as possible were examined. Particular attention was paid to those in Asia, Europe and North America. The goal of this research was not to perform a comprehensive survey of policies, but rather to conduct a sampling of policies sufficient to gain an understanding of the current state of regulation and government engagement.

The research team identified common policy and program types and examined how they varied by country. Many countries have established energy performance labeling requirements for many appliances, connected or not, and the major economies of the world have established energy consumption limits for connected devices when in idle or standby modes. These same countries are investing in research, development and demonstration of network connected devices in order to accelerate innovation and increase market adoption.

Connected devices use energy and have the ability to save energy. When part of a network that has the capacity to save energy through superior control of system or facility energy use, connected devices can be considered a form of Intelligent Efficiency, a term used to describe the suite of energy efficiency measures that use information and communications technologies (ICT) such as sensors, networks, and data analytics to save energy.

There are not many policies that specifically call out Intelligent Efficiency. Most of the policies identified are directed at broad product categories or broad sectors of the economy that include Intelligent Efficiency products, services or enabling technologies.

The research revealed that a majority of existing policies fall into six categories:

- Providing information and education, and expanding awareness
- Creating performance and endorsement labels
- Establishing labeling requirements
- Creating performance requirements
- Direct investment in technology research, development and demonstration
- Voluntary agreements

A barriers analysis identified obstacles to greater market adoption of Intelligent Efficiency. Each barrier was connected to one or more possible policy solutions and, where available, to existing examples. There are a few barriers that arise from the use of information and communication technologies such as privacy issues, consumer awareness, education and workforce training. However, most of the barriers to Intelligent Efficiency are the same barriers faced by most emerging technologies.

Customers are not aware of Intelligent Efficiency products and services and do not fully understand the opportunity they present to reduce costs or provide other benefits such as streamlined control of building systems. Energy costs are not a significant expense for many organizations and therefore not a priority. In some instances, the benefits of connected devices are not realized by the end user but by the larger electric utility system in an ability to operate a system more efficiently and at lower cost. The split-incentive issue is very common in the energy efficiency sector and so it seems with connected devices: users of connected devices are often not responsible for energy expenses.

There continues to be a great degree of incompatibility between proprietary networks and electronic devices. This has become a concern to agencies interested in expanding the use of Intelligent Efficiency and connected devices. To address this issue, many government agencies have formed and are leading collaborative efforts to develop open source software platforms and common communication protocols for networks and devices. Product features that lend themselves to connectedness are being included in labeling schemes such as the U.S. Environmental Protection Agency's ENERGY STAR connected thermostat program. In this initiative, manufacturers are encouraged to build in to their products common interfaces and the ability to respond to demand response signals from electric grid operators.

Most countries have engaged their business sectors for many years to reduce energy consumption. The education, training, goal-setting, and financial assistance initiatives they have created to do so are now starting to include information and technical assistance related to Intelligent Efficiency and connected devices.

Participation by the private sector in most government initiatives is voluntary, but receipt of assistance is sometimes conditioned on performance obligations that are framed in legally binding contracts. Obligations can be tied to active pursuit and even achievement of specific energy efficiency or pollution prevention goals.

A key discovery was that a network of policies and programs can be created to effectively stimulate greater investment in Intelligent Efficiency when there is compatibility of goals and communication between agencies. For example, if performance regulations are being developed to limit the amount of energy a connected device can consume when in idle mode, it makes sense that research activities support development of products that can meet that goal. Additionally, collaborative efforts to develop common network protocols should be aware of and contribute to the rulemaking process so that new network practices don't run afoul of the performance standards and that regulations don't prevent the system-level efficiency gains that are possible through networks and connected devices.

Looking forward, governments can facilitate greater adoption of Intelligent Efficiency through support of a broader scope of technology research, development, demonstration and deployment; creation of performance labels and standards; leadership in the development of common software platforms and communication protocols, and harmonization of performance standards across jurisdictions. These outcomes will require a new level of communication and coordination between agencies and between initiatives. It will also require collaboration among countries, joint effort in overcoming barriers, and agreement on common goals to deploying Intelligent Efficiency because of its global nature.

1 Introduction

1.1 Objective

Following the work of the Connected Devices Alliance[1], The IEA 4E Electronic Devices and Networks Annex (EDNA) has commissioned a study of government policy opportunities for encouraging Intelligent Efficiency, the results of which are contained in this report. EDNA was conceived from governments' concern that the proliferation of network-connected devices may result in an increase in energy consumption, due to the power consumed by these devices in network standby mode (refer IEA publication: More Data Less Energy[2]).

The objective of the study is to identify and analyse the range of government policy options that can be implemented to stimulate greater uptake of Intelligent Efficiency. The analysis also explores the relationship between Intelligent Efficiency and product-specific efficiency programs, such as mandatory and voluntary appliance standards programs, and how they might affect the benefits of Intelligent Efficiency. The policy analysis concludes with a discussion of barriers to greater adoption of Intelligent Efficiency and recommendations for policies to address them.

This report represents a high-level introduction to the topic, and it is anticipated that further study, e.g. of specific market segments, may be required in order to develop more specific recommendations.

1.2 Definition

Energy savings can be realized at the device level, such as with high-efficient light bulbs; at the system level, such as with a heating, ventilating and air-conditioning (HVAC) system; and at the whole building or facility level. Device-level savings are typically realized through superior product design resulting in a more efficient technology (for example: LEDs replacing incandescent bulbs). System-level savings are achievable through designing and selecting the components of a system with the goals of the system in mind, as is done with heating and cooling systems. Facility-level savings require operating multiple systems in a harmonized fashion so that they work together to meet the needs of the people in the building while at the same time minimizing energy use. System and facility level savings require the coordination of multiple components towards a common goal. When that goal, such as human comfort and productivity, is a rapidly changing target, achieving it can be quite difficult. Intelligent Efficiency has the promise of having the capability to address these types of challenges.

The emergence of information and communications technologies (ICT), such as computers and connected mobile devices, data analytics and Cloud computing, the Internet, and wireless networks, has made it possible to continuously optimize the performance of complex systems such as building heating and cooling systems or industrial manufacturing processes.

The ability to network-connect sensors, processors, data storage and energy-using equipment (e.g. heating, cooling, lighting, etc.) with local and or remote data analytical tools has made it possible to

[1] Connected Devices Alliance (CDA) website: cda.iea-4e.org.

[2] www.iea.org/publications/freepublications/publication/more-data-less-energy.html

collect relevant device and system performance data, analyse it in near real-time, and make adaptive, anticipatory, and "intelligent" decisions about how equipment can be operated in an energy-efficient manner.

With this in mind, for the purpose of this report Intelligent Efficiency means:

> *The deployment of network-connected ICT technologies to facilitate efficient operation of energy-using equipment, leading to energy savings.*

Furthermore, in order to formulate policy recommendations, which might act upon specific aspects of Intelligent Efficiency, it is useful to understand what these aspects are. Thus, for the purpose and scope of this report, an Intelligent Efficiency system is typically comprised of the following network-connected elements:

- Communications network
- Communications protocols
- User interface, for providing contextualized performance information and control
- Sensors, for detecting environmental changes, equipment states, etc.
- Processing capability and memory
- Firmware / software
- Software as a Service (SaaS) (in some cases)
- Cloud computing (in some cases)
- Control algorithms
- Energy-using equipment, incorporating:
    - Primary function (lighting, heating, cooling, etc.)
    - Network connection (and associated network standby energy use)
- An interdependent system of multiple components of energy-consuming equipment (in some cases)

There are many permutations of ways in which the above elements can be arranged and interconnected in an Intelligent Efficiency system, however most of these elements should be incorporated, other than those marked "in some cases".

Example: Commercial Buildings and Networked Devices

There are times when optimizing each individual device does not lead to the best full-system design due to the complex interaction of devices within a system. In the heating, ventilating and air-conditioning (HVAC) systems in large buildings, there are multiple zones (usually one room or office suite) each controlled by its own temperature sensor. These sensors tell a controller to change the amount of cooling and outdoor air provided to the space. However, this method of controlling each part of the system separately does not take into account the interaction among these various demands on the system, which can actually increase energy use while reducing occupant comfort. As equipment cycles to respond to coincident demands, it can easily overshoot target temperatures when adjacent areas call for heating and cooling concurrently.

Energy can be saved by connecting all of the room thermostats to a network that is also connected to the central heating and cooling systems. The building automation system directs the HVAC system to deliver the required cooling or heating and air quality to each zone. Additionally, each device, such as a fan or pump, can monitor its performance and communicate current operating conditions to the building automation system so that it can detect any faults and alert building operators of the need for maintenance. Although the savings from each improvement is small, in aggregate building energy use can be reduced by 10 to 30%.

1.3 Scope

Broadly speaking, there are three categories of Intelligent Efficiency:

1) **Automation**, where system changes to reduce energy use are made without human intervention. An example is a learning thermostat that uses machine learning to understand and then predict resident heating and cooling preferences and patterns. Energy is saved by matching room temperature to resident preferences and occupancy.
2) **Real-time feedback** of information to humans, who can then make system changes to improve efficiency. An example is a smart manufacturing process control system that analyses inputs from throughout the process and presents the operator with timely and contextualized production information that is actionable.
3) **Substitution/dematerialization**, where ICT is used to displace energy intensive activities. An example is replacing an on-site server with a Cloud-based virtual server.

The focus of this analysis is an examination of policies affecting connected devices in residential and non-residential buildings. Therefore, the study is concerned primarily with the first two mechanisms, especially the first where energy savings actions are automated. The third mechanism - substitution / dematerialization - is not a focus for this study. While there are examples that impact upon equipment energy use, for example replacing face-to-face meetings with video-conferencing and telework, this area is outside the scope of this study. For these reasons and for the sake of simplicity, substitution/dematerialization, and similarly Intelligent Efficiency related to transportation, are excluded from the scope of this study.

1.4 The ICT-Energy Nexus

The emergence of Intelligent Efficiency and its manifestation in the connection of millions of devices to networks is having two profound effects on the use of energy in systems. The first is the energy consumption of the connected devices themselves (ICT footprint). The second is energy savings brought about through optimized operation of the building systems and facilities (ICT handprint).

The policies analysed in this study are applicable to both the footprint and the handprint of ICT.

1.4.1 ICT footprint

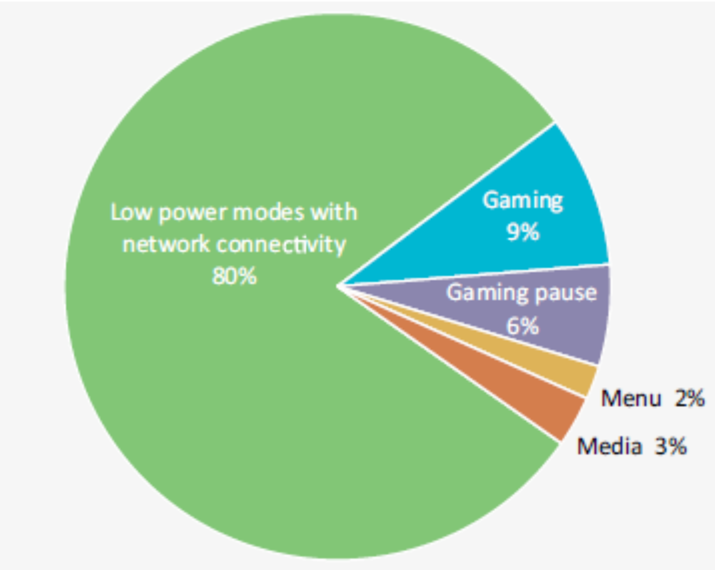
There is a hierarchy of connected devices. There are of course unconnected, or standalone devices. These may be electronic or not. Examples are a conventional TV or dishwasher. A device that is connected to a network (a "connected device"), may or may not have internal logic and the ability to communicate bi-directionally with other devices in the network. Devices without logic that are connected to and that can be controlled through a network, such as speakers or microphones, are often referred to as being "networked." They are input or output devices and can only receive or send data through the network. A connected device with internal logic is capable of both sending and receiving data These devices communicate bi-directionally and are often referred to as "network" devices. These devices will have a network Internet Protocol (IP) address, which enables them to be found and identified within a network.

Unconnected devices do not need to be on all of the time to stay in communication with a network because they are not connected. Networked devices on the other hand may be on all the time consuming a small amount of power so that they can respond to commands instantaneously. Network devices will routinely exchange information with other devices in the network and in doing so, continuously consume power. In this report, the term *connected devices* will cover both of these sets of devices.

By design, network devices are always linked and ready to receive or send information. As such, they are always consuming some energy so that they can at the very least, receive a command. Unlike their conventional counterparts, connected electronic devices such as televisions and other home electronic appliances that used to consume no energy when turned off, now consume some energy all the time. These devices have *low power* or *standby* modes to remain connected to the network.

As demonstrated in Figure 1, connected game consoles consume energy unless completely shut off or unplugged. The low power mode of connected game consoles represents 80% of their annual energy consumption (IEA 2014). Some common connected gaming consoles have low power modes ranging as high as 8-16 watts per hour (Delforge and Horowitz 2014).

Figure 1: Annual energy consumption using a typical duty cycle of a 2010 game console model.



Source: **IEA 2014.**

The energy consumed by network devices, for the purpose of sustaining the network and exchanging information between devices is often referred to as the energy footprint of a network. The number of connected devices that continuously draw power will rise exponentially in the coming years. Current predictions are that 50 billion devices will be connected to the Internet by 2020. The IEA projects that global standby electricity consumption of networked devices, the energy footprint, will reach 1140 Terawatt-hours per year (TWh/yr) of electricity by 2025.

This expanding consumption is a concern for many governments because meeting this demand for power will require new investments in electricity infrastructure. To address this issue, many policy makers are pursuing policies to reduce the power requirements of connected devices. The IEA estimates that over half, 739 TWh/yr, could be saved through the use of more efficient standby modes in connected devices (IEA 2014).

1.4.2 ICT Handprint

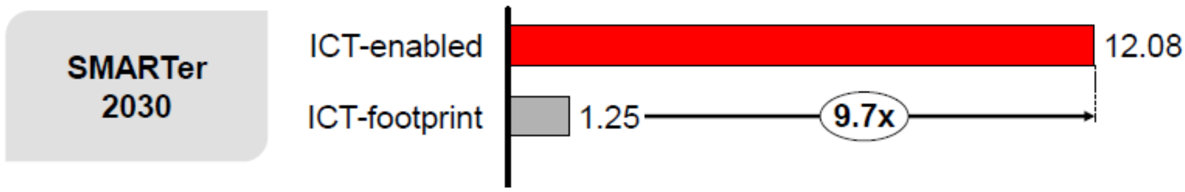
Though it is important to reduce the power draw of devices when not in use, the energy consumed by connected devices while in standby or idle mode is not necessarily wasted. The networking of multiple devices within a system and the networking of multiple systems within a facility, have potential to save energy. While network energy use is regarded as the energy footprint, the energy savings through using networks can be considered an energy savings handprint.

The purpose of some networks is more related to system efficiency than others. For example, the network associated with a building management system has among its purposes the enabling of superior control of building equipment. In such cases, the handprint has the dominant influence on energy use.

By contrast, the network associated with a gaming console is intended to provide a greater level of entertainment. Having all parts of the network available instantaneously is part of the entertainment package. In this example, the footprint dominates.

Research predicts that while the ICT footprint could reach 1.25 Gigatonnes (Gt) of Carbon Dioxide (CO_2) equivalent in 2030, or 1.97% of global emissions, the handprint would result in avoiding 12 Gt of CO_2 equivalent. The use of ICT will result in nearly 10 times more energy saved then consumed (GeSI 2014).

Figure 2: ICT footprint versus ICT handprint.



***Source: Smarter 2030*, GeSI 2014.**

The proper goal of policies affecting Intelligent Efficiency is to minimize the footprint without limiting the benefits of a positive handprint.

2 Existing Policies

In the literature review phase of this project, the government policies, agency programs, and public-private collaborative initiatives of over twenty countries were examined. The goal was to determine if there are common policy mechanisms in use, and if there is a preference for mandatory over voluntary compliance with performance and labelling standards[3]. Another goal was to determine if policies are exclusive to networks and connected devices or if the regulations that affect them also address other products. A third goal was to determine if governments see themselves as a catalyst for growing awareness, interest, and investment in Intelligent Efficiency.

This report uses the IEA policy classification system, reproduced below in table 1, to categorise policies examples and analyses. The relevant alphabetic codes of the table are repeated in the headers of subsequent sections for easy reference. Shaded fields in table 1 represent policies discussed in the Existing Policies, Barriers Analysis, and Recommendations sections of the report.

[3] A discussion of the difference between regulatory and consensus, voluntary standards is included on page 5 of the Scoping Study that is included as an appendix in this report.

Table 1: IEA policy classification system

Main type		Subtype 1		Subtype 2	
Economic Instruments	E	Direct investment	D	Funds to sub-national governments	F
				Infrastructure investments	I
				Procurement rules	P
				RD&D funding	R
		Fiscal/financial incentives	F	Feed-in tariffs/premiums	F
				Grants and subsidies	G
				Loans	L
				Tax relief	Tr
				Taxes	T
				User charges	C
		Market-based instruments	M	GHG emissions allowances	A
				Green certificates	G
				White certificates	W
Information & Education	I	Implementation advice/aid	A		
		Information provision	I		
		Performance Label	L	Comparison label	C
				Endorsement label	E
		Professional training & qualification	T		
Policy Support	P	Institution creation	I		
		Strategic planning	S		
Regulatory Instruments	R	Auditing	A		
		Codes & standards	C	Building codes & standards	B
				Product standards	P
				Sectoral standards	S
				Vehicle fuel-economy & emissions standards	V
		Monitoring	M		
		Obligation schemes	Ob		
		Other mandatory requirements	O		
Research, Development & Deployment (RD&D)	RD	Demonstration project	D		
		Research program	R	Technology deployment and diffusion	Dp
				Technology development	Dv
Voluntary Approaches	V	Negotiated agreements (Public-private sector)	N		
		Public voluntary schemes	V		
		Unilateral commitments (Private sector)	C		

***Source*: IEA**

The IEA categories are useful in understanding the perspectives of a governing body and in helping organize a portfolio of policies. However, it does not capture the perspective of the public. From a citizen's point of view, policies and programs may support energy efficiency by providing information, technical or financial assistance. Alternatively, government regulation may set voluntary or mandatory requirements for product performance. These policies and programs can provide information or financial assistance, or require a financial expenditure or conformity with a regulation or performance standard. It is with this perspective that the type and nature of Intelligent Efficiency policies are categorized in table 2. The table is organized left to right and top to bottom with more voluntary, informational policies towards the upper left and mandatory, coercive policies to the lower right. Each of the examples in table 2 are explained in greater detail in the following sections.

Table 2: Categorisation of policy types and nature

		Nature of policy measure		
		Supportive	***Voluntary***	***Mandatory***
Type of policy measure	***Information***	Policy: making available information (I-I, I-T) Example: disseminating information on smart lighting systems	Policy: voluntary energy label (I-L-E) Example: ENERGYSTAR	Policy: mandatory energy label (I-L-C) Example: Korean Rational Energy Utilization Act
	Financial	Policy: direct Investment in infrastructure and RD&D (E-D-I, -R) Examples: OpenADR, National Laboratories	Policy: grants, loans, tax incentives for energy efficiency (E-F-G, -Tr) Example: grants and tax relief in Korea	Policy: taxes and fees on devices and networks (E-F-T, -C) Example: absence of taxes or fees on Internet
	Conformity	Policy: technology development and deployment (RD-R-Dp) Example: Green Button	Policy: voluntary agreement by manufacturers (V-N) Example: Set-Top Box voluntary agreement	Policy: minimum efficiency performance standards (R-C-B, R-C-P) Examples: building codes and product standards

***Source*: adapted from Siderius 2014. P.4.**

The framework of table 2 will help policy stakeholders understand how a given policy is likely to be perceived by those it is intended to affect and is repeated in the policy analyses that follow. The alphabetic abbreviations of table 1 are included in table 2 as a cross reference and repeated in the headings of the following subsections. The examples of policies contained in table 2 are also discussed in more detail in the individual policy analyses.

2.1 Supportive Information

Information dissemination and education are fundamental roles for government. Information programs are designed to assist energy consumers to understand and employ technologies and practices that use energy more efficiently. These programs aim to increase consumer awareness, acceptance, and use of particular technologies or utility energy conservation programs. Programs can range from general awareness efforts to technical assistance outreach. Examples of information programs include educational brochures, infolines, videos, home energy rating systems, design assistance programs, energy audits, energy use feedback programs, and labelling programs.

2.1.1 Providing Information (I-I)

The publications of the Connected Devices Alliance and the EDNA are examples of government agencies collecting, organizing, and making available information. The distribution of such information often involves presentations at events, trade shows, and interactions with end users at the local level.

2.1.1.1 Example: MEEA distributes DOE information

It is common for national and multi-national organizations to support regional and local organizations in order to facilitate greater distribution of information resources. For example, the US DOE provides a wealth of information on solid state lighting and control systems that utilize machine learning. Information includes lists of available products, comparisons of performance, results of demonstrations (DOE 2017b). The information they provide is shared by regional and state organizations such as the Midwest Energy Efficiency Alliance (MEEA) and delivered in a more retail fashion through its events and direct engagements with end users (MEEA 2017).

2.2 Voluntary Information

Information disclosure often comes in the form of a label or some type of mark that identify products with superior performance. A mark may indicate compliance with a standard or where a product's performance falls within a spectrum of similar products. A label may contain performance information or be just a logo. The value of a label is that it differentiates a product or group of products by communicating value.

Many manufacturers belong to trade associations that have created and promote their own performance documentation schemes. The National Electrical Manufacturers Association (NEMA) has developed many performance standards and labeling protocols for electrical products. Some of their test methods and performance standards, such as for induction motors, have been adopted by government agencies and become mandatory. But they have all started out as voluntary efforts to disclose information about the features and performance of manufacturers' products. NEMA currently has working groups developing information disclosure protocols for products in multiple sectors including building electrical systems, lighting systems, Smart Grid, and industrial products (NEMA 2017). Government agencies have created similar information sharing initiatives in the past to bring about greater awareness of energy-efficient technologies and practices. There are a few new initiatives that are focused on connected devices.

2.2.1 Endorsement Label (I-L-E)

Policies creating endorsement labels can be mandatory in the form of a requirement, or they can be optional. The example in this section is for a label program that manufacturers are not required to participate in, but many chose to do so because the label is widely valued by consumers. Consumers can infer from the labels that a government agency has required the measurement of energy consumption and that labeled products are efficient.

2.2.1.1 Examples: ENERGY STAR

The US Environmental Protection Agency's (EPA) ENERGY STAR program is one of the most successful voluntary labeling initiatives in the world. Started in 1992, it been a driving force behind voluntary performance specifications for many consumer products such as fluorescent lighting, household appliances, and power management systems for office equipment. Savings attributable to ENERGY STAR labels were estimated to be over $24 billion in 2012 (ENERGY STAR 2016a).

EPA is exploring the potential of extending the ENERGY STAR certified product label to many categories of connected devices and networks. Connected appliances to be covered include clothes washers and dryers, room air conditioners, lighting systems, connected thermostats, and refrigerator-freezers (ENERGY STAR 2017b).

2.3 Mandatory Information

With the number of connected devices expanding in the residential and commercial sectors, many governments are adopting labeling requirements for different power modes to encourage less energy consumption. Several countries require product labeling related to the standby power consumption of electronic devices such as video recorders and televisions. Recently, the list of products has expanded to include devices connected to networks. Labeling requirements may be standalone policies that seek to influence consumer behaviour by providing comparative information or be part of regulations that set minimum performance standards. The labels that are a part of the latter will inform customers that a product is compliant, and may also document that a product exceeds minimum performance standards.

2.3.1 Comparison Label (I-L-C)

Most G20 countries have a single mandatory comparative label that reports energy consumption and minimum energy requirements. The label may also break energy use down into standby and active energy use. In the US performance requirements are set by the Department of Energy, mandatory product performance labeling (Energy Guide) by the Federal Trade Commission, and voluntary recognition labeling (ENERGY STAR) by the Environmental Protection Agency. The EnergyGuide is the comparison label and the ENERGY STAR mark is the endorsement label. The EnergyGuide and ENERGY STAR labels appears on some, but not all types of consumer electronics and appliances (FTC 2017). Many other countries, such as demonstrated in the example below, also require comparison labels on electronic devices.

2.3.1.1 Example: Korean Rational Utilization of Energy Act, e-Standby Program

Korean Energy Management Corporation (KEMCO) was created in 1980 by the Rational Energy Utilization Act to implement energy efficiency programs. KEMCO created a mandatory rating label program that rates products based on their network standby power requirements on a scale of 1 to 5, with 1 being the most efficient. Products that use less energy than the target levels for their product category, as set forth in a performance table, are rated a 1. Products that exceed the maximum standby power limit must display a warning label attesting to that fact. This program has reduced the ratio of products sold in Korea with excessive standby power requirements from 40% to 1.4% (KEMCO 2008, IEA 2015a).

2.4 Supportive Finance

All policies have a financial component to them. From a citizen's point of view, government may use tax revenues to finance an investment or initiative; it may provide direct financial assistance; or it may assess a fee or tax. Supportive finance is the first of these three. Supportive financial policies that affect Intelligent Efficiency can take the form of technical assistance, research and development, and investments in infrastructure.

2.4.1 Investment in Research, Development and Deployment (E-D-R)

From a policy maker's perspective, the path to providing these types of assistance will start with a direct investment. Encouraging Intelligent Efficiency will require investment in research, development and deployment (RD&D). As demonstrated in the examples below, many countries already focus some of their RD&D on energy efficiency.

2.4.1.1 Examples: U.S. National Laboratories, and Japan Ministry of Economy, Trade and Industry (METI)

The development of new technologies has many steps, and developed countries have created agencies and programs to support each with technical and financial support. The US Department of Energy (DOE) supports a dozen National Laboratories that lead the nation's primary research in energy and energy efficiency related subjects. Other DOE programs such as the Advanced Manufacturing Office (AMO) and Advanced Research Projects Agency-Energy (ARPA-E) take emerging technologies from concept to field demonstration. In Japan, the Ministry of Economy, Trade and Industry (METI) is responsible for energy use and associated technology innovation (METI 2012). Much of the research into Intelligent Efficiency in general and reducing the energy consumption of connected devices in particular will be funded through these types of agencies.

2.4.2 Investment in Infrastructure (E-D-I)

Government initiatives can create software platforms that serve as the basis or infrastructure for new economic activity. For example, networked devices benefit from improved broadband Internet service. Programs that support private sector investment in expanding and improving broadband will benefit the Intelligent Efficiency sector. In a similar vein, facilitating greater innovation related to the Smart Grid is likely to benefit network devices and smart buildings. This and the case study below, are examples of investments in infrastructure.

2.4.2.1 Example: OpenADR

To facilitate the growth of demand response, the US Lawrence Berkeley National Laboratory (LBNL) and several US utilities and grid operators came together to create the Open Automated Demand Response (OpenADR) bidirectional communications protocol. Later, LBNL facilitated the creation of the Open Automated Demand Response (OpenADR) Alliance to propagate use of the platform in the utility sector. The OpenADR platform can become the basis not just for demand response, but also for utility facilitation of distributed energy resources, including distributed generation and energy efficiency. Coupled with the analytical capabilities of building management systems, OpenADR enables businesses to better manage their energy requirements and expenses. Utilities can use the protocol to dispatch on-site distributed generation resources, just as they currently dispatch their own generation resources, and communicate demand-response requests that customers can respond to with any combination of energy efficiency and on-site generation resources (OpenADR 2016).

2.5 Voluntary Finance

Many governments invest in innovation, economic development, and energy efficiency. All three come together in Intelligent Efficiency. The investment may take the form of direct investment in research and development of Intelligent Efficiency technologies that support the entire sector, or it make take the form of providing financial inducements to specific sets of customers to make desired investments. Financial assistance may take the form of loans, grants, or tax incentives. Unlike taxes, which are mandatory financial obligations, tax incentives, grants and loans are optional financial instruments. Acceptance of an incentive is voluntary.

2.5.1 Grants and Subsidies (E-F-G,-Tr)

Markets can be transformed through tax incentives for producing or purchasing more efficient products. Taxes can also be used to penalize the use or purchase of less efficient or more polluting products. However, taxes can be a blunt instrument, and many times governments will choose to directly invest in bringing new products to market with grants and other subsidies.

2.5.1.1 Example: South Korean 2nd National Energy Master Plan

In January 2014 the Korean government announced the 2nd National Energy Master Plan which outlines future energy policy direction through 2035. In an effort to turn Korea into a low-carbon society, it calls for the development and deployment of renewable energy, nuclear energy and energy efficiency. The plan's goal is to reduce total energy consumption in 2035 by 13% below current trends (IEA 2016). Businesses that enter into voluntary agreements to invest in energy-savings technologies are entitled to financial and technical support and tax credits covering up to 20 per cent of the investment costs (ABB 2013c). Since Intelligent Efficiency can save businesses energy, the National Energy Master Plan is likely to increase investments in Intelligent Efficiency. This is an example of how a policy can encourage Intelligent Efficiency even though that is not a focus of the policy.

2.6 Mandatory Finance

Taxes are the most common form of a mandatory financial requirement. User fees and charges are also common tools to raise revenues or discourage certain economic behaviours. Investments in Intelligent Efficiency can be encouraged by low or no taxes or fees on enabling technologies. Or, the revenues raised from taxes and fees can be used to support policies to encourage investments in Intelligent Efficiency. With respect to connected devices, taxes and fees can be used to encourage investments in more efficient technologies and discourage purchase of less efficient devices.

2.6.1 Taxes and User Charges (E-F-T, -C)

Governments have regulated the fees that can be charged for telephone services almost since the introduction of the telephone in the early Twentieth Century. Policies that limit what service companies can charge or charge for can shape the evolving market for the Internet of Things and this in turn affects the use of networks to manage energy. That most countries did not develop new taxes or fees to access or conduct commerce over the Internet is likely due to the fear that doing so would have a suppressive effect on activity and growth of the market. There continue to be federal bans in many countries on Internet access fees and sales over the Internet are usually not taxed.

Reversing such policies could discourage greater use of Cloud computing and other emerging applications of Intelligent Efficiency. This topic is beyond the scope of this report, but it is important to note that telecommunications policies likely have and likely will continue to affect the market acceptance of Intelligent Efficiency.

2.7 Supportive Conformity

Government agencies are often well suited to convene the necessary stakeholders to develop industry standards. Private sector entities may be interested in developing voluntary protocols and standards in order to stimulate growth in a market, but challenged to accomplish it on their own. It is often helpful to include a neutral party to facilitate an effort. Agencies can also bring technical expertise, financial assistance, and influence to bring conformity to a market. Depending upon the needs of the industry and the complexity of the issue, policy makers may chose to facilitate conformity by leading the development of test procedures and common protocols, negotiating voluntary agreements with private sector interests, or requiring conformance with performance standards.

Technology development, demonstration, deployment and diffusion are a few of the many supportive policies that can advance Intelligent Efficiency.

2.7.1 Technology Deployment and Diffusion (RD-R-Dp)

The funding of research to develop the software behind the Green Button platform, discussed below is an example of supportive funding for the development and deployment of technology. Green Button is also an example of how one policy, in this case funding of RD&D, can enable subsequent policies such as providing information, and technology deployment and diffusion.

2.7.1.1 Example: US Green Button Challenge

Improving accessibility to energy use information can help people understand and manage their energy bills better. Launched by the US White House in 2011, the Green Button Challenge is a voluntary program that encourages utilities to provide consumers electronic access to their energy information. Formerly known as the North American Energy Standards Boards' (NAESB) REQ21, Energy Services Provider Interface (ESPI), the standard has been adopted by dozens of utilities in the US and currently serves 60 million homes and businesses, allowing owners to easily download their energy data in a standard format (Green Button 2016, Murray and Hawley 2016).

The open-data approach of Green Button allows more open-ended data collection and leads to innovation in the field of energy efficiency. New products and services are being created using the Green Button platform to help residential and commercial customers track and manage their energy use.

2.8 Voluntary Conformity

Given the difficulty and complexity of developing new regulations, there are often limits to what can be achieved. One type of government practice that can achieve goals beyond the mandatory requirements of regulation is to negotiate voluntary performance agreements with the private sector. A benefit of some agreements is that they are essentially contracts and are therefore legally binding.

Voluntary agreements between government agencies and private sector entities have been successful in achieving energy efficiency goals, creating awareness, and changing the attitudes of managerial and technical staff regarding energy efficiency. Agreements may be with a single private sector entity or an entire sector. They are a flexible method for addressing barriers to technology adoption and innovation and bringing about market transformation. Companies are also keen to avoid disincentives such as regulation or taxes and will enter into agreements to avoid them.

2.8.1 Negotiated Agreements (V-N, -V)

The motivation for an agency to enter into voluntary agreements may be related to energy efficiency, economic development, or environmental goals. The following case studies are examples of using voluntary agreements to secure energy savings from a large set of manufacturers. The first example affects an entire industry, includes reporting requirements, and is a legally enforceable contract. The second is much less rigorous and only requires a public commitment. Each company has a separate agreement with its own details and energy savings targets.

2.8.1.1 Example: Set-Top Box Voluntary Agreement

The US Set-top Box Energy Conservation Agreement is a voluntary agreement between the US Department of Energy, the US Environmental Protection Agency, and the providers and manufacturers of set-top boxes. The companies agreed that 90% of all sales after 2013 would meet the ENERGYSTAR 3.0 efficiency levels. Participants will report actions taken to achieve compliance as well as aggregated annual results (IEA 2015a, CableLabs 2014).

2.8.1.2 Example: ENERGY STAR Challenge for Industry

The US EPA is focused on pollution prevention but through its ENERGY STAR Challenge for Industry, it secures commitments from companies to reduce their energy intensity by 10 per cent in 5 years (ENERGY STAR 2017). That EPA has secured commitments from over 1000 industrial facilities to reduce their energy intensity speaks to the potential of agencies not necessarily focused on energy efficiency to lead initiatives to encourage investments in Intelligent Efficiency. Many of the companies that participate in the EPA program are in energy-intensive industries such as steel, metal casting and glass. The program also provides EPA a pathway to share information on emerging best practices such as Intelligent Efficiency.

2.9 Mandatory Conformity

Governments play important roles in the development of regulatory and consensus standards[4]. They are uniquely positioned to convene national standard writing bodies and provide them with funding and technical resources, all of which can accelerate the consensus standards writing process. Similarly, they can plan an important role in working with other national standards writing bodies to facilitate harmonization of these voluntary standards. With respect to mandatory standards, this is clearly an area of activity for government.

Building codes have been around for many years and are generally focused on the building envelope and mechanical systems. More recently, building energy policies have been developed that set

[4] A discussion of standards can be found on page 5 of the Scoping Study in the Appendix.

requirements for the overall energy efficiency of a building. These policies are now expanding to address the contribution of building energy management systems.

Building codes and product performance standards are two pathways to control the energy-intensity of connected devices and associated networks. They are also pathways to encourage greater investment in such technologies.

Many of the networked devices within homes and offices will have an effect on the heating and cooling of the building. They will either participate in energy management or be part of the heating and cooling system. The performance of these types of devices can be addressed in part by building energy codes.

The performance of these and the other networked and network devices can be addressed by product standards. By setting performance and labeling requirements, regulators can prevent less efficient appliances from entering into the market, increase the uptake of efficient devices, and therein enable market transformation from lower to higher efficiency devices.

2.9.1 Building Codes (R-C-B)

Building energy codes are just one of the model building codes. Other model codes include fire, electrical, mechanical, and plumbing. Some countries address building codes at the federal level, others at the regional and yet others at the local. There may also be a cascading set of standards with the least rigorous at the national level and the most stringent at the local level (DOE 2016).

2.9.1.1 Examples: EU-EPBD, EU prEN 15232, and Germany EnEV

European Union Energy Performance of Buildings Directive (EPBD) is an instrument for enhancing the building regulations on energy performance of building stock in EU member states. It sets requirements for building energy performance certificates and sets the Directive's objectives for automation, control and monitoring and intelligent metering (EU 2015).

The EU standard prEN 15232 was devised to establish conventions and methods for estimating the impact of building automation and energy management control on building energy performance.

In Germany, through the 2013 amendment of the EnEV – Energy Saving Ordinance, building automation became a tool for calculating the energy performance of buildings. In conformance with the EU directive, the EnEV is a performance-based code that requires a mandatory energy calculation to establish the expected primary energy consumption of residential and non-residential buildings.

The new part of the EnEV (DIN V 18599-11) addresses the influence of building control and incorporates energy management as part of the building management system. This standard addresses the issue of energy management functions and their interactions with other fields of energy use in the building (EU 2015).

2.9.1.2 Example: ISO 16484-2

Another example is the ISO 16484-2 standard for design of new buildings and retrofit of existing buildings for acceptable indoor environment, practical energy conservation and efficiency. This standard provides an outline for interfacing connected devices and systems through building automation to building control systems (Kranz 2015).

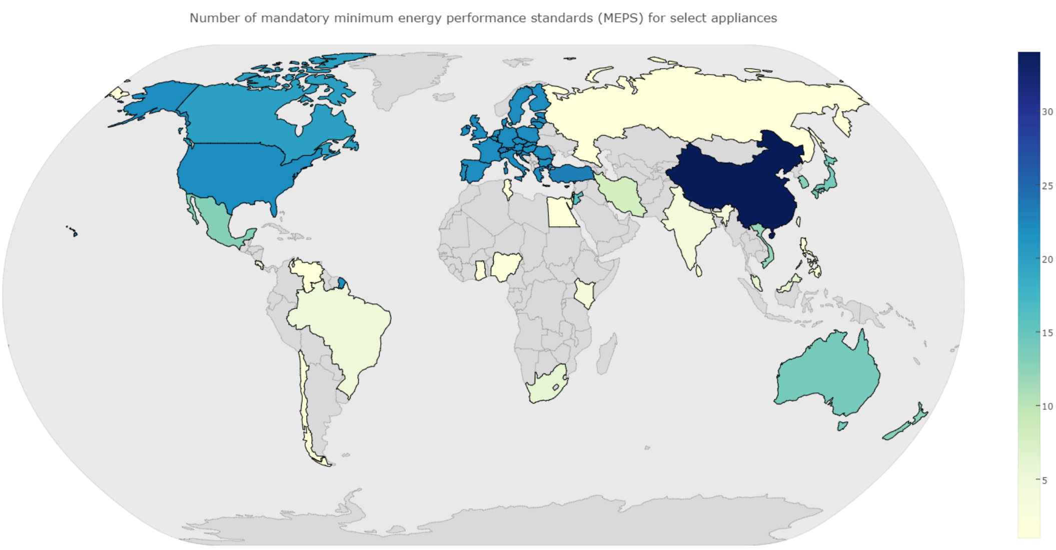
The standard requires the functional integration of building systems other than HVAC. These include lighting and electric power distribution control, security control, vehicle charging, and facilities management. This integration allows the user to take advantage of synergies between the different applications.

The standard also addresses features of devices and other components of a building automation and control system (BACS). Interfaces between devices and networks are defined. This avoids designed obsolescence and allows for expansion of the network. A manufacturer can still design a product to meet its specific marketing objectives but must also include the option to integrate the device into a multi-application BACS.

2.9.2 Product Standards (R-C-P)

Many countries have established mandatory performance standards for appliances, entertainment systems and office equipment. Figure 3 reflects the number of countries that have adopted mandatory minimum energy performance standards (MEPS) for information and communication technologies (ICT), computers, cooking and dishwashing, lighting, office equipment, power supply and power conversion devices, televisions, display, and audio visual equipment. Not all of the appliances covered by these regulations are connected devices, but many are in categories that have shown innovation around the use of data and are likely to have network features and capabilities in the future.

Figure 3: Countries with mandatory minimum energy performance standards for relevant appliance groups, presenting the number of devices covered in a country.



Source: **CLASP 2016.**

2.9.2.1 Example: ENERGY STAR Connected Products

In the United States, the Appliance and Equipment Standards Program of the US Department of Energy (DOE) issues regulations for appliance and equipment standards and test procedures, and for implementation, certification, and enforcement. To date DOE has issued performance standards for more than 60 categories of appliances and equipment (DOE 2017a). DOE also develops the product energy performance test procedures, which are also used by the voluntary ENERGY STAR program administered by the US Environmental Protection Agency. DOE also collaborates with Natural Resources Canada through the Regulatory Cooperation Council to coordinate labels and standards between the two countries (DOE 2017a).

Even though some of the devices covered by DOE MEPS have the potential to connect to networks, there are no broad standby energy consumption requirements in the US for connected devices. Standby energy consumption is addressed in the individual standards for covered products. DOE has issued standards for both external power supplies (EPS) and for battery charging systems (BCS) that do include a standby power requirement, so to the extent that electronic products use EPS and BCS, they are subject to those standards (C. Granda, Sr. Researcher/Advocate, Appliance Standards Awareness Project, pers. comm., January 9, 2017).

2.9.2.2 Example: CEC Standby Power Requirements

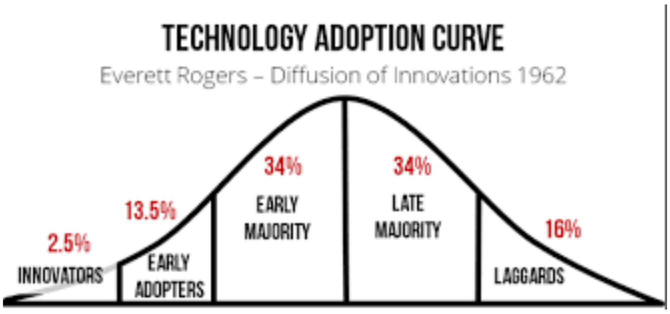
Federal efficiency standards pre-empt state efficiency standards, but when the DOE does not establish standards for a class of products, states may impose their own regulations on those products sold within the state. So far, end-use electronic products like TVs and computers and displays have not been covered by federal efficiency standards in the US.

In 2004, the California Energy Commission (CEC) set limits on standby power consumption of various consumer electronics devices in various conditions of standby. In 2016 the CEC issued new standards for computers and monitors that effectively include requirements for both regular standby and network standby (called sleep mode). CEC elected not to set specific minimum requirements for when an appliance is turned off or is in sleep mode, but to set requirements for typical energy consumption (TEC) which is determined by a weighted formula including idle, sleep, and off mode power weighted by the expected time a device will spend in each mode. Under the recent CEC standards, monitors may consume no more than 1.2 watts in sleep mode and off mode combined. There are allowances for higher consumption by monitors with additional functionality like touchscreens. Allowable sleep mode power limits for computers are a function of rated memory capacity (CEC 2015).

3 The Role of Government

The rate of diffusion and adoption of any new technology tends to follow a standard pattern. As identified in the Rogers Curve (illustrated in Figure 4), there are five groups of people, each with a different affinity for adopting new technologies. In a simplified technology adoption model, the earliest adopters are the innovators who have disposable income and can take the risk associated with failure. Following the innovators are the early adopters and the early majority who serve to establish the technology in society. At the other end of the spectrum are the late majority who adopt either after all uncertainty around the technology is resolved or give in to peer pressure. The last group to adopt the new technology are the laggards who find it difficult to afford or accept the technology even after it is well established. For Intelligent Efficiency, which is influenced by fast evolving information technology, this curve may get skewed heavily depending on a faster rate of adoption.

Figure 4: Technology adoption curve



Source: **Endangered Thinking.com**

Perhaps no technology has diffused faster than information and communication technology (ICT). Thus, there has been a huge uptake of connected devices, which enable end users to avail themselves of ICT. In 2012 there were close to 15 billion devices, including TVs, personal computers, mobile phones, and office equipment were manufactured with the capacity to connect to networks, implying they could exchange data and information with other devices any minute of any day, as long as they were never unplugged or otherwise powered off (IEA 2014).

Connected devices are playing a key role in sharing information and transforming the global economy. Education, healthcare, mobility, manufacturing, energy systems, business processes and many other sectors are benefitting from improved connectivity and data driven solutions (GeSI 2014). Given the many benefits to people and to the world's economies, the growth of ICT and connected devices is likely to follow a normally shaped Rogers Curve.

On the other hand, energy efficiency technologies often follow longer diffusion paths and face greater barriers than most technologies. As will be explained further in the barriers analysis, energy efficiency technologies have faced market barriers ranging from high initial costs to market structures that favour incumbent technologies. Historically, government intervention has played a major role in energy efficiency's gains in the marketplace.

The merging of ICT and energy efficiency holds the promise of changing the paradigm around energy efficiency and making it easier to reduce the energy consumption of many common appliances and everyday experiences. It is therefore a worthwhile endeavour of governments to pursue policies that facilitate the adoption of Intelligent Efficiency and that break down the barriers preventing or delaying greater investment.

3.1 Barriers analysis

Intelligent Efficiency faces many of the same barriers as conventional energy efficiency plus some of the challenges of ICT. Barriers are often grouped into three broad categories: social, financial, and structural.

The social barriers include the lack of awareness of Intelligent Efficiency technologies such as connected devices and that people are naturally resistant to new and potentially risky ideas that are complex.

Financial barriers encompass the upfront costs of purchasing and networking connected devices and the split-incentive problem that frequently bedevils other kinds of efficiency efforts. For example, landlords of multi-family buildings or commercial office buildings bear the cost of installing new equipment, but the tenants are often the ones who realize the financial benefits of the energy savings. Landlords in this case have limited incentive to make energy efficiency upgrades.

There are many structural barriers inhibiting greater investment in Intelligent Efficiency. Given the newness of many products and services, there is a shortage of quantitative data on their benefits. Collecting such data can require a considerable upfront investment of time and resources. Networks must be built, energy management systems must be programed, and workers must be trained. There are also important privacy and cyber security issues to resolve.

3.2 Using policy to remove barriers

For each type of barrier, there are one or more policy options available to policy makers. In this section, the most common barriers are described and policy solutions proposed. Existing policies are included to demonstrate how some countries are currently addressing these barriers.

3.2.1 Social Barriers

3.2.1.1 Awareness

Consumers of energy services are often simply unaware of ICT solutions for energy efficiency and their benefits. This lack of awareness prevents consumers from trying to find information or explore Intelligent Efficiency options (Thollander et al. 2010). Adding to this issue is the need to spend time and effort to learn about Intelligent Efficiency before one can make an informed decision. Without well-established proof of the benefits of Intelligent Efficiency, consumers may weigh the cost of acquiring information to be greater than the perceived benefits.

As demonstrated in previous examples, governments can overcome the information gap through dissemination of information, technical assistance, and the providing of education and workforce training programs. (Policies I-A, I-I, and I-T)

3.2.1.2 Uneasiness with new technologies

Inertia is a common economic barrier to change, and Intelligent Efficiency is no exception. Consumers and organizations may be unmotivated to adopt Intelligent Efficiency despite being well aware of all its benefits simply because of being habituated to existing processes and lacking a culture of innovation.

Many customers worry about how reliable networked devices will stay in comparison to conventional controls. Mechanical and simple automation methods of controlling building appliances are proven technologies. Additionally, they may have concern about unknown or underestimated costs associated with investments in Intelligent Efficiency.

To address this preference for the status quo, policy makers can create technical assistance programs, and fund and publicize demonstration projects in an effort to mitigate customer concerns. A more aggressive posture would be to establish codes and standards that raise the efficiency of equipment over time, forcing companies to upgrade equipment when replacing units at end of life. For example, Luxembourg's RGD 2010 policy sets supplementary requirements for the installation of measurement and control equipment for new non-residential buildings and in some cases also requires the installation of such equipment for certain appliances in existing non-residential buildings (EU 2015). Such a requirement forces adoption of more efficient and more advanced technologies, accelerating market transformation. (Policy R-C-B)

3.2.1.3 Complexity

Setting up a network that connects the most energy-intensive systems in a building with an energy management system can often be a significant undertaking. Success of such an investment may depend upon the compatibility of multiple vendors' products and the ability to connect legacy systems to the new network.

Governments have a role to play in reducing complexity where it is inhibiting market growth. In the case of connected devices, the market desires plug-and-play capabilities such as exists with office equipment. With such capability, a new device such as a chiller or air conditioner, upon installation, will connect to a building's network wirelessly, and announce itself to a building management system. Once the electronic handshake has been completed, facility operators will be able to see the new device and have real-time access to its performance data. Governments can facilitate the development of such hardware interfaces through their convening of collaborative efforts to develop interface standards, through their purchases of such equipment, and setting of purchasing specifications that stipulate only equipment with open source and common interface features can be purchased. (Policies E-D-P and R-C-S)

An example of governments working to reduce complexity in the market is the participation in the development and adoption of the BACnet protocol for building automation. BACnet enables controls devices of different manufacturers to communicate with each other by specifying a common communication protocol (BACnet 2016). It is not a product of government policy but is supported by many governments including the United States, Korea, China, Japan, and all of the countries in Europe.

Development of the ISO 16484-2 standard for energy efficient design of new buildings and retrofits of existing buildings was also supported by many governments. This standard provides a basis for interfacing connected devices with building automation and control systems. It also requires a unified data communication protocol and information model. (Policy R-C-B)

3.2.2 Financial Barriers

3.2.2.1 Upfront costs

The cost of an Intelligent Efficiency solution may be too high for a consumer to cover through its operating budget, requiring it to finance the cost through capital investment. If it hasn't sufficient access to capital, a consumer will not be able to make the investment.

Another financial barrier may be the real or perceived rate of return on the investment. If the future value of energy savings is not sufficient to yield a return sufficient to meet an organization's desired rate of return, it will not make the investment.

Some investments in technology require in-place infrastructure such as access to the Internet or a local area network. If a facility does not have these in place, their costs become part of the cost of the new investment, which in turn lowers the rate of return of the investment.

All of these hurdles can be addressed through financial assistance policies such as tax incentives or programs that provide subsidies. For example, Germany has programs that support greater energy efficiency in manufacturing production processes by providing subsidies for upgrading technology and equipment. Germany also targets small and medium-sized enterprises, helping them improve the efficiency of their facilities by providing 30% of the funding for energy-efficient motors, pumps, air-conditioning systems, and compressed air devices (IEA 2015c). If connected devices are not already covered by this policy, it could be amended to include the devices and supporting networks. (Policies E-F-L,-G, and -Tr)

3.2.2.2 Split incentives

Like many energy efficiency technologies, Intelligent Efficiency can suffer from split incentive challenges. The party that invests in this technology may not be the recipient of all the benefits. Neither a building owner nor tenant is likely to invest if only the other stands to gain. However, since Intelligent Efficiency offers more granular energy data and superior energy management and control, it may provide a pathway for dissecting the costs and benefits in ways that allow landlords to recover their investment. For example, the availability of smart meter data could enable the landlord to incorporate into the lease the cost recovery of efficiency upgrades and sharing of the energy cost savings. This may be enough to overcome the split incentive barrier, but if not, building codes, consumer education initiatives, building labelling requirements, and financial assistance programs might be used to fill the gap. (Policies R-C-B, I-I, I-L-C, and E-F-G)

3.2.2.3 Difficulty Quantifying System Benefits

Assessing the future value of a new network of controllers and devices can be challenging, and it comes with a greater than usual degree of uncertainty. Incentive programs that aim to encourage energy efficiency share these concerns. Conventional energy efficiency programs have focused on component energy efficiency, but not on system-level efficiency because savings from the latter can be hard to attribute (Rogers et al. 2015). This limitation poses many obstacles to advancing Intelligent Efficiency. The first is an attribution challenge—in a complex project involving multiple components and controls, the energy savings happens at the device level even though it is influenced at the control level. What, if any, portion of the energy savings realized can be attributed to the controls? This issue and possible solutions are discussed in more detail in section 3.2.3.3.

The inability to associate net savings with an asset requires a paradigm shift in how policy makers define what constitutes an energy efficiency measure. The development of new energy efficiency financial incentive program models is still in its infancy, but there appears to be an interest in paying for actual savings instead of specific assets. Programs may take on the features of performance contracts or may take the form of markets in which energy savings or associated environmental benefits are sold to meet system resource capacity needs or pollution limits.

In New England, the Regional Greenhouse Gas Initiative (RGGI) operates a carbon cap and trade market that funds investments in renewable energy and energy efficiency through the sale of carbon allowances. Many of the energy efficiency financial assistance programs in New England are funded in part by RGGI and some of them are targeting learning thermostats, building management systems, and other network dependent energy efficiency measures.

In Europe, several countries have creating markets in which tradable certificates for energy savings (TCES) can be bought and sold. Often referred to as white certificates or white tags, each certificate is a unique and traceable commodity carrying a property right over a defined amount of energy savings (EC 2016). The ability to automate the tracking of energy savings with Intelligent Efficiency presents an opportunity to expand such trading schemes. (Policies E-M)

3.2.3 Structural Barriers

3.2.3.1 Insufficiently trained workforce

Most of the residential market for connected devices such as office equipment, entertainment systems, and appliances requires self install. If consumers hire specialists to set up their networks, they can usually source that service through computer and electronic retailers. Residential systems are fairly simple and the knowledge and skills needed to set them up can be satisfied through existing channels.

In the commercial, institutional and industrial sectors, the systems are more complicated and require people with the expertise to design and install networks. Not all companies have the trained manpower to design and implement Intelligent Efficiency projects. This can be addressed by creating a pipeline of trained specialists.

Many countries have created energy manager training programs or require energy managers at more energy-intensive facilities. By requiring companies to have energy managers, not only do the facilities have a higher probability of implementing projects, but also the market for education and training in energy management is developed, and students who attend training can be more assured of a career path. (Policy I-T)

In its 12th Five-Year Plan, China requires its top-10,000 Energy-Consuming Enterprises to appoint energy managers. In India's Energy Conservation Act (2001), large industrial energy consumers in nine sectors must implement energy audits, appoint certified energy managers and report energy consumption data (ABB 2013a). In 2009 the Indonesian government issued an Energy Efficiency Regulation in which large energy consumers are obliged to conduct energy audits, designate an energy manager, and implement energy conservation programs (ABB 2013b). (Policies R-A and R-O)

3.2.3.2 Lack of informational tools

Customers may have difficulty getting verified performance information. Vendors of appliances, office equipment, and other connectable devices may not be effectively sharing the energy savings benefits of networked equipment with potential consumers because it is not a key feature of such products. Intelligent Efficiency products such as smart lighting systems and building automation software provide centralized control, ease of maintenance, and improved operations, apart from energy and monetary savings. While the vendors may themselves be aware of these advantages, they may not always credibly convey this information to consumers (Gillingham and Palmer 2013).

There may also be trust issues. Manufacturer claims in marketing materials are helpful, but most businesses will want to see actual field data that documents cost savings. Getting case study information is often difficult because companies are often reluctant to release data related to internal operations.

Governments can fund demonstration projects; or conduct them in their own buildings, and make performance data public. They can also develop guides that can help customers assess the future value of investments in Intelligent Efficiency. Over the years, many governments around the world have sponsored these types of guides and informational tools. (Policy I-I)

3.2.3.3 Measurement and verification of energy savings

To realize the potential benefits of connected devices it is important to ensure that the energy savings made possible by the connectedness of the devices can be measured and verified (M&V). This is a particularly challenging task because of the difficulty in establishing a baseline of energy consumption. Conventional device-level efficiency only requires a comparison of an efficient device against a standard efficient device under identical conditions. This is most often performed under laboratory conditions. Connecting a device to a network enables superior control and it is that control that can lead to system optimization. In such a scenario, the baseline is related to the system, or even the entire building, and not the device. Therefore, the M&V must be performed in the field and as the energy savings take place. Many organizations including European and North American institutions are involved in adapting existing M&V protocols or developing new ones to address this issue.

The International Performance Measurement and Verification Protocol (IPMVP),[5] which has been a standard method for assessing savings of energy performance contracts, is being considered by many energy efficiency programs for use in assessing the energy savings from Intelligent Efficiency projects.

New methods are being developed that utilize Big Data and data analytics to compare the energy use of thousands of buildings with similar energy use patterns to identify energy savings opportunities and to track the savings post implementation. They have proven successful at determining the energy savings of buildings that are similar in form and function to large numbers of their peers, but these techniques are still in their infancy and there is much variability in precision and accuracy. There is seldom transparency to the mathematics behind the proprietary algorithms that power the data analytic engines, making the task of confirming the accuracy of results difficult. There is also a lack of commonality or comparison of how data is defined and exchanged, which limits the fluidity of information exchange across platforms. Governments can help break down this barrier by bringing companies together to develop common practices for data treatment, reporting of results, and describing a software tool's accuracy.

There is a project underway at Lawrence Berkeley National Laboratory to develop a test method that utilizes a known set of building energy consumption and savings data and compares the energy savings conclusions generated by a software product's analysis of the consumption information in the data set with the known energy savings of the data set. Development and use of this data test-stand approach, while still in its infancy, is promising and may have applicability beyond the current test subjects (Rogers et al. 2015). (Policy E-D-R)

US EPA recently launched a new initiative to develop a methodology for assessing the performance of connected thermostats. The ENERGY STAR Connected Thermostats program encompasses both

[5] The purpose of the IPMVP® is to increase certainty, reliability, and level of savings; reduce transaction costs by providing an international, industry consensus approach and methodologies; and reduce financing costs by providing a project with a Measurement and Verification Plan (M&V Plan) standardisation, thereby allowing project bundling and pooled project financing. It aims to provide a basis for demonstrating emission reduction and delivering enhanced environmental quality; also to provide a basis for negotiating the contractual terms to ensure that an energy efficiency project achieves or exceeds its goals of saving money and improving energy efficiency.

hardware and software aspects of smart thermostats. The proposed methodology bypasses the question of how energy savings are achieved and concentrates on whether or not savings have occurred. To accomplish this, large customer energy consumption data sets, publicly available weather data, and data available from thermostats after installation are combined and analysed to assess energy savings for a group of customers. (ENERGY STAR 2016b). (Policy RD-R-Dv)

Breaking down structural barriers is also an activity in which state agencies and non-profit organizations can engage. The New England Energy Efficiency Partnerships (NEEP), a regional energy efficiency convening organization, has recently launched a pilot project to analyse the efficacy of new M&V protocols. The three-year pilot is the result of a competitive solicitation from the US Department of Energy to which a collaborative of NEEP and agencies in Connecticut, Delaware, District of Columbia, New York and Pennsylvania responded. NEEP as the project facilitator will organize two pilot studies comparing traditional approaches to estimating savings from energy efficiency programs in buildings with the use of software that uses Smart Meter data to estimate savings (E. Titus, Director, Regional EM&V Forum, NEEP, pers.comm., December 14, 2016). (Policy RD-R-Dp)

3.2.3.4 Privacy and cyber security

It is the timely access to large volumes of performance data that powers many applications of Intelligent Efficiency. However, data that reveals details about personal or firm behaviour is sensitive, and its release can be perceived as a violation of privacy. Protecting the privacy of customer energy-usage information is critical to consumer protection and customer acceptance of these new technologies, and of the new services they will enable. The challenges are similar to those of on-line banking and shopping, and many of the same solutions will apply to Intelligent Efficiency.

The fair information practice principles recommended by agencies such as the U.S. Federal Trade Commission and European Trade Commission for online commerce are good models for what could be extended to the treatment of energy usage data.[6]

Consumers should be informed of what data will be collected and should have some choice of whether to allow the collection and sharing of their data and to how it can and can't be used in the future. Policymakers should deal with this issue proactively as it can be a difficult issue to deal with once people have come to perceive it as a violation of their privacy.

Consumers should also have ready access to their own energy usage information. It can help them identify and track energy savings opportunities as well as determine with whom they are willing to share it. Government has a leadership role to play in addressing this market barrier. Consumers are unlikely to trust the private sector on this issue and will look to government to set standards for transparency and limits for data sharing.

The European Commission published a proposal in November 2016 stating that all consumers should be able to request their meter data. Consumer personal data is already protected by EU rules on the processing of data and sharing data. The European Network and Information Security Agency (ENISA) has drawn up security measures to help Smart Grid providers improve the cyber resilience of their systems (EC 2017). (Policy R-O)

[6] For information on fair information practice principles, see http://www.ftc.gov/reports/privacy3/fairinfo.shtm

The issue of energy data sharing can also extend to tenant, property-owner relationships. Many commercial and residential buildings have individual meters for each tenant. Energy savings from networks such as learning thermostats and building management systems may be contingent on their receiving all tenant energy data. Many jurisdictions do not allow property owners to see tenant energy bills. In such instances, the property owner must either get permission from each tenant or request historical aggregated building data from the utility. Neither of these approaches addresses the need for continued data access for ongoing tracking of energy savings progress. To address this need, the EPA created Portfolio Manager web services that connect to its Portfolio Manager database. Among its many features, this offering enables the collection and aggregation of whole-building data for building owners without compromising tenant privacy (SEE Action 2013). (Policy RD-R-Dp)

3.2.3.5 Patents, path dependency, and incompatibility

Suppliers of Intelligent Efficiency solutions may seek to maintain exclusivity in the market by patenting, trademarking, or otherwise limiting access to core communications protocols. This practice limits market growth and discourages investments in new technologies. Without common protocols and interfaces, customers are at risk of getting locked into proprietary data formats and communication protocols that prevent them from being able to purchase equipment from other vendors in the future. Proprietary systems can also limit the ability of organizations to network and centralize the control of multiple buildings. Many customers will forego an investment because the risk of being reliant on a single vendor is too great.

The benefits to vendors of common standards and protocols are long-term and uncertain while the benefits of proprietary ones are short term and more predictable. Given this dichotomy, there is a preference in the private sector for short term gains that can be difficult to overcome when approaching technical barriers. It is also often the case that no single private sector entity has the capacity or the influence to develop a comprehensive open source software platform. By contrast, government agencies are often ideally suited to overcome such challenges because they can bring all parties to the table. In the US, Europe and Asia many government agencies are leading and participating in collaborative efforts to reduce barriers to communication of data between devices and networks.

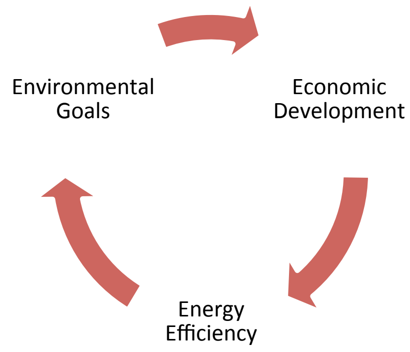
Examples of government action facilitating the growth of emerging markets are the Green Button and Green Button Connect, OpenADR, BACnet and many ISO standards. All required the leadership and participation of government agencies over extended periods of time. (Policies RD-R-Dp, and –Dv)

3.3 Discussion of the interactions between policies

The development of new policies should take into consideration both the intended benefits and the potential for unintended consequences. For example, early in the development of standby energy standards for connected devices, the stakeholders considered the potential effects on a network if equipment was fully powered down. The opinions of many groups were included in discussions and collectively they came to realize that certain powering down requirements could inhibit the ability of networks to achieve system and facility-level energy savings. Too much focus on the undesirable energy footprint of connected devices might prevent the desirable handprint of network-enabled energy savings. Because many stakeholders were involved in the process, the potential for unintended consequence was minimized and better rules eventually developed.

This experience is an excellent example of how complicated policies affecting Intelligent Efficiency can get, and it is also educational in that it teaches us that challenging the manufacturers of existing technologies through proposed rulemaking processes can be an effective way to initiate innovation. Because of standby power standards, developers of electronic and network devices are now developing new hardware and software solutions that lower energy consumption by networked devices not at full capacity and do so without loss of functionality.

Many of the goals of energy efficiency policies are environmental in nature. Another motivation for energy efficiency policies is economic development. This makes sense since there is a correlation between the cost of something and the energy it took to make it. Many agencies have come to view support of energy efficiency as an economic development policy tool as well as a mechanism to achieve environmental goals. This three-way relationship can be used to examine how policies can achieve multiple societal goals.



Concern with growing energy consumption and depletion of energy resources was a key driver of the development of standby performance standards for connected devices. That effort in turn drove innovation, which will ultimately have a positive effect on the economy. Government not only initiated the chain of events, government research institutions participated in the innovation and government agencies demonstrated the technologies.

Sometimes even labelling requirements can have much broader impacts on the economy. As demonstrated by the Korean example in section 2.3.1, a requirement to have comparative labels has significantly changed the products Koreans are purchasing. Thus, the average standby-power level of appliances sold has decreased.

Other times, agencies have the opportunity to leverage the development of performance standards to create entirely new markets or business models within existing markets. One example of this is the ENERGY STAR connected products program. Products that satisfy the energy efficiency, connectivity, and demand response criteria set by EPA, can be certified as ENERGY STAR connected products, a label that conveys to consumers a product’s reliability and superior performance. In essence, EPA has created a mechanism to create consumer confidence in connected devices. (ENERGY STAR 2017b).

ENERGY STAR connected product categories are: clothes dryers, clothes washers, lighting, refrigerator-freezers, room air conditioners, pool pumps and connected thermostats. As a result of this initiative, potentially millions of products will be purchased that can be grid responsive, something that most customers would not expect or request in a product. In the process, EPA is making available a demand response resource that the private sector would not be able to create on its own.

The important lesson to learn from these examples is that policy makers should think cross-functionally whenever possible. They should look for opportunities to leverage improvements in one area to benefit another. The corollary is of course to be mindful of the potential to negatively affect efforts to achieve one set of goals in the process of advancing another.

4 Discussion and Recommendations

The first step a country may want to consider is to develop a national policy on Intelligent Efficiency. This can be done within an existing energy policy or possibly an economic development policy. Regional and local governments should also look for ways to encourage adoption of Intelligent Efficiency in their policies. Any policy that has a technology component such as building codes can become a vehicle for advancing Intelligent Efficiency. A well thought out Intelligent Efficiency policy will bridge the jurisdictions and goals of multiple agencies for maximum effect.

4.1 Information dissemination

A number of barriers can be lowered by government initiatives that disseminate information with the public. Many government agencies have websites that the public go to for information on energy management and energy savings. Australia's Your Energy Savings website is a centralized resource for information on utilities including energy and water, as well as associated rebates in the regional jurisdictions. As previously discussed, training programs, technical assistance, and labeling requirements are all effective methods to address social barriers. (Policies I-A, -I, -L, -T)

4.2 Lead by Example

The next step is for government agencies to set the example. The experiences of government agencies can become the case studies that inform and familiarize the public with the new technologies and lessen their perception of risk. Due to limited resources and a bias towards short term gains, many private sector organizations have a limited capacity to experiment with new technologies. By virtue of their long-term mission, government agencies are often in a better position to demonstrate new technologies and pave the way for private sector adoption. In 2013, the US General Services Administration (GSA), a federal agency of the US, established design principles for its buildings. Since then, GSA has been working towards embedding smart technologies within its built space and requires buildings of 100,000 square feet (9290 square metres) or more to have a building automation system to lower operating costs and improve ease of operation (GSA 2003).

The GSA also became the first federal agency to migrate its email users (17,000) from a locally hosted email system to a Cloud-based service. Cloud-basing, or virtualizing some or all of a software system is a form of Intelligent Efficiency often referred to as substitution or dematerialization. By eliminating on-site servers that supported the email system, GSA reduced its energy consumption. It also gained capacity, capabilities and reduced operating expenses by more than 50 per cent. This example demonstrated the efficacy of Cloud-based services to meet the needs of large organizations and by publicizing it, GSA facilitated market education (Seidel and Ye 2013). (Policy RD-D)

4.3 Procurement rules

Governments can also drive market growth through their purchasing power. Most governments have stipulations for procurement of appliances and equipment. For example, the United Kingdom recently updated its guidelines for procuring sustainable electrical goods in government agencies (UK 2015). Recognizing efficiency in procurement and construction policies can institutionalize energy efficiency in government departments' day-to-day work. Proven Intelligent Efficiency technologies can be added to these policies. The US Office of Management and Budget (OMB) developed a standardized procurement for Cloud services. In August of 2012, using the protocol, GSA awarded purchases to 17 vendors offering Cloud-based services (Seidel and Ye 2013). (Policy E-D-P)

4.4 Investment in research

Government has a role to play in primary research. The long term nature and uncertain outcomes of RD&D require the resources and far sighted goals of national action. Several Organisation for Economic Co-operation and Development (OECD) countries have annual research and development budgets for ICT and energy efficiency (OECD 2016). Governments can help speed up the adoption of Intelligent Efficiency with investment in RD&D on these technologies as well as cross cutting technologies. Countries like Korea and Canada have earmarked budgets for Building Management Systems and efficient ICT systems (OECD 2015). Stipulating that research plans include research into the application of ICT to manage energy is one way to advance Intelligent Efficiency. (Policies R-C-P, -S)

4.5 Compatibility and common standards

The market for connected devices will benefit from devices with common interfaces and communication standards. Customers are seeking plug-and-play capabilities such as exists with office equipment. With such a feature, upon installation, a new device such as a chiller or air conditioner will locate and connect to a building's network wirelessly, announcing itself to a building management system. Information will be exchanged, and going forward the facility operator will be able to see the new device and have real-time access to its performance data. This will require the development of open source software platforms, standardized communication protocols, common data characterization and exchange protocols.

The market will also benefit from common methods for measuring the energy intensity of buildings and the energy savings capability of various types of automation. The European Union standard prEN 15232 attempts to address both of these issues. It was devised to establish conventions and methods for estimating the impact of automation, control and management on energy performance and energy use in buildings (EU 2015). (Policy V-V)

4.6 Labels and standards

The general public may find it difficult to visualise Intelligent Efficiency. At a stage when ICT uptake in energy efficiency is still taking off, governments can give the technology a much needed push by creating labels and certifications that serve both as a seal of approval, and as a mechanism to recognize the features and benefits of Intelligent Efficiency. Governments should pursue development of comparison and endorsement labels such as the EnergyGuide and ENERGY STAR labels in the United States and Canada, and the EU Energy Label in Europe. Governments should also support the development of performance test methods and measurement protocols in the private sector. Once adopted by their respective industries, governments can recognize them in rulemakings and ultimately in performance standards. Governments can also play an active role in the research, development, and standardization of measurement and verification programs for the energy savings aspect of Intelligent Efficiency applications. (Policies I-L-C and -E)

One challenge that governments have with developing standards related to Intelligent Efficiency is the speed with which Intelligent Efficiency products and practices evolve. The standards writing and regulatory processes are slow and deliberative by design. Therefore, it is possible that innovation will stay one step ahead of regulatory action and that efforts to create mandatory performance standards may find it challenging to provide value to consumers. It is therefore prudent for regulatory agencies to show restraint when working in the Intelligent Efficiency area and to seek opportunities to enable progress without unintentionally stifling evolution and innovation.

On the other hand, the predicted energy demand from connected devices is significant as will be the resources required to satisfy that demand. It is therefore appropriate that policy makers and regulators consider setting performance standards. Minimum energy performance standards have a long history of saving customers energy, reducing their operating costs, and reducing the need for new energy infrastructure (Lowenberger et al. 2012). Regulation can also drive innovation and result in the development of new markets.

4.7 Incentives for energy management systems

Government grants, rebates, loan programs and tax incentives can help lower or spread out the upfront costs of Intelligent Efficiency, thereby making an investment more attractive. By growing the demand for products and services, subsidies can improve market dynamics and expand the universe of potential customers. This in turn can bring more suppliers into the market and drive economies of scale, resulting in lowering the variable costs of production. The growth in the market for smart thermostats has been fuelled in part by incentive programs such as the one available to residents in Ottawa, Canada. The municipal utility offers rebates of up to $150 for smart thermostats. Home owners can control their home's heating and cooling from anywhere, and the utility benefits from new energy efficiency and demand response resources (IEA 2015b). (Policy E-F-G)

5 Conclusion

In order for Intelligent Efficiency to realize its full potential, social, financial and structural barriers must be lowered. The ultimate manifestation of Intelligent Efficiency is the networking of entire business units and supply chains. To achieve this goal, end users desire the same level of compatibility they have with office equipment in the devices and appliances they use in their homes and businesses. A coordinated portfolio of policies can facilitate this unfolding in a timelier fashion than the market will accomplish on its own.

Governments can facilitate this development through support of innovation, creation of performance standards, and bringing market actors together to create common platforms and protocols. This outcome will require a new level of communication between agencies and between initiatives. It will require collaboration among countries and agreement on common goals. These are not new challenges. The results of past and currently ongoing efforts related to ICT are indicative of a high potential for success. The addition of energy efficiency may add complexity, but it does not fundamentally change the challenge or the reward. Many policy goals can be achieved through greater market acceptance of Intelligent Efficiency. It is therefore a worthwhile undertaking for policymakers.

Many countries do see a role for policy to facilitate market growth and are starting to take on this opportunity. The focus of many policies has been on the energy consumption of connected devices while in idle mode. There is also interest in encouraging more integration of building systems so that the energy savings benefits of ICT can be realized.

There appears to be awareness of the complexity of the issue and in response, agencies are taking a measured approach to the development of new policies. This is especially true with respect to performance standards. Agencies are engaging industry to develop voluntary protocols, labels, and standards, and where there is consensus, finding a greater willingness to establish regulatory requirements.

Much has been accomplished through labeling requirements. Comparative labels facilitate market transformation to products with superior performance. They facilitate customer understanding of the features and benefits and provide transparency to product performance. Transparency leads to trust and trust leads to customer acceptance of new technologies.

The last step on the policy ladder is establishing minimum energy performance standards. Before MEPS can be put in place, test methods must be developed and accepted. That appears to be where the market is right now. The ability to quantify the energy savings of systems is challenging and requires a different approach than has been used for measuring device efficiency. Many public and private organizations are working on this challenge and their initial work is promising.

Should they prove successful, the ability to measure and document energy savings at the system level will potentially transform the energy efficiency sector. Much greater savings will be available to consumers and greater energy efficiency resources will be available to policy makers.

If there is one key conclusion to draw from this analysis, it is that realizing the benefits of connected devices and Intelligent Efficiency will require a portfolio of policies and that countries should consider many different policy approaches to achieve their goals.

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Glossary

4E	Energy Efficient End-use Equipment
BACnet	Building Automation Control networks
CDA	Connected Devices Alliance
EDNA	Electronic Devices and Networks Annex
EE	Energy Efficiency
G20	Group of Twenty
HVAC	Heating, Ventilation and Air-Conditioning
ICT	Information and Communication Technologies
IE	Intelligent Efficiency
IEA	International Energy Agency
IPMVP	International Performance Measurement and Verification Protocol
ISO	International Organisation for Standardization
LED	Light Emitting Diode
M&V	Measurement and Verification
MEPS	Minimum Energy Performance Standards
OpenADR	Open Automated Demand Response
SaaS	Software as a service
TCP/IP	Transmission Control Protocol / Internet Protocol
TWh	Terawatt hours, a unit of energy consumption

Attachment 1: Scoping Study

International Intelligent Efficiency Policy Analysis

Scoping Study

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Scoping Study: Table of Contents

1 Introduction

ACEEE has been contracted by the Electronic Devices and Networks Annex (EDNA) of the International Energy Agency's 4E Implementation Agreement (4E) to conduct a qualitative survey and analysis of the policies, regulations, and programmatic efforts to encourage and regulate the use of intelligent efficiency in residential and commercial buildings of a dozen countries. This information, along with a series of recommendations for government action will be included in a Policy Study to be delivered at the end of the project.

This Scoping Study paper is a project milestone as identified in the scope of work, and summarizes the planned research methodology current understanding of the subject matter, along with a contextualization of these findings. Also contained in this paper is a list of references and resources identified in ACEEE's literature review.

1.1 Research Methodology

The survey and analysis is being conducted by a team of ACEEE researchers with experience analysing federal and international policies, and analysing the impacts of intelligent efficiency on energy use, the economy, and existing policies. The research team is leveraging their existing research and contacts in these areas during this initial scoping phase of the project.

In particular, the team is working with contacts and representatives from organizations associated with the Connected Devices Alliance to answer the following questions:

- What are governments doing to encourage intelligent efficiency?
- What have been the impacts of such government activity?
- What could and should governments be doing?
- What are the near-term policy and programmatic opportunities?

Throughout the project, the team will engage with representatives of the EDNA to seek their input and keep them apprised of the status of ongoing work. Their guidance and insights have been sought in the writing of this preliminary Scoping Study, and will be sought for the intermediate draft Policy Study report and Final Policy Study report.

Upon conclusion of the project, ACEEE will participate in the dissemination of project findings through its website, its own conferences, and the presentations its staff make at events throughout the United States and around the world.

2 Overview of Intelligent Efficiency

Information and communication technologies (ICT) —sensors, computers, data storage, networks, cloud computing— are making possible analysis of energy use and levels of performance that could not be achieved as recently as ten years ago. Equipment and systems used in buildings, transportation, and manufacturing are becoming adaptive to environmental inputs, anticipatory in their performance, and networked to one another within a facility as well as throughout a supply chain. This new capability enables users to determine the most energy efficient method of operation for a device, system, process, facility, or group facilities.

These intelligent or smart technologies exist along a continuum of complexity and potential for energy savings. The defining feature of intelligent efficiency technologies is they are connected to networks and in so have the ability to communicate and receive performance information and to respond to the external stimuli.

3 Policies, Programs and Practices

A way to understand the role of government in affecting intelligent efficiency and the success of various policies may be to frame policies in terms of the level of government involvement. Public policy and action exists on a continuum of government and private sector involvement. At one extreme is voluntary private sector activity facilitated by government resources. At the other extreme is mandatory behaviour by private sector required by the government.

This inter-relationship between government and private sector participation is captured in table 1. At the top, representing the most aggressive action government might take is mandatory regulation. At this level, government may compel or prohibit certain economic behaviour. The most poignant example is an energy efficiency requirement. At the level with the least amount of government involvement we see government agencies initiate or support collaborative efforts through use of their ability to convene stakeholders.

Table 1. Government Regulations, Policies, Programs and Practices

Government Mandated

Category	Government Role	Description and Examples
Mandatory	Set Standards	Government regulations that establish levels of performance (EU 1-watt standby requirement), labeling requirements (METI), building codes,
Invest	Fund	Research, development and demonstration, tax incentives, energy efficiency programs; establish research agenda
Lead	Set Example	Agency set example and create markets by setting purchasing specifications and establishing standard operating procedures (GSA purchasing specs.; FEMP SOPs)
Voluntary Agreements	Initiate	Secure voluntary agreements from private sector to meet performance targets (Set-top boxes, METI, C02e goals, (requirement)
Supporting Programs	Support	Collaborative efforts to catalyse economic activity such as development of open source software, best practices (GreenButton, CDA)
Collaborative	Convene	Industry led collaborative efforts to establish common protocols and practices (ISO, GreenGrid, voluntary performance levels and labels.

Industry Led

Source: **ACEEE.**

In between these two extremes we have government financial and technical support that catalyses economic activity by the private sector. With government's capacity to plan for the future, it can fund research, development and demonstration efforts that are too risky for the private sector. Energy efficiency programs that provide technical and financial assistance fall into this category.

Governments also lead by example, being an early adopter. As one of the largest purchasers of products and services and as a consumer with a higher tolerance for risk, by their leadership, agencies can create support and an economic market for new performance labels and higher efficiency products.

Government agencies also seek to achieve many environmental and economic development goals through the establishment of voluntary agreements with specific private sector companies or economic sectors. Though voluntary in that organizations are not compelled to enter into agreement, they can be legally enforceable once executed.

Governments support economic activity through various initiatives to establish best practices and accepted protocols. Though voluntary by design, the benefits of common practices are often a sufficient economic incentive for wide adoption by the private sector.

These six levels of engagement are not distinct, with many policies and programs could fit into multiple categories. This list is only intended to provide an organizing structure for discussion. In the body of this paper, we will examine examples of each of these six levels of engagement and discuss each level's strengths and weaknesses in achieving policy goals.

3.1 Mandatory Performance and Labeling Standards for Connected Devices

Many governments around the world establish performance requirements for products and setting maximum or minimum energy performance levels to reduce the demand for and consumption of energy. With the number of connected devices expanding in residential and commercial sectors, many governments have begun adopting performance and labeling standards for different power modes can help control energy consumption.

For example, the Australian Government, states and territories and the New Zealand Government collaborated to deliver a single, integrated program on energy efficiency standards and energy labelling for equipment and appliances through the Equipment Energy Efficiency (E3) program.

Figure 1 reflects the number of countries that have adopted mandatory performance standards for selected groups of appliances. Appliance product groups represented in the map include information and communication technologies (ICT), computers, cooking and dishwashing, lighting, office equipment, power supply and power conversion devices, televisions, display, and audio visual equipment. Not all of the appliances covered by these regulations are connected devices. Some are in categories which have shown innovation around the use of data and are likely to have network features and capabilities in the future.

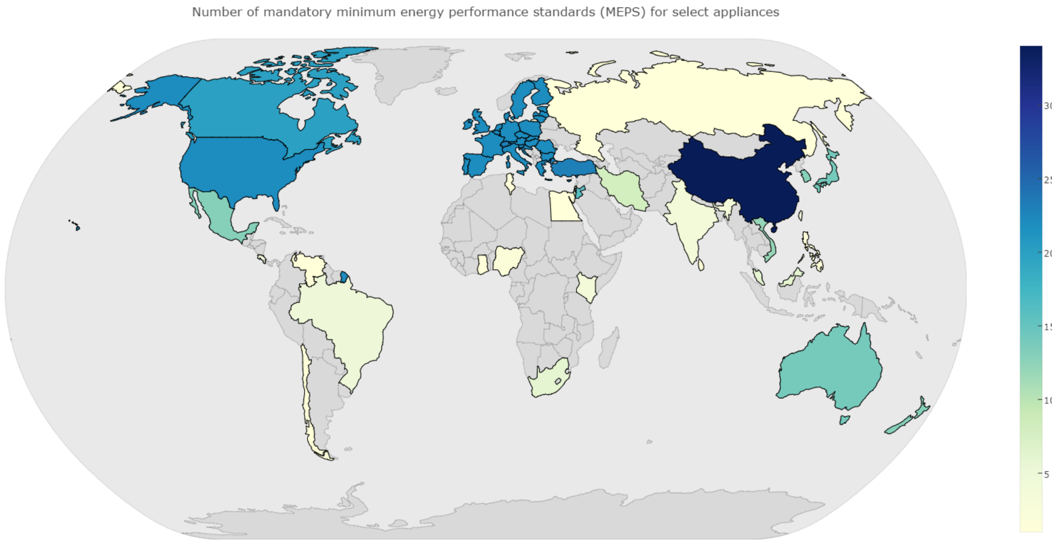

Figure 1. Countries with mandatory minimum energy performance standards for relevant appliance groups, presenting the number of devices covered in a country. *Source:* CLASP 2016.

3.1.1 Standby Power Requirements

By setting performance standards, regulators can prevent less efficient appliances from entering into the market. Mandatory performance standards and labeling directly address the uptake of efficient devices, enable market transformation from lower to higher efficiency connected devices.

EXAMPLE: UNITED STATES OF AMERICA
In the United States, the Building Technologies Office (BTO) of the Department of Energy (DOE) implements minimum energy conservation standards for more than 60 categories of appliances and equipment, including network connected devices.

In the US, states can impose additional regulations on the products sold within the state. In 2004, the California Energy Commission set limits on standby power consumption of various consumer-electronic devices. Products covered included DVD players, external power adapters and stereos. The initial standby mode limit was 3 watts. It was reduced to 0.5W in 2008.

3.1.2 Labeling Standards

Several countries require product labeling related to the standby power consumption of electronic devices. Such labels may be standalone policies that seek to influence consumer behaviour by providing comparative information. Others may be in addition to MEPs that let customers know that the product meets the MEP and/or exceeds the MEP.

EXAMPLE: KOREAN RATIONAL UTILIZATION OF ENERGY ACT, E-STANDBY PROGRAM
Korean Energy Management Corporation (KEMCO) was created in 1980 by the Rational Energy Utilization Act to implement energy efficiency programs. KEMCO created a mandatory rating label program that rates products based on their standby power requirements on a scale of 1 to 5, with 1 being the most efficient. Products that use less energy than the target levels for their product

category, as set forth in a performance table, can be rated 1. Products that exceed the maximum standby power limit must display a warning label attesting to that fact. This program has reduced from 40% to 1.4% the ratio of products sold in Korea with excessive standby power requirements (KEMCO 2008).

3.1.3 Resources

- The Collaborative Labeling and Appliance Standards Program (CLASP) maintains a database of minimum energy performance standards and labeling requirements. A portion of that database in reproduced in Appendix A. The appendix table lists mandatory and voluntary standards and labels focusing exclusively on standby power consumption in various countries.
- A table that lists the standby power usage of devices sold in Korea is reproduced in Appendix C.
- Lawrence Berkeley National Laboratory (LBNL 2016) analysed the power draw of many electrical appliances in standby mode.

Standards

The term standards is used in two distinct, though interrelated ways: regulatory standards, which are discussed in this section, and voluntary, consensus standards that are discussed in subsequent sections. Both have significant impact on the acceptance and implementation of intelligent efficiency.

Regulatory standards establish minimum performance of products (e.g., minimum efficiency performance standards or MEPS) and minimum levels of practice (for example mandatory building performance codes). In most cases, these regulations are built upon the voluntary standards, with the statutory language referencing the voluntary standards. By relying upon voluntary standards, regulations can ensure that the test procedures and technical specifications are reasonably, reflecting stakeholder input and are not at odds with market practices.

Voluntary standards reflect the product and practice standards that established by technical societies and associations across the globe. Many of these entities participate through their national standards writing bodies in the International Standards Organization (ISO), which is an independent, non-governmental organization that provides a consensus-based standards writing frame work. One-hundred sixty one national standards writing bodies are members of ISO, with the majority of standards writing organizations in member countries participating through their national bodies. The consensus standards process ensures that all stakeholder interests are represented and considered in the resulting standards conferring a level of acceptance and credibility to the resulting standards, thus facilitating commerce that makes use of these standards for procurement and practice.

There are three international standards organizations that form what's called the World Standards Cooperation. These are the three largest and most well-established organization for voluntary consensus-based international standards making. Connected devices are within the purview of all three of these organizations.

International Organization for Standardization (ISO) – international standards covering almost every industry, from technology, to food safety, to agriculture and healthcare.

International Electrotechnical Commission (IEC) - international standards and conformity assessment for all electrical, electronic and related technologies.

International Telecommunication Union (ITU) - United Nations agency for information and communication technologies. Develop technical standards for interconnectivity of networks and technologies.

IEA 4E has identified standardization organizations as key actors in the larger international effort to influence the energy use of connected devices. It has assembled a working group to develop definitions, energy efficiency metrics, and test procedures (More Data, Less Energy. IEA 4E 2014). Since that working group will be addressing this issue in detail in its report, we will not duplicate that analysis here.

3.2 Investing and Funding

Many governments invest in innovation and energy efficiency, which come together in intelligent efficiency. The investment may take the form of research, development and demonstration of intelligent efficiency technologies. Financing may also take the form of economic development in the form of tax incentives for certain types of investments for energy and environmentally focused policy goals in the form of energy efficiency financial and technical assistance programs. Participation in all of these activities by the private sector is voluntary.

3.2.1 Research, Development and Demonstration

The development of new technologies has many steps and developed countries have created agencies and programs to support each with technical and financial support. The US Department of Energy (DOE) supports a dozen National Laboratories that lead the nation's primary research. Other DOE programs such as the Advanced Manufacturing Office (AMO) and Advanced Research Project Agency-Energy (ARPA-E) take emerging technologies from concept to field demonstration.

DOE is investing millions of dollars in developing methods for networking devices, buildings, manufacturing, appliances, and vehicles. A recent focus has been on technologies that allow dynamic balancing of supply and demand of electricity. Such innovations promise to facilitate greater use of variable renewable energy resources such as solar and wind power.

EXAMPLE: CASE STUDY: PACIFIC NORTHWEST NATIONAL LABORATORY GRIDWISE DEMONSTRATION OF TRANSACTIVE CONTROL

The potential for connected devices and buildings to connect to the Smart Grid and even respond to time-of-use pricing has been theorized for many years but due to the complexity and expense of testing such a concept, very few demonstrations have taken place. The Pacific Northwest National Laboratory (PNNL) worked with Bonneville Power Administration (BPA) and several technology companies to test a reactive and predictive grid demand model. Though none of the district utilities in the BPA territory currently uses time-of-use pricing, the pilot leverages a time-of-use pricing model to communicate the value of supplied energy and system constraints to them. Each utility functions as a node that received and transmitted information about supply and demand. The power system modeling and simulation software analyses current information from the many nodes, compared it with historical information and predicted future supply and demand. Each utility then shared the information with its larger customers in a way that enabled them to response by curtailing load (Rogers 2014). Future research is likely to examine communicating time-of-use pricing to the facility where smart building management systems and connected devices can automatically respond according to their programming.

3.2.2 Financial and Technical Assistance Programs

Economic growth in intelligent efficiency can be facilitated by many types of agencies, being done through direct financial incentives such as tax credits, rebates, grants and loans, or through technical assistance such as access to expertise and technical resources, and workforce training.

In Japan, the Ministry of Economy, Trade and Industry (METI) has responsibilities for energy use and associated technology innovation. In 2011, METI provided a subsidy for home energy management systems as a demand-side measure that could be used to reduce electric system peak demand (METI 2012).

In North America, much of the financial and technical assistance to energy customers is delivered through electric, natural gas and water utilities.

EXAMPLE: AUSTIN ENERGY EEP FINANCING SMART THERMOSTATS FOR RESIDENTIAL PROPERTY OWNERS.
The municipal utility, Austin Energy, has been exploring the use of learning thermostats to reduce residential energy consumption for several years. They currently offer rebates to residential customers for the purchase of approved Internet-connected thermostats that are enrolled in a demand response program that automatically turns down the setting about 15 days a year during the hotter summer months (Austin Energy 2016).

3.2.3 Economic Development

It is not unusual for an emergent technology to attract the attention of policy makers, but without an obvious role for government to play. In such situations, government still has at its disposal many tools to encourage greater economic activity. A current example of this is section within the 2016 US Senate Bill S-2012, "Energy Policy Modernization Act of 2015" focused on information and communications technologies (ICT). The Act calls for the following supporting activities with government resources.

- Study the economic implications of ICT on the economy
- Study the energy intensity of data centres every four years. Consider using the Green Grid's Data Center Maturity Model[1] (DCMM) to evaluate the efficiency of government data centres.
- The US Department of Energy's Federal Energy Management Program (FEMP) shall conduct pilot projects involving smart buildings and evaluate their features and benefits
- Create training programs to develop an energy savvy workforce

[1] www.thegreengrid.org/en/Global/Content/Tools/DataCenterMaturityModel

3.2.4 Resources

Several organization keep track of government policies and programs. We have not identified a single resource that focuses on intelligent efficiency related policies, however there is information on such policies in the following databases.

- ACEEE maintains a State Policy Database. aceee.org/sector/state-policy
- The Database of State Incentives for Renewables & Efficiency (DSIRE) housed at North Carolina State University maintains a list of all energy related incentive program. www.dsireusa.org/
- OECD maintains a database of R&D investment by country. Investments are organized by sector. Appendix B contains a chart of investments in R&D related to ICT and building management systems. www.oecd.org/innovation/inno/

3.3 Leading by Example

Federal governments are often the largest consumer of a given service or product within a country. At regional and local levels, state, provincial and municipal governments are also significant consumers of products and services. Government agencies can establish purchasing specifications that require all products purchased meet a performance standard. These types of purchasing specs can create markets for high-efficiency products and establish label awareness within the marketplace.

In 2001, US President George Bush signed Executive Order 13221 which states that every government agency "when it purchases commercially available, off-the-shelf products that use external standby power devices, or that contain an internal standby power function, shall purchase products that use no more than one watt in their standby power consuming mode" (Ye and Seidel 2012).

Since then, the FEMP requires federal agencies to purchase energy-efficient products in that:

- Meet FEMP-designated efficiency requirements or be Energy Star certified. FEMP-designated products are in the upper 25% of their class in energy efficiency.
- Have a low standby power level of 1 watt or less when compliant models are available on the market. If a product with a standby power level of 1 watt or less is not currently available, a product with the lowest possible standby power level in the product category should be purchased.

A 2010 US Office of Management and Budget (OMB) directive calls on agencies to reduce number of data centres and adopt a "cloud-first" policy (Ye and Seidel 2012).

3.4 Voluntary Agreements, Performance Standards and Labels

One type of government practice that can achieve goals in excess of mandatory requirements is to negotiate voluntary performance agreements with the private sector. Such agreements are essentially contracts and are therefore legally binding. Agreements may be along the lines of getting a commitment to lower overall CO2 emissions in the Steel Sector or agree to maximum standby power levels for set-top boxes. The US Environmental Protection Agency's ENERGYSTAR program is a combination of voluntary agreements to make products that conform to voluntary performance standards and a labeling scheme that communicates compliance with those standards.

Voluntary agreements have been successful in achieving energy efficiency goals and creating awareness by and changing the attitudes of managerial and technical staff regarding energy efficiency. They are also a more flexible method for addressing barriers to technology adoption and innovation and brining about market transformation.

Private sector stakeholders are often engaged through the use of incentives and avoidance of disincentives. Incentives range for helping companies benchmark the performance of their products to creating labeling programs that differentiate their products and provide the opportunity to increase sales. Companies are often keen to avoid disincentives such as regulation or taxes and will enter into agreements to avoid them.

EXAMPLE: EUROPEAN UNION (EU) VOLUNTARY AGREEMENT STANDBY POWER LIMITS
Voluntary policies such as the IEA 1-watt plan launched in 1999 promoted the harmonization of standby power consumption, definitions, and test procedures among IEA member countries. The agreement on set-top boxes set a maximum of 1.0 W for passive standby and off-mode starting in 2010 and reduced it to 0.5 W in 2013.

EXAMPLE: SOUTH KOREAN E-STANDBY PROGRAM FOR ELECTRONIC DEVICES
The Basic National Energy Plan 2008-2030 sets an energy use reduction target of nearly 17 Mtoe in industry by 2030. KEMCO promotes five-year voluntary agreements with industrial groups. Businesses that enter into voluntary agreements or invest in energy-saving technologies are entitled to financial and technical support and tax credits covering up to 20 per cent of the investment cost (ABB 2013).

EXAMPLE: NORTH AMERICAN UTILITY COOPERATIVE AGREEMENTS
Eversource, a large electric utility in New England, achieves much of its annual goal for customer energy efficiency through cooperative agreements with its largest customers. The agreements commit a customer to invest a certain amount each year in energy efficiency and to achieve agreed upon targets in energy savings. In exchange, they receive financial incentives to help offset a per cent of the investments. Investments in smart building and other networked technologies can be funded through these agreements.

3.5 Supporting Programs

Governments support economic activity and energy efficiency through various initiatives to establish best practices and common protocols. Though such standards and practices are voluntary by design, the benefits of common practice are often a sufficient economic incentive to become widely adopted.

Sometimes the needed involvement from government is related to goal setting. The goal may be related to an innovation milestone, a common market practice, or a performance target related to energy savings or emission reduction.

3.5.1 Technology Enabling

A number of other government efforts support private sector by creating a platform or venue for new economic activity. For example, networked devices benefit from improved broadband internet service. Programs that support private sector investment in expanding and improving broadband will benefit the intelligent efficiency sector. In a similar vein, facilitating greater innovation related to the Smart Grid is likely to benefit networked devices and smart buildings.

EXAMPLE: US GREEN BUTTON INITIATIVE
Improving accessibility to energy use information can help people understand and manage their energy bills better. Launched by the US administration in 2011, the Green Button Challenge is a voluntary program that urges utilities to provide consumers electronic access to their energy information. The program currently serves 60 million homes and businesses who can easily download their energy data in a standard format (Green Button 2016).

The open-data approach of Green Button allows more open-ended data collection and leads to innovation in the field of energy efficiency. New products and services are being created using the Green Button platform that help residential and commercial customers to track and manage their energy use.

EXAMPLE: OPENADR
To facilitate the growth of demand response, the US Lawrence Berkeley National Laboratory (LBNL) and several US utilities and grid operators came together create the Open Automated Demand Response (OpenADR) bidirectional communications protocol. Later, the Open Automated Demand Response (OpenADR) Alliance was created to propagate its use in the utility sector. The OpenADR platform could become the basis not just for demand response but also for utility facilitation of distributed generation and energy efficiency. Coupled with the analytical capabilities of building management systems, OpenADR gives businesses a new ability to manage their future energy consumption needs and supplies. Utilities could use the protocol to dispatch on-site distributed generation resources, just as they currently dispatch their own generation resources. They could communicate demand-response requests that customers could respond to with any combination of energy efficiency and on-site generation resources (OpenADR 2016).

3.5.2 Goal Setting Programs

Setting targets can be a motivating action that brings together many public and private resources. Policy makers can set the goals or work with private sector stakeholders to develop goals. Internationally, collaborative efforts between countries to set common goals such as minimizing the energy use of networked devices.

At a local level, energy efficiency programs can help individual organizations develop goals and strategies for reducing energy use or adopting new technologies and practices.

EXAMPLE: UNITED NATIONS' SUSTAINABLE DEVELOPMENT GOALS (SDGS)
On January 1, 2016 the United Nations' Sustainable Development Goals (SDGs) went into effect. The 17 (SDGs) are part of the 2030 Agenda for Sustainable Development and were adopted by 193 world leaders in September 2015 at the 2015 UN Sustainable Development Summit. Goal 9c significantly increase access to information and communications technology and strives to provide universal and affordable access to the Internet in least developed countries by 2020.

Example: Connected Devices Alliance (CDA) - Voluntary Principles for Networked Devices

The Connected Devices Alliance (CDA) is an initiative of the Networked Devices Task Group (NDTG) of the G20. A set of voluntary Principles for Networked Devices was called for in the G20 Energy Efficiency Action Plan in 2015. The Alliance is a network of 300 government and industry participants across the many key sectors that influence the energy consumption of networked devices and networks. The principles will recommend best practices for the design and operation of connected devices and policies affecting both (IEA 2016).

Example: Australia "Your Energy Savings" program

The department of Industry, Innovation, and Science in the Australian government hosts a website that provides people with information on how to save energy in their homes and offices, and available government assistance. Called "Your Energy Savings", this program enables greater uptake of environmental programs for energy and water conservation.

3.5.3 Resources

The Organization for Economic Co-operation and Development (OECD) maintains a portal to track broadband statistics among member countries including geographic coverage, internet speeds, pricing, investment, demographics. Countries are leveraging information technology to improve energy information transfer.
www.oecd.org/innovation/inno/

The international conglomerate ABB maintains a database of country polices and has reports for over four dozen countries including G20 countries. new.abb.com/energy-efficiency/global-trends-in-energy-efficiency/country-reports

The International Energy Agency (IEA) has many reports on country policies relating to energy efficiency and environmental issues.
www.iea.org/topics/energyefficiency/publications/

3.6 Collaborative

This category is intended to capture all of the IE-related activity that is not being led by a government agency. It is likely that they may be involved as a technical resource or to help with the convening, but government is not the driver. It may function as a convener, a facilitator or a technical resource.

Government can assist in the development of the most mundane and yet fundamental standards. For example, even machine–human interfaces will benefit from standardization. All consumers and manufacturers benefit from the use of a common keyboard layout, common icons on those keyboards and computer screens and electronic devices. Connected devices and smart buildings will also benefit from common icons, definitions, and interfaces. It is not necessarily the role of government to develop such standards, but its participation in collaborative efforts to develop them can motivate others to participate in and ultimately use the output of such initiatives.

Example: BACnet

BACnet International is an industry association that facilitates the successful use of the BACnet protocol in building automation and control systems through interoperability testing, educational programs and promotional activities. BACnet enables controls devices of different manufacturers to communicate with each other by specifying a common communication protocol that allows for building systems to communicate with each other using a common language and is the only standard protocol developed specifically for commercial building automation systems (BAS) applications.

BACnet was developed by American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), which is a professional society. It is not a product of government action but has been supported by many governments. It was adopted as a national standard in the United States in 1995 and later by Korea, China, Japan, and Europe. In 2004, BACnet became an international standard (ISO 16484-5).

Example: Intelligent Efficiency Labeling Initiative
Two Washington, DC based non-profits, ACEEE and ITIC, have joined together to engage the technology and energy efficiency sectors to develop voluntary performance metrics and labels for intelligent efficiency devices such as learning thermostats and smart lighting systems. Government involvement in this initiative includes participation in the steering committee and working groups by researchers from three of the National Laboratories. It is anticipated that representatives from several federal and state agencies will participate in an advisory role.

4 Analysis

Our analysis focused on policies targeting networkable appliances and connected devices for the residential and commercial sectors. Most of the policies we examined came from Europe, North America, Japan and South Korea. As our research continues, we intend to expand our analysis to the policies of more G20 countries. We also intend to look for more policies focused on connectivity.

We discovered policies that target the industrial and transportation sectors in our literature review and some of them have been mentioned in passing. It is interesting to note that many vehicles now have connectivity with the Internet and are becoming more connected to residential and commercial buildings. This market development could be an area for future research as the sources of energy supply and demand in each sector of the economy start to intertwine.

Our preliminary findings of policies in the six categories are summarized below. Considerably more was uncovered in the regulatory and investing categories, however more countries are pursuing collaborative and voluntary measures than mandatory ones. The reach of non-mandatory policies is also much greater affecting more products and more industry stakeholders.

4.1 Regulation

Most regulatory policies to date have been related to maximum energy consumption during standby for connected devices. In some countries such as the US, there are standby requirements for all electronic devices. In other countries like Chile, an incremental approach has been taken that expands coverage to one product group at a time.

Governments play important roles in the development of regulatory and consensus standards. They are uniquely positioned to convene national standard writing bodies, provide them funding and technical resources, all of which can accelerate the consensus standards writing process. Similarly, they can plan an important role in working with other national standards writing bodies to facilitate harmonization of these voluntary standards. With respect to regulatory standards, this is clearly an area of activity for government.

One challenge that governments have with developing both kinds of standards related intelligent efficiency is the rapidity with which intelligent efficiency products and practices are evolving. The standards writing and regulatory processes are slow and deliberative by design. Therefore, it is possible that innovation will stay one step ahead of regulatory action and that attempts to create performance standards will not provide any value to consumers. It is therefore prudent for regulatory agencies to should show restraint when working in the intelligent efficiency area and to seek for opportunities to enable progress without unintentionally stifling evolution and innovation.

On initial analysis, it appears the many of the governments around the globe are aware of this and taking a cautious approach to regulation. There appears to be a preference for voluntary performance and labeling schemes on devices and limiting regulation to well defined product categories and setting performance limits that have the support of industry.

4.2 Investing in RD&D

Many governments are investing millions, and in some cases, billions of dollars in research and development. And their investment does not stop at the R&D level. North American and European countries have energy efficiency and environmental programs that provide financial and technical assistance to accelerate the uptake of smart devices.

4.3 Financial Incentives

One of the policy challenges with providing incentives for intelligent efficiency measures, such as building management systems is that of energy savings attribution. Though it may be easy to understand how automation can save energy, it is more difficult to determine how it can be incorporated into an energy efficiency program. And though the net energy savings is not in dispute, this type of measure creates challenges for the conventional energy efficiency program.

Conventional energy efficiency programs have focused on component energy efficiency, which poses several challenges to advancing intelligent efficiency measures. The first is a connectional challenge—in a complex project involving multiple components and controls, the energy savings happens at the device level even though it is influenced at the control level. What, if any, portion of the energy savings realized can be attributed to the controls? When performing M&V, how should energy savings be attributed?

This inability to associate net savings with an asset requires a paradigm shift in how policy makers think about what constitutes an energy efficiency measure. Development of new energy efficiency financial incentive program models are still in their infancy, but there appears to be, especially in North America, an interest in paying for actual savings instead of specific assets. If this comes to pass, connected devices are more likely to be included in projects that receive financial incentives.

4.4 Setting the Example

Establishing purchasing specifications and solicitation requirements can be an effective policy for initiating changes in product availability and market behaviour. It also has the additional benefits of driving down government operating costs and providing case studies that can inform policy makers on what is and is not likely to be useful legislation and regulation. We have identified that the US government is serious about using these two levers to influence market activities. As our research continues, we will seek out examples in other countries.

4.5 Voluntary Agreements

Our analysis has revealed many uses of voluntary agreements and negotiations with industry to set targets for the energy performance of devices, labeling requirements for appliances, and the environmental performance of business sectors. Many of these agreements are enforceable in court and have proven to be quite successful in achieving policymaker goals. Where regulation is difficult due to the complexity of products and dynamism of the market, agreements are an effective tool for government agencies.

4.6 Supporting Programs and Collaborative Efforts

Many government agencies are facilitating common communication and measurement protocols through their convening powers and participation in private sector collaborative efforts. Without common communication protocols, the uptake of connected devices and investments in smart buildings will be limited. Building control and automation systems implemented in piecemeal fashion will continue to limit innovation and capability. Entrenched software platform providers use proprietary data formats and communication protocols to essentially lock customers into using their hardware and software products preventing them from being able to purchase from other vendors in the future. Proprietary systems can also limit the ability of organizations to network and centralize the control of buildings that have different systems.

The private sector is challenged to overcome such a technical barrier by itself. No single private sector entity has the capacity or the influence to develop a comprehensive software platform nor would they be likely to make it open access. By contrast, many government agencies are often ideally suited to overcome such challenges because they can bring all parties to the table. In the US, the Department of Energy, Environmental Protection Agency and Department of Commerce are doing just that. In Europe, many government agencies, the European Union, IEA and G20 are all participating in collaborative efforts to reduce barriers and improve the performance of networked devices and intelligent efficiency.

5 Conclusion

Using the level of government involvement as a lens through which to view policies is a useful tool to gaining an understanding of the scope of how governments can influence the uptake of intelligent efficiency. A majority of efforts around the world appear to be supporting the development of new technologies and practices. Many of the performance and labeling requirements are targeting standby power levels, and there is considerable effort to breakdown market barriers preventing greater use of data and connectivity. Government involvement in this sector has produced encouraging results and promises to facilitate greater market acceptance of connected devices that can save energy and reduce greenhouse gases.

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Appendix A: Country Minimum Energy Performance Standards & Labeling Policies

Table A1. Mandatory energy performance standards and labels for standby power consumption in various countries

Economy	Implementing Organization	Product Type	Sector	Scope	Policy Name	Policy Type	Mandatory/ Voluntary	Policy Status	Most Recent Effective Date
Argentina	Secretaría de Energía (Secretary of Energy)	All Equipment Types	Multi-Sector	Standby mode energy consumption for electric devices.	IRAM 62301	Label Comparative	Mandatory	Development Completed - Pending Implementation	
Chile	Superintendencia de Electricidad y Combustibles - SEC (Fuel and Electricity Superintendence)	All Equipment Types	Multi-Sector	Standby mode for Blu-ray	PE 8-4_2	Label Comparative	Mandatory	Entered into Force - No Activity	1/1/2012
Chile	Superintendencia de Electricidad y Combustibles - SEC (Fuel and Electricity Superintendence)	All Equipment Types	Residential	Specifications for energy efficiency labeling in standby mode of electronic audio and video products	PE No 8/02/1	Label Comparative	Mandatory	Entered into Force - No Activity	1/1/2011
Chile	Superintendencia de Electricidad y Combustibles - SEC (Fuel and Electricity Superintendence)	All Equipment Types	Residential	Specifications for energy efficiency labeling in standby mode of a decoder that can be used in conjunction with televisions and works connected to supply power.	PE No 8/02/2	Label Comparative	Mandatory	Entered into Force - No Activity	1/1/2011
Chile	Superintendencia de Electricidad y Combustibles - SEC (Fuel and Electricity Superintendence)	All Equipment Types	Multi-Sector	Standby consumption of printers	PE No 8/7/2	Label Comparative	Mandatory	Development Completed - Pending Implementation	12/31/2012
Chile	Superintendencia de Electricidad y Combustibles - SEC (Fuel and Electricity Superintendence)	All Equipment Types	Multi-Sector	Standby mode for mini-component and micro-component stereos	PE 8-5_2	Label Comparative	Mandatory	Entered into Force - No Activity	12/1/2011
Chile	Superintendencia de Electricidad y Combustibles - SEC (Fuel and Electricity Superintendence)	All Equipment Types	Multi-Sector	Standby mode for DVDs	PE 8-3_2	Label Comparative	Mandatory	Entered into Force - No Activity	1/1/2012

Economy	Implementing Organization	Product Type	Sector	Scope	Policy Name	Policy Type	Mandatory/ Voluntary	Policy Status	Most Recent Effective Date
Chile	Superintendencia de Electricidad y Combustibles - SEC (Fuel and Electricity Superintendence)	All Equipment Types	Residential	This protocol provides specifications for energy efficiency in standby mode of microwave cooking ovens for domestic use, using a digital control panel.	PE No 1/18/2	Label Comparative	Mandatory	Entered into Force - No Activity	1/1/2010
Chile	Superintendencia de Electricidad y Combustibles - SEC (Fuel and Electricity Superintendence)	All Equipment Types	Multi-Sector	Standby consumption of home theaters with the following components: audio system, video playback system (CD, DVD, Blu-ray, and USB playback units)	PE No 8/6/2	Label Comparative	Mandatory	Entered into Force - No Activity	12/31/2012
European Union	European Commission - DG Energy	Network	Multi-Sector	Eco-design requirements related to standby and off mode, and networked standby electric power consumption for the placing on the market of electrical and electronic household and office equipment. Not applicable to electrical and electronic household and office equipment placed on the market with a low voltage external power supply.		Minimum Energy Performance Standard	Mandatory	Development Completed - Pending Implementation	
European Union	European Commission - DG Energy	All Equipment Types	Multi-Sector	Eco-design requirements related to standby and off mode electric power consumption. This Regulation applies to electrical and electronic household and office equipment.	Commission Regulation (EC) No 1275/2008 of 17 December 2008	Minimum Energy Performance Standard	Mandatory	Entered into Force - No Activity	1/7/2013

Economy	Implementing Organization	Product Type	Sector	Scope	Policy Name	Policy Type	Mandatory/ Voluntary	Policy Status	Most Recent Effective Date
Israel	Standards Institute of Israel (SII)	Network	Multi-Sector	Regulation for maximum energy demands for an active standby mode for top box sets	unknown	Minimum Energy Performance Standard	Mandatory	Under Consideration for Development	
Israel	Standards Institute of Israel (SII)	All Equipment Types	Multi-Sector	Regulation for maximum consumption in standby mode for electrical appliances for domestic and office electric appliances	The Energy Sources Regulations (Maximum Electric Output in Standby Mode for Domestic and Office Electric Appliances), 2011 / SI 62301 Domestic electrical appliances: measurement of output in standby mode	Minimum Energy Performance Standard	Mandatory	Entered into Force - No Activity	1/1/2012
Jordan	National Energy Resource Center (NERC)	All Equipment Types	Multi-Sector	Eco-design requirements related to standby and off mode electric power consumption. This Regulation applies to electrical and electronic household and office equipment.	Draft Technical Regulation on eco-design requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment (transposition of 1275/2008/EC)	Minimum Energy Performance Standard	Mandatory	Under Development	1/1/2014
Mexico	Comisión Nacional para el Uso Eficiente de la Energía - CONUEE (National Commission for the Efficient Use of Energy)	All Equipment Types	Multi-Sector	Maximum limits for standby power for various appliances and equipment	NOM-032-ENER-2013	Minimum Energy Performance Standard	Mandatory	Entered into Force - No Activity	1/23/2014
New Zealand	Energy Efficiency and Conservation Authority (EECA)	All Equipment Types	Multi-Sector		MEPS for standby power	Minimum Energy Performance Standard	Mandatory	Under Consideration for Development	

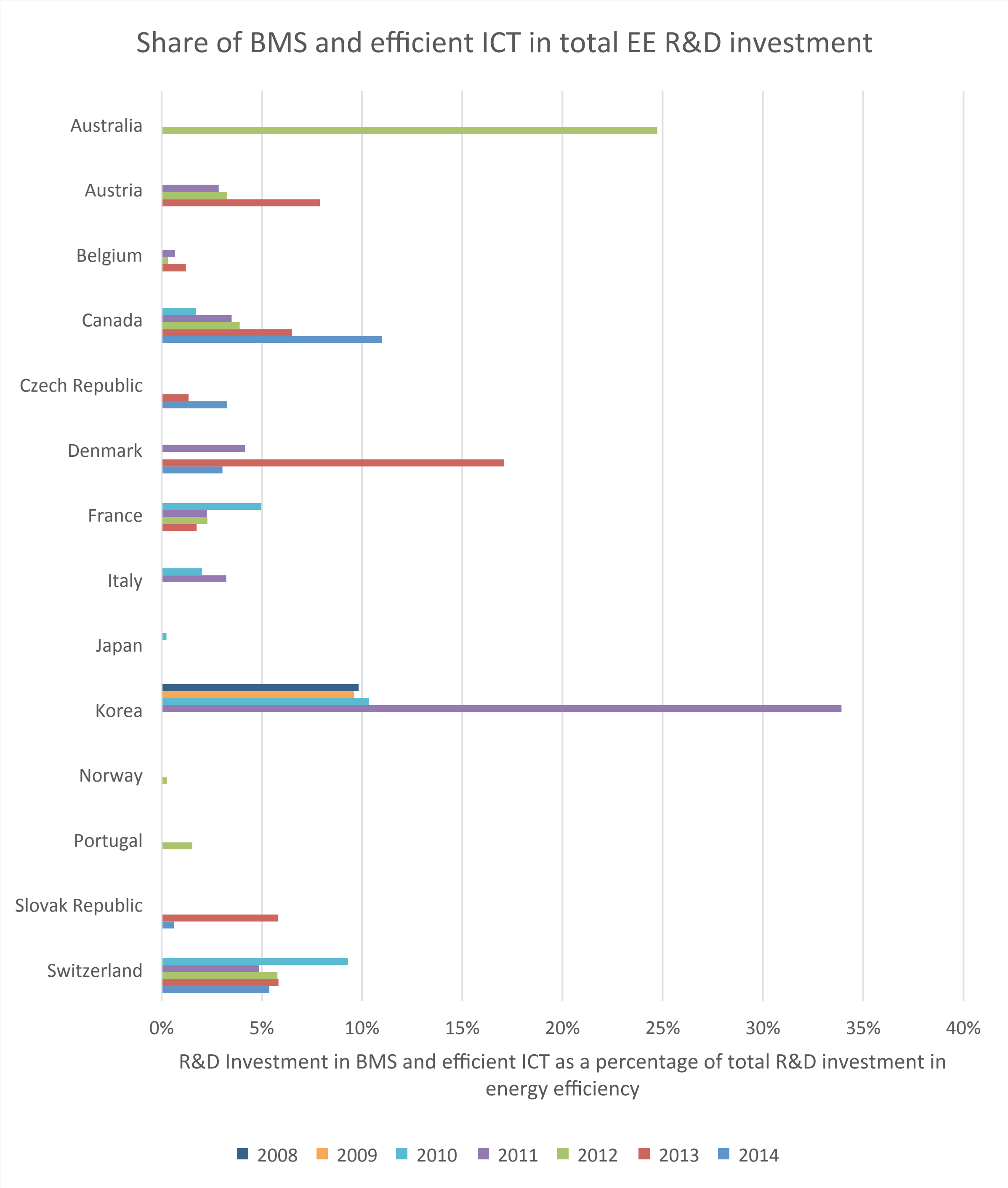
Economy	Implementing Organization	Product Type	Sector	Scope	Policy Name	Policy Type	Mandatory/ Voluntary	Policy Status	Most Recent Effective Date
Switzerland	Swiss Federal Office of Energy (SFOE)	All Equipment Types	Multi-Sector	Eco-design requirements related to standby off mode, and networked standby, electric power consumption for the placing on the market of electrical and electronic household and office equipment. Not applicable to electrical and electronic household and office equipment placed on the market with a low voltage external power supply to work as intended.	EC 1275/2008	Minimum Energy Performance Standard	Mandatory	Entered into Force - No Activity	1/8/2014
Switzerland	Swiss Federal Office of Energy (SFOE)	Network	Multi-Sector	Eco-design requirements related to standby off mode, and networked standby, electric power consumption for the placing on the market of electrical and electronic household and office equipment. Not applicable to electrical and electronic household and office equipment placed on the market with a low voltage external power supply to work as intended.	COMMISSION REGULATION (EU) No 801/2013 of 22 August 2013 amending Regulation (EC) No 1275/2008 with regard to eco-design requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) No 642/2009 with regard to eco-design requirements for televisions	Minimum Energy Performance Standard	Mandatory	Entered into Force - No Activity	1/8/2014
Thailand	Electricity Generating Authority Thailand (EGAT)	All Equipment Types	Multi-Sector	Standby power 1 watt for computer monitor and television receiver	The Energy Efficiency Label No.5 for standby power	Label Comparative	Voluntary	Entered into Force - No Activity	8/31/2010

Economy	Implementing Organization	Product Type	Sector	Scope	Policy Name	Policy Type	Mandatory/ Voluntary	Policy Status	Most Recent Effective Date
Turkey	Ministry of Energy and Natural Resources (MoENR/DG) and the Ministry of Science, Industry, and Technology (MOSIT)	Network	Multi-Sector	Eco-design requirements related to standby and off mode, and networked standby electric power consumption for the placing on the market of electrical and electronic household and office equipment. Not applicable to electrical and electronic household and office equipment placed on the market with a low voltage external power supply.	European Commission Regulation No 801/2013	Minimum Energy Performance Standard	Mandatory	Development Completed - Pending Implementation	4/17/2013
Turkey	Ministry of Energy and Natural Resources (MoENR/DG) and the Ministry of Science, Industry, and Technology (MOSIT)	All Equipment Types	Multi-Sector	Eco-design requirements related to standby and off mode electric power consumption. This Regulation applies to electrical and electronic household and office equipment.	Turkish Official Gazette No 28038 (transposition of EC 1275/2008)	Minimum Energy Performance Standard	Mandatory	Under Revision	8/27/2011

Source: CLASP 2016

Appendix B: Country Investments in R&D

The figure below shows R&D investment in building management systems and efficient ICT as a percentage of total R&D investment in energy efficiency for select OECD countries from 2008 to 2014. Data were not consistently available across the years for all the countries.



Source: IEA 2016a.

Appendix C: Standby Power Consumption of Electrical Appliances in Korea

Type	Electrical Appliances	Standby power(W)
Kitchen appliances	Rice cookers	3.5
	Refrigerator	Always on
	Kimchi Refrigerator	Always on
	Microwave	2.2
	Electric Frying Pan	1
	Toaster	0
	Coffee Machine	1
	Dishwasher	1
	Blender	0
	Water Purifier	5,8
	Oven	0.6
Office machine & Recreational goods	Computer	2.6
	Monitor	2.6
	Laptop	1
	TV	1.3
	Set top box	12.3
	Audio	4.4
	Video	4.9
	Telephone	0.2
	Printer	2.6
	Fax	3.4
	Scanner	2.9
Health Support &Personal hygiene	Iron	0
	Washing machine	1
	Humidifier	3.5
	Air Cleaner	0.7
	Hair Drier	0
	Vacuum	0
	Bidet	2.2
	Vibrator	8
Air conditioning and heating	Electric pad	0.59
	Electric fans	0.22
	Air conditioner	5.8
	Desk lamp	0.4

***Source*: (JiSun Lee 2013)**

Appendix D: Power Levels of Connected Devices

Connectedness makes possible great operational, energy efficiency, and environmental benefit but also requires that devices be on all the time. Turning equipment off is no longer a binary decision. All types of residential and commercial devices and appliances have multiple levels of operation ranging from completely off (zero power draw) to fully operational (maximum power draw). In 2014, the IEA released the report *More Data, Less Energy* (IEA 2014) that explored the various standby levels of electronic equipment. The graphic on page 64 is reproduced below.

Off

Still means that the energy-using device may be connected to a mains power source but is inactive. But the "new" off is no longer zero energy demand: now all devices draw some power, all the time.

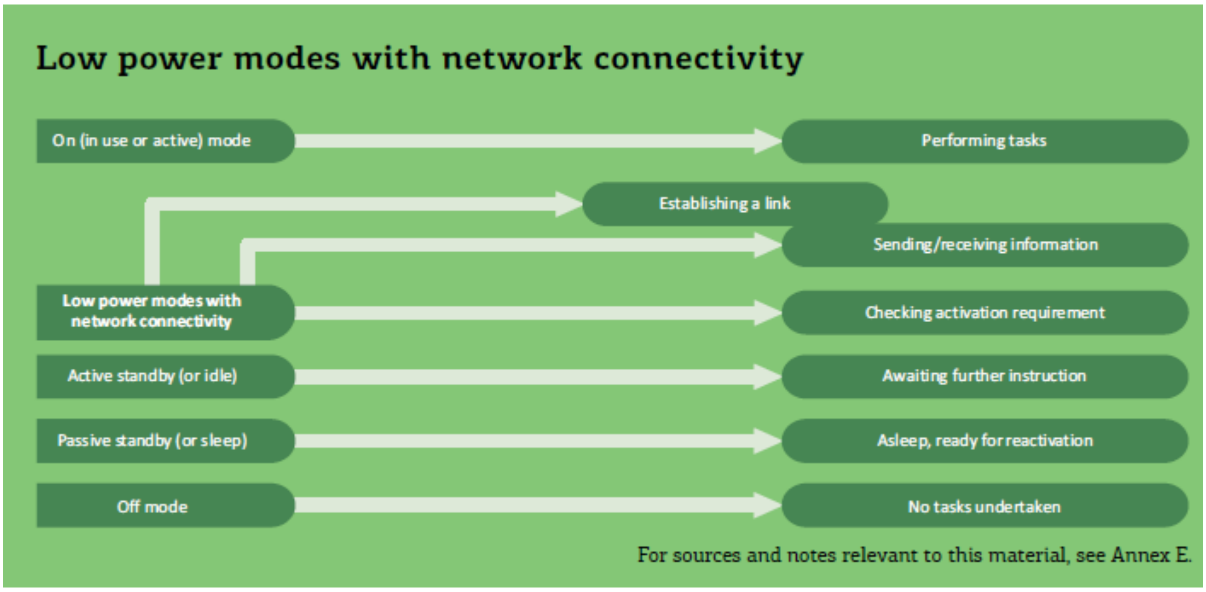
On

Means that the energy-using device is connected to a mains power source and has been activated so it can provide one or more primary functions. The amount of energy draw increases to reflect the actual workload of the function(s) being performed (see below).

Standby

Covers a spectrum of modes from almost asleep to almost awake; any point on the spectrum needs at least a small input of energy.

- **Low power mode includes any "non-active" mode (sometimes referred to as "standby" or "sleep") in which the device is not performing its main function(s). Some, but not all, devices are designed such that reduced function prompts a corresponding reduction in the power draw.**
  - **Passive standby (asleep) indicates that the device is connected to a power source; although it is inactive, it is able to respond to signals that cause it to wake up.**
  - **Active standby (idle) refers to the state in which the device is awake, but not actively performing any functions; rather it is waiting for signals that would cause it to launch functions.**
- **Network mode includes any state in which a device performs some function that requires interaction with a network.**
- **Low power mode with network connectivity refers to states in which a device is not delivering its primary/secondary function(s) but retains the capability to resume applications via a network connection. The device may be establishing a link, sending/receiving information or checking activation requirements.**



***Source*: IEA 2014**